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# ESTIMATING POWER NEEDED TO FUEL ELECTRIC PARATRANSITS IN BANDUNG

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#### **Abstract**

This is the preliminary finding of a study elaborating the total energy consumption when paratransits in Bandung are altered into electric and the scenario to fulfill it. Therefore, there are lots to be done further concerning result of this initial research, of which will be discussed in another publication. In this paper calculation was done to find out the volume of power needed to fuel electric paratransits in Bandung. Steps carried out include computing total energy consumption for all paratransits, clustering stations from classified routes established by local Department of Transport, and estimating the electricity demand in every clustered station. Data used for this study was acquired from *Badan Pusat Statistik Kota Bandung* and *PT PLN DJA APD Jawa Barat and Banten*. A total demand of 61.12 MWh per month will surface to charge the total of 5,521 paratransits from 38 available routes in 15 clustered stations under the assumptions that all paratransits only make 6 return travels per day, operate 30 days per month, and use batteries with 50% State of Charge.

Keywords: transportation; electric paratransit; in town; electricity demand; feasibility study.

#### I. Introduction

Functioning in a small yet busy city, Bandung transportation is excessively active while on the other hand pollution it produces is too much. These facts make Bandung a potential project site for electric car initiative. Despite its pricey purchase cost [1], electric vehicle (EV) provides solution to lower pollution level and operation as well as maintenance costs reduction [2-5]. Best when applied for mass transport [6] for the sake of more pollution cutback, electric vehicle conversion then could be suitable when implemented to paratransit.

Existing research on Indonesian paratransit mainly discuss about general problems surrounding paratransit [7-9], tariff, service and customer perception [9, 10], the effect of air pollution it creates [11, 12], driver welfare [13-15], routes and programming [16-19], paratransit stop design [20], and feasibility on fleet addition [21]. On Bandung paratransit in particular, main

\* Corresponding Author.Tel: +62-22-2503055 E-mail: vedderforeva@yahoo.com research were done related to user satisfaction [9, 22, 23] and feasibility of electric paratransit initiative [24] which emphasizes on cost rather than energy implication.

As the pilot of a more comprehensive research, this paper is limited only to find out total electricity should be made available by the government to guarantee full operation of paratransits when they are converted into electric in Bandung. Conversion could cover retrofitting the available paratransit into electric or procure a full brand new electric vehicle for paratransit. How the demand would be satisfied is beyond the scope of this paper.

#### II. METHODOLOGY

This study was done according to simple steps illustrated in Figure 1. With single aim of giving rough estimation of energy demand when paratransits in Bandung turned electric, these following factors are not taken into account in all calculations performed. It has to be born in mind that this study assumes all routes to have the

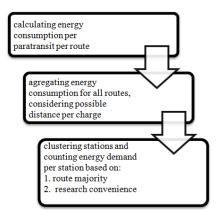


Figure 1. Methodology of this study

same topology, hence using average energy consumption. It is known that topology, traffic, driving style and temperature are of factors affecting energy consumption in EV [25]. In reality, routes topology probably a lot differs, resulting bias from the calculated energy consumption, either too high or even too low. Moreover, it was presumed that electric paratransits are retrofitted into electric using electric motor that still fulfills the function of their old internal combustion engines and fueled using lead acid batteries. Furthermore, regardless distance of each route, all routes are supposed to travel 6 returns per day. Actually, they can travel less and often, more. This will affect the concrete total energy consumption as well. To provide a glimpse of what is paratransit, Figure 2 displays the multicolored paratransits in Bandung whose colors define routes [26].

Using basic retrofitted paratransit in [24], presuming power consumption of retrofitted paratransit would be 500 Wh/mile, lead acid battery energy of 31,680 Wh and battery State of Charge (SoC) of 50%, maximum distance that can be obtained per charge is approximately 51 km. There are 5,521 paratransits available in Bandung, accommodating 38 routes with route distances range from 7 to more than 24 km one way [27].

For each route, first thing done was calculating kilometer traveled per day for each vehicle, which is 6 returns or equals to 12 times one-way distance. Using 1 mile = 1.61 km, we got energy consumption of 310.56 Wh/km. Considering vehicle load which is about to carry 15 people, this number is in line with other research where a Smart ED of 2 passengers consumes 0.17 Wh/km [28] and another passenger vehicle consumes an average of 0.62 MJ/km [29] or 172.22 Wh/km when air conditioner is off. By multiplying this energy consumption per kilometer with total distance traveled per day, energy consumption per day per vehicle was found. Multiplying again this number

with the quantity of paratransit per route, energy consumption of all paratransits per route per day then is resulted. To find total energy consumption for all paratransit, energy consumptions of all paratransits from all routes were aggregated.

Next step was clustering the avalaible routes to classify paratransits in which route should be charged in which station. Clusters are set in compliance with route and station convenience, and rough observation of paratransit in which route usually be mostly parked in or near which station. Routes, distance of each route, total energy consumption and alternative clustering are recapped in Table 1.

#### III. RESULTS AND DISCUSSION

Total energy needed per day to run all retrofitted paratransits Bandung in 2,037,397.824 Wh. This makes 61.12 MWh per month. Albeit an official yet confidential data obtained from PT PLN APD Jawa Barat and Banten [30] which seems like a safe supply for the charging needs, it does not mean that charging process can be done anywhere at any time. Mapping should be done in defining which nearest main distributing point can supply the power and at what time slot charging should be done to make sure electricity is sufficiently available, hence preventing blackout. This will be covered in another paper.

As this is a paper that leads to a feasibility study and not analyzing present application, scenario concerning number of paratransits involved in this electrification project can actually later be extrapolated. This is critical to define which number will match Bandung capability in providing electricity to support e-paratransits. Extrapolation can be executed concerning degree of electrification covering which routes should be involved, number of altered paratransits per route, work hours, number of travels and State of Charge (SoC).

Lessening routes number will decrease the power demand. From road topology point of view, this would be wise if implemented to routes that have hilly road topology. Hilly road calls for higher energy consumption than estimated, hence higher energy demand. For shorter routes (10 km and below), e-paratransit application would be convenience as charging can be done after 2-time returns. Cutting the number of paratransits to be converted to electric will cut the total energy consumption as well. Not to mention reducing the number of work hour and travels per day. In contrast, lowering or increasing SoC will not significant effect to total consumption. To charging process, the action

Table 1.
Total energy consumption and proposed stations clustering

About Man Lander, Entry Britand	No.	Route*	Distance*	Σ Distance/way	Σ Vehicles	Σ Vehicles	Energy consumption	Σ Energy consumption	Clustered station
only         115.3         96.9         67.04           oth         115.3         48.13         100         50.36         45.044         170.441.57           oth         9.30         27.3         10.0         36.36         45.044         170.441.57           oth         9.30         27.3         27.3         28.0         144.896.13         144.896.13           oth         10.00         30.9         27.3         28.0         31.468         148.896.13           oth         10.00         30.0         24.4         28.0         148.896.13         148.896.13           oth         12.00         24.4         28.0         124.896.13         28.0         148.896.13         148.896.13         148.896.13         148.896.13         148.896.13         148.896.13         148.896.13         148.896.13         148.896.13         148.896.13         148.896.13         148.896.13         148.896.13         148.896.13         148.896.13         148.896.13         148.896.13         148.996.13         148.996.13         148.996.13         148.996.13         148.996.13         148.996.13         148.996.13         148.996.13         148.996.13         148.996.13         148.996.13         148.996.13         148.996.13         148.996.13			(km)	/station (km)	/route (units)	/station (units)	/12 way or a day (Wh)	/station/day (Wh)	name
Abbit Mate – Emage and Match Mate – Emage and Abbit Mate – Monggart         11.54         48.14         17.94.14.5           Abbit Mate – Emage and Match Mate – Monggart         10.35         2.35         2.45.36         17.94.14.5           Abbit Mate – Monggart         10.37         2.30         2.3         2.45.6         18.40.6           Abbit Mate – Monggart         10.06         2.0         2.0         2.0         18.40.6           Abbit Mate – Lebong         10.00         2.0         2.0         2.0         18.40.6           Dago – Retain Lebong         14.25         2.0         2.0         2.0         18.40.6           Match Mate – Lebong         14.25         2.0         2.0         2.0         18.40.6           Match Mater – Lebong         14.25         2.0         2.0         2.0         18.6           Cicabana – Choung         11.00         2.0         2.0         2.0         2.0           Cicabana – Change         11.00         2.0         2.0         2.0         2.0           Stain Hall – Change Lebong         11.00         2.0         2.0         2.0         2.0           Stain Hall – Change Retain         18.0         2.0         2.0         2.0         2.0		Abdul Muis – Cicaheum via Binong	16.30		369		60,746		
Abolal Mate, Enough         9.75         **1.1         10.0         20.5         9.6.1.5         1.75.4.5.1           Abolal Mate, Enough         9.83         4.84         10.0         2.93         3.6.68         1.6.66         1.75.4.5.2           Abolal Mate, Enough         10.00         3.00         2.93         2.93         3.6.68         1.6.66         1.75.4.5.2           Abola Mate, Enough         10.00         2.00         2.01         2.01         2.04         2.04         3.6.6.2.3         1.6.66         1.75.4.2         1.6.66         1.75.4.2         1.6.66         1.75.4.2         1.6.66         1.75.7.2         1.6.66         1.75.7.2         1.6.66         1.75.7.2         1.6.66         1.75.7.2         1.6.66         1.75.7.2         1.6.66         1.75.7.2         1.6.66         1.75.7.2 <td></td> <td>Abdul Muis - Cicaheum via Aceh</td> <td>11.55</td> <td></td> <td>100</td> <td>l C</td> <td>43,044</td> <td>0.00</td> <td></td>		Abdul Muis - Cicaheum via Aceh	11.55		100	l C	43,044	0.00	
Abatal Mate, Degree         9.90         2.5         8.94         8.94         1.86.66.13         1.86.67.23		Abdul Muis – Elang	9.75	- CL.84	101	- cec	36,336	1/9,441.5/	I. Abdul Muis
Analyst Meine Digo         930         273         94688         148.09613           Askath Mein Digo         100         99.0         273         95.0         148.09613           Digo - Round Bantung         20.0         20.4         20.4         75.77         148.09613           Cocheloral - Ledeng         15.0         20.0         21.5         24.6         57.05         186.25.34           Cocheloral - Chronic         15.0         20.0         20.0         20.0         35.0         66.354         186.20.34           Cocheloral - Chronic - Chronic         15.0         20.0         20.0         20.0         66.354         186.20.34           Cichleran - Chronic - Chronic - Chronic         15.0         20.0         20.0         20.0         35.0         66.354         186.0         46.0         46.0         46.0         186.0         46.0		Abdul Muis – Mengger	10.55	ı	25	I	39,317		
Mangahanghanghanghanghanghanghanghanghang		Abdul Muis – Dago	9:30		273		34,658		
Page-Ring Banding         2004         244         577         577         577         578         578         578         588         586         587         588         587         588         587         588         587         588         587         588         587         588         587         588         587         588         587         588         587         588         587         588         587         588         587         588         588         588         588         588         588         588         6000<		Stasiun Hall – Dago	10.00	39.90	52	526	37,267	148,696.13	2. Dago
Abula Music – Ledeng         1600         9.052 <td></td> <td>Dago – Riung Bandung</td> <td>20.60</td> <td>1</td> <td>201</td> <td>I</td> <td>76,770</td> <td></td> <td></td>		Dago – Riung Bandung	20.60	1	201	I	76,770		
Cichelmur - Lideng         1435         5005         214         584         55.106         186.5234           Maggatyuy - Ledeng         1936         214         354         55.1369         18.65.254           Cichelmur - Curyon         1700         210         206         556         66.354         186.708 67           Cichelmur - Curyon         1100         201         150         36         66.354         186.708 67           Cichelmur - Curyon         1100         201         150         36         66.354         186.708 67           Sachish Half - Saming Sermag         1100         20.1         20.0         40.994         40.994         186.708 67           Sachish Half - Saming Half - Saming Half - Cambridateir via Champelat         8.30         8.30         36.22         67.454         18.475         4.00         36.52         67.454         18.475         18.475         18.475         4.00         36.52         67.454         18.475         4.00         18.475         18.475         18.475         18.475         18.475         18.475         18.475         18.475         18.475         18.475         18.475         18.475         18.475         18.475         18.475         18.475         18.475         18.475		Abdul Muis – Ledeng	16.00		245		59,628		
Munghiayu Lokeng         1980         112         73.739           Cuchaleum Corosana Lokeng         1700         50.10         200         556         65.354         186.708.67           Cuchaleum Corosana Lokeng         1700         50.10         20.0         556         65.354         186.708.67           Stoicheum Corosana Lokeng         18.0         20.1         20.0         55.0         40.994         100.405           Stoicheum Corosana Lokeng         18.0         20.1         20.0         50.0         50.0         66.354         100.405           Stoicheum Corosana Santan Hall – Stoiche Hall – Stoiche Hall – Gede Biger to The Corosana Santan Hall – Corombiant via Champalana Lokeng         8.30         18.1         4.0         70         50.052         67.453.63           Stoich Hall – Gode Biger to The Corosana Santan Hall – Corona Santan Hall – Corosana Santan Hall – Coros		Cicaheum - Ledeng	14.25	50.05	214	584	53,106	186,522.34	3. Ledeng
Cuchateum – Chroyonn         Chrohateum – Chroyonn         17.00         9.0         20.0         55.6         65.534         186.708.67           Cuchateum – Chroyonn         Chrohateum – Chroyonn         17.00         9.0         18.0		Margahayu – Ledeng	19.80	ı	125	I	73,789		
Cicalcium - Civostavat         17.00         \$9.10         20.0         55.5         66.254         186.708.67           Cicalcium - Civostavat         16.10         29.10         159         3.6         66.0094         186.708.67           Steakini Hall - Sadund Stermig         18.10         29.10         150         3.6         66.454         108.447.55           Steakini Hall - Chrimbolacit via Champelus         8.30         18.10         40         10.0         10.0         40.954         10.84.75.55           Steakini Hall - Chrimbolacit via Champelus         2.10         8.20         8.20         16.40         16.40         16.40         16.45.55         67.45.36           Steakin Hall - Chrimbolacit via Champelus         1.00         8.50         8.50         8.50         9.75         67.45.36         9.75.50		Cicaheum – Ciroyom	17.00		206		63,354		
Ciciple of Teach		Cicaheum - Ciwastra - Derwati	17.00	50.10	200	556	63,354	186,708.67	4. Cicaheum
Stabium Hall — Sadang Sterang         11,00         29,10         180         350         40,994         108,447,355           Sadang Sterang         Chrimblest via Eyktam         98.0         18,10         29,10         100         60,454         100         60,454         100,447,356         53,652         60,445         60,454         60,453         60,453         60,454 <t< td=""><td></td><td>Cicaheum – Cibaduyut</td><td>16.10</td><td>'</td><td>150</td><td>I</td><td>000'09</td><td></td><td></td></t<>		Cicaheum – Cibaduyut	16.10	'	150	I	000'09		
Staking Stering         Carding         27.10         200         350         67.454         100.44.1.3           Staking Stering         Claim         4.80         18.10         60         10         56.522         67.453.63           Stasiun Hall – Clampolleut via Chlampellas         8.30         18.10         60         10         56.522         67.453.63           Stasiun Hall – Clampolleut via Chlampella         8.30         21.00         39.70         200         78.261         147.590.78           Stasiun Hall – Clampolleut via Chlampella         8.50         21.00         39.70         200         78.261         147.590.78         147.		Stasiun Hall – Sadang Serang	11.00	6	150	G G	40,994	124 000	o u
Sussiun Hall—Commobilent via Eyknam         980         1810         60         95.22         67.453.63           Stasian Hall—Commobilent via Eyknam         21.00         10.20         39.70         10.20         30.70         147.950.78           Stasian Hall—Combolient via Champellas         10.20         39.70         175         3.90         18.001         147.950.78           Stasian Hall—Combolient via Champellas         10.20         39.70         155         18.00         38.013         147.950.78           Stasian Hall—Combolient via Champellas         19.85         4.20         18.6         25.05         3.00		Sadang Serang – Caringin	18.10	- 01.67	200	- 0cc	67,454	108,447.53	<ol> <li>Sadang Serang</li> </ol>
Stastiun Hall – Graubbuleut via Cilumpellas         8.30         19.10         40         100         30.932         07.453.202           Stastiun Hall – Graubbuleut via Cilumpellas         21.00         39.70         55         330         73.61         147.950.78           Stastiun Hall – Graubg         Band Farightel Permait – Diagoth Rar – Diagoth         10.20         39.70         55         330         38.013         147.950.78           Passt Induk Caringia – Dago         19.35         63.55         155         120         73.975         236.833.06           Bund Farylander – Dago         11.75         1.175         15.7         15.7         23.683.30         36.833.06           Circyonn – Surijadi         2.435         1.175         97         43.78         43.78         174.037.82           Circyonn – Buni Axri         8.35         4.67         11.5         47.78         43.78         174.037.82           Circyonn – Buni Axri         13.70         1.25         1.55         1.56         174.037.82         174.037.82           Circyonn – Buni Axri         1.30         3.35         2.56         2.26         2.58         1.74.037.82           Sederhana – Cilyaglo         1.30         3.35         3.35         3.35         3		Stasiun Hall – Ciumbuleuit via Eykman	98.6	0-0-	09	8	36,522	() (34 17)	.:
Stasiun Hall - Gede Bage         21,00         39,0         36         78,26H         147,950.78           Stasiun Hall - Sträjadi         10,20         39,7         35         38,013         147,950.78           Stasium Hall - Sträjadi         10,20         39,7         155         420         38,013         147,950.78           Pasar Indik Carnajiu - Dago         19,85         63,5         155         155         20,345         236,833.06           Buni Panyleukan - Dago         19,35         43,35         125         97         72,112         236,833.06           Buni Panyleukan - Sekemirung         24,35         115         97         43,789         74,637.82           Circyonn - Sarjadi         11,290         12,5         175         40,7         44,03         44,03           Circyonn - Cirkadapareuh         11,290         33,6         12,6         14,03         36,8         14,037.82           Anapari - Circyonn - Cirkadapareuh         18,0         33,5         6         36,8         33,4         14,037.82           Sederhama - Circhada         13,0         33,5         6         36,8         33,5         13,5           Circha- Circhada         13,0         32,0         32,0         32,0 </td <td></td> <td>Stasiun Hall – Ciumbuleuit via Cihampelas</td> <td>8.30</td> <td>18.10</td> <td>40</td> <td>I 001</td> <td>30,932</td> <td>07,453.03</td> <td>o. Ciumbuleuit</td>		Stasiun Hall – Ciumbuleuit via Cihampelas	8.30	18.10	40	I 001	30,932	07,453.03	o. Ciumbuleuit
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Statistin Hall – Granung Batu         8.50         55         140         17.975         18.677           Pasar Indak Caringin – Dago         19.85         140         73.975         236,833.06           Bung para Permai – Dagatinkur – Dago         19.35         63.56         125         97.46         236,833.06           Bung para Permai – Dagatinkur – Dago         11.75         97         97         43.789         174,037.82           Ciroyon – Surjadi         11.75         97         45.789         174,037.82         174,037.82           Ciroyon – Surjadi         12.90         46.70         11.5         97         45.789         174,037.82           Ciroyon – Surjadi         12.90         46.70         11.5         97         45.789         174,037.82           Ciroyon – Surjadi         12.90         46.70         11.5         46.70         48.075         174,037.82           Ciroyon – Surjadi         16.00         33.95         67         8.81         8.81         174,037.82           Sederhama – Cijerah         18.90         13.95         82         82         18.30         18.30         18.30         18.30         18.30         18.30         18.30         18.30         18.30         18.30		Stasiun Hall – Sarijadi	10.20	39.70	75	330	38,013	147,950.78	7. Stasiun Hall
Pasar Induk Caringin – Dago         19.85         63.55         140         73.975         236.833.06           Pangbegar Permai – Dipatinkur – Dago         19.35         63.55         155         420         72.112         236.833.06           Bumi Panyileukur – Dago         11.75         97         43.78         45.78         174.037.82           Circyonn – Sarijadi         11.75         97         487         48.075         174.037.82           Circyonn – Bumi Axi         11.290         11.5         497         48.075         174.037.82           Circyonn – Bumi Axi         11.290         11.5         160         51.056         174.037.82           Antapani – Circyonn – Cikudapateuh         11.370         33.95         276         58.814         174.037.82           Sederhana – Cipada         16.05         33.95         35.6         35.814         174.037.82           Sederhana – Cimindi         9.00         35.70         200         232         83.106         13.640           Cisatu – Tegallega         13.40         47.50         30.5         82.05         83.106         17.019.20           Cisatu – Tegallega         13.95         13.95         82         82         51.988         17.00 <tr< td=""><td></td><td>Stasiun Hall – Gunung Batu</td><td>8.50</td><td>ı</td><td>55</td><td>I</td><td>31,677</td><td></td><td></td></tr<>		Stasiun Hall – Gunung Batu	8.50	ı	55	I	31,677		
Panghegar Permai – Dipathukur – Dago         19.35         63.55         155         420         72,112         236,833.0           Bumi Panyijeukan – Sekemirung         24.35         24.35         125         7         125         90,746         174,037.82           Ciroyom – Sarijadi         11.75         24.50         11.5         49.7         48,075         174,037.82           Ciroyom – Cikudapateuth         12.09         12.09         16.05         276         85,814         174,037.82           Antapati – Ciroyom – Cikudapateuth         16.05         276         276         85,814         174,037.82           Sederhama – Cikudapateuth         18.09         33.55         67         87         15,656           Sederhama – Cikudapateuth         18.00         33.55         67         83,640         174,057           Sederhama – Cikudapateuth         18.00         33.55         67         83,640         174,057           Sistura – Ujimgbermag         13.40         35.70         82         83,640         174,09           Cickutu – Tegallega         13.95         13.95         82         82,064         17,09           Cickutu – Englega         13.00         13.00         200         200         20,07 <td></td> <td>Pasar Induk Caringin – Dago</td> <td>19.85</td> <td></td> <td>140</td> <td></td> <td>73,975</td> <td></td> <td></td>		Pasar Induk Caringin – Dago	19.85		140		73,975		
Bunni Panyileukan – Sekemirung         24.35         125         90,746           Ciroyom – Sarijadd         11.75         97         43.789           Ciroyom – Sarijadd         11.29         46.70         115         48.778           Ciroyom – Straindapateuh         12.90         12.90         12.90         14.07         17.03           Antapani – Ciroyom         13.0         2.0         2.0         2.0         17.05         174.037.82           Sederham – Cirologalo         16.0         3.3         67         5.8         17.05         174.037.82           Sederhama – Cirologalo         16.0         3.3         67         5.8         17.03         17.03.73           Sederhama – Cirologalo         16.0         3.5         67         5.8         17.03.73         17.01.32           Cistara – Cipicalo         13.40         35.7         2.0         2.0         49.938         13.043.90         17.01.93           Cistara – Derwati         13.5         13.5         13.5         13.5         11.5         17.01.93         17.01.93           Cistara – Tegallega         18.0         47.5         2.0         47.5         2.0         2.0         2.0         2.0         2.0         2.0		Panghegar Permai – Dipatiukur – Dago	19.35	63.55	155	420	72,112	236,833.06	8. Dipati Ukur
Circyom – Sarijadi         11.75         46.70         97         497         43.789           Circyom – Bumi Asri         8.35         46.70         115         497         31.118         174,037.82           Circyom – Bumi Asri         12.90         12.90         12.6         12.6         11.6         11.4         174,037.82           Circyom – Circyom         16.60         3.3         6.7         20.6         11.66         11.4         174,037.82           Sederhama – Cipagloh         8.90         33.9         6.7         8.8         11.6,522.14         11.6,522.14         11.6,522.14         11.6,522.14         11.6,522.14         11.6,522.14         11.6,522.14         11.6,522.14         11.6,632.24         11.6		Bumi Panyileukan – Sekemirung	24.35	ı	125	I	90,746		
Ciroyom – Bumi Asri         8.35         46.70         115         46.70         115         46.70         115         46.70         115         46.70         115         46.70         115         46.70         115         46.70         115         46.70         115         46.70         115         46.70         115         46.70         115         48.075         46.07         46.70         115         48.07         48.075         48.07         48.07         48.07         48.07         48.07         48.07         48.07         49.04         49.04         49.04         49.03         114,037.82         114,037.82         114,037.82         114,037.82         114,037.82         114,037.82         114,037.82         114,037.82         114,037.82         114,037.82         114,037.82         113,048         114,037.82 </td <td></td> <td>Ciroyom – Sarijadi</td> <td>11.75</td> <td></td> <td>76</td> <td></td> <td>43,789</td> <td></td> <td></td>		Ciroyom – Sarijadi	11.75		76		43,789		
Ciroyom – Cikudapateuh         12.90         40.70         125         48.075         12.00           Antapani – Ciroyom         13.70         16.05         33.95         33.95         51,056         17,027.02           Sederhana – Ciroyom         16.05         33.95         33.95         33.98         33.168         156,522.14           Sederhana – Ciroyaglo         18.00         35.70         35         49,938         135,40         156,522.14           Sederhana – Cirindi         13.40         35.70         32         49,938         133,443.00           Ciyarah – Cirindic         13.95         13.95         82         82         83,106         13,043.00           Ciyarah – Cirindic         22.30         82         82         83,106         13,043.00         13,043.00           Cistar – Tegalige         13.95         82         82         83,106         13,043.00         177,019.20           Cistogo – Elang         7.00         47.50         350         26,087         177,019.20         177,019.20           Cicadas – Elang         18.05         13.65         13.65         200         200         50,870         61,864         61,864           Cibaduyut – Karang Serra         16.60		Ciroyom – Bumi Asri	8.35	01.34	115	L 201	31,118	00 750 471	
Antapani – Ciroyom         13.70         16.05 <td></td> <td>Ciroyom – Cikudapateuh</td> <td>12.90</td> <td>0.01</td> <td>125</td> <td>1</td> <td>48,075</td> <td>79:100:411</td> <td>2. Choyom</td>		Ciroyom – Cikudapateuh	12.90	0.01	125	1	48,075	79:100:411	2. Choyom
Sederhana – Cipagalo         16.05         276         59,814         59,814         126,522.14           Sederhana – Ciparah         8.90         33.95         67         38         33,168         126,522.14           Sederhana – Cimindi         9.00         35.76         32         49,938         135,493         126,522.14           Civastra – Ujungberung         13.95         13.95         13.95         82         82         83,106         133,043.90           Cisitu – Tegallega         13.95         13.95         82         82         81,088         51,988         51,987.74           Elang – Gede Bage – Ujungberung         22.45         47.50         82         82         83,665         51,988         51,987.74           Elang – Gede Bage – Ujungberung         18.05         47.50         35         82         67,087         51,988         51,987.74           Cicadas – Elang         18.05         13.65         20         20         26,087         56,087         50,889.73           Cicadas – Elang         16.60         16.60         201         201         61,864         61,864         61,864           Cicadas – Elang         16.60         16.60         201         201         61,864		Antapani – Ciroyom	13.70		160		51,056		
Sederhana – Cijerah         890         33.95         67         398         33,168         126,522.14           Sederhana – Cimindi         9,00         3.5.70         32         49,938         13,540         126,522.14           Ciwastra – Ujungberung         13.40         35.70         32         82         82         83,106         133,043.90           Cijerah – Ciwastra – Derwati         13.95         13.95         13.95         13.95         13.95         13.95         13.95         13.95         13.98         13.043.90           Cijerah – Ciwastra – Derwati         22.45         82         82         82         82         83,106         13.043.90           Cisitu – Tegallega         22.45         47.50         35         45         83,665         177,019.20           Cibogo – Elang         18.05         18.05         36         83,665         83,665         177,019.20           Cicadas – Elang         18.05         18.05         18.05         20         50,87         50,87         50,87           Cicadas – Elang         18.05         18.05         18.05         20         50,87         50,87         50,87         50,87         50,37,397         50,37,397		Sederhana – Cipagalo	16.05	'	276		59,814		
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		Sederhana – Cijerah	8.90	33.95	<i>L</i> 9	398	33,168	126,522.14	10. Sederhana
Ciwastra – Ujungbenung         13.40         35.70         32         49,938         133,043.90           Cijerah – Ciwastra – Derwati         22.30         13.95         13.95         82         82         81,066         13,043.90           Cisitu – Tegallega         13.95         13.95         13.95         15,98         51,987.74         13,087.74           Elang – Gede Bage – Ujungberung         22.45         47.50         35         450         83,665         177,019.20           Cibogo – Elang         18.05         13.65         20         56,087         177,019.20           Cicadas – Elang         13.65         13.65         20         50,870         50,870           Cicadas – Cibiru – Panyileukan         16.60         16.60         201         61,864         61,863.55           TOTAL         5.521         5,521         5,521         5,037,397         2,037,397         2,037,397		Sederhana – Cimindi	00.6		55		33,540		
22.30         23.70         200         2.35         83,106         135,452.00           13.95         13.95         13.95         82         82         51,988         51,987.74           22.45         17.00         47.50         35         450         26,087         177,019.20           18.05         13.65         13.65         20         20         50,870         50,869.73           16.60         56.01         56.1         55.21         5,521         5,037,397         2,037,397,82		Ciwastra – Ujungberung	13.40	35 70	32	737	49,938	122 042 00	11 Circusotto
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		Cijerah – Ciwastra – Derwati	22.30	. 07.66	200	757	83,106	155,045.90	II. CIWasura
Elang – Gede Bage – Ujungberung         22.45         115         83.665           Cibogo – Elang         7.00         47.50         35         450         26.087         177,019.20           Cicadas – Elang         18.65         13.65         200         200         50,870         50,869.73           Cicadas – Cibiru – Panyileukan         16.60         16.60         201         61,864         61,863.55           TOTAL         547.00         547.00         5521         5,521         2,037,397         2,037,397		Cisitu – Tegallega	13.95	13.95	82	82	51,988	51,987.74	12. Cisitu
Cibogo – Blang         7.00         47.50         35         450         26,087         17,019.20           Cicadas – Elang         18.05         13.65         13.65         200         200         50         50,870         50,869.73           Cicadas – Cibiru – Panyileukan         16.60         16.60         16.60         201         61,864         61,863.53           TOTAL         547.00         547.00         55.21         5,521         2,037,397         2,037,397		Elang – Gede Bage – Ujungberung	22.45		115		83,665		
Cicadas – Elang         18.05         300         67.267           Cicadas – Cibiru – Panyileukan         13.65         13.65         200         200         50,870         50,869.73           Cibaduyut – Karang Setra         16.60         16.60         201         201         61,864         61,863.55           TOTAL         547.00         547.00         5,521         5,521         2,037,397         2,037,397		Cibogo – Elang	7.00	47.50	35	450	26,087	177,019.20	13. Elang
Cicadas – Cibiru – Panyileukan         13.65         13.65         200         200         50,870         50,869.73           Cibaduyut – Karang Setra         16.60         16.60         201         201         61,864         61,863.55           TOTAL         547.00         547.00         5,521         5,521         2,037,397         2,037,397		Cicadas – Elang	18.05		300		67,267		
Cibaduyut – Karang Setra         16.60         16.60         201         201         61,864         61,863.55           TOTAL         547.00         547.00         5,521         5,521         2,037,397         2,037,397		Cicadas – Cibiru – Panyileukan	13.65	13.65	200	200	50,870	50,869.73	14. Cibiru
547.00 547.00 5,521 5,231 2,037,397		Cibaduyut – Karang Setra	16.60	16.60	201	201	61,864	61,863.55	15. Cibaduyut
		TOTAL	547.00	547.00	5,521	5,521	2,037,397	2,037,397.82	

\*Data is taken from [27]



Figure 2. Paratransit colors interpret its specific route [26] will only affect charging schedule since the charging should be done earlier and shorter (when SoC is smaller) or later and longer (when SoC is bigger).

From 38 routes, it was created 15 charging stations based on rough observation of majority paratransit settled on the stations when not in operation, and distance of paratransit parking and owner dwellings. Table 1 lists all that proposed charging locations. Actually, this kind of clustering might not be effective since there will be lots of efforts to put it into realization. The problem is when not in use paratransits are usually parked within the close proximity of the owners, which are often located far from the stations. Therefore, if paratransits are charged in the stations, then to be brought home to the owners, the energy reserved for the next run the day after will be lessened. There are two proposed ways to overcome this. First, build a station where people can park their paratransit as well as charge them. Even though this is one manifestation of government interference, the cost would be massive, for building and security officer for instance. Or instead, conduct a survey to map locations of each paratransit park lot, and subsequently create new locations for charging station and its new capacity as oppose from the old charging stations clustered above. This can be solved by providing a battery exchange, a big wide warehouse where batteries are charged to be readily used later.

This is just a convenience clustering that actually needs to be further investigated. The ideal should incorporate detail process comprising mapping paratransit parking locations, mapping electricity supply at potential or designated charging hours, matching number of charging needs with charging supply, and last but not least, interviewing stakeholders.

As transportation is the main contributor for air pollution in Bandung [31], and shifting to environmentally safe fuel and vehicle can be the way out [32] [33], paratransit electrification could be the answer to Bandung's circumstances. Beside, global condition creates a more conducive movement for electric vehicle application [34].

In accordance to fund in creating start-up fleet, government should do its best to establish a funding policy for this matter [2]. Be it the government, private sectors or other possible third parties. As considering cost to procure one electric paratransit could reach IDR 500 million, or IDR 450 million via retrofitting [24], sum of money should be provided would be huge. This cost falls mostly for batteries, which need to be replaced approximately once a year when lead acid is used. This cost will decline due to mass electrification since for example, battery price will decrease from bulk buy [3, 35]. Nevertheless, it still involved so much money. Further discussion about this is not within the reach of this paper.

Another option of charging stations is battery exchange or battery swapping stations. When battery is low, paratransit could visit a battery exchange station to have its empty battery be replaced with the fully loaded one. Nonetheless, as the consequence, a big warehouse containing stacks of battery should be provided. This will bring new obligations like land acquisition, building construction, operational management and security. Since the two alternatives in really have their own advantages and disadvantages, both can be executed according to circumstances of the future charging station locations.

#### IV. CONCLUSION

Paratransit electrification in Bandung yields a power demand of virtually 62 MWh per month that should be met by energy provider, which in this case is Indonesian Government through PLN Indonesian national of electricity company). Even the demand seems can be sufficiently fulfilled, careful planning should be conducted to ensure the demand will be satisfied without disturbing other industry. The planning will embrace obtaining real data on energy demand for paratransit electrification in Bandung. Field survey would be crucial in acquiring data to design and map places of charging stations taken into account paratransit parking and electricity availability at certain charging hours.

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