

Network Analysis of Intercity Bus Terminal and Inner-City Toll Road Development – The Case of Bandung City

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Abstract

This paper explores the impact of Gedebage Terminal development to traffic performance in Bandung City, as well as the development of the inner-city toll road that connects eastern and western part of Bandung City. In addition, the study also analyzes the potential of minibus / public transport route that connects three terminals, namely Gedebage, Cicaheum and Leuwipanjang Terminal, in Bandung City. The study is carried out by using the 4-step modeling principle, by utilizing EMME/4 software. According to the analysis, the development of inner-city toll road will impact the city's road performance significantly. On the other hand, the development of Gedebage Terminal as a terminal that serves intercity travel replacing Cicaheum Terminal will influence road network performance around the terminal in terms of traffic flow, vehicle speed and volume capacity ratio. The analysis results also suggest that the addition of public transport fleet with high capacity, such as bus, that connects the bus terminals is necessary to support public transport performance in Bandung City.

Keywords

Bus terminal development; Traffic performance; Network modelling; Bandung city

1 Introduction

Bandung City is one of the biggest city in Indonesia and is the core of Bandung Metropolitan Area. This city has two main bus terminals, namely Leuwi Panjang and Cicaheum terminal. The main problem is that these two terminals have deteriorating performance as a result of overloading.

In 2016, Cicaheum Terminal, which serves 20 bus routes with the destination is to East Bandung, has been overloaded. With the capacity only to serve 200 buses, Cicaheum terminal actually serves 360 bus unit. Leuwi Panjang terminal is actually experiencing the same problem. With the capacity of 400 bus unit in a day, the terminal serves approximately 20 bus routes and 600 bus unit in a day. This high load to serve buses that exceeds the terminal capacity has been causing congestion in the area around the Terminal. Congestion, as explained in [1], will results in time value loss and reduced productivity. The problem is exacerbated by uncertain bus departure as well as buses that stops not in the proper place to get passengers. The congestion which is caused by overloading terminal capacity certainly has negative consequences. One of which is high level of pollution which threaten human health, particularly the most vulnerable segment of the society, as stated in [2].

On the other hand, Bandung City will have a new transit-oriented development area in Gedebage area. To cope with the challenge and the development plan, Bandung City local government, as explained in [3], [4] is planning to build an integrated terminal in Gedebage Transit Oriented Development (TOD) area. As this terminal is located at the eastern area in Bandung City, which is the same with Cicaheum Terminal, ideas then arise to make Gedebage Terminal the one that serves intercity transport fleet, replacing the function that is now currently held by Cicaheum Terminal. In addition, an inner-city toll road is planned to be built in that will connect the western and eastern area of Bandung City. Those various development has a great potential to support each other. As stated in [5], an integrated transport development / masterplan, to achieve sustainable transportation. However, such development may be an inaccurate decision if not analyzed holistically. To avoid inaccurate decision making, which will result in inefficient the government budget spending, policy makers should understand the likely impact of the new Gedebage Terminal development.

This study attempts to understand the impact of such development by analyzing the road network performance, in Bandung City as well is at roads around the terminals (including Gedebage, Cicaheum and Leuwi Panjang Terminal) as a result of Gedebage

Terminal Development. More specifically, the study highlights traffic performance indicator i.e. speeds and volume capacity ratio (VCR) and also the change in traffic flow pattern. The study also analyzes the performance of newly added minibus route with respect to load factor.

2 Literature Review

2.1 4-step modeling approach

The main approach that is used for this study is the 4-step modeling approach. As explained in [6], [7], the 4-step modeling is a four sequential process aiming to determine the number of vehicle / passenger that use different transportation mode on a particular network. The process is as follows i) trip generation, ii) trip distribution, iii) modal split, iv) trip assignment.

The “trip generation” is a process to determine the number of vehicles generated or attracted by a particular zone. The zone is defined as activity centers. It can be in form of a city, district or even a building depending on the size of the network model. The next process is “trip distribution” where, after the number of trips generated or attracted has been calculated, the origin and destination of such trip is also estimated. The results are in form of origin and destination matrix (O-D matrix). The next process is to determine the transport mode used from the origin to destination. This process is called modal split. This process involves cost function / utility function associated with particular transport modes. Such cost function then determines the estimation of people choice on the transport mode they want to use. The estimate is commonly carried out by using logit / probit model. After the number of passenger / people using particular transport modes has been determined, the next step is the “trip assignment” step. As its name implies, this is a process where the trip, by using different kind of transport modes, is assigned to transport network. The purpose is to understand the performance of transport network, in terms of speed, volume capacity ratio, flow, under the assignment. After the 4-sequential process has been finished, one can get a picture whether a transport policy scenario proposed may impact in a positive way.

2.2 Terminal

According to [8], Terminal is divided into three types, namely passenger terminal type A, type B and type C.

Type A terminal is the terminal that serves various public transport route including inter country route, intercity route, inner city route and rural area route. Among other type, this is the terminal with the most complete facilities. This type of terminal should be

located in district / province capital and should be adjacent to arterial road. Type B terminal is the type which is one level below Type A terminal. Its purpose is to serve public transport for intercity route, inner city route as well as rural area. This terminal type should be located in a district / province and within inner province public transport network. In addition, this terminal type should be located in arterial or collector road. Type C terminal is a terminal that serves only inner city and rural area public transport line. This type of terminal should be located in a city or district and within the inner-city transport network. The terminal should also be located I collector or local road.

According to [9], there are three common issues faced by a terminal. The issues are i) capacity, ii) efficiency, iii) safety and iv) security. The main issue faced by the Terminals in Bandung is related to capacity where the demand has exceeded the capacity of the existing terminals.

2.3 Public transport

According to [10], public transport is defined as every motor vehicle that is used by public and applies certain amount of tariff, either directly or indirectly. Among public transport type, there is a city public transportation, which according to [10], city public transport is defined as public transport that serves particular origin and destination within a city and attached on a particular route. There are several performance indicators for a public transport to determine whether the transport mode is operating well. Brief explanation of those indicators is explained in Table 1. The other indicators that reflects public transport performance are number of fleet operated, access to station, pedestrian / cyclist / disabled people access.

Table 1 Public transport performance indicator [10], [11]

Indicators	Brief Description
Load Factor	Ratio between the number of passenger and vehicle capacity
Headway	Time lapse from one public transport fleet to the following fleet
Frequency	Number of fleet operating for a certain period of time
Travel Speed	The speed of a fleet when traveling for a particular origin and destination pair
Travel Time	The time required to travel from one origin to one destination
Passenger Waiting Time	The duration passenger should wait to get a ride in a public transport
Service Time	The duration a public transport mode operates in a day

3 Study Area

The main object of this study is the planned Gedebage Terminal, which will be located in Gedebage Area (a sub-district in Bandung City). Bandung City itself is the 3rd biggest city in Indonesia, with the population of 2.497.938 in 2017 [12]. Furthermore, Bandung City is the center of Bandung Metropolitan Area, consisting of several cities and regencies, namely Bandung City, Cimahi City, Bandung Regency and West Bandung Regency. The government predicts that the Bandung Metropolitan Area will continue to sprawl and reach

12.8 million population in year 2025 [13]. Bandung city also has high number of registered vehicle, namely at 1,811,491 in 2017 which is dominated by Motorcycle, at 73.4% followed by passenger vehicle at 22.1% [12]. This strengthens the case than Bandung City will need policies or measures to alleviate traffic congestion.

The impact of the new terminal development will be analyzed in road network around Gedebage Terminal as well as those around Leuwi Panjang and Cicaheum Terminal. The location of the terminals can be seen in Figure 1 which represented by the red dots.



Figure 1 Bandung City map and bus terminal location

4 Methodology

This study starts by identifying the problem relating to bus terminals in Bandung City. The problem which is the main object of this study is the deteriorating performance of Leuwi Panjang and Cicaheum Terminal which is planned to be solved by the development of Gedebage Terminal. As the study uses the 4-step modeling approach based on [6], several required data were collected. Those data are i) public transport route, ii) road network, iii) sub-district population, iv) origin destination matrix (Bandung internal and external zone), v) Public transport tariff, and vi) traffic counting data year 2015.

The data are then analyzed by using EMM4 software, a network modeling software which is able to generate traffic / road performance indicators such as traffic flow, speed, volume capacity ratio, etc. In addition, the software can generate public transport performance indicator such as load factor.

Two scenarios are developed for the model, namely do-nothing and do-something scenario. The “do-nothing scenario” is defined as the existing scenario or the scenario where the Gedebage Terminal does not exist while the “do-something scenario” is the one in which Gedebage Terminal has started its operation in year 2020. These two scenarios are then compared to see which one is better in terms of road traffic and also public transport performance. The inner-city toll road development is also incorporated in these scenarios.

The base model for “do-nothing scenario” is created for 2015 condition, which is dependent on the characteristics of private vehicle and public transport (minibus, intercity bus and inner-city bus) in that year. After the model has been created, the model is validated. There are two type of validation that are carried out. The 1st is network database validation and the 2nd is traffic assignment validation. The purpose of network database validation is to ensure that there are no missing elements on the network model while the

aim of traffic assignment validation is to compare the output of the model, particularly in terms of traffic flow, and the actual flow on the road. The difference between the model flow and actual flow should not be significant. Otherwise, adjustment need to be made on the model volume delay function and origin destination matrix.

The base model is the forecasted to year 2020 which then compared to the model for “do-something” scenario for year 2020. In more detail, the scenarios which are developed for this study is presented in Table 2.

Table 2 Modeling scenario

Scenario	Condition
Scenario 1	2015 existing condition
Scenario 2	2020 condition without inner city toll road
Scenario 3	2020 condition with inner city toll road
Scenario 2.1	The development of Cicaheum, Terminal type A, without the inner-city toll road, and the addition of new minibus line
Scenario 2.2	The development of Cicaheum Terminal type C, without the inner-city toll road, and the addition of new minibus line
Scenario 3.1	The development of Cicaheum Terminal type A, with the inner-city toll road, and the addition of new minibus line
Scenario 3.2	The development of Cicaheum Terminal type C, with the inner-city toll road, and the addition of new minibus line

*please note that the scenario 2.1 to 3.2 includes the development of Type A Gedebage Terminal

With the development of Gedebage Terminal within Bandung City network, it is assumed that there will be the addition of minibus line connecting Leuwi Panjang, Cicaheum and Gedebage. In addition to that, the type change of Cicaheum terminal into type 2 terminal will cause intercity bus to divert their origin or destination from Cicaheum Terminal to Gedebage Terminal.

The output from the software that will be generated and analyzed are average speed, volume capacity ratio, diverting traffic, and public transport performance in terms of load factor.

5 Data, Modeling, and Validation

5.1 Study area network database

The network database for this study is the network model for Bandung City, Cimahi and East and West Bandung Regency. The network database consists of 161 zones with 151 internal zones and 10 external zones. The 151 internal zones are developed based on sub-districts in Bandung City while the other 10 external zones are determined based on areas that has

high influence on the study area. The network database itself is developed by using EMME/4 software. As this study explores the impact of terminal development to Bandung City transport network, the external zones are influenced through bus route from the terminal to the external zone.

The public transport which is included in the network database are i) minibus (angkot), ii) damri bus and iii) Trans Metro Bandung Bus. In the model, these public transport routes are defined as “transit line”.

The minibus route which is included in the model consists of 39 inner city routes and 10 routes in the city peripheral area. The data on minibus route are obtained from Bandung City Department for Transportation. The Damri bus route is that are included in the model consists of 10 routes which is based on Bandung Transportation Master Plan.

Finally, for the Trans Metro Bandung bus route, the route that are included in the database are Elang-Cibiru route and Cicaheum-Cibereum route.

5.2 Network validation

Network database validation

This network validation type aims to check if there is any missing element form the model that prevents the model to assign the traffic to the network. It can be in form of missing line, missing centroid connector etc. the EMME/4 software has a feature to carry out the network database validation and the results shows that the network database for all scenario are ready to run.

Traffic assignment validation

This validation process compares the traffic flow generated by the model and the actual flow, which is obtained through a traffic counting survey in several particular road segments. The results are then plotted in a graph and the R^2 is then calculated. The R^2 of the linear regression will explain whether the model has a certain level of validity. The validity level of a network model based on R^2 value refers on the Table 3.

The Table 4 shows that the R^2 value is at 0.538. This means that the model has a moderate validity. To improve the model validity, demand adjustment is carried out by using a feature on the software. The demand adjustment feature will adjust the O-D matrix in accordance with the traffic counts data. After 5 iterations of demand adjustment, the model is validated again, and the results is also shown in Table 4.

The result shows the R^2 value at 0.928, which means that the model now has a high validity. The model is

therefore valid and ready to be developed further and used for the analysis.

Table 3 R² value and validity level [14]

R ²	Validity Level
0.8 – 1	Very High
0.6 – 0.8	High
0.4 – 0.6	Moderate
0.2 – 0.4	Low
0 – 0.2	Very Low

Table 4 Regression comparison before and after O-D Matrix Adjustment

Condition	A	B	R ²
Before OD Matrix Adjustment	2401.52	0.270	0.538
After OD Matrix Adjustment	293.39	0.926	0.928
Ideal Condition	0	1	1

5.3 Network model development for different scenarios

Different scenarios are developed and used to predict the transport network performance after Gedebage Terminal starts its operation. For that purpose, several additional elements need to be included in the model. This includes:

1. Existing and new terminals
2. Intercity public transport route that starts / ends at Gedebage Terminal
3. New inner-city toll road
4. Inner city public transport route connecting terminals
5. Type A and C terminal

The existing and new terminal, which includes Cicaheum, Leuwi Panjang and the new Gedebage Terminal are modeled by the reduction of road capacity around terminal location. This is due to the tendency that many buses will stop in the road where the terminals are located to wait for passengers.

When the Gedebage terminal starts its operation, it will start to serve intercity bus route. In this study, Gedebage Terminal will serve the intercity bus route from or to East Bandung Regency. This is shown in Figure 2.

Referring to Bandung City Spatial Plan for Gedebage area, inner-city toll road will be built that connects the current toll road in Pasteur Area and two spots on the eastern area of Bandung City. This development plan is also included in the model as shown in Figure 3.

After the terminal has been operated, possibilities that there will be additional minibus route that connects the existing terminal with the new Gedebage terminal. This scenario is also considered in the study and included in

the model. The new minibus route in the model is shown in Figure 4 and Figure 5.

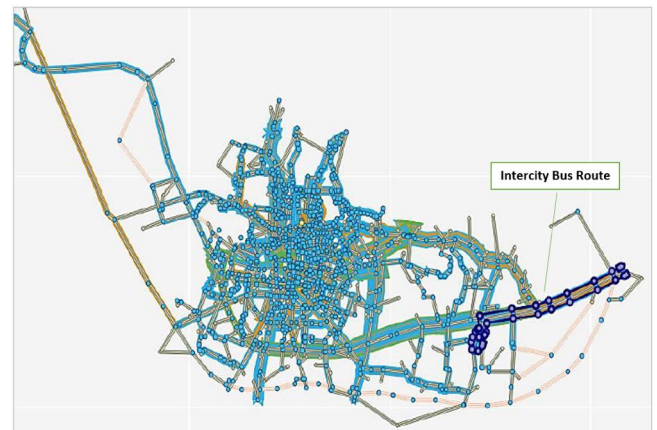


Figure 2 Intercity Bus Route from Gedebage Terminal



Figure 3 Inner-city toll road for Gedebage Terminal plan

Finally, to reflect changes on the change of type for Cicaheum Terminal, from Type A terminal to Type C terminal, the intercity bus route which is served by Cicaheum Terminal will disappear as Type C terminal only serves inner city bus route. The route which will disappear can be seen in Figure 6.

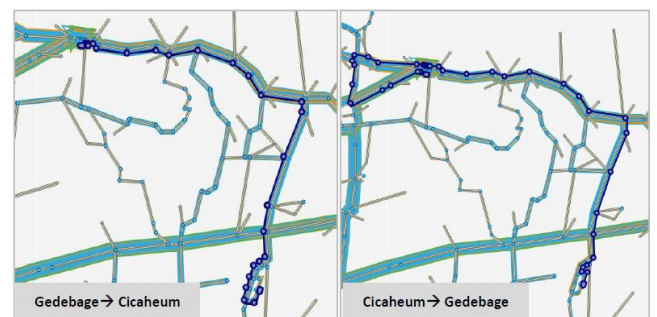


Figure 4 Additional minibus route (Cicaheum – Gedebage)



Figure 5 Additional minibus route (Gedebage – Leuwipanjang)



Figure 6 Deleted transit line for type C Cicaheum Terminal

6 Results and Analysis

The analysis of traffic performance is represented in accordance with the scenario explained in Table 5.

Table 5 Modeling and analysis scenario

Scenario	Year	Description
1	2015	Existing
2	2020	Without Toll Road Initial Condition
3	2020	With Toll Road Initial Condition
21	2020	Without Toll Road Cicaheum A + the addition of minibus route
22	2020	Without Toll Road Cicaheum C + the addition of minibus route
31	2020	With Toll Road Cicaheum A + the addition of minibus route
32	2020	With Toll Road Cicaheum C + the addition of minibus route

6.1 Average speed

The Table 6 shows that in year 2020, the road network in Bandung City will have reduced speed without toll road development as shown by scenario 2, 21 and 22. This is due to the increase of travel demand, which is reflected in the O-D matrix, while the total length of the network remains the same.

It also can be seen on the Table 6 that the scenario which has the highest speed, among the scenario without toll road development, is the scenario 22 (when Cicaheum Terminal is converted from A type to C type terminal). When the Cicaheum Terminal is converted to type C terminal, it only serves inner city route. As a result, people who are going outside the city through East Bandung will have to go to Gedebage Terminal. This frees up traffic load within the City, as Cicaheum Terminal is located in within the city, a shift the traffic to Gedebage Terminal, which is located at the eastern edge of Bandung City. This results in higher average speed in Bandung City road network for scenario 22.

Table 6 The change on average speed

Scenario	Year	Speed (km/h)	VCR
1	2015	42.701	0.781
2	2020	41.694	0.835
3	2020	43.783	0.722
21	2020	41.683	0.835
22	2020	41.737	0.828
31	2020	43.786	0.721
32	2020	43.813	0.72

*The highlighted scenarios are the ones in which the toll road is built and operated.

The case is different if the toll road is built and operated in 2020, as represented in scenario 3, 31 and 32. In these scenarios, the overall average speed in Bandung City network increases as now the increases in travel demand is balanced by the addition of road infrastructure. Similar to the scenarios without toll road, the scenario which has the highest travel speed is the scenario 32, where the Cicaheum Terminal is converted to type C terminal. This makes people who want to go outside the city go through Gedebage Terminal and shift the traffic from inside to the eastern edge of the city where Gedebage Terminal is located.

6.2 Average volume capacity ratio (VCR)

The traffic performance in terms of V/C ratio follows the same pattern with average as the two indicators is strongly correlated. For both the scenario with and without toll road development, the scenarios which have highest speed is the scenario 22, if the toll road is not built, and the scenario 32, if the toll road is built.

The two scenarios have one aspect in common, namely the Cicaheum Terminal is converted into type C terminal, and making the intercity travel to eastern Bandung is served by Gedebage Terminal. This frees up the traffic within the city and shift it to eastern edge of the city. The value of VCRs are also shown in Table 6.

6.3 Traffic volume

The change of traffic flow for different scenario is explained visually, in a figure, by the modeling software. Each figure is divided into two parts. The 1st is a table containing the scenario shown on the upper left corner of the figure. The scenario that is shown in the figure is highlighted in green. The 2nd part is the traffic flow change in the network model. This part shows the difference between the compared scenario (which is highlighted in the 1st part). The red bar indicates positive difference (traffic flow increase) while the green bar indicates negative difference (traffic flow decrease)

while the green bar indicates negative difference (traffic flow decrease)

With the development of toll road network in Bandung City, a significant amount of traffic will shift from roads located in the southern part of Bandung City, particularly in Soekarno Hatta and Padaleunyi Toll Road. This result is generated by comparing the scenario 2 and the scenario 3. The result is shown in the Figure 7 where the green bars are concentrated in the southern part of the city while the red bars (traffic increase) are concentrated at where the new toll road is located. If the scenario 21 and 2 are compared, namely the Cicaheum Terminal stays as type A terminal, there will not be any significant change in traffic flow pattern, as shown in Figure 8. This is due to the fact that no significant change, aside from the development of Type A Gedebage Terminal, has been made on the network. Hence, no significant change occurs.

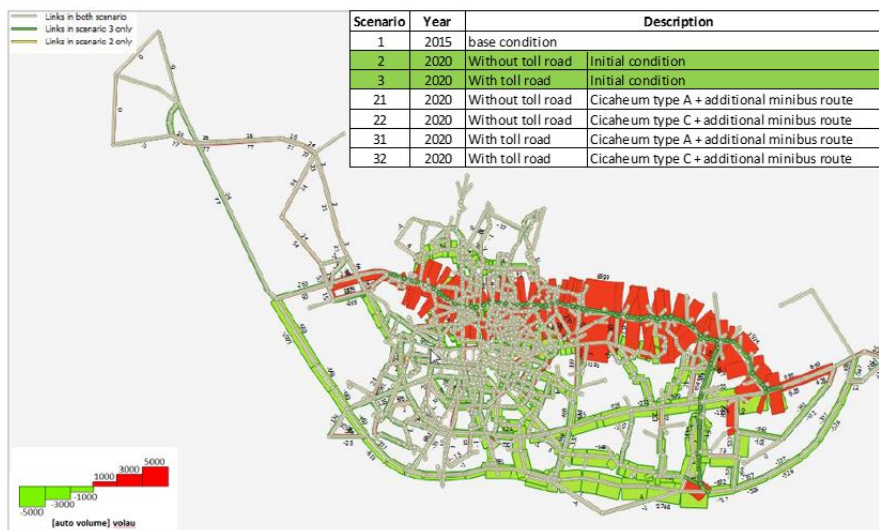


Figure 7 Traffic shift to Bandung inner-city toll road

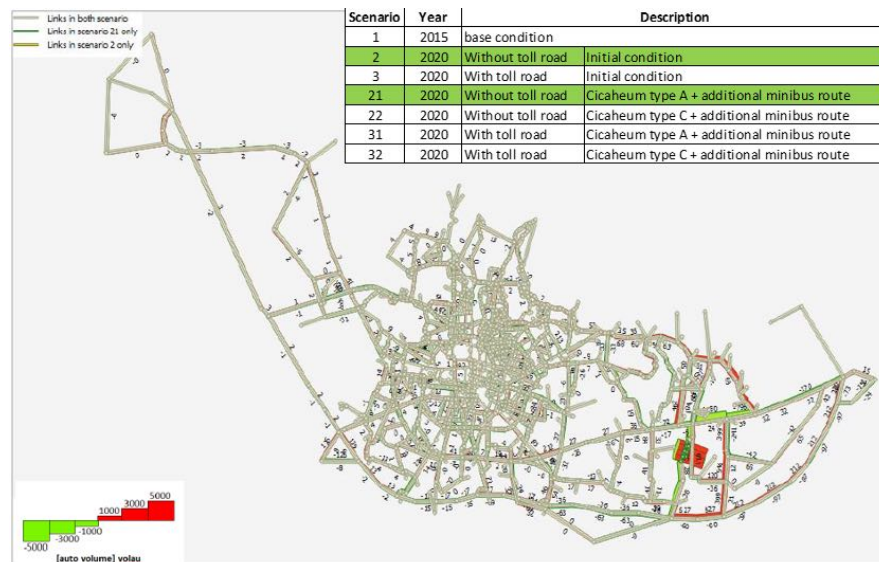


Figure 8 Flow comparison between scenario 2 (initial condition) and 21

If the Cicaheum Terminal is converted to type C terminal, the terminal will no longer serve the intercity route travelling to the eastern side of Bandung City. The role to serve intercity travel is taken by Gedebage Terminal. As a result of that, there will be less busses stopping on the road around the terminal which reduces road capacity. Thus, the road capacity around Cicaheum Terminal will increase and more traffic will choose to go through this road. This phenomenon is explained by Figure 9 where the red bars are concentrated around Cicaheum terminal.

The difference between scenarios if the scenario 3 and 31 is compared, namely the initial condition in 2020 with toll road compared with the scenario that includes toll road development, additional minibus route and Cicaheum Terminal stays as a type A Terminal is not significant. This insignificant difference may be caused by vehicle flows that has been spread on the new toll road.

Finally, the comparison between scenario 2 and scenario 32, as seen in Figure 10 shows that there is an additional traffic flows around Cicaheum Terminal and traffic flow reduction on the inner city toll road. The conversion of Cicaheum Terminal to type C terminal will add more capacity to roads around Cicaheum Terminal as there will be less busses stopping around the road. This additional capacity will make traffic flow shift its route to roads around Cicaheum Terminal.

According to various scenarios that has been simulated and compared, it can be seen that the most significant

factor influencing traffic flow on Bandung City network is the addition of inner-city toll road. This toll road development influences almost all road segment in Bandung City which is more significant than the type conversion of Cicaheum Terminal.

With respect to the network around the three terminals, the performance in terms of total flow, speed and VC ratio are represented in Table 7, Table 8, and Table 9.

On the Table 7, it can be seen that the presence of inner-city toll road reduces the traffic flow around Cicaheum and Gedebage Terminal. This is due to the fact that road users will use the inner-city toll road and thus reducing the flow around the terminal. However, the flow reduction is not significant around Leuwi Panjang Terminal. This is because the Terminal location is far from the inner-city toll road, which is not the case for Cicaheum and Gedebage Terminal.

Furthermore, the conversion of Cicaheum Terminal from type A to Type C terminal (as shown by scenario 31 and 32 comparison) will increase the traffic flow on the network around Cicaheum Terminal. This is due to less intercity bus stopping on roads around Cicaheum Terminal and make the road capacity increase. In contrast, such conversion will reduce traffic flow on roads around Gedebage Terminal as now it serves intercity busses. The Leuwi Panjang Terminal does not experience significant change as it is located far from Cicaheum and Gedebage Terminal.

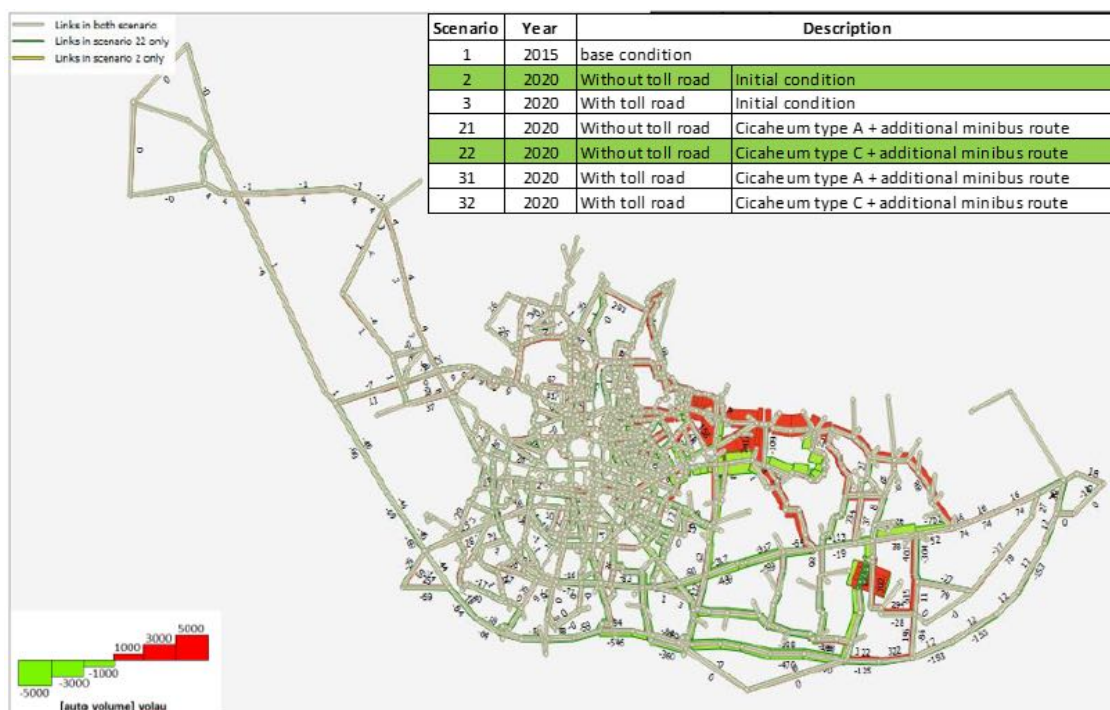


Figure 9 Increasing traffic around Cicaheum Terminal

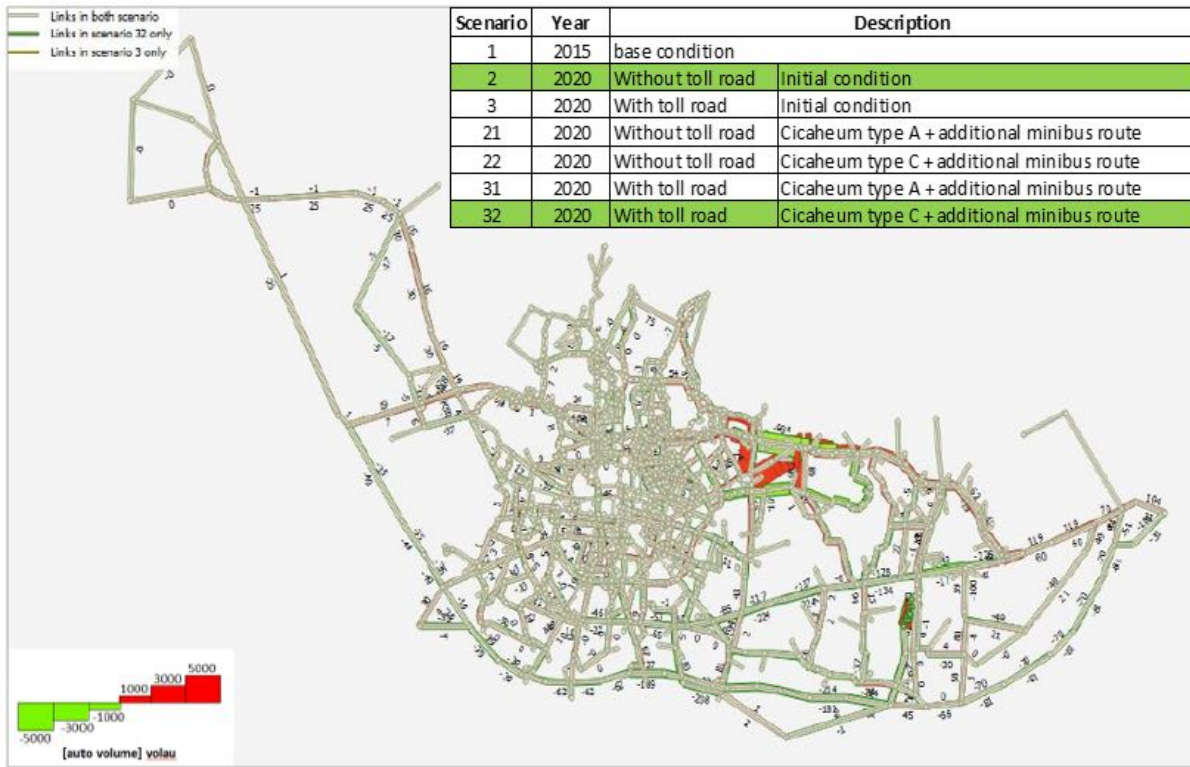


Figure 10 Flow comparison between scenario 2 (initial condition) and scenario 32

Table 7 Traffic flow around the terminals for different scenarios

Scenario	Year	Total Flow (pcu/hr)		
		Terminal Leuwi Panjang	Cicaheum Terminal	Gedebage Terminal
2	2020	276500	362013	209863
21	2020	272907	369583	205067
22	2020	270940	403818	200667
3	2020	253899	265538	136888
31	2020	259327	267399	134074
32	2020	259455	295903	132314

Table 8 Traffic Speed around the terminals for different scenarios

Scenario	Year	Speed (km/hr)		
		Terminal Leuwi Panjang	Cicaheum Terminal	Gedebage Terminal
2	2020	46.04	38.0	41.9
21	2020	46.10	37.4	41.6
22	2020	46.19	36.5	42.0
3	2020	46.87	43.4	47.6
31	2020	46.74	43.4	47.2
32	2020	46.73	42.9	47.2

The speed around the three terminals also follows the same pattern as traffic flow. The speed difference among scenarios, which is shown in Table 8 indicates that the toll road development creates significant speed improvement compared to the change of Cicaheum Terminal type. The Leuwi Panjang terminal also does not experience significant speed change as the location is far from the inner-city toll road. This condition also applies for Volume Capacity Ratio (VCR).

In line with the change on traffic flow, the conversion of Cicaheum Terminal from type A to type C terminal will reduce the speed on roads around Cicaheum Terminal and increase the speed around Gedebage Terminal, which is in line with the increase of flow around Cicaheum Terminal and the reduction of flow around Gedebage Terminal.

The change of flow and speed then impacts the average volume capacity ratio (VCR) on roads around terminal. In general, the conversion of Cicaheum Terminal from type A to type C will reduce VCR around Gedebage Terminal and increase VCR around Cicaheum Station.

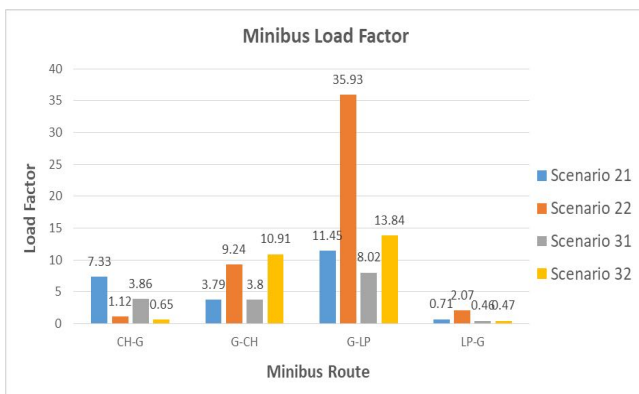
In addition, the development of the inner-city toll road will significantly reduce VCR on roads around Cicaheum Terminal and Gedebage Terminal. This is because now vehicles are shifting their route to the toll road thus freeing up the space on roads around the terminals. The VCR values for different scenarios are shown in Table 9.

Table 9 Average VCR the terminals for different scenarios

Average Volume Capacity Ratio (VCR)				
Scenario	Year	Terminal Leuwi Panjang	Cicaheum Terminal	Gedebage Terminal
2	2020	0.68	1.13	0.92
21	2020	0.67	1.16	0.93
22	2020	0.67	1.16	0.91
3	2020	0.63	0.81	0.59
31	2020	0.64	0.82	0.61
32	2020	0.64	0.84	0.60

6.4 Public transport performance (load factor)

The performance of additional minibus route connecting the three terminals is also analyzed in terms of load factor. The load factor value is shown in the Figure 11. The minibus routes are shown on the X-axis. Note that CH stands for Cicaheum Terminal, G for Gedebage Terminal and LP for Leuwipanjang Terminal.



*The scenario on the figure refers to the Table 5.
*CH = Cicaheum Terminal, G = Gedebage Terminal, LP = Leuwipanjang Terminal

Figure 11 Additional minibus load factor

According to the analysis, the Gedebage (G) – Leuwipanjang (LP) route is the route with the highest load factor and higher than 1. Thus, a new minibus route can be added in that route. As the load factor of minibus connecting Gedebage – Leuwipanjang and Gedebage - Cicaheum exceeds 1, additional minibus fleet can be added or a new public transport mode, with higher capacity, can be considered to serve the route.

7 Conclusion

This study analyzes the impact of Gedebage Terminal and the inner-city toll road development to road networks in Bandung City. The study is carried out by using network modeling approach and the road network

performance, in terms of traffic flow, speed, volume capacity ratio (VCR) and public transport load factor, is assessed.

According to the simulation results, the development of inner-city toll road will impact road network in Bandung City significantly. This impact is indicated by the increase of average speed and the decrease of average volume capacity ratio on the whole Bandung City Network. This significant improvement is due to the fact that the toll road will span from the eastern area to the western area of Bandung City. In other words, it will add significant road capacity to Bandung City Network. In addition, the presence of inner-city toll road will shift the traffic mostly from the southern area of Bandung City to the inner-city toll road, which is located on the northern part of Bandung City.

With respect to the development of Gedebage Terminal, the development of the new terminal as type A terminal (terminal that serves intercity route) and the conversion of Cicaheum Terminal from type A terminal to type C terminal will shift the traffic load from Cicaheum Terminal to Gedebage Terminal. This is due to the fact that there are many intercity busses stopping on roads around type A terminal to wait for intercity passenger. If Gedebage Terminal is developed as type A terminal, then road capacity around it will be reduced as there will be many intercity busses stopping on the road to wait for passenger. This will impact in traffic flow, speed and volume capacity ratio.

If minibus route is added between Terminals, the analysis shows that Cicaheum-Gedebage route and Gedebage-Leuwipanjang route have load factor more than one. This makes the operation of the new minibus on that route is justified. Moreover, the operation of other type of transportation mode with higher capacity can also be considered.

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