

# Integration of Electric Vehicle Transport with TOD in Medan Railway Station Area

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DOI: <https://doi.org/10.5281/zenodo.13890177>

Published Date: 04-October-2024

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**Abstract:** With air pollution having reached alarming limits, as well as fossil fuels that have begun to become limited in quantity, this has paved the way for electric vehicles to be increasingly used by people in other countries. However, until now, most of the urban cities in Indonesia have not attempted to start the development of necessary infrastructure in supporting electric vehicles due to various obstacles. To solve that, this study aims to find out what factors must be considered in building a transit-oriented development with a site in Medan, especially focusing on the necessary infrastructure to support charging of electric vehicles. The method used for this research is qualitative in nature, in which the author will collect various data to be analyzed and synthesized using selected indicators to produce a conclusion that will answer the research questions and obtain results necessary for research objectives. Based on the results, the researcher concludes that the most important factors that must be considered in building a transit oriented development with supporting infrastructure for electric vehicles are: (a) the distance of the building to the nearest public transportation point must be within walking distance, (b) there must be entertainment facilities around the site, (c) the project must be close to an office area or university area in order to provide convenience for employees or students who use electric vehicles, (d) the project must be in an area with a high level of air pollution in order to become a solution that can reduce these problems, and (e) Building must have a supporting concept so that it becomes a project that's more acceptable towards the general public.

**Keywords:** Air pollution, electric vehicles (EV), Medan, transit-oriented.

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## I. INTRODUCTION

With the rapid increase in the number of motorised vehicles in urban cities over time, the level of air pollution produced by car exhausts has reached a very alarming and dangerous level in certain cases, so action is needed to reduce air pollution. If not reduced, the impacts of such air pollution on the environment and life are:

- Disturbing health. Excessive air pollutants have both acute and chronic effects on the health of living beings, which can range from mild upper respiratory irritation (URTI) to chronic respiratory and heart diseases, to lung cancer. In addition, short- and long-term exposures have also been linked to premature death and reduced life expectancy [1] [2].
- Damage the ecosystem environment. Air pollution also has the potential to damage the ecosystem environment where various kinds of living things live such as land, water, and plant animals [3] [4].
- The occurrence of acid rain. Acid rain is a pollutant that comes from car exhaust and industries that use fuel oil and coal. In the atmosphere, these pollutants form sulfuric acid (H<sub>2</sub>SO<sub>4</sub>) and nitric acid (HNO<sub>3</sub>) and fall to the ground as acid rain. The acidity level exceeding the threshold can harm the health of human skin, other living things, and plants. Acid rain will also damage buildings around us [5]

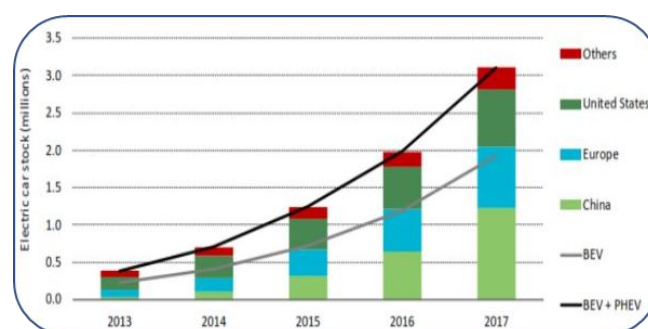
The use of electric vehicles around the world has increased rapidly [6] due to the advanced technology that allows users to enjoy the advantages of these vehicles, without the disadvantages that used to be synonymous with a non-electric vehicle [7]. In fact, due to fossil fuel depletion and air pollution levels exceeding thresholds around the world, electric vehicles have become an increasingly desirable alternative to the future of the automotive world as they can be sourced from a variety of different methods and thus last longer and also have a lower annual usage cost when compared to the current high price of petrol [8].

Indonesia is not a country that can impose such progressive laws, but basically our country has also begun to move towards a world that is more supportive of electric vehicles through tax incentives for the purchase of electric vehicles, or import duty incentives for battery-based vehicles, as well as incentives for the manufacture of public electric vehicle charging unit equipment, and other incentives. Support from the Government of the Republic of Indonesia through Presidential Regulation No. 55/2019 concerning the Acceleration of the Battery-Based Electric Vehicle [4] Programme for Road Transportation, the government has poured out plans to provide incentives to the industry in order to accelerate the battery-based or electric vehicle programme [9] [10].

Although the technology of electric vehicles has advanced, the development is still limited and has not yet spread to cheaper and more affordable vehicles, so the weaknesses of electric cars in general remain a problem/issue that must be overcome. Weaknesses that often have a significant impact on electric vehicles are grouped into 3 main categories, namely operational costs, infrastructure completeness, and performance or travelling power [4] [11].

- Operating costs: electric cars are expensive due to the relatively high price of batteries and public charging of electric vehicles, the rapidly increasing use of electric power at home, and the very high tax on electric vehicles, although it has begun to be reduced through government incentives.
- Infrastructure Completeness: in terms of infrastructure completeness, this is still a weakness of electric vehicles, due to the lack of charging places or electric vehicle charging. In addition, due to the large electricity demand, electric vehicles can only be enjoyed by certain areas such as in big cities that already have a more stable electricity network.
- Performance or mileage: this is a noteworthy drawback because the battery charging time is still long between 4-6 hours and can only be used for a range of 160 km. Although there are also electric cars that have a battery capacity of 38.3 kWh and can be recharged to 80% in just 57 minutes, called fast-charging (50-kW) with a range of 373 km, vehicles with this technology are still less affordable for public.

Electric vehicles have become an alternative vehicle that is increasingly chosen by people in other countries, especially in developed countries such as China or America where the projected number of electric vehicles per year shows that the number has gradually increased every year, and is projected to increase significantly in the future so that it even exceeds the number of fossil fuel vehicles. Figure 1 below is a graph showing that until 2014, electric vehicles in these countries still totalled under 1 million. However, by 2015, the figure had reached 1.25 million and is still increasing steadily each year, with the number increasing even more each year [7] [12] [13]. From Figure 2 below, the number of electric vehicles has increased slowly starting from 2020. Based on the projection graph in the future, to be precise starting from 2030, electric vehicles will increase very rapidly, before in 2047 the number of electric vehicles in the world will already exceed the number of ordinary fuel vehicles [14].



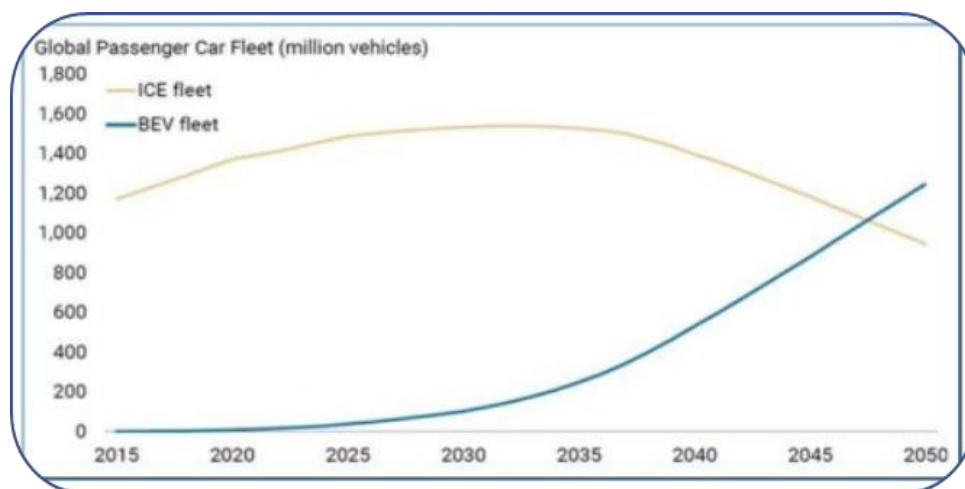
**Fig. 1. Graph of the number of electric vehicles per year in several countries**

(Source: PLN, 2020)

To overcome the increasing number of motorised vehicles in urban cities that have an impact on air pollution levels, the concept of integrating electric vehicles with Transit Oriented Development (TOD) is needed. The Transit-Oriented Development (TOD) concept has a main objective to provide an alternative and problem-solving for metropolitan growth that tends to have an orientated and unconnected development pattern. Therefore, as a concept that encourages community mobility through integrated public transport hubs, it has the potential to create a good quality urban environment by reducing the use of private vehicles by the community while minimising the air pollution generated by these vehicles [15].

Some of the key principles that form the essence behind the success or failure of the TOD concept by architects [16] [17], are:

- Pedestrian: The resulting project should have adequate, comfortable, and safe pedestrian pathways so that people can best perform their daily mobility or transit activities,
- Bicycle Lanes: The project should provide well-designed bicycle lanes that encourage cyclists to ride safely and comfortably,
- Connectivity: Projects should have a movement network design that connects different activities and programmes, with particular emphasis on access to basic amenities and public transport,
- Public Transport: The project should ensure that it provides high-frequency, fast, and reliable public transport options, and will be reduce the reliance of public on private vehicle use,
- Car Parks: The project should have a parking lot that gives more importance or focus to the parking of non-polluting bicycles or electric vehicles, while the parking of motorised vehicles is reduced so that the use of motorised vehicles can be reduced,
- Densification: The project should be able to densify or combine residential and commercial areas around existing transit stations so that public can access public transport easily,
- Mix: Projects should also be developed with the aim of delivering mixed programs such as the provision of residential and commercial programs; to reduce the movement of people, and the need for a mixed programme, and
- Compact: The project should encourage a movement to redevelop the area around the site.



**Fig. 2. Comparative forecast graph of the number of electric and regular fuel vehicles per 5 years**

(Source: PLN, 2020)

Some of the benefits of applying the TOD concept that are worthy of attention in a city or building design [18] [19] are:

- Reduce the number of private vehicle users,
- Increase transit passenger transport,

- Increase access to jobs and economic opportunities for the community,
- Create a pedestrianised community to accommodate people to live healthier and more active lives,
- Improving the quality of life of urban communities by providing more compact and accessible places to live, work and recreate,
- Increase the competitiveness of an area as investment opportunities in the area increase,
- Leads to stability in property prices in locations around the site, and
- Creating a mix of various building functions, namely residential and commercial in one place to provide a more vibrant and diverse city atmosphere in one area (one stop living concept).

## II. RESEARCH METHOD

The research method that will be used is a qualitative method [20] through the collection of related data and information needed about the topic to be discussed, to be analysed and synthesized into a conclusion that can answer research questions, and get the results of research objectives. Data collection in this research is done using the internet, to find journals, research papers, and final presentations that can provide the necessary data.

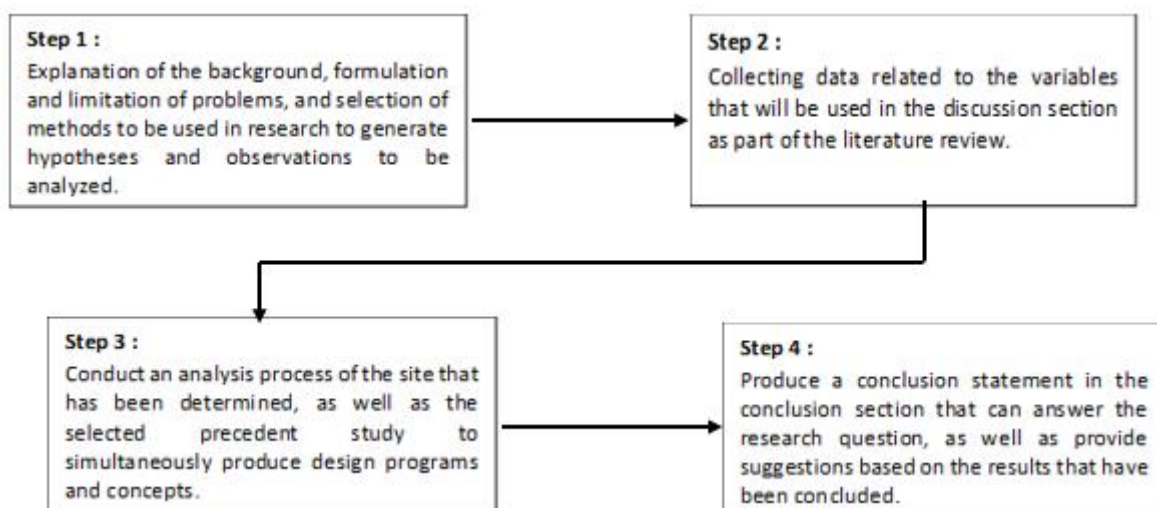


Fig 3. The stages of research

The data collected in the data collection stage will be elaborated as a theoretical basis for related problems/issues [21]. In addition, it will be used as a benchmark in the site selection process, and to generate hypotheses along with precedent studies that will be described in the results and discussion section, so that it becomes a conclusion to the research question. The case study taken is in Medan City. One of the areas where the problem is most visible is at Medan Railway Station where many public vehicles stop beside the road to wait for passengers. This becomes a traffic bottleneck, as well as worsening the environmental conditions of the area which is already filled with motor vehicle pollution from the use of many private vehicles. These data will then be used as a benchmark in the site selection process.

## III. RESULT AND DISCUSSION

### A. Discussion on Hypothesis from Literature Study in Site Selection

1) Hypothesis: A travel system that combines the use of electric vehicles and public transportation transit points is a suitable alternative to be implemented for commuters who come from/ live in suburban areas.

Discussion: It can be concluded that the selected site should be relatively close to a public transportation point, specifically within 4-8 km so that commuters coming from suburban areas can use the station as a transit point.

2) Hypothesis: Placement of electric vehicle charging infrastructure at transit points or even just adjacent to public transportation points can promote the use of electric vehicles to a wider public.

Discussion: From the observation, the conclusion is that to increase the attractiveness of electric vehicles to the public, the project must be able to emphasize the infrastructure aspect of the electric vehicle because the presence of charging modules in the building has proven to be successful in attracting people's attention.

3) Hypothesis: One electric vehicle charging module is sufficient for use by multiple customers

Discussion: The results of the observation point 3 resulted in the conclusion that the charging modules provided on the site should not be too little because it will result in less modules if there are several users who want to use at one time, but also not too much because it will be idle when no one is charging.

4) Hypothesis: Not all transit points have enough land area to implement the infrastructure to support electric vehicles.

Discussion: Point 4 leads to the conclusion that since most stations do not have enough land to build the infrastructure, we should be able to find a site outside the station but still close enough to have the same goals and results.

5) Hypothesis: Commuting to and from work makes up a large portion of people's daily travel time on weekdays

Discussion: From these observations, it can be concluded that the target users of the office zone are only one of the zones to be considered, and not the only zone to be considered. Location.

### ***B. Indicator Results Based on Hypothesis Discussion in Analysing Site***

The selected site is in the centre of Medan City where the human density is one of the highest in the area, especially since it is surrounded by office zones and government buildings (Fig 4). This is a good potential as it increases the number of potential visitors who use the site as a place to park and ride to work. In addition, the site is also a train station, which is usually filled with public vehicles on the outside, making it an alternative public transportation transit point for those coming from the suburbs.



**Fig 4. Zoning of land around the site.**

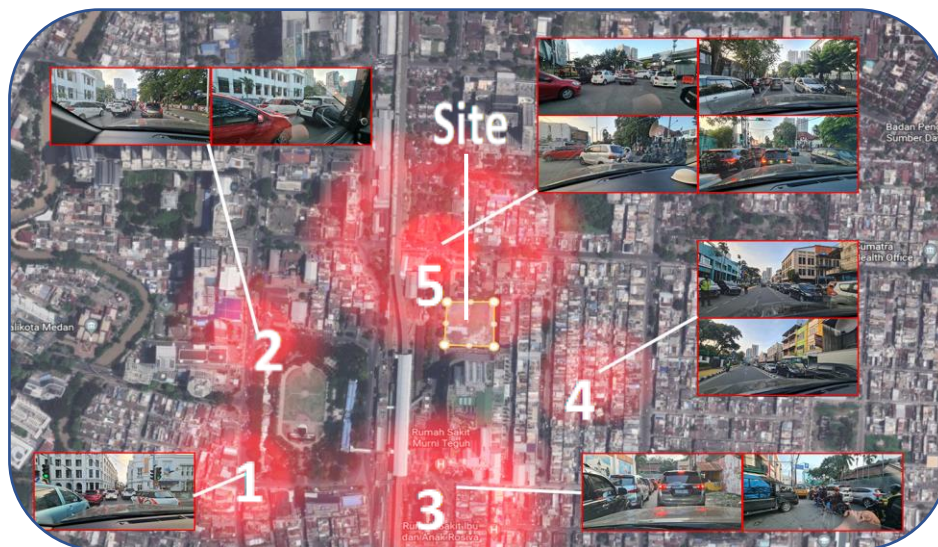
(Source: Google Earth, 2021)

There are several other factors that make the site in Fig 4 a very suitable alternative to be selected, based on the analysis of indicators that have been selected in the method section and presented in the Table 1 as follows:

**Table 1. Indicator analysis table and discussion in determining the site**

Indicator	Discussion
Distance to office area	As can be seen from Figure 4, the site is surrounded by office zones so that the project will become a place for office employees who use electric vehicles to use the charging facilities on the site when not using their vehicles.
Distance to entertainment facilities or malls	The site is located right next to a shopping centre called Centre Point Mall, so it will give users of the charging infrastructure on the site a place to spend time while waiting for their vehicles to be fully charged.
Distance to nearest public transportation transit point	In front of the site there is a train station, which is often also a gathering point for public transportation, making it easier for the site to become a park and ride area if needed.
Level of air pollution in the site	The level of air pollution in the site area is very high due to the heavy density of fossil fuel vehicles, especially during working hours where congestion in the area is very high.
Distance from site to city centre	The site is located 500 meters from the city centre, so it is an ideal point to start the development of supporting infrastructure for electric vehicles because it is easily accessible to most people.
Distance to campus or school	There are two universities within 500 meters radius around the site. Thus, the site can be a place for students who use electric vehicles to park and charge their vehicles.

There are 5 (five) main points which are the points with the highest vehicle density around the site (Fig 5). These points are spread between several locations, namely in the Merdeka Walk area at points 1 and 2 which are the hangout centre for young people. In addition, points 3 and 4, which are office areas, are also filled with vehicles of various types from trucks to private cars, causing congestion and greatly extending the travel time to and from work. However, the highest congestion point, with the largest radius coverage of vehicle density is at point 5 which is located very close to the site. The four-way intersection (Fig 5) has a very high vehicle density due to the large number of vehicles from four sides converging at that point, and the presence of a nearby railway tracks so that often at the intersection, the irregular traffic flow makes the point the centre of a long and time-consuming traffic jam.

**Fig 5. The highest density point around the site based on the author's survey**

These points can be used as benchmarks in the placement of electric vehicle charging infrastructure, because they will be the most draining locations for electric vehicles due to the severe congestion problems that exist at that point. They will also be the most likely locations for electric vehicle drivers to stop and charge their vehicles, either because they run out of electricity, or simply because they want to take a break. Therefore, these locations can be interconnected in a system that is integrated with the infrastructure on the site so that it becomes a project that can simultaneously ease the burden of pollution and vehicles in the area.

### C. Program Overview of Selected Sites

Based on the literature study research that has been conducted, it can be concluded that to build an electric vehicle charging station that is integrated and connected to the optimal circulation paths of the Medan city community, the place must have 3 (three) main programs, namely a Park and Ride Centre, Entertainment and Recreational Centre, and Electric Vehicle Charging Station. The resulting supporting programs are programs that will support the success of these main programs. The selection of the main programs is also based on the concept of the building to be built, which is a Transit-Oriented Development, so that the building is expected to be a transit point that supports the daily activities of its visitors, as well as integrated with existing and future technologies, such as the discourse of MRT (Mass Rapid Transport) construction, etc. The supporting space programs that are expected to exist in the development of this project are as shown in Table 2.

**Table 2. Selected site program with percentage of area and reason for selection**

Site Program	Area (%)	Reasons for Selection
1. Retail services centre	20	The program is provided to support the needs of visitors while waiting for their public transport schedules, or for those who come to take a break. The retail shops available allow them to walk around and look at goods while they wait, as well as pass the time.
2. Park, charge, and ride station	30	The program was chosen based on one of the main objectives of the building in the future, which is to become a transit point for electric and public vehicle users in Medan City. The program will greatly support the existence of the resulting transit point because the electric vehicle users can easily park their vehicles in the parking area, then charge their vehicles, before continuing their journey to their offices through various public transportation that is already available around or within the site.
3. Solar panel garden and exhibition	10	The resulting program is based on the goal of creating an open space that can incorporate the desired functional aspects, as well as the artistic or aesthetic aspects that support the comfort of the visitor's experience while in the project. Since the building is an electric vehicle charging center, it is certain that it will require a lot of electricity to be able to generate the electricity needed, so the use of solar panels is needed. So that the functional aspect of the use of solar panels can be an aesthetic value as well, the panels will be arranged and arranged into a main display in the open garden that will exist so as to simultaneously make the area an exhibition area.
Site Program	Area (%)	Reasons for Selection
4. Automatic food and beverages cafeteria	10	The project will also have a cafeteria that aims to sell food and drinks to electric vehicle drivers who are waiting for their vehicles to be charged. However, it is also open to the public who are just passing by or want to come, as well as to those who just want to use the bus and taxi stations on the site. The automated aspect is presented in the robots that will be available to deliver food or drinks to the drive-in theater patrons, some of whom are also electric vehicle users.
5. Bike sharing and bike supporting facilities	10	The program aims to encourage the local community to be more interested in using bicycles as a way of mobility to and from the surrounding area. The bicycle support facilities provided make it easier for cyclists to use bicycles in their daily activities.

### D. Design Concept

The design concept to be used has an emphasis on sustainable architecture using solar panels, and other methods, and on transit-oriented development, especially in terms of transit points and supporting programs that will be presented. Therefore, the three main programs that underlie the selection of space programs are also on Entertainment and Recreational Activities, Park and Ride Stations, and Electric Charging Infrastructures. In addition, because based on the site analysis, the surrounding location is very dense and filled with buildings and very many human activities, the building

design concept is expected to be something that provides tranquillity or becomes a place to rest for those who are tired of the density and noise, and the fatigue of an urban city. The third-place concept (where the first place is home and the second place is work or school) is very important in generating and expressing these feelings and goals because it emphasizes ways to create a spatial atmosphere that is like what humans feel at home or in other familiar spaces. With the third-place concept, the project is expected to be a resting place that presents a home-like atmosphere or a place with a similar level of comfort.

The concept to be applied to the building is about locality, through design aspects that highlight or introduce to the wider community the uniqueness and identity of architecture that is identical to the people or citizens of Medan City. This concept was chosen because with a building program and purpose that is arguably already very innovative and looks to the future, the absence of applying locality aspects to the building will result in the building becoming very unfamiliar to residents, and not in context with the environment in which it is located, namely in the centre of Medan City. For the building to still have an identity that is connected to the location of its existence, namely in Medan City, the locality aspect can be shown using local materials, ornaments that are identical to local tribal culture, traditional building design aspects of local tribes, or other ways. One of the traditional buildings of the Batak Tribe which is the majority tribe in Medan that will be used as design inspiration is the Bolon House, which has a unique design with a pointed roof at each end, and a sloping body shape, as well as stilt construction at the bottom.

#### IV. CONCLUSION

With the development of electric vehicle technology, it is certain that the infrastructure supporting electric vehicles will grow, and it is also time for urban cities that are not the capital city in Indonesia to start building the necessary infrastructure in the buildings around the city. From this research, the results obtained through the discussion section that to integrate the electric vehicle supporting infrastructure optimally in an urban development, several indicators in site selection must be considered such as the distance from the site to the office zone, distance to entertainment facilities, distance to educational facilities, the level of air pollution in the area is quite alarming, the nearest public transportation point is how many meters away, and also whether the site is far from the city centre. Some of these factors are to support the transit-oriented development aspect of the building to be presented.

Conceptually and programmatically, a form of development that aims to reduce air pollution must have aspects of the application of sustainable architecture such as through its materials, or the use of solar panels that also provide alternative sources of clean energy, and other factors so that it becomes something that can last for a long time in the future. In the city of Medan, which does not yet have electric vehicle charging facilities, this kind of novelty should also be highlighted and promoted to the maximum to encourage a larger percentage of the public to start changing to the use of electric vehicles, because basically something new will attract people's attention.

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