The Viability of Tricycle Electrification through vehicle unit conversion in the City of Manila, Philippines

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Abstract: This research investigated the viability of the scaling up of the conversion of gasoline fueled tricycles into electric tricycles in the Philippine Capital Manila. Two different Tricycle Operators and Drivers Associations (TODA) with different fleet composition were surveyed using SafeTravelPH vehicle tracking app for their actual routing and loading and unloading areas and interviewed to get an overview of their socio-economic profile and the daily and annual costs. These results were presented to their representatives along with the local government in a validation meeting and were found to be similar to their daily experiences. The results are then used as a basis to create a pre-feasibility study to test the viability of scaling up and increasing the electric tricycle fleet of the city. The study found out that shifting to e-trikes can lead to avoiding 741.20 kg of CO_2 emissions per vehicle annually, and that the business model option of City-led investment in the conversion of tricycles to electric having the highest benefit-cost ratio compared to the operator-led investment.

Keywords: Tricycle-for-Hire, Informal Public Transport, Electric Tricycles, Crowdsourcing

1. INTRODUCTION

1.1 Background

Tricycles comprise a large part of the public transportation system in the capital city of Manila. They are the primary choice of transport, especially for some areas with narrow roads and those far from the coverage of formal public transportation. In other cities, they serve as a feeder service for people who want to ride a larger capacity public transport service if the distance from their origin to the public transportation is not viable through walking. However, in Manila City, tricycles also compete with the Light Rail Transit (LRT), buses, and jeepneys. Compared to the mass transit options that are regulated by the Department of Transportation (DOTr) and Land Transportation Franchising and Regulatory Board (LTFRB), the regulation of the three-

wheeled vehicles has been devolved to the local governments because of the Local Government Code. The Code gave local governments the authority to franchise, permit, and determine the total number of tricycles-for-hire in their respective towns or cities.

Despite the devolution, some memorandum circulars have been released by the Department of the Interior and Local Government instructing local governments to ban tricycles from plying the national highways and requiring them to submit a tricycle route plan to implement this policy (DILG, 2020). The implementation of this memorandum was reiterated in another memorandum circular in 2023 (DILG, 2023). However, this memorandum conflicts with the electric tricycle livelihood program of Manila City.

In 2016, the ADB-DOE project of donating electric tricycles to different local government units commenced, including the city of Manila, which received 280 electric tricycle units. As part of the initiative, the local government is then instructed to facilitate the transition to electric vehicles and for the beneficiary drivers to eventually own them (DOE, 2019). One implementation of the electric tricycle livelihood program is to implement fixed routes to maximize passenger occupancy and increase the feasibility of the livelihood program.

The enactment of the Electric Vehicle Industry Development Act (EVIDA) in 2022 sought to provide an enabling environment for electric vehicle development and adoption. The law supports the provision of road infrastructure support for electric vehicles and required corporate, government, and public transport fleets to have a 5% EV fleet share based on the timeline identified by the Comprehensive Roadmap for the Electric Vehicle Industry (CREVI) (RA 11697, 2022). This study explored the feasibility of converting tricycle-for-hire vehicles to electric and how local governments can support the transition to electric tricycles.

1.2 Research Objective

The specific objective of this research is to study the economic and technical viability of converting gasoline-powered tricycles into electric tricycles without any changes to their current operations. A pre-feasibility study is done by determining the typical daily service patterns of the tricycle, the cost of operating and maintaining the tricycle and the other policies within the city that affect the tricycle operations.

1.3. Scope and Limitations

The scope of the data collection is limited to two TODAs (gasoline-powered and electric tricycles). The selection of the gasoline-powered TODA is limited to the TODA in the most strategic location, where it is possible for the tricycles to service passengers to several districts of the city. Realtime tricycle trip data were collected from the tricycles through a boarding and alighting survey, the cost of operations was determined from the self-reported estimates of the drivers.

2. REVIEW OF RELATED LITERATURE

The lack of formal public transportation in some key cities in the Global South, particularly in Africa, South and Southeast Asia, enabled three-wheeled vehicles to be popular in these areas because of their quick terminal-to-destination services, despite sometimes being more expensive than formal public transport. These are known locally as the *tuk-tuk* in Thailand,

moto in Vietnam, *Keke Marwa* in Nigeria, *Bajaj* in India, and *tricycle* in the Philippines (Guillen, 2011).

Cabanatuan City, which calls itself the “Tricycle Capital of the Philippines” due to having 30,000 four-stroke tricycles registered throughout the city, showed that a majority has an amenable perception of shifting to e-trikes. They have found that in the long term, the E-trike can become sustainable both from the operators' point of view and from the commuters. Challenges in the political and governance side are anticipated from the shift, as pressures from the sector could arise (Balaria, 2017).

Gumasing and co-authors studied e-trike operation sustainability indicators in the City of Manila. They found that the quality of service needed several improvements and provided criteria for prioritizing and focusing on improving the quality of service (Gumasing, 2022). A similar study was done for motorcycles called habal-habal in Davao City (Guillen, 2011), for university-based paratransit services (Tiglao, et al., 2020), and for informal transport services in Ibadan, Nigeria (Olowosegun, et al., 2021).

A study by Tiglao, et al (2023) transport data through collaboration with the stakeholders in General Santos City, Philippines showed the efficiency of the method of using the SafeTravelPH Platform, the source, and the stakeholders themselves. In the end, an information exchange happens between the operators and the researchers to discuss the data's insights further.

3. STUDY AREA

3.1 City Profile

Manila, the capital city of the Philippines, has a population of 1.78 million residents (PSA, 2020), accounting for around 14% of the Metro Manila population. Manila is one of the densest cities in the world, with a population density of 43,611.5 people per square kilometer. The total land area of the city is 42.34 square kilometers.

There are 897 barangays and 6 legislative districts in Manila. The legislative districts are the basis of the tricycle service areas when a new ordinance legalizes the tricycle-for-hire operations of a certain Tricycle Operator and Driver Association (TODA) in the city.

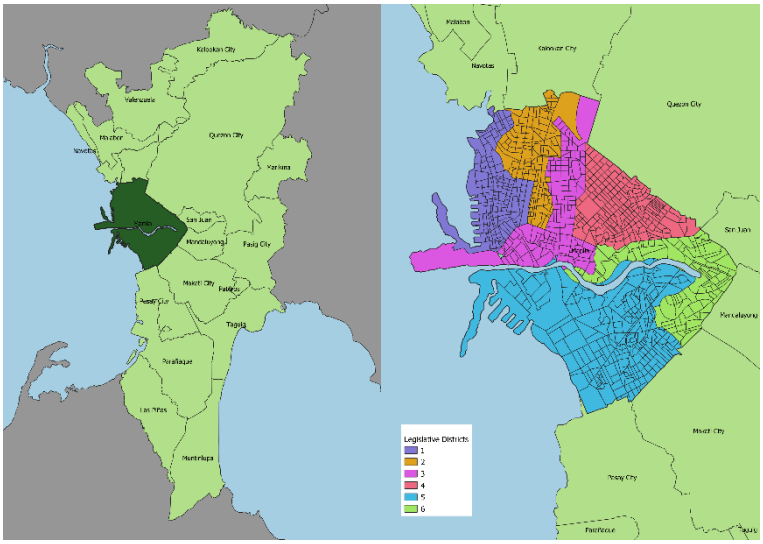

Figure 1. Location of Manila in Metro Manila (left) and Manila Legislative Districts (right)

There are currently 5,598 tricycles-for-hire in the city and an additional 1,831 registered for private use based on the data from the Manila Traffic and Parking Bureau (MTPB) as of 2023. Due to underreporting and unregistered tricycles operating, the real number could be higher.

Table 1. Statistics of Franchised Tricycles (MTPB, 2023)

District	Number of TODA	Number of TODA Members	Number of Permits	Resident Population (2020 CPH)
District 1	19	1,392	439	441,282
District 2	27	1,929	675	212,938
District 3	35	2,650	973	220,029
District 4	53	3,206	1,475	388,305
District 5	36	2,772	913	395,065
District 6	24	1,553	1,123	300,186
No Tricycle Federation affiliation	18	2,008		
Total	212	15,510	5,598	
Private (Citywide)	N/A	5822	1831	
E-Trike	N/A	N/A	280	

The DILG Memorandum Circular 2020-036, which is reiterated in 2023 through Memorandum Circular 2023-195, created a ban on tricycles to ply along national roads. Manila, the capital city, has several national roads traversing its area. These national roads make the tricycle ban difficult to implement, as it is likely impossible for a tricycle to bypass national roads from origin to destination entirely.

4. METHODOLOGY

4.1 Analytical Framework

The study consists of different methods, both quantitative and qualitative methods, to ensure the data collected is validated and verified by the stakeholders. The figure below shows the framework of the research.

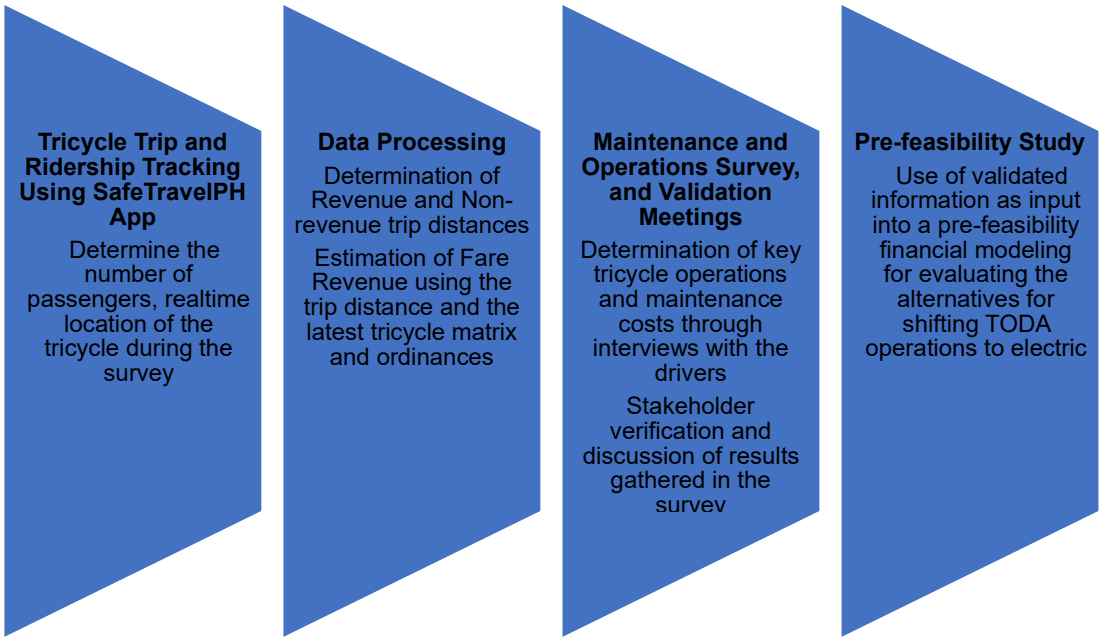

Figure 2. Analytical Framework

4.2. Tricycle Trip Ridership and Tracking and Data Processing

An onboard vehicle tracking survey with a surveyor was performed to provide an overview of the actual daily operations of the tricycles in the study. A dedicated surveyor is onboard the vehicle and uses the SafetravelPH mobile app to track the location of the tricycle while on service time, the boarding and alighting points, and time. The data will then be downloaded from a server where the data can be processed for map visualization and determination of operating speed and daily ridership.

The fare revenue was then estimated using the latest fare matrix of the city, as well as the daily ridership and route data. For tricycles, the minimum fare per passenger in Manila is Php 16.00 for the first kilometer and an additional Php 5.00 per additional 500 meters. For electric tricycles, the fare for any distance within the route is a flat rate of Php 20.00. Tricycles are also allowed to do “special trips” that are akin to taxi service where they will directly drive the passengers to their destination. In the special service, the passengers will sometime have to pay for the intended capacity of the whole tricycle, including the unoccupied seats. The fare is estimated based on the distance that was calculated in the post-processing of the trip data. The capacity of the tricycle is 5 excluding the surveyor and the driver.

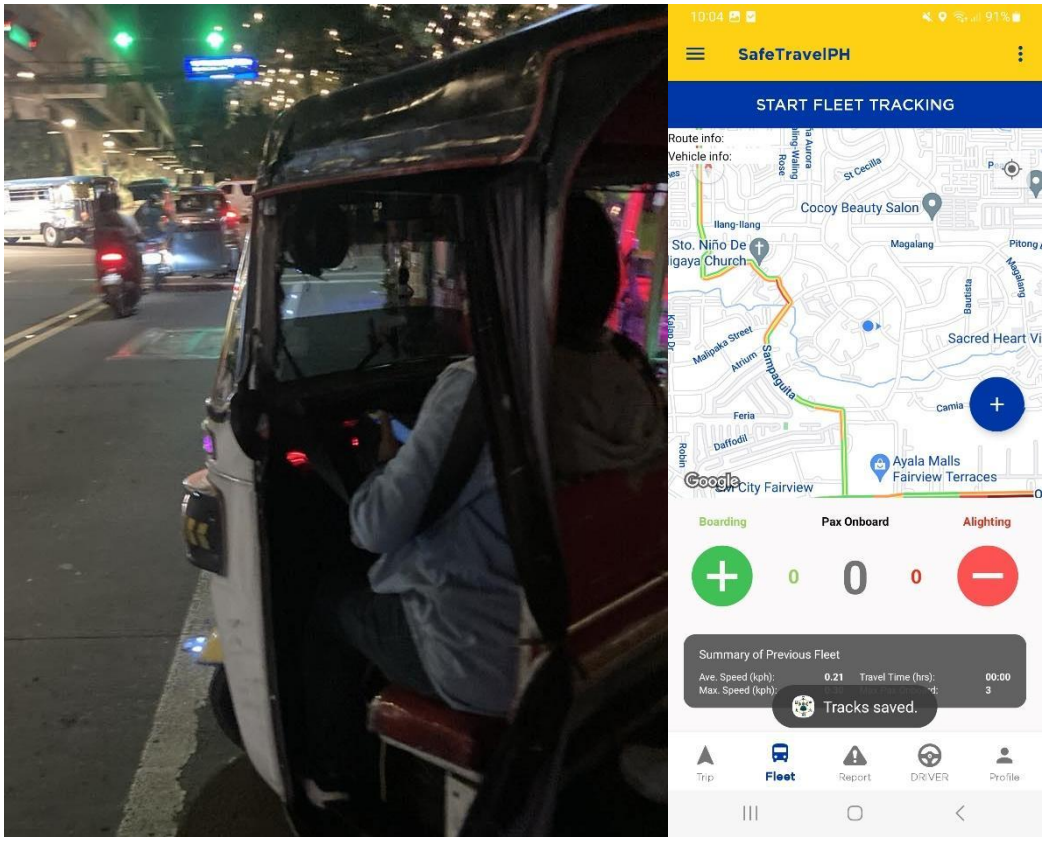

Figure 3. Surveyor onboard surveying with the SafeTravelPH App and SafeTravelPH App UI

4.3. Maintenance and Operations Survey, and Validation Meetings

A few TODA members were interviewed and surveyed to get an overview of their daily expenses and annual expenses like fuel or annual registration of vehicle renewal of franchises to operate as per hire, as well as the usual spare parts that needed frequent maintenance. The survey also determined their current socioeconomic status and the length of their work in the tricycle industry.

Along with the determined results of the Tricycle Trip Tracking Survey, the maintenance and operations survey results are validated with stakeholders from the Tricycle Drivers and some representatives from the MTPB through a validation meeting. Separate validation meetings for both the tricycles and electric tricycles were held after the data collection and processing for each tricycle.

4.4. Pre-feasibility Study

A business model that aims to determine the viability of the conversion of current gasoline powered tricycles to electric models was created using the data from the trip tracking and validated by the drivers. A scenario where the operators and drivers will shoulder most of the cost of the investment and a scenario where the city government will shoulder some the cost of investment were studied. In analyzing and creating the business model, several alternatives, including the status quo alternative were considered, and the cost of operations and financing costs were studied and the evaluation of each alternative through the calculation of the Net Present Value (NPV), Financial Internal Return on Investment (FIRR) and Benefit-Cost Ratio.

Figure 4. Business model creation framework

5. HISTORICAL TRICYCLE TRIP INFORMATION

Household Interview Survey databases from Metro Manila Urban Transportation Integration Study (MMUTIS, 1999) and MMUTIS Update and Capacity Enhancement Project (MUCEP, 2015). While the MUCEP database is still subject to access permissions, the MMUTIS Household Interview Survey database is now open for research access. For the MMUTIS data, 40 percent of tricycle trips are first or last-mile trips, and 38% are middle-continuing trips. Direct trips, those who complete the journey from their origin to destination without transferring from the tricycle, comprise 22% of all tricycle trips in the MMUTIS.

The share of tricycles rose from 13.4% in 1996 to 16% in 2014, while jeepneys shrank from 39.1% to 19.1% in 2014. Subsequently, the share of trains rose from 2.3%. From the MMUTIS to the MUCEP Study, there has been a considerable drop in the average occupancy of 2.64 person per trip to 0.94 person per trip (daily average) or 1.24 person per trip (peak hour).

Table 2. Mode Shares of selected Public Transportation Modes

	MMUTIS, 1999	MUCEP, 2015
Tricycle	13.4	16
Jeepney	39.1	19.1
Train	2.3	4.2

6. TRICYCLE TRIP TRACKING SURVEY OUTPUT

6.1. SMC TODA (RE BAJAJ tricycles)

SMC operates its passenger terminal at Antonio Villegas St, near Manila City Hall and SM City Manila. The terminal, also at the intersection with N. Lopez Street, connects the area to different educational institutions, commercial and shopping areas, and transit transfers to different modes, particularly the LRT 1 Central Station. Their allotted terminal length is 30 meters, and they can queue 10 tricycles throughout the length. Aside from the SMC TODA, SNACTWA, and SMACQ TODA have their terminal nearby but do not directly compete with SMC TODA given their different service areas. Tricycles should queue in the terminal to get passengers, or they will be bypassed by other tricycles queueing in the area. Most of the trips of SMC TODA are “special trips” in which the passenger arrives directly at their destination, and they pay out the whole passenger capacity of the tricycle.

Figure 4. SMC Terminal Location

A terminal dispatch survey was conducted along with trip tracking surveys to track the frequency of tricycle dispatches out of the terminal. The dispatch survey results show that the weekday dispatches surpass the weekend by 23%, reflecting more trips were made during the weekdays. The number of unique body numbers lined up at the terminal was 26 vehicles on the weekend and 28 vehicles on the weekday. The SMC TODA has a membership of 100 units based on the MTPB list and validated by the TODA officials, and the dispatch results show only 26-28% percent of the whole membership. During the validation meeting, the TODA officials disclosed that some already stopped in favor of motorcycle-for-hire and delivery works.

Table 5. Dispatch Data from SMC TODA

December 2 (Saturday)	112
December 4 (Monday)	146
Difference	34
Difference (%)	23.3%

The average frequency is 11.23 vehicles per hour and 9 vehicles per hour for weekday and weekend trips, respectively. In terms of average vehicles counted during the peak, there are between 3-4 minutes between vehicle dispatches. The hourly dispatch data for the weekday and weekend also reveals distinct patterns regarding trip behavior. The weekend survey closely follows the operating hours of the mall nearby, and the offices and schools are closed during the weekend. During the weekday, the dispatch peaks in the morning from 8AM to 9AM, when most offices and schools are about to open, and peaks again in the afternoon at 5PM.

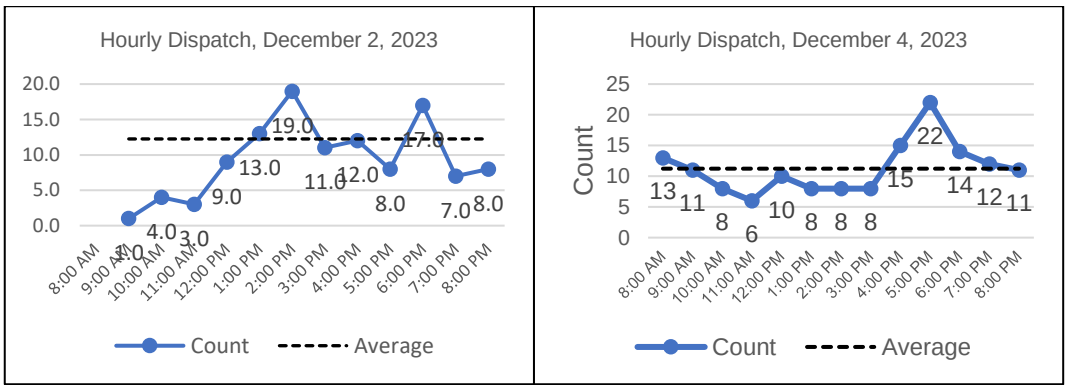

Figure 4. Hourly Dispatches

The dispatch per vehicle shows that the average number of dispatches per unique vehicle is

around 4.3 to 5.3 dispatches per day. This means that a single vehicle only gets to serve passengers around 4 to 5 times a day. The weekday dispatches are less the weekend dispatches, which is caused by the increased number of vehicles queuing during the weekday. Upon their return, they will queue behind the line and slowly go to the front as soon as the vehicles in front of the queue leave to find passengers. This process can take two hours and twenty-five minutes to go from behind the queue to the front. There are times when the tricycles leave the terminal without a passenger and rove around to find one. This results in a dispatch occupancy of less than 1.

Table 6. Dispatch Statistics per Vehicle		
Average number of dispatches per vehicle	5.2	4.3
Duration of Survey	12:41:00	10:28:00
Average Dispatch Interval (hh:mm:ss)	00:05:13	00:05:33
Average Dispatch Interval (decimal minutes)	5.22	5.55
Average Waiting Time per Vehicle (hh:mm:ss)	02:25:57	02:24:30
Average Dispatch Interval (minutes)	145.95	144.5
Average Occupancy per dispatch	0.90	0.85

Headway is the time between dispatches between two vehicles. The peak morning hour headway occurs differently during weekends than weekdays (Table 10). The weekend headways have the peak headway at around 4.6 minutes or around 13 tricycle dispatches per hour in the morning and 14 in the afternoon. In the weekday dispatches, the peak hour is at 15 minutes or 4 vehicles per hour in the morning and around 3.2 minutes or 19 vehicles per hour in the afternoon.

Table 7. Dispatch Data from SMC TODA

	12/04/2023 (Monday)		**12/02/2023 (Saturday)**	
	Peak Morning Hour			
	Count	**Headway (minutes)**	**Count**	**Headway (minutes)**
8:00 am	13	4.6		
10:00 am			4.0	15.0
	Peak Afternoon Hour			
2:00 pm			19.0	3.2
6:00 pm	14	4.3		

Tables 8 and 9 present the result of the vehicle trip tracking and passenger boarding and alighting using the SafeTravelPH App. The survey tracked the typical daily operation of ten different tricycles in the app, with 5 tricycles for the weekday and 5 tricycles for the weekend survey. For all tricycles surveyed, only 3 out of 10 tricycles have the most distance traveled as revenue trips with at least one (1) passenger on-board. The rest have more non-revenue or “dead-miles” trips than the revenue distance. These unproductive distances covered range from 50.23% to 61.98% of the total distances. As a paratransit mode, most tricycle-for-hire trips follow the special trip service not just in Metro Manila but in many parts of the country.

Table 8. Revenue and Non-revenue runs Distance (December 2, 2023 ,Saturday)

	Distance (km)			Classification	
Driver	**Total**	**Revenue**	**Non-revenue**	**% Revenue**	**% Non-revenue**
Trike A	44.3	22.3	22.1	50.23%	49.77%
Trike B	24.1	10.2	13.9	42.21%	57.79%
Trike C	58.6	25.3	33.3	43.20%	56.80%
Trike D	52.5	20.0	32.5	38.02%	61.98%
Trike E	31.3	18.6	12.7	59.37%	40.63%
Average	42.2	19.3	22.9	45.73%	54.32%
Total	210.837	96.310	114.526	45.68%	54.32%

Table 9. Revenue and Non-revenue runs Distance (December 4, 2023 ,Monday)

		Distance (km)		Classification	
Driver	**Total**	**Revenue Distance**	**Non-revenue Distance**	**% Revenue**	**% Non-revenue**
Trike F	48.37	22.97	25.40	47.49%	52.51%
Trike G	46.35	24.56	21.79	52.99%	47.01%
Trike H	38.29	15.91	22.37	41.56%	58.44%
Trike I	50.49	22.72	27.78	44.99%	55.01%
Trike J	26.27	10.98	15.29	41.79%	58.21%
Average	42.00	19.40	22.50	46.31%	53.69%
Total	209.769	97.138	112.631	45.68%	54.32%

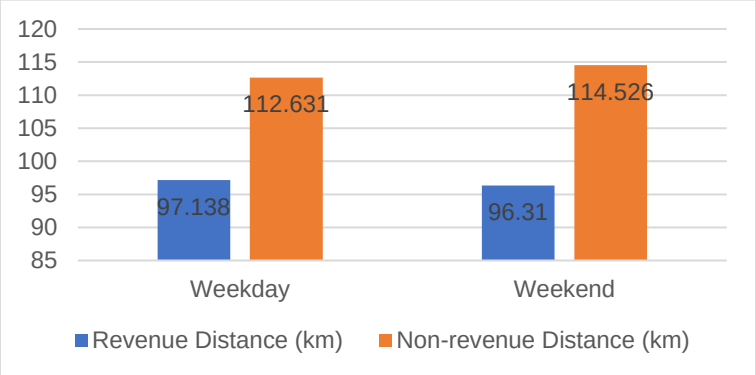

Figure 5. Weekday and Weekend Trips Distances Comparison

Tables 10 and 11 show the ridership calculations based on the boarding-alighting data from the SafeTravelPH App. The weekend survey has a higher revenue than the weekday survey, comparing the two surveys' daily ridership, occupancy rate, median revenue, and round trips. All of the trips are special trips, meaning the fare was estimated to be paid by the passenger in full capacity.

Table 10. Occupancy Calculations, December 2, 2023

	Daily Occupancy	Capacity (Excluding Driver)	% Occupancy	No. Of Trips
Trike A	19	5	42.2%	9
Trike B	18	5	72.0%	5
Trike C	23	5	46.0%	10
Trike D	17	5	68.0%	5
Trike E	15	5	42.9%	7
% Occupancy			51.11%	
Total Boarding			92	
Median Revenue			728	
Average Number of Trips			7.2	

Table 11. Occupancy Calculations, December 4, 2023

	Daily Occupancy	Capacity (Excluding Driver)	% Occupancy	No of Trips
Trike F	12	5	48.0%	5
Trike G	19	5	38.0%	10
Trike H	13	5	52.0%	5
Trike I	21	5	52.5%	8
Trike J	9	5	30.0%	6
% Occupancy			43.53%	
Total Boarding			74	
Median Revenue			684	
Average Number of Trips			6.8	

A visualization of one vehicle daily trip tracks is shown in Figure 6. Most of the boarding points are at the terminal at SM City Manila, and there is only one instance of it picking a passenger at the Binondo area. The trips ended in different city points, with Tondo and Malate being the furthest districts. During the validation meeting, the operators and drivers confirmed that there is a regulation that drivers should not be picking up passengers in other areas assigned to other TODAs. Additionally, the TODA operations ordinance specifies only one terminal per TODA.

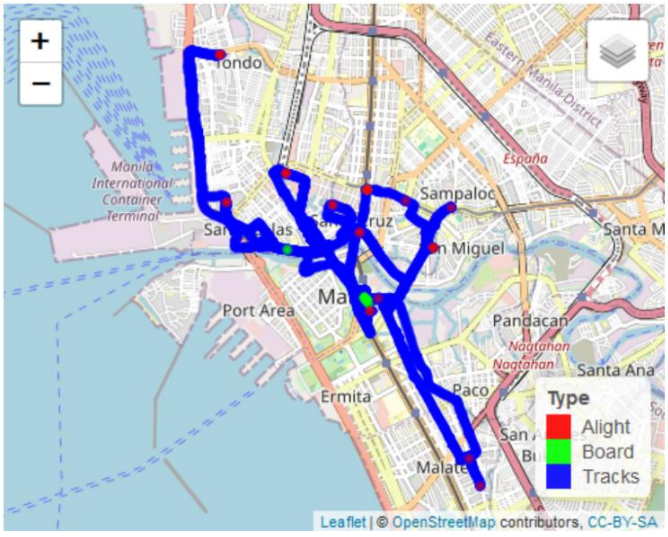

Figure 6. Boarding and Alighting and Trip Tracks from SafeTravelPH App

6.2. Electric Tricycle Trip Tracking

The Terminal of the Electric Tricycles is located at the San Andres Sports Complex, which also serves as the terminal of their route and the depot and charging facility for the e-trikes. Unlike the SMC TODA, which mainly involves special trips, The route is from Quirino Avenue to Divisoria via Taft Avenue and Binondo, and vice versa. The Northbound distance and Southbound distances are 4.6 and 4.9 kilometers, respectively. The Trip Tracking survey tracked the duration of their stay at their chosen passenger pick-up areas or at charging times at the depot. The tricycles return to the depot to charge after their morning runs to have their batteries fully charged for the afternoon run, which coincides with the rush hours around 4 PM to 6 PM The surveyed vehicles took up to 5 hours in the depot to charge and prepare the electric tricycles for the afternoon runs.

A fully charged battery can run up to 50 kilometers of continuous run without recharging. The dashboard shows 5 led lights which shows 20% of battery capacity per light. When the dashboard shows only one green light or 20% battery remaining, the e-trike will then return to San Andres to recharge. During charging times, there is a full stop of operations since the vehicle cannot operate while charging. While there are other charging facilities within the city in Binondo, Algeciras, City Motorpool and Tondo, they cannot recharge batteries outside of their assigned charging stations hence the requirement to return to San Andres.

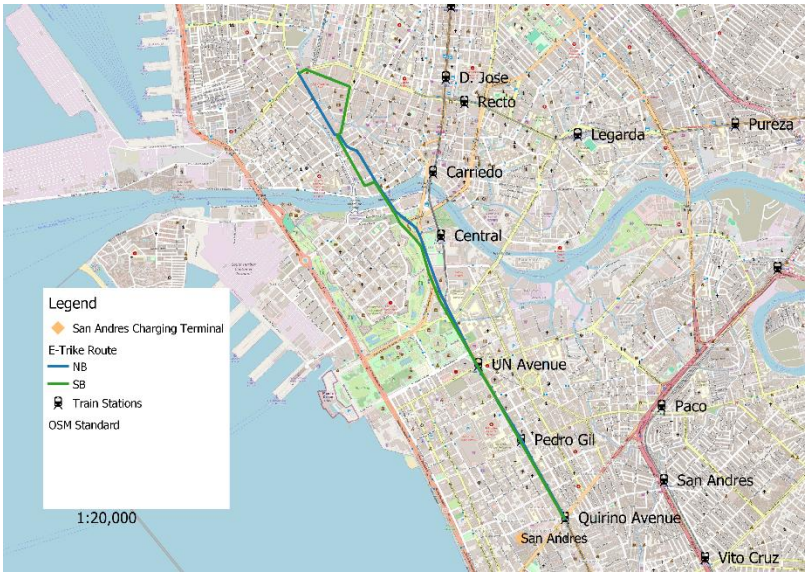

Figure 10. Electric Tricycle Route

For the passenger operations, 4 out of 5 are characterized in the route defined in Figure 7, and the others served special trips throughout their daily operation (E-Trike A). Surveyed e-trikes have more than half of their running distance had at least one passenger, with those who had operated their vehicle along the route having higher percentages of revenue distances (69.78% to 77.25%). E-Trike A's revenue distance is comparable to the SMC TODA revenue distance share.

Table 12. Daily Trip Distances (January 27, 2024 Saturday)

	Distance (km)			Classification	
Driver	**Total**	**Revenue**	**Non-revenue**	**% Revenue**	**% Non-revenue**
C	4.980	3.475	1.505	**69.78%**	30.22%
D	6.1	4.5	1.6	**74.33%**	25.67%
E	24.8	19.1	5.6	**77.25%**	22.75%
Average	11.938	9.039	2.899	75.71%	24.29%
Total	35.814	27.116	8.698	75.71%	24.29%

Table 13. Daily Trip Distances (January 29, 2024 Monday)

	Distance (km)			Classification	
Driver	**Total**	**Revenue**	**Non-revenue**	**% Revenue**	**% Non-revenue**
A	38.225	22.476	15.748	**58.80%**	41.20%
B	70.6	54.4	16.2	**77.05%**	22.95%
Average	54.397	38.425	15.971	70.64%	29.36%
Total	108.793	76.850	31.943	70.64%	29.36%

The weekday survey done last January 29, 2024, recorded more revenue than the weekend survey done last January 27, 2024. Based on the normalized indicator of the passenger by distance run, the weekend operations had greater potential as they mostly operated during peak hours. In the validation meeting, the e-trike drivers said they earn more during the weekdays.

Table 14. Total Boardings per day

January 27, 2024 Survey						
Name	**Boarding**	**Capacity (Excluding Driver)**	**% Occupancy**	**No of Trips**	**Fare Revenue**	**Pax per km**
C	10	9	111.1%	1	200	**2.0**
D	22	9	122.2%	2	440	**3.6**
E	47	9	130.5%	4	940	**1.9**
January 29, 2024 survey						
A	26	9	41.3%	7	860	**0.7**
B	92	9	146.0%	7	1840	**1.3**

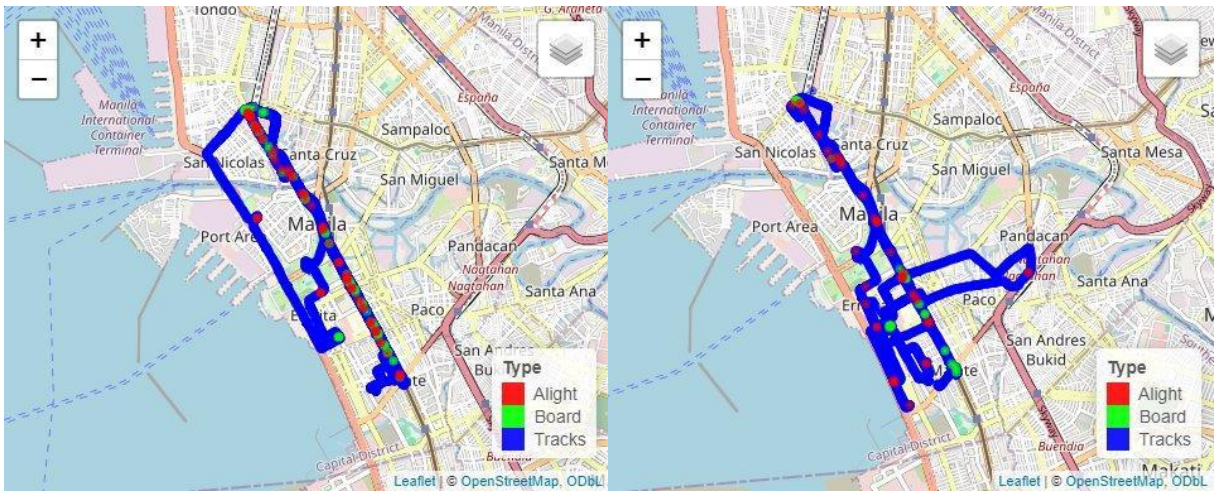

Figure 10. Vehicle GPS Tracks, route based operations (left) and special trip based operations (right)

6.3. Emissions Inventory

The estimated fuel consumption and emission of tricycles and potential emissions avoidance for shifting to electric were based on the surveyed daily trip with the highest coverage, i.e. Tricycle C at 58.57 km. As indicated in the queuing survey and validation meeting, the fleet utilization of SMC TODA of around 22 units is typical. It allows them to earn more and not become too saturated at the terminal.

Table 14. Fuel Consumption

Model Tricycle	Distance (km)	Fuel Consumption (g fuel/km)		
		Revenue	Non-revenue	Total
Tricycle C	58.57	892.85	1173.93	2066.78

Table 15. Total Emissions

Emission Factors - Total Run (g/g fuel)									
Model Tricycle	**NMVOC**	**CO**	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**SO_x**	**CH_4**	**N_2O**	**CO_2**
Tricycle C	133	2,118	14	0.90	0.90	0.2	133	0.13	3,049
Total Max Daily Fleet Utilization = 22 units									
Total Fleet Emissions	2926	46,596	308	19.8	19.8	4.4	2,926	2.86	67,078
Total per passenger at 23 pax	127	2,026	13	0.86	0.86	0.19	127	0.12	2,916

The total CO_2 emissions for a terminal-based tricycle operation with 22 units and covering around 59km daily per unit is 67,078 g of fuel. At 5 liters (2.21 k/L), the total CO_2 emission avoidance is around 741.20 kg. The 5 liters was determined using the self reported average daily fuel refueling cost of 250 pesos, and around 503 to 63 pesos per liter of diesel during the dates of survey (Department of Energy). The price range of gasoline during the time of the survey was According to the US Environmental Protection Agency, such emission avoidance translates to:

- not driving a typical gasoline passenger car for about 3,200 km.
- similar to the amount of CO2 that would be emitted by using electricity to power an average household for about 3 months
- the amount of CO2 that about 30 trees can absorb in a year.

7. PRE-FEASIBILITY FINANCIAL ANALYSIS

7.1. Determination of Alternatives

For this analysis, two alternatives, in addition to the status quo of operating the same vehicles, were chosen to be studied for their financial viability. i.e.

- Staying within the terminal-based operation but shifting to an electric tricycle with similar capacity and dimension
- Same tricycle operation under a city-led livelihood and investment program, like the ADB-DOE model.

The specifications and the photos of the alternatives are shown in Table 15.

Table 15. Electric Tricycles specifications available in Manila City

	E-Tricycle, 4-seater	**E-Tricycle, 7-seater**

Market Price (PHP)	216,000	455,000
Dimensions (Length x Width x Height)	2650 x 1380 x 1760 mm	3300 x 1440 x1820 mm
Max Load Weight	375 kg	530 kg
Motor Power	1200W	5000W
Maximum Speed	40 kph	40 kph
Range (stated) at constant 20 kph	135 km	60 km
Battery	Lit-Ion, 4.8kWh	Li-Ion 4.4 kWh with BMS
Charging Time	6-8 hours	4 hours
Passenger Capacity (excluding driver)	3	6

Figure 11. RE Bajaj Tricycle (left) and BEMAC Tricycle (right)

7.2. Determination of Costs

The list of costs related to operating a tricycle is the basis for the creation of the business model is shown in table 16. These costs of operation and maintenance are collected from the self-reported dues of the driver and previous ADB study. These are validated with the representatives of the SMC TODA, San Andres Electric tricycle drivers and the Manila Traffic and Parking Bureau of the Manila Local Government.

Some costs for the operations are not paid daily. Items like franchise renewal are paid annually, and some maintenance or parts replacement costs are paid once or twice a year, depending on the part that needs repair or replacement. Sometimes, to cut costs, the drivers fix the item to be repaired if it is a minor problem. The battery for electric vehicles degrades every year and must be replaced by the fifth year. This costs around 180,000 pesos at the end of the fifth year and at the end of the tenth year for the Lithium-Ion battery of at least 4.4kWh capacity, based on the interview with e-Trike fleet operations representatives.

The daily fare revenues of the tricycle driver are assumed to be 800 pesos and 1000 pesos for gasoline-fed and electric tricycles, respectively. The 7-seater e-Trike operations have the advantage of having a fixed route while operating like a traditional tricycle from a fixed point to any place in its assigned district (special trips).

Table 16. Operational and Maintenance Costs

Item	Unit	ADB Assumptions	TODA Operation	Electric Tricycle	Notes
Driver's Daily Gross Income	PHP	900	800	1,000	The gross income estimates were determined from the validation meetings with SMC TODA and e-Trike Fleet drivers.
Maintenance and Operating Cost	PHP/ Year	12,645	10,000	11,880	Tires, brakes, cables, bearings, motor rewinding, controller maintenance. For gasoline trikes, there are additional costs for oil changes, spark plugs, lead acid batteries, engine overhaul, carburetor, and coolants. LGU requires 45 daily maintenance contributions or 11,880 annually (22 days/month).
Fuel/Battery Charging Cost	PHP	79.06	100	100	7-seater e-Trike drivers pay 100 per day for electricity costs. It could be down the same for a smaller 4-seater unit that may require city government support so they can have their terminal-based charger.
Battery Replacement	PHP	247,500	NA	180,000	Battery has a 5-year replacement cycle, so the annual battery maintenance cost is 36k/year. The 180,000 value came from a market survey and was assumed to be the same price for both alternatives for simplification.
Annual Franchise renewal	PHP /year		700	700	Assumed the same for both TODA and city e-trikes
Association or Operator Boundary fees/ Gen Fund Contribution average		150	300	150	A boundary or lease fee, around 300 pesos, is determined to be the maximum they should be allotting daily during the validation meeting.
TODA Facility fees			20	20	Standard association fee.
Salvage value			50,000 (at end of 5th year; per tricycle owner during the validation meeting)	22,750 (at end of useful life: 10-15 years)	5% of the acquisition for E-Trikes was purchased by the city in 2016. 50,000 pesos for old gasoline tricycles that can be sold in second-hand markets.

The following assumptions will be used to evaluate alternatives for electrifying the current TODA, terminal-based operations of most gasoline-fed tricycles in the city.

1. The determined median gross income for TODA operations of 800 pesos will also be used as the common income level for the same operation but with e-Trike. The

maximum income will be at 1,000 pesos, the same level for e-Trike fleet, provided that similar favorable regulations are provided to those electrifying their TODA fleet.

2. The annual maintenance cost will be that of the current e-Trike level: 11,880 pesos per year.
3. The charging cost, whether it will be part of a package from the EV supplier or a city-subsidized infrastructure, will be based on the current LGU level of 100 pesos per day. This is higher than the ADB predicted cost of 79.06 pesos in 2019.
4. Franchise renewal and association fees shall remain at 700 pesos per year and 20 pesos per day, respectively.
5. The operator-based investment shall be at 300 pesos per day, covering the 2-year amortization, provided that the vehicle is available and utilized for at least 22 days per month. The city-led investment will be at the current price of 150 pesos per day.
6. The acquisition cost of gasoline tricycles is the same as the electric counterpart of the same size and passenger capacity. The electric counterpart will have the higher cost over the long run with battery replacements.

7.3. Evaluation of Alternatives

For evaluating alternatives, the Net Present Value, the Financial Internal Rate of Return, the Benefit-Cost Ratio, and the Payback period for the investment. The electric alternatives presented better viability in all evaluation metrics than the status quo. However, all metrics will improve further if the electrification of tricycles is city-led. The city government takes the lead in acquiring the tricycle fleet, continuing support in charging stations, reducing electricity costs by subsidizing the electricity bill, and eventually transferring vehicle ownership. The payback period for electric alternatives is 1.89 years, shorter than the 2-3 years financing scheme suppliers provide to tricycle operators. It is a viable option for those wanting to own a vehicle.

Table 16. Evaluation of Each Alternative

NPV (Net Present Value)

Net Present Value (NPV) is the value of all future cash flows (positive and negative) over the entire life of an investment discounted to the present.

Gasoline Tricycle	Operator-led electrification of TODA fleet (median/max income)	City-led 4-seater e-Trike Program (median/max income)
	10 years	
419,096	688,156	1,067,6727
796,666	1,010,318	1,067,727
	15 years	
545,543	970,067	1,321,451
1,042,024	1,321,451	1,466,528

FIRR (Financial Internal Rate of Return)

The FIRR is an indicator to measure the financial return on the personal investment made by the driver or operator as an income generation project. An FIRR of more than 30% is considered a good investment.

Gasoline Tricycle	Operator-led electrification of TODA fleet (median/max income)	City-led 4-seater e-Trike Program (median/max income)
	10 years	
32.92%	52.06%	NA
37.10%	48.18%	
	15 years	

34.54%	52.06%	NA
38.45%	49.02%	

BCR (Benefit Cost Ratio) – Driver Perspective

The BCR compares the present value of all benefits generated from a project/asset to the present value of all costs. A BCR exceeding one indicates that the asset/project is expected to generate incremental value.

Gasoline Tricycle	**Operator-led electrification of TODA fleet** (median/max income)	**City-led 4-seater e-Trike Program** (median/max income)
	10 years	
1.24	1.51	1.76
2.12	2.78	3.33
	15 years	
1.29	1.57	1.96
1.97	2.53	3.26
	Payback Period (personal investment)	
2.86 years	1.89 years	NA

8. CONCLUSION

This research studied the financial viability of scaling up the passenger electric tricycle fleet in Manila through the conversion of the existing TODAs with franchises within the city into electric tricycles without changing their zone and characteristics of operation, which is special and/or terminal-based operations.

The study concludes that the shift to electric tricycles has better financial viability than staying in the current fleet that is gasoline-fueled, and the viability of such transition increases if the shift is City-led. This is a pre-feasibility study, and for a complete feasibility study, inviting more manufacturers and suppliers of electric tricycles in real-world test runs and performance estimates to better estimate the electric cost per kilometer, informing city and TODA charging costing and enhancing the study of suitability and properly designed spacing and locations of charging facilities. Despite the limitations, the study shown promise in showing the initial benefits of the conversion in terms of added income for the drivers and reduction of roadside air pollution.

For the TODA operations, it is recommended that scenarios for terminal-based operations be further tested to achieve a more efficient revenue run comparable to the city-led e-trike fleet. Moreover, the city should study the rationalization and determination of appropriate service areas and operations and the number of tricycles for service areas for different TODAs. The impact and magnitude of the benefits to drivers with the extent of the government support should be studied.

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