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PROCEEDING

International Conference on Green Technology and Design

"A Dissemination platform for supporting green energy, green building, green automation, green transportation and environmental sustainability"

BANDUNG 4 – 5, DECEMBER 2019

BALE DAYANG SUMBI
INSTITUT TEKNOLOGI NASIONAL BANDUNG
WEST JAVA - INDONESIA

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BOOK OF PROCEEDING

INTERNATIONAL CONFERENCE ON GREEN TECHNOLOGY AND DESIGN

Bandung, 4 – 5 December 2019

Bale Dayang Sumbi
Institut Teknologi Nasional Bandung
West Java - Indonesia

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RUNDOWN ICGTD

Day	*Time*	*Description*
Wednesday, December 4th 2019	*08.00 – 08.30*	*Registration*
	08.30 – 09.00	*Welcome speech:* ***ICGTD Chair, Rector of Itenas*** *and Opening*
	09.00 – 09.45	*Plenary Session: "Assessment of Solar PV Power Potential over Asia Pacific Region with Remote Sensing and GIS"* ***Jeark A. Principe, Ph.D (Philipine)***
	09.45 – 10.30	*Plenary Session: "Emissions and Mitigation Scenarios for Residential Combustion of Solid Fuels in Developing Countries"* ***Dr. Ekbordin Winijkul (Thailand)***
	10.30 – 10.45	*Coffee Break*
	10.45 – 11.30	*Plenary Session: "Water Resource Management Framework For West Java Province, Indonesia"* ***Iwan Juwana Ph.D (Indonesia)***
	11.30 – 12.30	*Ishoma Break*
	12.30 – 16.45	*Parallel Sessions – as attached*
	16.45 – 19.00	*Closing*

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1	Niken Syafitri	Institut Teknologi Nasional Bandung	Green Automation	13.00	GSG Bale Dayang Sumbi Lt 1 (A)
2	Febrian Hadiatna	Institut Teknologi Nasional Bandung	Green Automation	13.15	
3	Florentinus budi setiawan	Soegijapranata catholic university	Green Automation	13.30	
4	Waluyo	Institut Teknologi Nasional Bandung	Green Automation	13.45	
5	Priyo Agus Setiawan	Politeknik Perkapalan Negeri Surabaya	Green Energy	14.00	
6	Lita Lidyawati	Institut Teknologi Nasional Bandung	Green Energy	14.15	
7	Bagus Rizky Pratama Budiajih	Institute Technologi Sepuluh Nopember	Green Energy	14.30	
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9	Rachmad Ramadhan Yogaswara	Universitas Pembangunan Nasional (UPN) "Veteran"	Green Energy	15.00	
10	Lisa Kristiana	Institut Teknologi Nasional Bandung	Green IT	15.15	
11	Achmad Hizazi	Universitas Jambi	Green IT	15.30	
12	Dewi Rosmala	Institut Teknologi Nasional Bandung	Green IT	15.45	
13	Diki Ismail Permana	Institut Teknologi Nasional Bandung	Green Energy	16.00	
14	Yusup Miftahuddin	Institut Teknologi Nasional Bandung	Green IT	16.15	
15	Yudi Widiawan	Institut Teknologi Nasional Bandung	Green IT	16.30	
16	Rifqi Finaldy	Institut Teknologi Nasional Bandung	Green IT	16.45	
17	Hafidz Dayu Aditya	Institut Teknologi Nasional Bandung	Green IT	17.15	
18	Agus Hermanto	Institut Teknologi Nasional Bandung	Green Energy	17.30	
19	Meilinda Nurbanasari	Institut Teknologi Nasional Bandung	Green Energy	17.45	
20	Alfan Ekajati Latief	Institut Teknologi Nasional Bandung	Green Energy	18.00	
21	Lakshmanan Gurusamy	Universiti Malaysia Sarawak (UNIMAS)	Green IT	18.15	

No.	Name	Institution	Paper Topic	Presentation Time	Place
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23	Yanuar Z. Arief	Universiti Malaysia Sarawak (UNIMAS)	Green IT	18.45	
24	Nur Laela Latifah	Institut Teknologi Nasional Bandung	Green Building	13.00	GSG Bale Dayang Sumbi Lt 2 B
25	Riny Yolandha Parapat	Technische Universität Berlin (TU-Berlin), Berlin, Germany	Green Transportation	13.15	
26	Erwin Yuniar Rahadian	Institut Teknologi Nasional Bandung	Green Building	13.30	
27	Ardhiana Muhsin Machdi	Institut Teknologi Nasional Bandung	Green Building	13.45	
28	Tiara Anantika	Institut Teknologi Nasional Bandung	Green Building	14.00	
29	Wahyudi	Institut Teknologi Nasional Bandung	Green Building	14.15	
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39	Nguyen Thi Kim Oanh	Asian Institute of Technology (AIT)	Suistanability Environment	13.30	
40	Agung Pramudya Wijaya	Institut Teknologi Nasional Bandung	Suistanability Environment	13.45	
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43	Elvira Rizqita Utami	Institut Teknologi Nasional Bandung	Suistanability Environment	14.30	
44	Farah Fauzia Raihana	Institut Teknologi Nasional Bandung	Suistanability Environment	14.45	
45	Byna Kameswara	Institut Teknologi Nasional Bandung	Suistanability Environment	15.00	
46	Ajeng Alya Hidrijanti	Institut Teknologi Nasional Bandung	Suistanability Environment	15.15	
47	Fenty Wastika Sari	Institut Teknologi Nasional Bandung	Suistanability Environment	15.30	
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50	Iredo Bettie Puspita	Institut Teknologi Nasional Bandung	Suistanability Environment	16.15	
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54	Maya Ramadianti Musadi	Institut Teknologi Nasional Bandung	Suistanability Environment	17.00	
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70	Agung Pramudya Wijaya	Institut Teknologi Nasional Bandung	Green Design	15.00	
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75	Aditya Januarsa	Institut Teknologi Nasional Bandung	Green Design	16.15	
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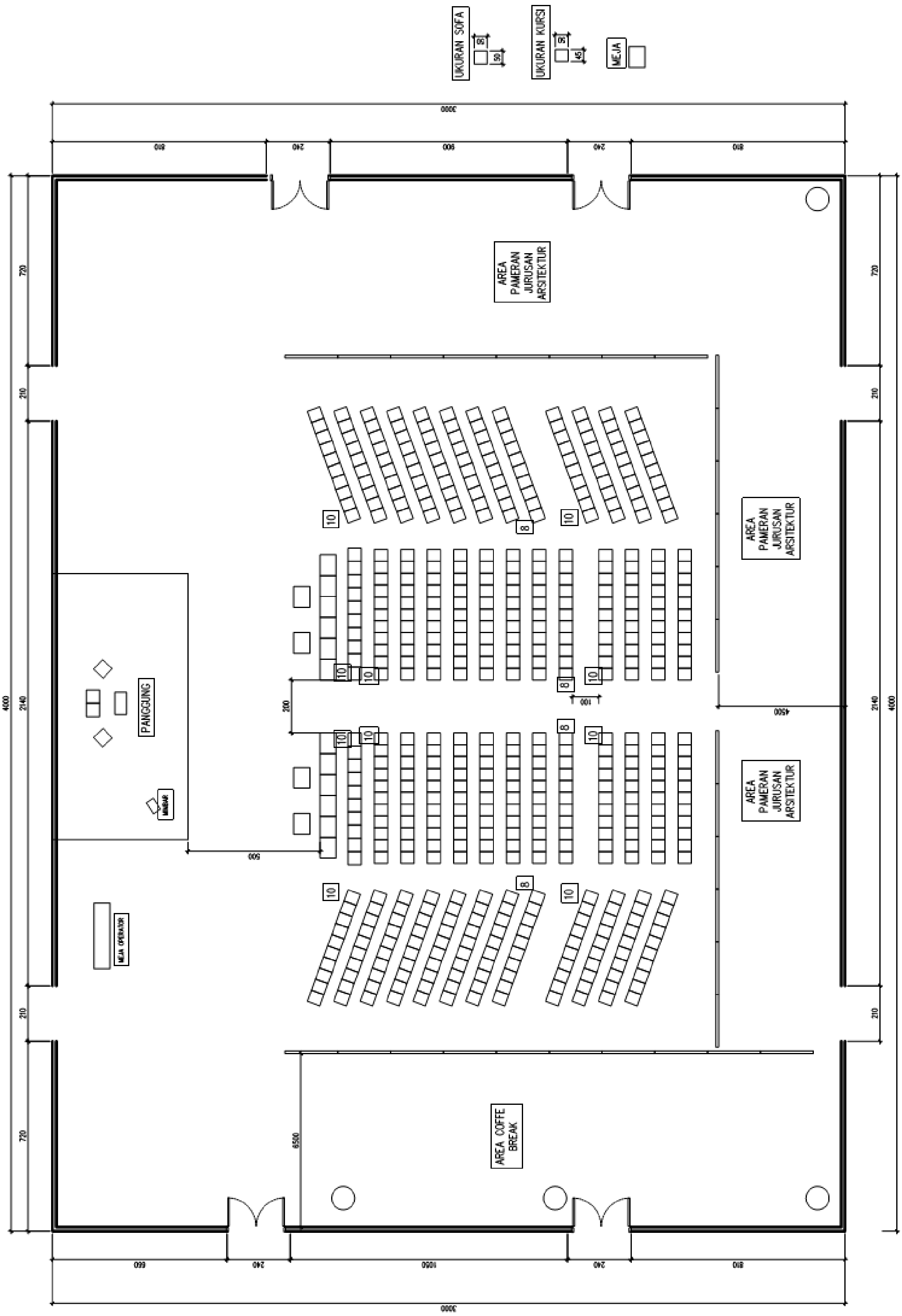
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FOREWARD

Welcome to the 1st International Conference on Green Technology and Design. This conference takes place in Bandung, 4th December 2019 and become our first international conference in green technology and design.

It is our responsibility to contribute in the national development and sustainability, the Institut Teknologi Nasional (Itenas) Bandung through its Lembaga Penelitian dan Pengabdian kepada Masyarakat (LP2M) conducts this conference and draws upon the expertise of wide range of knowledge.

The ICGTD 2019 conference aims to promote research in the field of Green Energy, Green Building Green Automation, Green Transportation, Sustainability Environment, Green IT and Green Design, and to facilitate the exchange of new ideas in these fields among academicians, engineers, junior and senior researchers, scientists and practitioners. It also includes the plenary, keynote and invited speakers.

On behalf of Organizing Committee, it is a great pleasure to welcome you in Itenas Bandung and look forward to meeting you at ICGTD2019.

Warm regards,

Chair
Dr. Ir. Nurtati Soewarno M.T.

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Green Design

Mathematical Modeling of Green Capacitated P-Centre Problem using Mixed Integer Linear Programming

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***Abstract*—This paper proposes a mathematical model for the stochastic green capacitated p-center problem a using mixed integer linear programming (MILP). A model is built considering the total emission produced by vehicles and the uncertain parameters including the customer demand, the travel time needed by a vehicle to travel from a facility to a customer and the capacity of a facility to satisfy the customer demand. The proposed model and method are evaluated using instances that are available in the literature. According to the computational experiments, the proposed methods produce interesting results.**

Keywords—stochastic, the capacitated p-center problem, MILP, emission

I. INTRODUCTION

According to Luis (2008), location problems can be classified based on topography, capacity restrictions, or objective functions. Based on topography of the site selection, location problems can be classified into continuous and discrete problems. In continuous location problems, the facilities can be located anywhere on a given plane where there is an infinite number of potential sites. In the discrete problems, there is a finite number of potential sites to locate the facility. Usually, the objective is to find the best locations among the potential sites in order to optimise an objective function such as the minimisation of the total cost.

Based on capacity restrictions, location problems can be divided into uncapacitated and capacitated problems. In the uncapacitated problems, there are no restrictions on the size or on the capacity of a facility to fulfil the demand of customers. In this model, the facility n for this case, the closest facility can always fulfil the demand of its customers. In the capacitated problems, the facility is restricted to its capacity. The customers were not always fulfilled by the closest facility because the nearest facility may not satisfy their demands. The assignment of customers to facilities is obtained by solving the transportation or the generalized assignment problem depending on whether or not customers are allowed to be served from a single facility only or not.

The location problems may be classified by their objective functions including the minimax, the maximin, or the minisum. Based on these objectives, location problems can be divided into three groups.

- Median Problems (minisum)
  The median problems are those problems where one or more facilities are to be located in order to minimise the average cost (average time) between the customer and the nearest facility. The problem is known as the minisum problem or the p-median problem, p denoting the number of facilities to be located.

- Centre Problems (minimax/maximin)
  Centre problems arise when a given number of facilities needs to be found with the objective of minimizing the maximum travel cost (travel time) be- tween customers and the nearest facility. The problem is known as the minimax problem or the p-centre problem. In the case of locating obnox- ious facilities such as nuclear/chemical station and waste disposal sites, the objective function reverses to a maximin instead of a minimax.

- Covering Problems
  Covering problems occur when there is a given critical coverage distance or cost or time within customers and facilities. The number of facilities is deemed sufficient if the distance between the customer and the nearest facility does not exceed some critical value, but deemed insufficient otherwise. This introduces the notion of coverage. Note that the p-centre can also be considered as a version of covering where the coverage value becomes a decision variable instead of an input.

Currently, the concern on environmental impact of business operations is increasing. Many companies now realise that carbon emissions produced by their operations need to be reduced as the emissions have a significant impact to global warming and severe negative impacts on business and society. In this study, to measure the environmental impact, we consider the amount of CO_2 emissions produced when transporting products from the facilities to customers. According to the World Meteorological Organization (2009), CO_2 is the single most human-emitted greenhouse gas emission (GHG) accounting for about 63.5% of the total global warming. Moreover, CO_2 is a very popular environment index and also easily measured. Other decision that has to be made beside the location of facility is to determine the type of the vehicle used by each facility considering CO_2 emissions produced. Therefore, here, we develop a problem called the green capacitated p-center problem (GCPCP).

In many real case applications, some uncertain parameters need to be considered when finding the best location for the facilities. Those parameters include the customer demand, the travel time from a facility to a customer and the capacity of the facilities. To deal with the problem with uncertainty, a mathematic model Mixed Integer Linear Programming are developed.

The main contributions of this paper is to develop a new mathematical model for the green capacitated *p*-center problem taking into account the environmental impact.

II. LITERATURE REVIEW

In this section, a review on the capacitated p-center problem is presented. The capacitated p-center problem on tree networks was studied by Jaeger and Goldberg [20]. The authors reveal that the problem can be addressed in polynomial time when the facility capacities are identical. Khuller and Sussmann [22] investigated the capacitated p-center problem where each facility can be assigned to at most L customers.

The *p*-centre problem, also known as the minimax location problem, aims to optimally locate *p* facilities among *n* potential sites and to assign demand points to these facilities in order to minimise the maximum distance between demand points and their nearest facility. Applications include the location of facilities in emergency services such as police, fire, and ambulance stations. In the conditional *p*-centre problem some (say *q*) facilities already exist and the objective is to locate *p* newfacilities in addition to the existing *q* facilities. A demand point can be served by the nearest facility whether it is new or existing. This problem is known as the (*p, q*) centre problem. When $q = 0$, the problem becomes the unconditional *p*-centre problem (the *p*-centre problem for short) whose formulation is given as follows:

$$\min r \quad (1)$$

Subject to:

$$\sum_{j\in J} Y_{ij} = 1, \quad \forall i \in I \quad (2)$$

$$\sum_{j\in J} X_j = p \quad (3)$$

$$Y_{ij} - X_j \leq 0, \quad \forall i \in I, j \in J \quad (4)$$

$$r \geq \sum_{j\in J} (d_{ij} \cdot Y_{ij}), \quad \forall i \in I \quad (5)$$

$$\sum_{i\in I} (w_i \cdot Y_{ij}) \leq b_j \cdot X_j, \quad \forall j \in J \quad (6)$$

$$X_j \in \{0,1\}, \quad \forall j \in J \quad (7)$$

$$Y_{ij} \in \{0,1\}, \quad \forall i \in I, j \in J \quad (8)$$

Where:

(*i, j*) : set of demand points/customers ($i \in I = \{1, ..., n\}$) and set of potential sites ($j \in J = \{1, ..., M\}$) (i.e.: $n = |I|$ and $M = |J|$), respectively

r : the maximum distance between a customer and its closest facility

$d_{(i,j)}$: the distance between customer *i* and potential site *j* (Euclidian distance is used in our study);

p : the required number of facilities;

Y_{ij} : 1, if customer *i* is served by a facility at site *j* and = 0 otherwise;

X_j : 1, if a facility is opened at potential site *j* and = 0 otherwise;

The objective function (1) is to minimise the maximum distance between a customer and its nearest facility. Constraints (2) guarantee that each customer *i* is assigned to exactly one open facility whereas constraint (3) restricts the number of open facilities to be exactly *p*. Constraints (4) ensure that customer *i* can only be allocated to an open facility (i.e., $X_j = 1$). Constraints (5) define the maximum distance between customer *i* and its closest facility. Constraints (6) and (7) refer to the binary nature of the decision variables.

The *p*-centre problem is known to be NP-hard problem (Kariv and Hakimi 1979). Though this problem can be optimally solved for medium size instances ($n \leq 4{,}000$, $p \leq 100$). The *p*-centre problem may consist of a large number of customers as well as potential facility sites. For example, a problem which includes individual private residences as customers may involve several thousands of demand points. One way to model such a problem is to aggregate customers from *n* to *m* points ($m << n$) so the reduced (approximated) problem becomes easier to solve. However, aggregation reduces the accuracy of the solution.

Daskin (1995) suggested a useful and interesting recursive type algorithm using the set covering problem (SCP) for obtaining an optimal solution for the problem. A unified limited column generation approach for facility problems including the *p*-centre problem on trees was presented by Shaw (1999). Efficient exact algorithms for the vertex *p*-centre problem were later proposed by Daskin (2000) and Ilhan and Pinar (2001). The former formulated the problem as a maximum set covering sub-problem and then Lagrangean relaxation is used to solve the problem. The latter proposed a method which consists of two phases namely the LP-Phase and the IP-Phase where in Phase 1 sub-problems with a certain covering distance are systematically discarded. Elloumi et al. (2004) used Minieka's technique incorporating a greedy heuristic and the IP formulation of the sub-problem for solving the problem optimally. Al-Khedhairi and Salhi (2005) introduced enhancements to the Daskin's method (1995) and Ilhan and Pinar (2001) with the aim in reducing the number of ILP iterations (calls to the SCPs). In the first approach, the gaps in the distance matrix are sorted and efficiently recorded whereas in the second approach, appropriate jumps in the covering distance are explored. Cheng et al. (2007) suggested an efficient algorithm by modelling the network as an interval graph. Chen and Chen (2009) introduced relaxation algorithms for both the continuous and discrete *p*-centre problems by solving optimally smaller reduced problems which are then augmented gradually by adding '*k*' customers at a time where *k* is a parameter that needs to be defined.

Salhi and Al-Khedhairi (2010) improved Daskin's approach (1995) even further by integrating heuristic information into exact methods. Tight upper bounds are obtained by a multilevel type meta-heuristic (Salhi and Sari

1997) which are then used to derive promising lower bounds. Davidovic et al. (2011) introduced a bee colony optimization heuristic algorithm and a non-deterministic Voronoi diagram algorithm for the unconstrained and constrained *p*-centre problem respectively.

III. PROBLEM FORMULATION

This section presents the mathematical model of the classical capacitated p-center problem followed by the proposed model for the deterministic green capacitated p-center problem (GCPCP).

A. The Capacitated p-Center Problem (CPCP)

The following notations are used to describe the sets, parameters and decision variables of the CPMP.

Sets

- I: a set of demand points/customers with i as its index and $n = |I|$
- J: a set of potential sites with j as its index and $M = |J|$

Parameters

- d_{ij}: the distance between customer $i \in I$ and potential site $j \in J$ (Euclidian distance will be used in this study)
- p: the number of open facilities
- w_i: the demand of customer $i \in I$
- b_j: the capacity of facility located at potential site $j \in J$

Decision Variables

- r: the maximum distance between customers and their facilities
- $Y_{ij} = \begin{cases} 1 & \text{if customer } i \in I \text{ is assigned to facility } j \in J, \\ 0 & \text{otherwise} \end{cases}$
- $X_j = \begin{cases} 1 & \text{if an open facility is located at site } j \in J, \\ 0 & \text{otherwise} \end{cases}$

Minimise $\sum_{i \in I} \sum_{j \in J} w_i \cdot t_{ij} \cdot c \cdot X_{ij}$

Subject to

$$\sum_{j \in J} X_{ij} = 1 \quad \forall i \in I$$

$$\sum_{j \in J} Y_j = p$$

$$\sum_{i \in I} w_i \cdot X_{ij} \le b_j \cdot Y_j, \quad \forall j \in J$$

$$X_{ij} - Y_j \le 0, \quad \forall i \in I, j \in J$$

$$Y_j \in \{0,1\} \quad \forall j \in J$$

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

B. The Green Capacitated p-Center Problem (GCPCP)

In this subsection, the mathematical model of the green CPCP (GCPCP) is presented where the presence of vehicle (truck) types is considered. In the new model, the vehicle type used by each open facility is treated as a decision variable. Each vehicle type has a different travel cost per unit time and produce a different amount of CO_2 emissions. To reduce the total CO_2 emission, each unit of CO_2 emissions produced is penalised. The notations used for sets, parameters and decision variables in the new model are similar with the one presented in the previous model with some additions described as follows:

<u>*Set*</u>

V the vehicle (truck) types

<u>*Parameters*</u>

c_v the travel cost per unit time to deliver one unit product using vehicle $v \in V$

e_v the amount of CO_2 emissions produced per unit time caused by delivering one unit product using vehicle $v \in V$

$\hat{c}$ the penalty cost per unit CO_2 emission produced

<u>Decision Variables</u>

$X_{vij} = \begin{cases} 1, \text{ if facility } j \text{ serves customer } i \text{ using vehicle } v \\ 0, \text{ otherwise} \end{cases}$

$\hat{Y}_{jv} = \begin{cases} 1, \text{ if a facility is located at site } j \text{ using vehicle } v; \\ 0, \text{ otherwise} \end{cases}$

The green CPCP is much harder to solve than the classical capacitated *p*-center problem as the proposed model aims to find the optimal solution for both facilities' location and their corresponding vehicle. The problem can be modelled as follows:

$$\text{Minimise } \sum_{i \in I} \sum_{j \in J} \sum_{v \in V} \left(w_i \cdot t_{ij} \cdot c \cdot X_{vij} + e_v \cdot t_{ij} \cdot \hat{c} \cdot X_{vij} \right) \quad (8)$$

Subject to

$$\sum_{j \in J} \sum_{v \in V} X_{vij} = 1 \quad \forall i \in I \quad (9)$$

$$\sum_{v \in V} \hat{Y}_{jv} \le 1, \quad \forall j \in J \quad (10)$$

$$\sum_{j \in J} \sum_{v \in V} \hat{Y}_{jv} = p \quad (11)$$

$$\sum_{i \in I} \sum_{v \in V} X_{vij} \cdot w_i \le \sum_{v \in V} \left(b_j \cdot \hat{Y}_{jv} \right), \quad \forall j \in J \quad (12)$$

$$X_{vij} - \hat{Y}_{jv} \le 0, \quad \forall i \in I, j \in J, v \in V \quad (13)$$

$$\hat{Y}_{jv} \in \{0,1\} \quad \forall j \in J, v \in V \quad (14)$$

$$X_{vij} \in \{0,1\} \quad \forall i \in I, j \in J, v \in V \quad (15)$$

The objective function (8) aims to minimise the total cost which consist of the total travel cost and the total penalty cost for producing CO_2 emissions. Constraints (9) make sure that each customer must be served by one facility only. Constraints (10) ensure that each open facility uses one vehicle type only. Constraint (11) guarantee that p open facilities are opened. Constraints (12) are the capacity constraints for each open facility. Constraints (13) ensure that each customer can only be assigned to an open facility. Constraints (14) and (15) state the integrality conditions of the decision variables.

IV. CONCLUSION

Based on the results of computational study, it can be concluded that:

1. Comparison of initial conditions with research results shows that using the p-center method and changing the determination delivery to 4 locations makes the company more efficient in terms of transportation and also saving time.
2. If the problem limitation and assumptions are removed then techniques and tools are needed that can handle the problem. However, the weakness of the research requires a long time in order to solve the

problem in accordance with the real conditions of the company and the results obtained are more accurate and relevant.

3. Comparison explains that the p-center method is better in terms of mileage compared to p-median. While the total distance of the p-median method is better than the p-center method.

4. The p-center method can be used for the case of determining any facility. These results provide advantages in minimizing maximum distance / travel time.

5. There are previous studies for cases in companies using the nearest neighbor method and taboo search. The purpose of this study is to determine the optimal distribution route. Whereas in the current study using the p-center method with the aim of finding the position of the p-facility to be placed so that all requests could be covered with the maximum distance between the request points and the placement of facilities to be minimal.

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