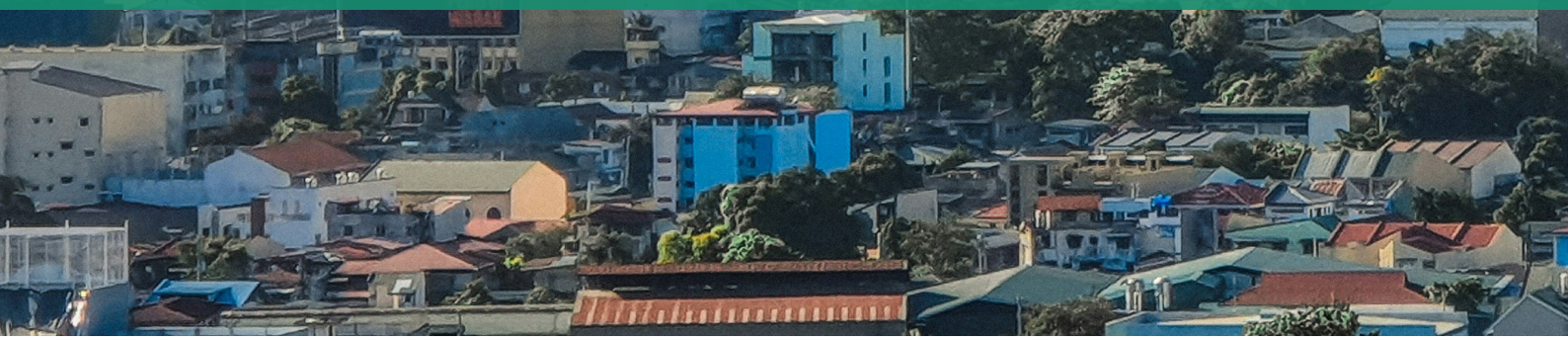
D1.6 IMPACT ASSESSMENT RESULTS
VOLUME 3: PASIG, PHILIPPINES



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EXECUTIVE SUMMARY

Context

The City of Pasig is comprised of 3,434 hectares of 30 barangays in Metro Manila, Philippines. Similar to other cities in the country, Pasig City is experiencing both rapid economic growth resulting in higher mobility accompanied by a sharper rise in air quality degradation. Local government units are seen as models of change in adapting to problems of both transportation and climate change. Addressing challenges in these areas requires new innovations seen at the city government level to demonstrate possible solutions to the common experiences of poor air quality and rising mobility needs.

Demonstration project: Electric Vehicle Sharing System

The demonstration project for Pasig City focuses on the concept of an "EV sharing system" where SOLUTIONSplus' new and innovative e-mobility solutions can be seamlessly integrated into the Pasig City Government's current vehicle fleet with the objective of optimizing daily operations and maximizing usage. Three complementary solutions are presented: (1) e-quadricycles developed by Tojo Motors for the delivery of medical supplies and personnel and (2) charging solutions (3) and an IT booking application to manage the operations of these e-quadricycles and other e-mobility vehicles of the city government.

The e-quadricycles are compared directly to the city government's existing internal combustion all-purpose vehicle (hereinafter, APV), currently used for transporting medical supplies and personnel. Various indicators are considered to assess the potential impact of the e-quadricycles on the city government, including environmental (noise, air quality), social (quality of service, accessibility, safety, security), institutional or political (policy), and financial (affordability) indicators.

Financial indicators

Affordability and financial sustainability are key considerations in adopting new e-mobility solutions. The ex-ante assessment shows that there is available financing for government-owned electric vehicles from city and national government funds as well as from the Pasig City Government's numerous partnerships with international organizations.

Because the e-quadricycles are government-owned and operated, there is no assessment of their commercial viability. However, using government funds to acquire and operate these vehicles requires a study of the financial costs to the city government using a Cost-Effectiveness Ratio (CER).

The CER assesses the APV and compares it to the e-quadricycle (Table ES-1). When considering the CER per passenger kilometers travelled (PKT), freight-ton kilometers (TKT) travelled, and vehicle kilometers travelled (VKT) on an annual basis, the e-quadricycle is easily more cost-effective than the APV. While these comparisons are based on different daily kilometers travelled (35 km/day for the e-quadricycle and 40 km/day for the APV), it is important to note that the e-quadricycles are still in their pilot phase and not completely optimized in the city's operations. Once maximized, the e-quadricycle is expected to perform even better.

Environmental indicators

The e-quadricycles improve the roadside environmental quality compared to the APV. E-quadricycle emissions arising from power generation are 70.11 g CO2/km, 0.0494

Table ES-1. Cost-effectiveness ratio of e-quadricycle against the APV

Cost-effectiveness ratio (CER) categories	OLD solution (APV)	NEW solution (e-quadricycle)	
		Current use (35km/day)	Optimal use (40km/day)
CER-VKT	75.07 pesos/vkt	55.76 pesos/vkt	48.79 pesos/VKT
CER-PKT	10.72 pesos/pkt	9.29 pesos/pkt	8.13 pesos/PKT
CER-FTK	125.11 pesos/ftk	113.80 pesos/ftk	99.58 pesos/TKT

g CO/km, 0,2089 g NOx/km, and 0.0206 g PM/km compared to the APV, which has emissions of 428.57 g CO2/km, 2.01 g CO/km, 0.064 g NOx/km, and 0.0011 g PM/km (Table ES-2). The difference in emissions can mitigate around 2.2368 metric tonnes (MT) CO2/year and 12.2341 MT CO/yr per unit (Table ES-3). Although e-quads do not have tailpipe NOx and PM2.5 emissions, their operation results in an increase of 0.9041 kg NOx/yr and 21.84 g PM2.5/yr per unit from power generation. Power generation emissions are mainly emitted in non-residential areas outside of Pasig City.

In addition to the assessment of air-quality, the e-quadricycle's impact on noise is also compared to the APV. Professional Pasig City drivers from the Pasig City Health Department reported that the e-quadricycles would make a screeching sound when running at 20-30kph and there would be a humming noise coming from the e-quadricycles' motors. However, the drivers still assessed that the e-quadricycles are "significantly quieter" than the APV.

Table ES-2. Vehicle emissions per km[1]

Vehicle *a single vehicle unit*	CO2 [g CO2/km]	CO [g CO/km]	NOx [g NOx/km]	$PM_{2.5}$ [g PM/km]
ICE APV	428.57	2.01	0.064	0.0011
E-quadricycle	70.11	0.0494	0.2089	0.0046

Table ES-3. Vehicle emissions per year. (6,420 km vehicle km annually)

Vehicle *a single vehicle unit*	CO2 [g CO2/km]	CO [g CO/km]	NOx [g NOx/km]	$PM_{2.5}$ [g PM/km]
ICE APV	2.674	12.5424	0.3994	6.864
E-quadricycle	0.4375	0.3083	1.3035	28.704
Abatement	2.2368	12.2341	-0.9041	-21.84

[1] For the APV, CO2 is based on manufacturer published fuel economy and gasoline carbon intensity, while criteria air pollutants are based on the EMEP Air Pollutant Emission Inventory Guidebook for N1 Euro 4 petrol vehicles. For the e-quadricycle, CO2 is estimated on the Department of Energy Statistics and WWF EU estimated grid emission factors for Philippine power plants.

Social indicators

On the impact on road safety of the e-quadricycles, the professional drivers reported that there was a positive effect on the road safety situation in the city, due to the restricted speed of the e-quadricycle and its light frame. Likewise, the e-quadricycles are also expected to have minimal impact on charging safety (such as electric shock and fire hazards) primarily due to the external environmental protections on the charging stations and strict adherence to existing Philippine codes and policies on charging infrastructure.

However, when compared to the APV on quality of services, professional Pasig City Government drivers assessed the APV to perform better than the e-quadricycles on suitability to adverse weather conditions, perceived comfort in travel, ease of charging/refueling, and personal security. On the other hand, professional Pasig City government drivers reported that the e-quadricycles performed better than the APV on ease of driving, safety within the city, and continuity of journey chains.

Institutional/political indicators

The transition to integrating e-quadricycles are aligned with national and regional initiatives on e-mobility. The demonstration supports policies in transportation (National Transportation Plan, Electric Vehicle Industry Development Act, Comprehensive Roadmap for the Electric Vehicle Industry), energy (Philippine Energy Plan, Energy Efficiency Conservation Act, Alternative Fuels and Energy Roadmap), environment (Philippine Environment Code), and other overarching policies (Nationally Determined Contributions).

Because of ongoing changes in the regulations of electric vehicles in the Philippines, it cannot yet be ascertained whether the e-quadricycles are fully or non-compliant to surpass-national, national, or city legislations and regulations. The EVIDA and CREVI have yet to consolidate standards for some e-mobility such as e-quadricycles. Additionally, although the Land Transportation Authority established their own registration and regulation processes, city governments can still mandate their own interpretations and implementations of standards that suit their cities' respective contexts.

Moreover, the new technology has yet to gain full support from existing political and institutional bodies. It is the hope that this demonstration will present e-quadricycles and its accompanying shared EV system as viable solutions to pressing challenges of environmentally friendly mobility around Philippine cities.

Scale-up scenarios and its impact to emissions

Given the current and past investment of the City Government of Pasig on e-mobility and the overall environmental, financial, and social benefits of the e-quadricycle compared to the currently mainstreamed APV, there is sufficient need to evaluate the impact of scale-up demonstration of the city's e-quadricycles and its integration to public transport potentially replacing internally combustion engine tricycles.

Three different scale-up scenarios were studied: (1) the first scenario (SU-1[2]) adds 100 e-quads to the city fleet by 2025 to serve as the vehicle for transporting health personnel and medicines to the 30 barangay health centers in the city; (2)the second scenario (SU-2) describes the effect of shifting 50% of the tricycle fleet to electric by 2040; and lastly, (3) the third scenario (SU-3) models a full electrification of the passenger tricycle fleet by 2040.

The baseline scenario estimates the total CO2 emissions from transport vehicles by 2040 as 26,927.67 metric tonnes. All scenarios that introduce electric vehicles to

the city fleet (SU-1) and public transport tricycle fleet (SU-2, SU-3) yielded emissions reduction by 0.61%, 13.39%, and 26.17%, respectively. This demonstrates that the magnitude and significance of electrification will substantially increase when adoption targets are expanded to a wider scale.

[2] SU-1' stands for 'scale-up scenario 1', 'SU-2' stands for scale-up scenario 2', and so forth.

CONTENTS

1 BACKGROUND AND CONTEXT

The City of Pasig is one of the 16 cities and 1 municipality comprising the Metropolitan Manila area. It used to be the capital of the Province of Rizal until the creation of Metropolitan Manila in 1975. In December 1994 by virtue of Republic Act 7829, Pasig acquired its cityhood status as a highly urbanized City. The city of Pasig has an aggregate area of 3,432 hectares constituting thirty (30) "barangays". In the Philippines, a "barangay" is the smallest administrative unit akin to villages wherein each "barangay" is led by a village chief or "barangay captain".

1.1 GEOGRAPHY AND THE SOCIAL/URBAN CONTEXT

Location and topography

Pasig is generally flat, characterized by level to undulating slopes with gradients ranging from 0-5%. All barangays have 0-2 percent slope, except for barangays Bagong Ilog, Pineda, Kapitolyo, and Oranbo (CLUP). The elevation of Pasig City is 1.00 meter below mean sea level.

There are two natural bodies of water traversing the City: Pasig River and Marikina River. There are also 17 creeks/esteros that run through the City's territory and its periphery. The Manggahan Floodway cuts across Pasig — from Marikina River bend in Barangay Rosario towards Laguna de Bay.

There are 4 major thoroughfares of Metro Manila that traverse through the City of Pasig -- Circumferential road C-5, Ortigas Avenue, Shaw Blvd, and Marcos Highway. These roads are critical to traffic flow in the whole urban agglomeration.

Climate

Philippines has a tropical and maritime climate which can be divided into two seasons - (1) the rainy season, from June to November; and (2) the dry season, from December to May (PAG-ASA, 2024). According to the country's climate agency PAG-ASA[3], the Philippine climate has a relatively high temperature (mean annual temperature of 26 degree Celsius), high humidity (between 71 and 85 percent and up to maximum uncomfortable levels in March to May), and abundant rainfall (mean annual from 965 to 2064mm).

Population/Urbanisation

According to the 2020 National Census, Pasig City boasts a population of 803 000, making up approximately 6% of Metro Manila's total population, ranking 5th in terms of population size among the 16 highly urbanized cities in Metro Manila. The 2020 census registered a population increase of 133,386 over a period of 10 years, showing an annual growth rate of 1.83% (PSA, 2020)

1.2 URBAN TRANSPORT

Modal shares

No city-specific transport activity and modal share figures are available, but passenger transport constitutes of public utility vehicles (PUVs – jeepneys and UV express or

[3] Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAG-ASA)

mini-vans), buses, and tricycles (3-wheelers), as well as private modes. Urban freight tasks involve heavy, and light duty trucks, as well as delivery vans, and motorcycles.

The most common means of travel within city using public transport is by public utility jeepneys (PUJs) and UV Express mini buses for travel within and outside the city and tricycles and city buses for in-city travel.

Vehicle fleet

There are around 200 units of e-tricycles in the city, provided by the National Department of Energy. 20% of these are being used by the different offices of the local government, part of which have been allocated to patient transport while 80% are distributed among public transport and private use.

Public transport

Due to their sheer number, the primary mode of public transportation in Pasig City is the tricycle, with a total of 13,169units registered with the local government. These vehicles, however, are limited to intra-city travel, and have limited access to National Roads – roads that are administratively run by the national agency Metro Manila Development Authority (MMDA). Other Public Utility Vehicles (PUVs), such as jeepneys and UV Express mini-buses, are privately owned but registered and regulated by the Land Transportation Franchising and Regulatory Board (LTFRB). Many of these units operate on fixed routes that extend beyond the boundaries of Pasig City.

In addition, the city government operates a fleet of 18 buses that provide fare-free service along four fixed routes within the city.

1.3 IDENTIFICATION OF MAIN PROBLEMS

If the current population growth rate persists, Pasig city's population will double in 24 years. This Increase in population and demand for urban land will result in increase in population density and additional demand for infrastructure and utility services.

In 2022, there were 372,083 new motor vehicle sales nationwide. Assuming Pasig City represents 6% of the total population of the Philippines, this would mean that approximately 22,324 new motor vehicle units are now on the roads in Pasig City alone.

Public transport regulation and monitoring

The absence of a road hierarchy and inter-connectivity in Pasig City is primarily attributed to the lack of an Integrated Transport and Traffic Master Plan. Without such a plan in place, there is no structured framework for organizing and managing the city's transportation networks effectively.

As a result, fixed routes that extend between cities are regulated and monitored by the Land Transportation Franchising and Regulatory Board (LTFRB), with limited coordination at the local level. This decentralized approach leads to inconsistencies and inefficiencies in transportation planning and implementation.

Furthermore, the local government of Pasig City manages tricycle operations through a system of franchises, where each franchise corresponds to one tricycle. While this system imposes a cap on the number of tricycles, it's gradually increasing in response to public demand, primarily from operators seeking additional franchises. Tricycles generally operate on a point-to-point basis, often extending beyond barangay borders as long as passengers are willing to pay a negotiated fee.

Obstacles, limitations and barriers for EVs

The scarcity of charging infrastructure presents a significant hurdle, as limited access to charging stations can cause range anxiety and discourage potential buyers.

The higher upfront costs of EVs compared to traditional vehicles pose a financial barrier for many consumers, despite potential long-term savings on fuel and maintenance. Concerns about range anxiety, or the fear of running out of charge before reaching a charging station, further deter adoption.

The longer charging times of EVs compared to refueling times for conventional vehicles can inconvenience drivers, particularly in areas with limited access to fast-charging infrastructure. The high investment required for developing comprehensive charging networks, coupled with the limited availability of EV models in the market, also slows down adoption rates.

1.4 DESCRIPTION OF DEMONSTRATION PROJECT

The Pasig demonstration focuses on efficient "shared vehicle" use concept for mixed purposes – both for passenger and cargo transport. On the ground, activities aim to maximize the usage of the city government-owned electric vehicle fleet by streamlining the vehicle sharing process among different types of users. More precisely, the SOL+ demo aims to create locally designed multi-purpose electric quadricycles, test the shared vehicle use concept using the developed IT system to automate the sharing process between users for various purposes.

Moreover, the demo also aims to develop business models to facilitate e-mobility in the private sector and enhance local stakeholders' knowledge and capacities in various aspects of e-mobility. The development of the e-quadricycles will be carried out by local manufacturers with imported equipment and technical support from the consortium.

In conducting the impact assessments, the e-quadricycles (i.e. 'NEW' solution) are directly compared to the city government's APV (i.e. 'OLD' solution), currently used for transporting medical supplies and personnel. Various indicators are considered to assess the potential impact of the e-quadricycles on the city government, including environmental (noise, air quality), social (quality of service, accessibility, safety, security), institutional or political (policy), and financial (affordability) indicators.

1.5 RELEVANT STAKEHOLDERS AND USER NEEDS

For the project demonstration activity and scoring of relevant key performance indicators, an updated weight scoring was conducted last April 2023 together with representatives from different offices within the city government of Pasig. A total of thirteen representatives from nine (9) different offices participated in the KPI weight scoring for the pilot demonstration, as shown in Table 1.

Aims of the city in relation to urban mobility

The city aims to improve urban mobility by enhancing accessibility within its boundaries and reducing reliance on conventional road-based public transport modes and private cars through incentivizing passengers to opt for alternative transportation methods. This involves promoting Mixed-Use Developments (MXDs) to foster walkability and community vitality, thereby decreasing car usage and fostering a cleaner, less congested environment. By encouraging a variety of housing types, unit sizes, rentals, and prices, the city seeks to promote diversity and inclusivity. Additionally, efforts are

Table 1. Stakeholders who participated in the KPI weight scoring

City stakeholder group	Name of department/ office	Mandates of department
Transport, traffic, and vehicle management department	Pasig Transport or City Transportation Development and Management Office (CTDMO) or Pasig Transport	Formulates policies and oversees local implementation concerning public transport, vehicles, and road
	Motorpool under the General Services Office (GSO)	Vehicle fleet management office
	Traffic and Parking Management Office (TPMO)	Formulates, coordinates, and monitors policies, standards, and programs relating to traffic and transport .
	Tricycle Operation and Regulatory Office (TORO)	Formulates policies and monitor implementation concerning tricycles
Local administrative offices	Barangay Affairs Office	Oversees 'barangays' within the city. Barangays are the smallest administrative unit in the Philippines followed by 'city'
	Mayor's office/secretariat office	Office representing the city mayor
Health department	City Health Department (CHD) or Office (CHO)	Health office; they are also the primary users of the e-quadricycles who will transport health officers/vaccinators as well as small size medicines and vaccines
Environment and natural resources office	City Environment & Natural Resources Office (CENRO)	Steward for the protection and preservation of natural environment and resources
Planning office	City Planning and Development Office (CPDO)	Prepares comprehensive plans and other development planning documents. Involved in the charging infrastructure planning, placement, etc.

underway to designate bikeways or bike lanes on major roads and expand their routes to encourage cycling as a sustainable mode of transportation. The expansion of linear parks along creeks, natural, and artificial drainageways, including the Manggahan Floodway, aims to provide green spaces and promote recreational activities. To prevent sprawl of high-density development beyond urban growth boundaries, certain types of building developments are concentrated within designated growth nodes or hubs. The provision of pedestrian-friendly sidewalks and elevated walkways, particularly in the Central Business District (CBD), enhances pedestrian safety and convenience. Furthermore, plans to enhance existing parks, such as the Rain Forest Park, aim to provide new activity areas for residents and visitors alike. In residential areas, livability

is prioritized through traffic calming measures, greenery, streetlights, and signage to create more pleasant environments. Lastly, the city promotes tree planting along streets and in green spaces to enhance urban aesthetics, provide shade, and improve air quality.

Regulations

As part of the city's regulations, the local government has entered into partnerships to develop the charging infrastructure within the city. This initiative aims to support the transition to electric vehicles (EVs) by providing adequate charging stations, thereby encouraging residents and businesses to adopt cleaner and more sustainable transportation options.

Additionally, in 2016, Pasig City enacted an ordinance (Pasig City Ordinance 16, s2016 entitled Tricycle Upgrading Ordinance) aimed at phasing out two-stroke motorcycles for use in public tricycles. Under this ordinance, franchise owners were mandated to transition to either a four-stroke motorcycle or an electric three-wheeler, aligning with efforts to reduce emissions and promote environmentally friendly modes of transport.

However, since electric vehicle (EV) technology was relatively new in 2016, adopters of electric three-wheelers encountered numerous technical issues as the years progressed, until being discontinued having them settle for four-stroke motorcycles.

The Department of Energy hoped to jumpstart the adoption of EVs by providing e-tricycles to various cities nationwide. Pasig was given 200 units, 80% of which was distributed to public transportation, school service, and homeowner associations' use. The remaining 20% was earmarked for government use and most of which was dedicated to patient and medicine transport beginning from the pandemic and continues to this day.

Business model

With the private sector commonly engaged in providing public transport services in the city, many stakeholders view public-private partnerships as a promising business model. This perception stems from the model's advantages, particularly in terms of necessary investments.

However, infrastructure and fleet management concerns may not be adequately addressed with the current regulations, underscoring the necessity for external development sources.

Implications for planning and urban development

Infrastructure development is important, necessitating strategic integration of electric vehicle (EV) charging stations across residential, commercial, and transportation hubs.

Land use planning should prioritize mixed-use developments (MXDs) and transit-oriented development (TOD), fostering compact, pedestrian-friendly neighborhoods with easy access to amenities and public transit.

Transportation planning must emphasize pedestrian-friendly infrastructure and designated bikeways to promote active transportation modes like walking and cycling.

Environmental sustainability initiatives, including green building practices and the preservation of green spaces, are essential for mitigating the city's carbon footprint and enhancing urban biodiversity.

2 KEY PERFORMANCE INDICATORS (KPIS)

2.1 PRIORITIZATION OF KPIS ADDRESSING THE SPECIFIC CITY NEEDS

As explained in the methodology section of D1.6 - Volume 1 (Section 2.1.4), the priorities of the stakeholders are formally determined through the weights assigned to the selected attributes (KPIs). The attribute weighting activity in Pasig took place in conjunction with the stakeholder interviews organised in relation to the user needs analysis of Section 1.5. The procedure described in Section 2.1.4 (Vol.1) was followed for all 13 interviewed stakeholders, representing eight stakeholder groups. The KPI weights are presented in Table 2.

Table 2. Pasig KPI weights based on stakeholders' input

		Pasig KPI weights based from stakeholders' input
Project finances	Financial viability	9.46
	Availability of finance	8.29
	Project finances, total	17.75
Institutional framework	Coherence with plans/goals	5.12
	Alignment with legislation	4.72
	Ease of implementation	5.25
	Institutional framework, total	15.09
Climate	Effect on GHG emissions	17.25
Environment	Effect on air pollutants	6.72
	Effect on noise	6.55
	Effect on resource use	6.62
	Environment, total	19.88
Society	Effect on accessibility	1.82
	Effect on affordability	1.75
	Effect on travel time	1.75
	Effect on road safety	1.76
	Effect on charging safety	1.71
	Effect on security	1.63

		Pasig KPI weights based from stakeholders' input
	Effect on well-being	1.81
	Effect on service quality	1.92
	Society, total	14.15
Wider economy	Effect on budget	6.33
	Effect on external trade	4.15
	Effect on employment	5.39
	Wider economy, total	15.87
Grand total		100.00

3 ASSESSMENT OF THE DEMONSTRATION PROJECT

This section will present the outcomes of the ex-ante assessment of the pilot demonstration of e-quadricycles for passenger transport of employees of Pasig city government. The e-quadricycles (i.e. 'NEW' solution) are directly compared to the city government's APV (i.e. 'OLD' solution), currently used for transporting medical supplies and personnel. Various indicators are considered to assess the potential impact of the e-quadricycles on the city government, including environmental (noise, air quality), social (quality of service, accessibility, safety, security), institutional or political (policy), and financial (affordability) indicators. Each sub-section represents each of the nine KPIs evaluated.

3.1 KPIS FOR ASSESSING THE DEMONSTRATION PROJECT

Challenges during pilot implementation resulted to the limited data collection for the impact assessment, particularly the ex-post evaluation. Some of the notable challenges include delays in the supply chain for parts and components of e-quads which directly affected development process of the vehicle, customs regulations for imported parts, as well as local political conditions such as the city elections and change of leadership within Pasig Transport department.

This section lists down all the impact assessment indicators and what were evaluated in the Pasig demo during the ex-ante evaluation (3.1.1), ex-post evaluation (3.1.2), and those that were not evaluated (3.1.3). For indicators that were not evaluated, corresponding justification is provided.

3.1.1 KPIs assessed in the ex-ante evaluation

The following indicators were assessed in the ex-ante evaluation of the demo project, as shown in Table 3.

Table 3. Assessed KPIs in the ex-ante phase

KPI - Level 1	KPI - Level 2	KPI - Level 3
Financial costs/ revenues	Financial viability	Cost-effectiveness ratio (CER)
	Availability of financial resources	N/A
Institutional/ political	Coherence with national plans and development goals	N/A
	Alignment with supra-national/national/city legislation & regulations	N/A
	Ease of implementation (in terms of administrative barriers)	N/A
Climate related	Impact on GHG emissions	Amount of carbon avoided (% change in various scenario definitions compared to business as usual)
Environmental	Impact on air pollutants	NOx emissions avoided
	Impact on air pollutants	PM2.5 emissions avoided
Social	Impact on accessibility	Access to jobs, opportunities and services (personal travel)
	Affordability of e-vehicle services	N/A
	Impact on travel time	Change in travel times due to e-mobility services (personal travel)
	Impact on road safety	(Annual) Number of road accidents with fatalities/serious injuries
	Impact on road safety	(Annual) Number of road accidents with minor injuries/material damage
	Impact on road safety	(Annual) Number of traffic related near accidents/dangerous situations
	Impact on charging safety	(Annual) Number of charging related safety incidents

3.1.2 KPIs assessed in the ex-post evaluation

Due to challenges on the ground, the data collected for ex-post evaluation is limited. As of this writing, only three out of the eight quadricycles have been completed and

delivered to Pasig city government. Meanwhile, only two units out of the three have been driven by for at least few weeks. Hence, the outcomes of the ex-post evaluation are considered preliminary at this stage.

The following indicators were assessed in the ex-post evaluation of the demo project, as shown in Table 4.

Table 4. KPIs assessed ex-post phase

KPI - Level 1	KPI - Level 2	KPI - Level 3
Environmental	Impact on noise	Perception of the impact of the demo EVs on noise level
Environmental	Quality of e-mobility services	Suitability of e-vehicles in changing climate conditions [Likert scale]
	Quality of e-mobility services	User perception of comfort of e-vehicles [Likert scale]
	Quality of e-mobility services	Ease of driving e-vehicles - other users [Likert scale]
	Quality of e-mobility services	Ease of charging the e-vehicle [Likert scale]
	Quality of e-mobility services	Perception of safety [Likert scale]
	Quality of e-mobility services	Perception of personal security [Likert scale]
	Quality of e-mobility services	User perception of continuity of journey chains, incl. modal inter-change from/to e-vehicles [Likert]

3.1.3 KPIs not assessed in the ex-post evaluation

Apart from limited pilot demonstration data, the following indicators were (Table 5) not assessed as they were identified as not relevant or feasible for assessment for the duration of the project. A brief explanation is provided for each indicator.

Table 5. Indicators not assessed in the ex-post phase

KPI - Level 1	KPI - Level 2	KPI - Level 3	Justification
Financial costs/ revenues	Financial viability	NPV (Net Present Value)	Not relevant because the city government of Pasig operates the vehicles for non-commercial purpose and is not allowed to make a profit by law. The efficiency using the Cost-Effectiveness-Ratio (CER) was evaluated instead.

KPI - Level 1	KPI - Level 2	KPI - Level 3	Justification
Financial costs/ revenues	Financial viability	IRR (Internal Rate of Return)	Not relevant because the city government of Pasig operates the vehicles for non-commercial purpose and is not allowed to make a profit by law. The efficiency using the Cost-Effectiveness-Ratio (CER) was evaluated instead.
Financial costs/ revenues	Financial viability	Payback period	Not relevant because the city government of Pasig operates the vehicles for non-commercial purpose and is not allowed to make a profit by law. The efficiency using the Cost-Effectiveness-Ratio (CER) was evaluated instead.
Environmental	Impact on environmental resources	Resources saved due to recycling (kg)	Out of scope as there is insufficient information on recycling of the current and future solution
Social	Impact on accessibility	Access to pickup/delivery locations (freight)	This pilot is about personal/passenger transport
Social	Impact on travel time	Change in travel times due to e-mobility services (freight)	This pilot is about personal/passenger transport
Social	Impact on well-being (physical and mental)	Change in well-being due to changes in active travel	There is no active travel / mode of transport involved in this pilot
Social	Impact on security	(Annual) Number of vandalism/ theft incidents	Pasig city government has no available data on the number of vandalism/theft incidents.
Economic	Impact on national/local budget	Required public investment as % of relevant national/local budget	The scope of the pilot is limited and data to measure this KPI for the scaled-up scenarios are limited and not available. A brief narrative on the scaled-up scenarios' impact to budget is briefly described.

KPI - Level 1	KPI - Level 2	KPI - Level 3	Justification
Economic	Impact on external trade	Abated fossil fuel imports as % of total imports	The scope of the pilot is limited and data to measure this KPI for the scaled-up scenarios are limited and not available. A brief narrative assessment on the scaled-up scenarios' impact is briefly presented and described.
Economic	Impact on external trade	Abated other imports as % of total imports	The scope of the pilot is limited and data to measure this KPI for the scaled-up scenarios are limited and not available. A brief narrative assessment on the scaled-up scenarios' impact is briefly presented and described.
Economic	Impact on employment	Number of additional jobs	The scope of the pilot is limited and data to measure this KPI for the scaled-up scenarios are limited and not available. A brief narrative assessment on the scaled-up scenarios' impact is briefly presented and described.
Economic	Impact on employment	Expected increase (%) in the average wage	The scope of the pilot is limited and data to measure this KPI for the scaled-up scenarios are limited and not available. A brief narrative assessment on the scaled-up scenarios' impact is briefly presented and described.

3.2 EX-ANTE ASSESSMENT OF THE DEMONSTRATION PROJECT

3.2.1 Financial viability (Cost-effectiveness ratio/CER)

By law, the city government of Pasig is not allowed to operate the electric quadricycles for profit or commercial purposes. Instead, these e-quadricycles will be part of their fleet primarily for the use of different offices in their daily operations.

Due to the non-business nature of the e-quadricycle operations, the financial assessment will focus on the cost-effectiveness ratio (CER), as shown in Table 6 and Table 7.

Using the input values of the two vehicles, the cost effectiveness ratio (CER) was calculated based on three key variables – the vehicle kilometers travelled(vkt), passenger kilometers travelled (PKT), and freight-ton kilometers (TKT) travelled on annual basis (Table 8). The computed CER based on each variable are computed respectively as CER-VKT, CER-PKT, and CER-TKT, as shown in the table 8.

Table 6. Input values for assessing the cost-effectiveness ratio of the old solution vehicle (APV)

Category	Parameter	Value	Units	Comments
General info	Year built	2021		
	Payload capacity	600	kg	
	Total distance per day	24	km/day	
	Number of passengers	7	passengers, not including the driver	
Propulsion	Battery type	Lead-acid	Motolite Enduro NS 60LS	
	Battery size	12	V	
	Number of batteries	1		
Capital cost	Purchase price	700,000	Philippine Peso	
	Expected useful life	11	years	
	Residual value	350,000	Philippine Peso	
	Depreciation schedule	10%		Per year (Declining balance method)
Operational profile	Average distance/day	24	km/day	
	Operating days/year	260	days/year	
	Trips per day	1	trip/day	
	Total distance per day	24	km/day	
Yearly operating cost	Total operating cost	**379,533**	Peso/year	(=sum(C18:C22)+C26+C30+C42)
	* Licencing/renewal	1,600	Peso/year	
	* Vehicle road tax	1,350	Peso/year	Php 1200 - 1500
	* Technical inspection	1,800	Peso/year	Vehicles with gross weight equal to or less than 4,500 kg: ₱1,800 Motorcycles: ₱600
	* Insurance	625	Peso/year	
	* Personnel cost	**258,715**	Peso/year	(=(C23+C24)*12+C25)
	- Basic monthly salary	14,181	Peso/mont	casual employee
	- Monthly allowance	2,000	Peso/month	
	- Yearly bonus	10,000	Peso/year	
	- Additional pay (hazard, clothing, etc.)	54,543	Peso/year	
	* Electricity cost	**0**	Peso/year	(=C15*C16*C28*C29)
	- Battery efficiency	n/a		
	- Specific energy consumption	n/a	kWh/km	battery usage: 40 kWh; travel distance of single charge battery: 20-40 miles (32-64 km) --> averaged = 48 km
	- Electricity tariff		Peso/kWh	
	* Maintenance cost	**114,723**	Pesos/year	Total maintenance costs from tires to airconditioning units
	- Tires	8,000	pesos/year	2,000 per tire
	- Break shoes	3,000	pesos/year	Amount for 4 tires
	- Dent paint	5,000	pesos/year	30,000pesos for repainting every 6 years
	- Suspension	10,000	pesos/year	For 4 tires
	- Wiring	2,700	pesos/year	
	- Headlights, tail lights	1,000	pesos/year	
	- differential crown gear	10000	pesos/year	Amount for 4 tires
	- Fuses	23	pesos/year	
	- Display system	0	pesos/year	
	- Throttle pedal	0	pesos/year	
	- Battery change	6,500	pesos/year	
	- Motor service	13,500	pesos/year	
	- Airconditioner	5,000	pesos/year	
	- Airconditioning unit parts	20,000	pesos/year	
	* Other	**720**	Pesos/year	Total of other costs not covered in maintenance cost
	- Parking	0	Pesos/year	
	- Vehicle cleaning	120	Pesos/year	
	- Driver license	120	Pesos/year	
	- Other (change oil)	480	Pesos/year	
Annualized cost	Capital	88,887	Pesos/year	(=(C22-C29/(1+C32)^C26)/(1/C32-1/(C32*(1+C32)^C26)))
	Operational	379,533	Pesos/year	(=C36)
	Total	468,420	Pesos/year	(=C57+C58)
Annual vehicle kilometers travelled (VKT)	Annual distance covered	6240	km/year	
Annual passenger kilometers travelled (PKT)	Passenger kilometer travelled	43680	pkm/year	
Annual Freight TKT*	Freight Ton-kilometer Traveled	3744	freight ton-km/year	

**Annual freight ton-kilometer traveled is based on payload capacity only, not on actual freight transported. This was due limited data attributed to on-the-ground implementation challenges.*

Table 7. Input values for assessing the cost effectiveness ratio of new solution vehicle (E-quadricycle)

Category	Parameter	Value	Units	Comments
General info	Year built			
	Parameter payload	490	kg	
	Total distance per day	35	km/day	*VKT or trip length per day
	Number of passengers	6	passengers, n	E-quad specifications
Propulsion	Battery type	Li-ion		
	Battery size	12	V	
	Number of batteries			
Capital cost	Purchase price	708,400	Philippine Peso	
	Expected useful life	6	years	15-20 years, depends on the usage
	Residual value	376,473	Philippine Pes	*computed using SV = P*(1-i)n
	Depreciation schedule	10%		Per year (Declining balance method)
Operational profile	Average distance/day	35	km/day	40-50 km
	Operating days/year	240	days/year	
	Trips/day	1	trips/day	
	Total distance per day	35	km/day	
Yearly operating cost	**Total operating cost**	**251,575**	Peso/year	(=sum(C18:C22)+C26+C30+C42)
	* Licencing/renewal	0	Peso/year	
	* Vehicle road tax	0	Peso/year	
	* Technical inspection	0	Peso/year	
	* Insurance	0	Peso/year	
	* **Personnel cost**	**203,200**	Peso/year	(=(C23+C24)*12+C25)
	- Basic monthly salary	14,600	Peso/month	casual employee
	- Monthly allowance	0	Peso/month	
	- Yearly bonus	28,000	Peso/year	
	- Additional pay (hazard, clothing, etc.)	0	Peso/year	
	* **Electricity cost**	**19,354**	Peso/year	(=C15*C16*C28*C29)
	- Battery efficiency	0.90		charge efficiency for e-three-wheelers
	- Specific energy consumption	0.200	kWh/km	battery usage: 4.8 kWh to 9.6 kWh; travel distance of single charge battery: 20-40 miles (32-64 km) --> averaged = 48 km
	- Electricity tariff	11.52	Peso/kWh	or 25-30 peso/charge
	* **Maintenance cost**	**28,902**	Pesos/year	(=sum(C31:C41))
	- Tires	900	pesos/year	Based on maintenance of Pasig's existing EV fleet. As the e-quad is at the Research and Development stage, Tojo could not provide estimates for maintenance cost.
	- Break shoes	200	Pesos	
	- Dent paint	67	Pesos	
	- Suspension	313	Pesos	
	- Wiring	2,000	Pesos	Battery change is derived using an estimated battery price of 300,000 pesos, divided by the number of age years which is 15 years. Hence, 20,000 pesos per year
	- Headlights, tail lights	340	Pesos	
	- differential crown gear	1333.33	Pesos	
	- Fuses	15	pesos/year	
	- Display system	200	Pesos	
	- Throttle pedal	1,200	pesos/year	
	- Battery change	20,000	Pesos/year	
	- Motor service	2,333	Pesos	
	- Airconditioner	0	pesos/year	
	- Airconditioning unit parts	0	Pesos/year	
	* **Other**	**120**	Pesos/year	
	- Parking	0	Pesos/year	
	- Vehicle cleaning	0	Pesos/year	
	- Driver license	120	Pesos/year	1200 pesos for 10 years
	- Other	0	Pesos/year	
Annualized cost	Capital	113,860	Pesos/year	(=(C22-C29/(1+C32)^C26)/(1/C32-1/(C32*(1+C32)^C26)))
	Operational	251,575	Pesos/year	(=C36)
	Total	365,435	Pesos/year	(=C57+C58)
Annual vehicle kilometers travelled (VKT)	Annual distance covered	8400	km/year	
Annual passenger kilometers travelled (PKT)	Passenger kilometer travelled	50400	pkm/year	
Annual Freight TKT*	Freight Ton-kilometer Traveled	4116	freight ton-km/year	

**Annual freight ton-kilometer traveled is based on payload capacity only, not on actual freight transported. This was due limited data attributed to on-the-ground implementation challenges (E-quadricycle)*

For all three categories of the cost-effectiveness ratio, **the e-quadricycle (new solution) is the more cost-effective vehicle than the APV (old solution)**.

Table 8. Summary results of the cost-effectiveness ratio of both the APV (old solution) and E-quadricycle (new solution)

Cost-effectiveness ratio (CER) categories	OLD solution (APV)	NEW solution (E-quadricycle)
CER-VKT	75.07 pesos/vkt	55.76 pesos/VKT
CER-PKT	10.72 pesos/pkt	9.29 pesos/PKT
CER-TKT	125.11 pesos/ftk	113.80 pesos/TKT

Despite operating at less than optimal performance, the e-quadricycle proved to be more cost-effective than the APV. Currently, the maximum vkt for the e-quad is 35km/day, which is 5km less than the expected 40km/day. Because the e-quad is still in the research and design development phase, it is not optimized. As an example, its motor was still not operating at its peak due to incompatibility of the battery pack with the motor.

In case the e-quadricycle is improved and will be running at optimal performance with a 40 VKT/day, it will be much more cost-efficient than the APV, with CER values of 48.79 pesos/VKT, 8.13 pesos/pkt, and 99.58 pesos/ftk, for CER-VKT, CER-PKT, and CER-TKT, respectively.

3.2.2 Availability of financial resources

Table 9. Availability of financial resources assessment results

A.2 Availability of financial resources			
Evaluation aspects		**E-quadricycles**	
		Answer	**Justification**
A.	Availability of government/regional/city funds for supporting the project	*Yes*	*[1]*
B.	Intention of international donors to get involved in funding e-mobility projects of the suggested nature	Yes	*[2] [3] [4] [5] [6]*
C.	Preparedness of commercial banks to support projects concerning e-mobility in the project city through preferential interest rates	Maybe	*[7] [8]*
SCORE		**4**	

Notes [Justification]

[1] As the EVIDA law mandates various market segments including national government agencies and local govermnent units to adopt at least 5% of the vehicle fleet to be EVs, for vehicle procurement will be the primary source of fund for the procurement of the intiial set of EVs. ADB, along with Wyntron, will expand the production of alternating current EV charger stations for residential and commercial purposes. DTI is looking to provide funds to subsidize costs for EVs in the PUV sector. There are also perks from the Electric Vehicle Incentive Strategy e-PUV+ Program such as fiscal incentives under the Corporate Recovery and Tax Incentives for Enterprises Law. Questions on other funding opportunities from the government might be asked, or raised during the CREVI public consultations happening later this year. [1b, 1c]

[2] Multiple active funding projects for e-mobility by Development Finance Institutions (DFIs) are currently ongoing in Southeast Asia, as well as numerous evidence of accomplished funding grants given in the previous years. Asian Development Bank (ADB), World Bank, and United Nations Environment Programme (UNEP)/United Nations Framework Convention on Climate Change (UNFCC) are particularly supportive of e-mobility projects. On the other hand, Japan International Cooperation Agency (JICA), European Bank for Reconstruction and Development (EBRD), and Australia Government's DFA and Trade have shown evidence of either infrastructure support for the Philippines or specifically EV funding support for other countries. [2a]

[3] Earlier August 2022, ADB had a series of project and support to different countries in Asia including Vietnam, Thailand, and Philippines. To name a few,

- Earlier August 2022, ADB granted a loan of $20 million to finance the operation and expansion of VinFast Electric Mobility Green Loan Project in Vietnam, including the production of electric vehicles, scooters, buses, electric vehicle charging stations, battery manufacturing facilities, and other EV-related activities. [3a]
- In February 2021, ADB and Energy Absolute Public Company Limited (Energy Absolute) also signed a 1.5 billion Thai baht ($47.62 million) green loan to finance ongoing renewable energy projects and a countrywide electric vehicle charging network in Thailand. [3b]
- ADB has also partnered with the Philippines not exactly for e-mobility yet but for other infrastructure projects as well (ex. Baguio Resilient City Tourism Project (2020) and Davao Public Transport Modernization Project (2022) - both currently in Proposed Status), showing great potential for EV and charging partnership in the future. [3c, 3d]

[4] Another relevant DFI is the United Nations Framework Convention on Climate Change (UNFCC) which created the Green Climate Fund that supports paradigm-shifting low emission (mitigation) and climate resilience (adaptation) projects and programs in developing countries. Climate finance is mobilized in various forms of investments including grants, loans (concessional), equity, and guarantees. There are currently 6 projects that have been implemented in the country with ASEAN Catalytic Green Finance Facility (ACGF): Green Recovery Program in 2021 being a prime example. Through co-financing, this currently targets the public sector of five SEA countries' low-emission investments to support their economic recovery after COVID-19, including support for transport and infrastructure.[4a, 4b]

[5] In the case of World Bank, the organization have recently shown multiple evidences of support for e-mobility. In February 2022, they have started their support towards the E-Mobility agenda in Egypt, Morocco and Jordan through 3 ground-breaking initiatives, including the introduction of e-buses in their public transport system, that seek to promote critical private sector participation (PSP) and investments at scale which are critical for the initiative to succeed in the Middle East and North Africa (MENA) region. In November 2021, Niti Aayog and the World Bank started working together to facilitate a program for faster and easier financing of electric vehicles (EV) by setting up a $300-million 'first loss risk sharing instrument', with State Bank of India (SBI) as its program manager. This seeks to garner around $1.5 billion in financing for EVs, as well as bring down the cost of financing for EVs by 10-12%. Lastly, the World Bank has also shown interest in pursuing Electric Vehicle transportation in Bhutan after releasing a roadmap research on its potential scenarios, implications, and economic impact in 2016. [5a, 5b, 5c]

[6] On the other hand, the Australian government has numerous projects relating

to EV development and partnership with least developed countries (LDCs), including the Katalis program (Indonesia-Australia partnership) which supports Indonesia's development of an electric vehicle industry which started in 2022. The European Bank for Reconstruction and Development (EBRD) also shows potential for funding as they recently financed their first-ever green taxi project (with GEF of UN) by mobilizing a financing package of up to US$ 4.5 million for taxi company Sayohon in Tajikistan. This allows the procurement of 100 electric vehicles and 30 charging stations. Lastly, Japan International Cooperation Agency (JICA) has shown a long history of support for infrastructure building in the Philippines, as well as interest in developing the country's EV transport. Multiple assistance schemes for the Philippines are available to potential use for EV transport (ODA Loan, Grant Aid, etc.). They have also released a report on their preliminary analysis on the Low-Emission Transport System in Laos or Lao PDR (LETS-EV) in 2016. [6a, 6b, 6c, 6d]

[7] Pre-existing financing programs for e-mobility initiatives, particularly that of the Public Utility Vehicles (PUV) Modernization Program (PUVMP) are currently available for the public from two commercial banks. The Land Bank of the Philippines and the Development Bank of the Philippines (DBP) provide loans to cover 95% of the acquisition cost of the vehicle, with the remaining 5% fully subsidized by the government (DOTr, 2022). The loans are to be paid in seven years, with a grace period of six months, and under a fixed interest rate of 6 percent per annum. It is also worth noting that apart from the concern of displacing transport workers from their jobs, PUVMP has been receiving resistance due to allegations of corruption which potentially slows down the financing process. [7a, 7b, 7c]

[8] The aforementioned is referring to Land Bank's Special Package for Environment-Friendly and Efficiently-Driven (SPEED) Public Utility Vehicles launched in March 2019 and DBP's Program Assistance to Support Alternative Driving Approaches (PASADA launched in 2017. Similarly, BDO Leasing and Finance Inc. (BDOLF), a subsidiary of BDO Unibank showed support for e-mobility programs. In 2018, the company became the first privately owned financial institution in the PH to enter into a loan agreement with 1-TEAM to finance modern jeepneys under PUVMP and provide funding for five units of modern jeepneys or Baong Jeep (BEEP). [8a, 8b]

[8] It is also worth noting that though financing jeepneys do not seem to be part of the bank's mainstream corporate program, they still continue to support green projects. By the end of December 2020, BDO has funded 50 sustainable finance projects worth P400.9B of primarily expressway infrastructure. Other commercial banks that have shown history of support for EV development, but has yet to finance public projects in the Philippines, include Bangkok Bank Public Co. Ltd., Bank of America, CBS China Bank Savings, Citibank, JP Morgan Chase Bank, The Bank of Tokyo-Mitsubishi UFJ, Ltd. [9a, 9b]

3.2.3 Coherence with national plans and development goals

Table 10. Coherence with national plans and development goals assessment results

B.1 Coherence with national plans and development goals			
Evaluation aspects		E-Quadricycles	
		Answer	Justification
A.	Alignment with **transport policy** at national or city level (e.g., National Transport Plan, City Master Plans, etc.)	*Yes*	*[1] [2]*
B.	Alignment with **energy policy** at national level (e.g., Energy Performance / Efficiency Standards, etc.)	Yes	*[3] [4]*
C.	Alignment with **environment policy** at national or city level (e.g., emission standards, waste and recycling policies, etc.)	Yes	*[5]*
D.	Alignment with **overarching policies** at national level (e.g., National Development Plans, Climate Action Plans, NDCs, etc.)	Yes	*[6]*
SCORE		5	

Notes [Justification]

[1] The National Transport Policy (2017) is the overarching policy framework for the development of transport systems in the Philippines. Part of its vision and priorities is to promote an environmentally sustainable national transport system through the use of clean and energy-efficient transport technologies such as hybrid and electric, and Euro IV or higher compliant vehicles. Specific light electric vehicles, mostly pertaining to electric 2-wheelers (i.e. e-bikes, e-scooters) were endorsed to be considered for the design of the active transport networks. **Broadly, the pilot demonstration which features electric quadricycles generally is aligned with the vision and priorities stipulated in the National Transport Policy. However, there is no specific part of the NTP that specifically endorses e-quads and FLEV, unless these will be considered "light electric vehicles" as per definition**. [1a, 1b, 1c]

Below are some clauses taken from the Implementing Rules and Regulations (IRR) of the National Transport Policy that are relevant for the e-mobility adoption in the country. The IRR serves as a guideline on the implementation of the policy.

- Section 3.4 Accelerating conversion to green, low-carbon or electric powered, resilient, and people-oriented transport systems that are inclusive and prioritize public health and well-being
- Section 12.8 Use of Environmentally Sustainable Technologies and Approaches. The use of clean and energy-efficient transport technology/fuels such as biofuels, natural gas, liquefied petroleum gas, hybrid, electric and Euro IV or higher compliant vehicles, will be promoted. The continuous adoption of technologically responsive and applicable standards for vehicle emissions will be pursued.
- Section 24.2 Light electric transport such as electric bicycles, electric scooters, and similar devices, which allow low-emission and space-efficient transport, are recognized for their benefits in expanding mobility, especially for persons with disabilities and the elderly. Such devices shall be given consideration in the design of active transport networks.

[2] Last April 2022, the Philippines has recently passed a law namely the Republic Act 11697 or Electric Vehicle Industry Development Act (EVIDA) Law, which serves as the regulatory framework to develop the EV industry in the country. In Section 16 of EVIDA law, corporate and government fleets are mandated to have at least 5% share of their fleets to be EVs, whether owned or leased. These fleets include those from industrial and commercial companies, public transport operators of

various vehicle segments(including Minibuses, Buses, Jeepneys, Vans, Tricycles, Taxis, Transport network vehicle services (TNVS)), and government agencies (both national and local) including government-owned corporations. Further, it also creates the CREVI, a national development plan with an annual workplan to accelerate the devleopment, commercialization, and utilization of EVs in the country. As with the pilot demonstration, there are opportunities that can be explored for scaling-up to various market segments, as stipulated in Section 16 of EVIDA law. The design of the e-quad which was tailored for last mile delivery in narrow roads (a common character not just in Pasig but also in other cities) but still carry a significant number of packages will be comparably useful to logistics companies, especially those catering to last mile logistics (e.g. JnT, NinjaVan, etc) . As an extension, it can also be used for other purposes for utility work, and tourism purposes for companies that are involved in such business. [2a, 2b, 2c]

[3] The Philippine Energy Plan aims to achieve a Clean Energy Scenario of having 10% penetration rate of EVs for road transport (motorcycles, cars, jeepneys) by 2040. Under this, DOE issued DC 2020-10-0023167: Policy Framework for the Development of the Fuel Economy Rating, Fuel Economy Performance, and Related Energy Efficiency and Conservation Policies for the Transport Sector and Other Support Infrastructures which requires the development and operation of Electric Vehicle (EV) and Electric Vehicle Charging Station (EVCS) to be structured to facilitate safe operation and growth, while ensuring equitable non-discriminatory and open access for all.

A complementing policy framework was also issued, the DC 2021-07-0023168 providing EVCS Policy Guidelines. This includes activities related to the establishment, use, and operation of EVCS. The DC outlines further activities on how to streamline EV adoption and maximize the combined economic, social, energy security, and environmental benefits.

Other energy policies: (1) RA 11285: Energy Efficiency and Conservation Act and Philippine National Standards (PNS) on Electrically Propelled Vehicles, (2) SB 1382: Electric vehicles and Charging Stations Bill, & (3) RA 9163: Electric Power Industry Reform Act (EPIRA) and RA 9513: Renewable Energy Act of 2008.

[4] The Department of Energy's (DOE) Alternative Fuels and Energy Technologies Roadmap 2017-2040 includes the deployment of applicable AFET (electric vehicles, LPG, CNG, LNG, hybrid electric vehicle) for transport and non-transport purposes as one of their priorities. Continuous assessment of emerging AFET and relevant policy studies, as well as conducting IEC on AFET benefits on stakeholders will be done throughout the whole period. This includes the formation of the Local Public Transport Route Plan (LPTRP) which is imperative for enabling low carbon transport, creating a planning and policy environment at local government level, and potentially expanding the market space for entry of low emitting road-based public transport. This encourages multimodality of public transport which the e-quad and FLEV can potentially become key contributing players.

[5] Presidential Decree No. 1152: Philippine Environment Code presents the standards for Noise-Producing Equipment in Chapter 1 Section 6 which sets a limit on the acceptable level of noise emitted from a given equipment for the protection of public health and welfare. Other environmental policies include (1) RA 6969: The Toxic Substances and Hazardous and Nuclear Waste Control Act, (2) RA 9003: Ecological Solid Waste Management Act, and (3) RA 8749 Clean Air Act and Philippine National Standards (PNS) on Electrically Propelled Vehicles.

[6] The Philippines' Nationally Determined Contributions (NDCs) include the

commitment to a projected GHG emissions reduction and avoidance of 75%, of which 2.71% is unconditional and 72.29% is conditional, representing the country's ambition for GHG mitigation for the period 2020 to 2030 for the sectors of agriculture, wastes, industry, transport, and energy. Other national overarching policies include (1) Philippine National Development Plan and (2) Philippine National Climate Change Action Plan.

3.2.4 Alignment with supra-national/national/city legislation & regulations

Table 11. Alignment with legislation & regulations assessment results

B.2 Alignment with supra-national/national/city legislation & regulations			
Evaluation aspects		E-quadricycles	
		Answer	Justification
A.	**Full compliance:** It can be ascertained that the relevant project element/s is/are fully compliant with the regulation.	None	-
B.	**Presence of uncertainty:** Situations wherein it cannot fully be ascertained whether the relevant element/s of the proposed project is either fully compliant to, or appropriately covered by existing regulations, or in cases where potential significant regulatory hurdles are foreseen (e.g. impending changes in regulations).	Maybe	[1] [2] [3]
C.	**Non-compliance:** It can be ascertained that the relevant project element/s would not comply with the applicable regulation/s.	None	-
SCORE		1	

Notes [Justification]

[1] With the ongoing development of the implementation of the EVIDA Law, impending changes in the regulations, standards adoption, and organizational structure pose significant level of uncertainty on the compliance of the project to these recent developments. However, efforts are being made to ensure that the project activities and outcomes are and will be aligned to the requirements and anticipated changes in the relevant regulations.

[2] The anticipated CREVI which defines the specific recommendations on Human Resource, Industry Development, Market Development, and R&D, - which includes standards adoption, technical requirements for vehicles, charging, and its integration to the grid and the transport system -- have yet to be released to the public. A series of public consultations with relevant stakeholders to address concerns on these matters is set to be scheduled this 3rd to 4th quarter of the year. Outcomes of the consultations will be used as inputs to the finalization of CREVI, which is targeted to be released before end of 2022.[2a, 2b]

[3] The LTO AO 2021-039 provides the consolidated guidelines on the registration and use of electric vehicles, however, the provisions stipulated are generally broad which has left implementing government agencies (i.e. the local government units) make their own interpretations for implementation in the city. As per vehicle definition of LTO AO 2021-039, the SOL+ equadricycles fall under the N1 category. [3a]

[4] Under EO 877-A, s. 2010: The Comprehensive Motor Vehicle Development Program, the e-quads and FLEV are classified as commercial vehicles which are required to follow Philippine National Standards (PNS) such as PNS IEC TS 62840-1&2:2019 Electric vehicle battery swap system - Part 1: General and guidance and 2: Safety Requirements, as well as PNS IEC 61851-21-1:2018 Electric vehicle conductive charging system – Part 21-1: Electric vehicle on-board charger EMC requirements for conductive connection to an AC/DC supply.

3.2.5 *Ease of implementation (in terms of administrative barriers)*

Table 12. Ease of implementation assessment results

B.3 Ease of implementation (in terms of administrative barriers)			
Evaluation aspects		E-quadricycles	
		Answer	Justification
A.	The project requires administrative interventions of limited scope from the relevant political and institutional bodies, e.g. activities for passing a new law that will make the uptake of an e-mobility solution possible	Yes	[1]
B.	The political and institutional bodies needed for supporting the implementation of the project are in place	Yes	[2]
C.	The existing national/city political and institutional bodies are (likely to be) supportive of the necessary actions required for the project implementation	Maybe	[3]
SCORE		3	

Notes [Justification]

[1] Last April 2022, the Philippines has recently passed a law namely the Republic Act 11697 or Electric Vehicle Industry Development Act (EVIDA) Law, which serves as the regulatory framework to develop the EV industry in the country. In Section 16 of EVIDA law, corporate and government fleets are mandated to have at least 5% share of their fleets to be EVs, whether owned or leased. These fleets include those from industrial and commercial companies, public transport operators of various vehicle segments(including Minibuses, Buses, Jeepneys, Vans, Tricycles, Taxis, Transport network vehicle services (TNVS)), and government agencies (both national and local) including government-owned corporations. Further, it also creates the CREVI, a national development plan with an annual workplan to accelerate the devleopment, commercialization, and utilization of EVs in the country. As with the pilot demonstration, there are opportunities that can be explored for scaling-up to various market segments, as stipulated in Section 16 of EVIDA law. The design of the e-quad which was tailored for last mile delivery in narrow roads (a common character not just in Pasig but also in other cities) but still carry a significant number of packages will be comparably useful to logistics companies, especially those catering to last mile logistics (e.g. JnT, NinjaVan, etc) . As an extension, it can also be used for other purposes for utility work, and tourism purposes for companies that are involved in such business.

[2] The EVIDA law formally creates Technical Working Group which is composed of DOE, DOTr, DTI, and DOST. The TWG will be the core group who will spearhead the implementation of the EVIDA law. Other government agencies and governnet units will also play a role, and the scope of their role are defined in EVIDA, as well as the CREVI. One barrier is the administrative creation of dedicated group of staff or assigning staff within agencies, focusing on the implementation of EVIDA - from experience with DOTr where they are awaiting the release of IRR.

[3] Knowing that the implementation of e-quads and FLEV are aligned with the country's transport, energy, environment, and other overaching policies, it is likely that existing political and institutional bodies will be supportive of the project implementation. For instance, Pasig may fall under special economic zones, or "ecozones", as self-sustaining and sector-specific centers that operate under separate customs regulations. Through Republic Act No. 7916: Special Economic Zone Act of 199, businesses operating in ecozones are eligible for tax exemptions, and instead, 5% of gross income is remitted

to the national government. In addition, Executive Order 226: Omnibus Investment Code on Fiscal and Non-Fiscal Incentives provides an Income Tax Holiday of six (6) years to a maximum of eight (8) years for new registered pioneering firms that will engage in the EV business, AFVs, charging stations and environment/climate change related projects, as well as Duty Free importation on capital equipment, spare parts, and supplies. All these provide greater ease of implementation through the support of greater bodies.

[4] The institutional policies that justify and support that continued use of the vehicles from the EV Pilot are already in place. The accompanying offices have likewise been established, mobilized, and are in constant coordination with one another. Despite such support, there still proves to be friction as to the administrative policies for project implementation and mobilization. This can be attributed to the existing internal policies for disbursement of project funds for implementation.

3.2.6 Effect on Climate and Air Pollution

Consultations with city government officials identified the existing ICE APV as the primary vehicle for delivering medical supplies and personnel. The APV is a typical 4-wheeler van used in urban settings due to its versatility and cost. Based on the Philippine setting, the emissions of the APV and e-quadricycle are summarized in Table 13.

Table 13. Vehicle emissions per km[4]

Vehicle	CO2 [g/VKM]	CO [g/VKM]	NOx [g/VKM]	PM2.5 [g/VKM]
ICE APV	428.5714	2.01	0.064	0.0011
E-quadricycle	70.11	0.0494	0.2089	0.0046

GHG emissions

Table 14. Annual vehicle emissions (6,420 km vehicle km annually)

	CO2 [MT CO2/yr]	CO [kg CO/yr]	NOx [kg NOx/yr]	PM2.5 [g PM2.5/yr]
ICE APV	2.674	12.5424	0.3994	6.864
E-quadricycle	0.4375	0.3083	1.3035	28.704
Abatement	2.2368	12.2341	-0.9041	-21.84

Drivers of the APV city government fleet completed a questionnaire that derived their annual operating characteristics. The consensus among drivers is that they use the vehicle 24 km/day for 260 days per year (6,240 km/year), on average. The APV is petrol-driven and averages around 0.1428 lt/km. Using the well-to-wheel (WtW) factor

[4]For the APV, CO2 is based on manufacturer published fuel economy and gasoline carbon intensity, while criteria air pollutants are based on the EMEP Air Pollutant Emission Inventory Guidebook for N1 Euro 4 petrol vehicles. For the e-quadricycle, CO2 is estimated on the Department of Energy Statistics and WWF EU

for petrol of the UNEP e-Mob calculator of 3,000 gr/lt, the vehicle generates 428.57 gCO2/km. Annually, a single APV produces 2.674 tonnes of CO2 emissions.

In contrast, an electric quadricycle (e-quad) with 6 passenger capacity can provide the nearly the same passenger capacity as the APV (7), but is limited by its 4.8 kWh battery (10.41 km/kWh) to a range of 50 VKM. The value is within the average route trip distance of 17 km per trip[5] . Assuming a grid emission factor of 685 gCO2/VKM (estimated from DOE generation statistics from 2016-2022), the emissions of e-quads are 70.11 gCO2/Vkm and 0.4375 tonnes CO2/yr, respectively. The values indicate that shifting from the APV to the e-quad provides an emissions mitigation of 2.2368 tonnes CO2/yr.

NOx emissions

According to the EMEP air pollutant emission inventory guidebook 2023 (1.A.3.b.i-iv)[6], the average NOx emission factor for a petrol-drive light-duty utility vehicle with Euro 4 emission standards is 0.064 g/VKM. The factor translates to an annual NOx emissions per ICE APV of 0.3994 kg/year. On the contrary, e-quads do not have tailpipe NOx emissions, but induce NOx emissions because of its electricity demand. Electricity supplied from the grid results in 0.2089 g/VKM, which results in 1.3035 kg/year. Replacing the APV with the e-quad will result in an annual increase of 0.9041 kg/year. However, these emissions will be outside Pasig City.

PM2.5 and CO emissions

PM2.5 and CO emissions factors for the APV (gasoline-powered) are 0.0011 g/VKM and 0.0046 g/VKM, respectively (EMEP, 2023). The factors estimate there will be an increase in PM2.5 emissions annually per unit of converted utility vehicle by 21.84 g, while abated CO emissions annually per unit amount to 12.54 kg.

3.3 PRELIMINARY EX-POST ASSESSMENT OF THE SOL+ DEMONSTRATION PROJECT

Due to delays in the development of the e-quadricycles, only two out of the eight units have been used and trialed by the driver employees of the Pasig city government. In the meantime, preliminary interviews and assessments have been made to relevant and applicable indicators.

3.3.1 Impact on noise

As of April 2024, only three out of the eight e-quadricycles have been delivered (wherein two units were delivered last February, and one unit recently in April). With this, only the two vehicles have been thoroughly tested as of writing. To this end, the respondents for the interview assessments were two regular professional e-quad drivers from Pasig City Government's City Health Department. One has been driving the e-quads since September 2023 while the other since February 2024. Their responses were based on the e-quad with GoGreen batteries[7] (latest e-quad received by the city).

The respondents observed that the e-quadricycle (e-quad) would make a screeching sound when riding at 20kph to 30kph. While moving, the respondents found that the e-quad's motors would ALSO have a humming noise. Despite this, the respondents

[5]Average distance of vehicles used by the City Health Office (according to questionnaire survey)
[6]https://efdb.apps.eea.europa.eu
[7] GoGreen batteries is one of the two types of batteries installed in the e-quadricycles. The other battery pack is the Betteries brand. Due to the incompatibility of the Valeo motors with the Betteries brand, the e-quadricycles with GoGreen batteries have been the preferred e-quad by the drive

gave it a score of " 5 – Significantly quieter" than the old solution of APV.

3.3.2 Impact on accessibility (passengers)

There are no added further stops in the pilot and city, hence there will be no impact on this indicator. In accordance with the D1.6 KPI guidance, the KPI value is 0%.

3.3.3 Effect on affordability

From the perspective of passengers or end-users, affordability cannot be measured and compared in this pilot project because the e-quadricycles are being tested for non-commercial use. Currently, it is used to support the Pasig city government in its daily operations.

However, the financial implications of electrifying the city-government-owned fleet can be presented by analysing its cost-effectiveness compared to their existing APV fleet, as discussed in Section 3.2.1.

3.3.4 Impact on travel time (passengers or personal travel)

The demonstration activity has no expected effect on the travel time for passengers because travel time is largely still affected by external factors such as road congestion and other local conditions.

3.3.5 Impact on road safety

Table 15. Assessment of road accidents with fatalities or serious injuries

C18: Road accidents with fatalities / serious injuries			
Evaluation aspects		**E-quadricycles**	
		Answer	**Justification**
A.	Number of road accidents with fatalities / serious injuries	*No difference*	*[1] [2] [3] [4]*
SCORE		**4**	

Effect on major accidents

Notes [Justification]

[1] About 48.11% of road crashes in Metro Manila involved cars, followed by motorcycles at 23.85% and trucks at 8.8% in 2021 (Statista, 2022). However, based on the 10-year data from Department of Health's (DOH) Online National Electronic Injury Surveillance System (ONEISS) from 2010–2019, fatal transport and vehicular crashes (TVC) are primarily motorcycles which account for 53% to 62% of patients brought to hospitals each year (followed by cars) and was found to be associated with worse emergency room outcome (Lu, Herbosa & Lu, 2022). The highest injury types are multiple injuries, abrasion, avulsion and burn with the drivers being the primary victims. Fatal TVCs were observed to occur from 6:00 pm to 5:00 am while most accidents occurred during leisure activities (32.5%) with the highest contributing factor being drunk driving and low compliance on the use of vehicular safety equipment. [1a, 1b]

[2] Based on MMDA's Annual Report in 2019, private cars (50.28%) (sedan, wagon, SUV, pick-up) and motorcycles (14.85%) have the highest percentage in road crash yearly as these have the most volume on the road (MMDA, 2019). Most fatalities are due to hitting pedestrians, and most motorcycles crashes are caused by human error (having lost control of the vehicle) and not so much on vehicle/mechanical defects. As

such, training and policy implementation are important factors when the sol+ vehicles are implemented in an upscale scenario. [2a]

[3] As the e-quadricycles are similar to motorocycles by having the same function of conducting deliveries in Pasig and would also be implementing a "shared vehicle use" concept, there is also great risk of increasing the percentage of TVCs in Pasig City if its use is not properly handled. The "flexible electric van" (FLEV) which features a chassis that can be used for multiple purposes (e.g. single/double cab pickup and passenger or cargo van) may also easily be mishandled as well if deemed incompatible for handling the same cargo in the e-quadricycles.

The recommendations from the previous cases include having properly working vehicular safety equipment, strong road safety policy implementation, better road infrastructure, and systematic post-crash response (Lu, Herbosa & Lu, 2022). Should the sol+ vehicles be implemented in an upscale scenario, the aforementioned recommendations must also be coupled with proper training for drivers in order to avoid TVCs when these vehicles are used. [3a, 3b]

[4] Similar to the PH sol+ context, EVs in Norway are mainly used for urban local commuting. In the case of Norway's road crashes from 2011 to 2018, the proportion of EV crashes in total traffic crashes had risen from zero to 3.11% (Liu, Zhao & Lu, 2022). However, in terms of severity, EV crashes do not show statistically significant differences from the Internal Combustion Engine Vehicle (ICEV) crashes. EVs are confirmed to be much more likely to collide with cyclists and pedestrians, probably due to their low-noise engines (Liu, Zhao & Lu, 2022). This calls for a re-evaluation of traffic safety policies and strategies as that EVs are quiet in nature during usage. [4a]

Effect on minor accidents

Table 16. Assessment of the impacts on minor accidents

Score	Description	Respondents		Overall score
		Number	Share	
Effect on minor accidents				
1	Significant negative effect on the road safety situation in the area/city (i.e., significant increase in number of road accidents with minor injuries/material damage)	0	0%	
2	Negative effect on the road safety situation in the area/city (i.e., moderate increase in number of road accidents with minor injuries/material damage)	0	0%	
3	Slight negative effect on road safety situation in the area/city (i.e., slight increase in number of road accidents with minor injuries/material damage)	0	0%	
4	No change in road safety situation in the area/city	0	0%	
5	Slight positive effect on the road safety situation in the area/city (i.e., slight decrease in number of road accidents with minor injuries/material damage)	0	0%	
6	Positive effect on the road safety situation in the area/city (i.e., moderate decrease in number of road accidents with minor injuries/material damage)	2	67%	
7	Significant positive effect in the road safety situation in the area/city (i.e., significant decrease in number of road accidents with minor injuries/material damage)	1	33%	
	Total	**3**	**100%**	**6.33**

Effect on vulnerable road users

Table 17. Assessment of the impacts on vulnerable road user safety

Score	Description	Respondents		Overall score
		Number	Share	
Effect on vulnerable users				
1	Significant negative effect on the road safety situation in the area/city (i.e., significant increase in number of road accidents involving VRUs)	0	0%	
2	Negative effect on the road safety situation in the area/city (i.e., moderate increase in number of road accidents involving VRUs)	0	0%	
3	Slight negative effect on road safety situation in the area/city (i.e., slight increase in number of road accidents involving VRUs)	0	0%	
4	No change in road safety situation in the area/city	0	0%	
5	Slight positive effect on the road safety situation in the area/city (i.e., slight decrease in number of road accidents involving VRUs)	0	0%	
6	Positive effect on the road safety situation in the area/city (i.e., moderate decrease in number of road accidents involving VRUs)	2	67%	
7	Significant positive effect in the road safety situation in the area/city (i.e., significant decrease in number of road accidents involving VRUs)	1	33%	
	Total	**3**	**100%**	**6.33**

3.3.6 Impact on charging safety

Table 18. Assessment of the charging safety hazards

Hazard Categories	Impact (consequences)	Probability (likelihood)	Risk Score (Impact* Probability)
Electric shock	2	2	4
Fire hazards	2	1	3
Power grid stability	N/A	N/A	N/A

The respondents who participated in this assessment are experts and researchers from the academe, specifically the from the Electrical and Electronics Engineering Institute of University of the Philippines Diliman. In addition, they also provide charging products and services for electric vehicles. The assessment of the hazards is presented in Table 17.

They recently installed the charging station in Pasig City under a project together with the city government. Because the said charging station is powered by solar panels, they have indicated an N/A score below for power grid stability.

All scores in Table 17 are in reference to the current solar-powered electric vehicle charging station (EVCS) at the Kabuhayan Center. There is relatively low impact and probability of encountering electric shock and fire hazards due to the EVCS's design, external environmental protection, and proper user training. The design of the EVCS use standard connectors and terminals based on the Philippine Electrical Code, EVIDA, and CREVI - ensuring safe use and operations. For example, terminals have safety provisions such as fuses and circuit breakers. Because the EVCS themselves follow standards and code faithfully, any hazards would likely come from the user or the user-equipment, such as faulty wiring in the user's vehicle.

The EVCS are protected from environmental factors such as the roof to protect the equipment, vehicles, and users from getting wet - thus having low risk of hazards relating to wet equipment. The Kabuhayan Center EVCS is also protected from flooding since its location is relatively high compared to surrounding villages.

The Pasig LGU received proper training on the use of the EVCS - especially on the use of electrical extensions (since these are fire and safety hazards). Fire extinguishers are available on-site (standard equipment for charging stations).

3.3.7 Effect on service quality

Due to the limited number of available e-quadricycles for driving test (only 2 out of the 3 delivered as of writing), the assessment was conducted with three regular professional-licensed drivers and one non-professional driver who are also employees of Pasig City Government's City Health Department. To provide actual comparisons between the old and new solutions, all respondents drivers also have experience driving the APV which is the "old solution" vehicles in this demonstration activity.

In the following text (Table 19 and Table 20), the following terms are defined as follows:

- NEW solution refers to the SOLUTIONSplus electric quadricycles
- OLD solution refers to the existing APV internal combustion engine vehicles owned by Pasig city government

Table 19. Assessment of the service quality indicators (part 1 of 2)

Score	Description	Respondents		Overall score
		Number	Share	
Suitability for adverse weather conditions				
1	The OLD solution is much better than the NEW one	4	100%	
2	The OLD solution is better than the NEW one	0	0%	
3	I don't see a difference between the two solutions in relation to this feature	0	0%	
4	The NEW solution is better than the OLD one	0	0%	
5	The NEW solution is much better than the OLD one	0	0%	
	Total	**4**	**100%**	**1.00**
Perceived comfort in travel				
1	The OLD solution is much better than the NEW one	4	100%	
2	The OLD solution is better than the NEW one	0	0%	
3	I don't see a difference between the two solutions in relation to this feature	0	0%	
4	The NEW solution is better than the OLD one	0	0%	
5	The NEW solution is much better than the OLD one	0	0%	
	Total	**4**	**100%**	**1.00**
Ease of driving (by professional drivers)				
1	The OLD solution is much better than the NEW one	0	0%	
2	The OLD solution is better than the NEW one	0	0%	
3	I don't see a difference between the two solutions in relation to this feature	0	0%	
4	The NEW solution is better than the OLD one	0	0%	
5	The NEW solution is much better than the OLD one	3	100%	
	Total	**3**	**100%**	**5.00**
Ease of driving (by other users)				
1	The OLD solution is much better than the NEW one	1	100%	
2	The OLD solution is better than the NEW one	0	0%	
3	I don't see a difference between the two solutions in relation to this feature	0	0%	
4	The NEW solution is better than the OLD one	0	0%	
5	The NEW solution is much better than the OLD one	0	0%	
	Total	**1**	**100%**	**1.00**

Table 20. Assessment of the service quality indicators (part 2 of 2)

Score	Description	Respondents		Overall score
		Number	Share	
Ease of charging/refuelling				
1	The OLD solution is much better than the NEW one	3	75%	
2	The OLD solution is better than the NEW one	0	0%	
3	I don't see a difference between the two solutions in relation to this feature	0	0%	
4	The NEW solution is better than the OLD one	0	0%	
5	The NEW solution is much better than the OLD one	1	25%	
	Total	**4**	**100%**	**2.00**
Safety * (within the city driving)				
1	The OLD solution is much better than the NEW one	0	0%	
2	The OLD solution is better than the NEW one	0	0%	
3	I don't see a difference between the two solutions in relation to this feature	1	25%	
4	The NEW solution is better than the OLD one	0	0%	
5	The NEW solution is much better than the OLD one	3	75%	
	Total	**4**	**100%**	**4.50**
Personal security (in terms of unlawful behaviors)				
1	The OLD solution is much better than the NEW one	3	75%	
2	The OLD solution is better than the NEW one	0	0%	
3	I don't see a difference between the two solutions in relation to this feature	0	0%	
4	The NEW solution is better than the OLD one	0	0%	
5	The NEW solution is much better than the OLD one	1	25%	
	Total	**4**	**100%**	**2.00**
Continuity of journey chains, including transshipment to other modes				
1	The OLD solution is much better than the NEW one	0	0%	
2	The OLD solution is better than the NEW one	0	0%	
3	I don't see a difference between the two solutions in relation to this feature	0	0%	
4	The NEW solution is better than the OLD one	0	0%	
5	The NEW solution is much better than the OLD one	4	100%	
	Total	**4**	**100%**	**5.00**

A summary of the scores with the explanation from the respondents is shown in the Table 21 below:

Table 21. Summary of the quality of e-mobility service with comments from respondents

Feature	Overall score	Comments from respondents
Suitability for adverse weather conditions	1.00	The NEW solution (e-quad) is not suitable for rainy seasons where flooding is expected. The fleet manager is cautious and thereby, avoids using the e-quad as there are specific areas in Pasig that are particularly flooded.
Perceived comfort in travel	1.00	The OLD solution (ICE APV) is a closed vehicle with air-conditioning which is always favorable for passengers and drivers in a tropical climate in the Philippines.
Ease of driving (by professional drivers)	5.00	According to the professional licensed drivers in the respondents, they find the NEW solution (e-quad) easier to drive.
Ease of driving (by other users)	1.00	In contrast, the non-professional driver among the respondents found the OLD solution easier to drive.

Feature	Overall score	Comments from respondents
Ease of charging/ refuelling	2.00	Three of the four respondents consider time as valuable factor since it affects the turnaround time of their assigned transport tasks. It takes less than 5 minutes to refuel for the OLD solution while it takes them 45 minutes to fully charge the NEW solution. Currently, there is no publicly available (free of charge) fast charging station in the city.
Safety*	4.50	The e-quad is overall the favored vehicle for driving within the city because its speeds matches to the speeds you can drive in the city (30-40km) due to local traffic conditions. However, one respondent said that in a worst case scenario where an accident / clash with other bigger vehicle will occur, the passengers and drivers inside the OLD solution vehicle (APV) would be much safer than in the NEW solution (e-quad). Moreover, the latter is also more vulnerable due to its physical build.
Personal security (in terms of unlawful behaviors)	2.00	The parts and components of the e-quad is vulnerable to theft due to its open build as opposed to the OLD solution. Also, drivers tend to get away / get excused from road violations using the NEW solution, according to one of the drivers.
Continuity of journey chains, including transshipment to other modes	5.00	Due to its compact size, the NEW solution is best for last mile transport and is capable of navigating narrow streets in Pasig. Moreover, using the NEW solution is less hassle because it does not need to be parked when dropping deliveries and/or servicing passenger.

Overall, the e-quad is favored for its ease of driving (by professional drivers), its safety for driving within the city, and for its continuity of journey chains due to its compact size. Meanwhile, it was not scored favorably in terms of suitability for adverse weather conditions, perceived comfort, ease of driving by other drivers, ease of charging and personal security.

4 ASSESSMENT OF SELECTED SCALED UP KPIS

Higher adoption of e-quads in the Pasig City Government is possible, as there is interest in adopting more EVs, in light of the Electric Vehicle Industry Act and scale-up of City Health Office services. Thus, CO¬2 and other air pollutant abatement can be estimated through the updating of the Pasig City 2019 mobile emissions inventory, with the updated 2022 vehicle inventory.

4.1 BASELINE SCENARIO

The baseline scenarios assume that vehicles operate 30 VKM/day for 330 days/year. The scenario also assumes an annual growth rate of 1.3% in vehicle mileage based on transport study estimates (JICA, 2019). The estimates growth reflects the growth in vehicle ownership and mileage as city services increase to address the mobility demands of personnel between office locations. The baseline scenario also includes the transition of two-stroke three-wheelers (tricycles) used for public transport into four-stroke petrol vehicles.

4.2 SCALED-UP SCENARIOS

The estimates model three scale-up EV adoption scenarios, as defined in Table 22. The first scenario (SU-1) adds 100 e-quads to the city fleet by 2025. The scenario also assumes that the e-quads will serve the additional transport demand growth (measured in VKM). The remaining two scale-up scenarios assume the impacts of successful EV demonstrations of e-quads in the city to the existing tricycle fleet used for public transport. The second scenario (SU-2) models the effect of 50% of the tricycle fleet shifting to electric by 2040. The third scenario (SU-2) models a full electrification of the passenger tricycle fleet by 2040.

The models assume a scrappage policy only for the three-wheeler fleet due to wear and tear of the units. On the contrary, scenarios relating to the city government fleet do not consider vehicle scrappage. Furthermore, the scenarios do not consider emissions related to vehicle production and removal from the fleet, as well as emissions leakage.

Table 22. List and description of potential scenarios including immediate scaled-up scenarios

Scenario ID and "short code"	Impact (consequences)
Scenario 1 (SU-1) "Gov + 100 e-quad"	By 2025, 100 new e-quads will be added to the existing fleet of the city government. (The e-quads will be distributed to the 30 barangays to serve as a transport vehicle for the medicines, vaccines, and health personnel. This is the immediate/proposed scaled-up scenario.)
Scenario 2 (SU-2) "Gov int + half TC electrification"	("Gov int") New e-quads will accommodate the increased EV demand of 1.3% and half (50%) of the city's public transport ICE three-wheeler or tricycles ("TC") fleet be electrified
Scenario 3 (SU-3) "Gov int + full TC electrification"	("Gov int") New e-quads will accommodate the increased EV demand of 1.3% all (100%) of the city's public transport ICE three-wheeler fleet or tricycles ("TC") will be fully electric

4.3 EFFECT ON EMISSIONS OF SCALED-UP SCENARIOS

GHG emissions

The emissions are modeled using the existing LEAP-IBC model of Pasig City (Clean Air Asia, 2019). The model considers the vehicle emissions standards of the existing government fleet. In the absence of emissions data from the city, the scenario assumed the vehicle emissions standard fleet shares according to the vehicle's year of procurement[8] and fuel type.

The baseline scenario estimates the total CO2 emissions from transport vehicles by 2040 as 26,927.67 metric tonnes. All scenarios that introduce electric vehicles to the city fleet and public transport tricycle fleet yielded emissions reduction by 0.61%, 13.39%, and 26.17%, respectively.

The baseline scenario decreased emissions by 2030 mostly due to the replacement of aging two-stroke tricycle stock. Figure 1 shows a 164.60 MT CO2/yr abatement by 2040 of the e-quad scenario from the baseline scenario because the adoption rate of electric vehicles in the demonstration is minimal. Further, the e-quad scenario includes other vehicles in the Pasig City Government fleet, which assumes better fuel economies in the LEAP-IBC model. The scale-up scenarios of public transport electrification yielded a higher GHG emissions abatement. The models reflect the significance of higher adoption rates in attaining higher GHG emissions abatement. Figure 2 demonstrates the impact of EV adoption rates to the city and tricycle fleets to the overall mobile source emissions in the city. The figure shows that electrification impacts will become more substantial if it targets a wider scale of adoption.

Table 23. Tabular data estimates of annual metric tonnes of carbon dioxide emissions per scenario in 2024, 2030, and 2040

Metric Tonnes CO2 emissions	2024	2030	2040
Baseline	24,840.83	23,664.89	26,927.67
Scenario 1 (SU-1)	24,840.83	23,539.57	26,763.07
Scenario 2 (SU-2)	24,840.83	22,934.63	23,321.41
Scenario 3 (SU-3)	24,840.83	21,271.08	19,879.73

Carbon monoxide (CO) emissions

Carbon monoxide emissions will also decrease under scenarios of more substantial EV adoption scenarios to the city and three-wheeler fleet, as shown in Figure 3. Like the abatement of CO¬2 emissions, the government-only adoption scenario (SU-1) will only reduce minimal amounts of CO. In contrast, the removal of two-stroke tricycles from the fleet results in thousands of CO reductions, as the newer vehicles conform to stricter vehicle emission standards and are equipped with three-way catalysts. The implementation of cleaner vehicles translates to abatement of more than 2,500 metric tonnes of CO.

[8] For example, vehicles that are purchased from January 2018 are considered Euro IV-compliant.

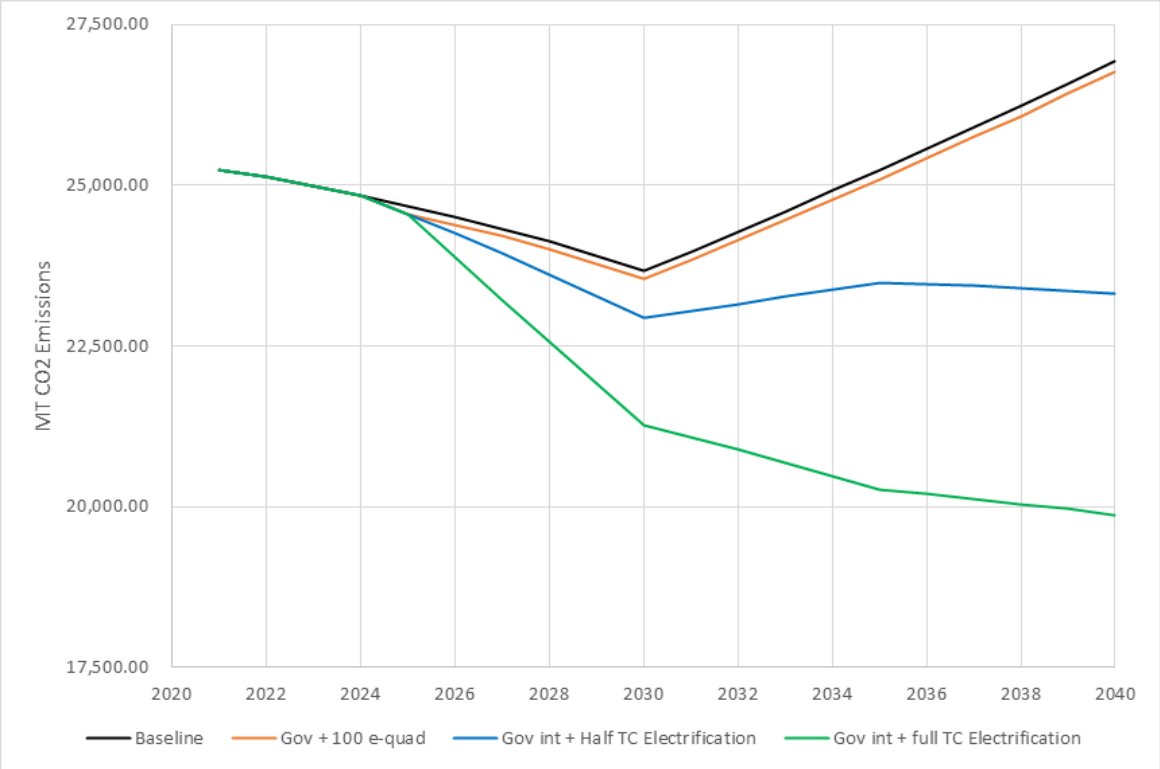

Figure 1. Annual metric tonnes of carbon dioxide emissions by scenario

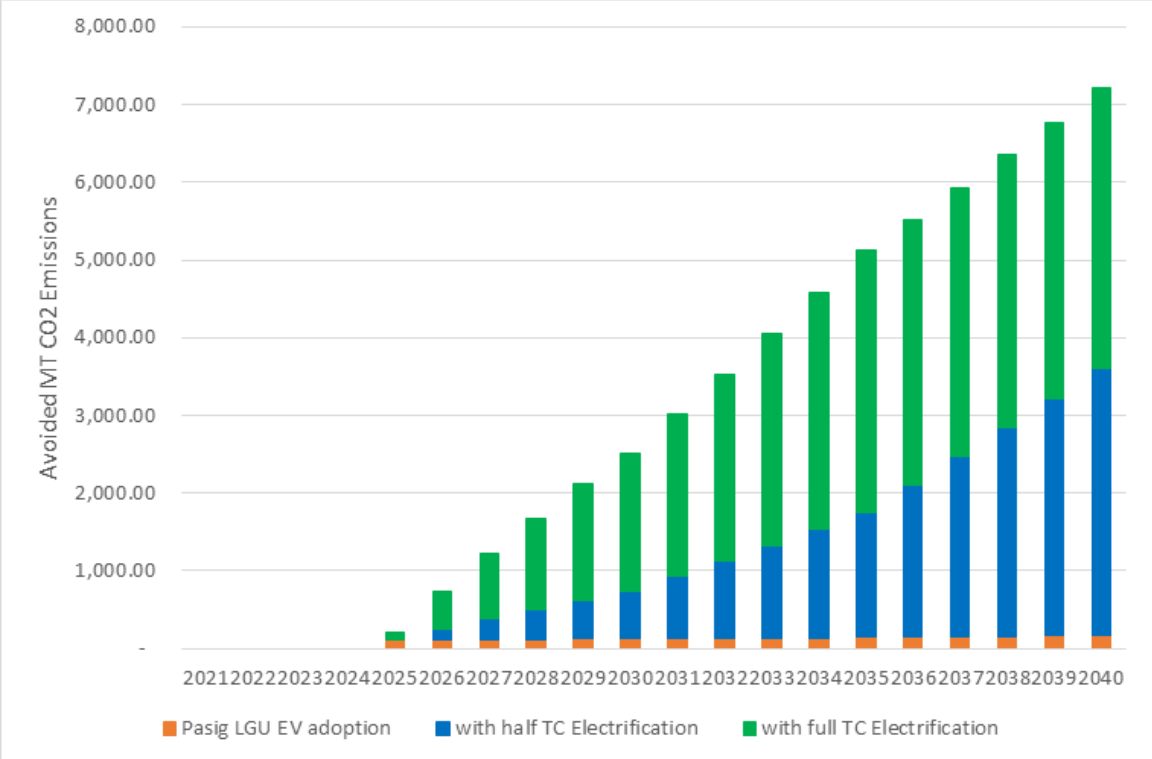

Figure 2. Annual abated metric tonnes of carbon dioxide as a result of increased ambition

Figure 3. Annual metric tonnes of carbon monoxide emissions from the government and three-wheeler public transport fleets

4.4 EFFECT ON BUDGET

Based on the cost-effectiveness ratio of the e-quad, it was seen as more favorable than the APV. It is also expected that the market price of the e-quad will be lower than the current purchase price since it is currently at the research and development phase. In the scale up scenario where adding 100 e-quads in the fleet by 2025 might still remain significant if the source of funding would come solely from Pasig. Due to limited information on procurement / annual expenditure of Pasig, it would be difficult to determine the level of impact on the local city budget for the scale-up scenario.

4.5 EFFECT ON FOSSIL FUEL IMPORTS

There will be no effect on fossil fuel imports on the scale-up scenarios involving increased e-quad adoption within city governments alone (not just Pasig, including all city governments in the Philippines). This is because the vehicle kilometer travelled (i.e. demand) is relatively small and the fleet size is also small to have an impact.

However, on the scenarios involving public transport ICE tricycles which have a higher population in cities, both at urban and rural, it will likely have an impact on the fossil fuel imports compared to the scenarios involving city government-owned fleet alone. In Pasig city alone, there is an estimated 11,000 units of ICE tricycles for last mile public transport. In rural areas where high-capacity transport vehicles are not common, these ICE tricycles often serve as the main modes of public transport. In urban setting, these serve as last-mile passenger transport connecting commuters to their homes and other high-capacity utility vehicles. Combining the population of ICE tricycles in all cities will create a relatively significant demand, compared to city-government owned fleets. Further studies to quantify this impact across all scenarios will have to be undertaken.

4.6 EFFECT ON JOBS AND TECHNICAL SKILLS

Currently, the demonstration activity along with the increasing share of electric vehicles in the assets or vehicle fleet of Pasig city has created a need for an in-house staff dedicated to repairing and maintaining these electric vehicles. If an increased demand among other local governments will be observed or the scale-up scenarios (first and second) will happen, we are seeing the possibility that a new position will open up and be permanent. Based on the feedback from Pasig, the priority technical skill is on maintenance of the electric vehicle and its components. In the meantime, the Pasig city government is reliant on the technical support staff of the electric vehicle supplier. Further studies to quantify this impact across all scenarios will have to be undertaken.

5 DISCUSSION

In the Philippines, the transport sector is the largest fossil-fuel consuming sector and source of urban air pollution in cities like Pasig, according to Worldbank's country climate and development report[9]. Land transport alone is responsible for 92.6 of the emissions within the transport sector. The country commits to reduce its emissions by 75% by 2030 through its nationally-determined contributions and electrification of vehicles is considered to have the most potential to reduce transport emissions.

The demonstration in Pasig was motivated by this long-term aspiration of reducing transport emissions and making cities like Pasig healthier and livable. The pilot concept of "EV sharing system" was aimed at maximizing the usage and efficiency of the city government-owned electric vehicle fleet by streamlining the vehicle sharing process among different types of users and for different purposes. Although the demonstration vehicle was an e-quadricycle, the EV sharing system is aimed to include other existing electric vehicle fleet of the city government.

Due to complexities and challenges of on-the-ground implementation, the data used in the impact assessment was limited. As of April 2024, only three out of the eight quadricycles have been completed and delivered to Pasig city government but only two have been trialed by end-users. In between deliveries, back and forth modifications to the e-quads were made to fit to the local conditions and need of the end-users. Delays in the global supply chain during and post-pandemic had a negative impact, as well as the high-volume requirement of some suppliers for vehicle parts which made it difficult for the local manufacturer to source the needed parts for the e-quad. There were also customs delays for imported parts of the e-quad.

During the pilot, the performance of the e-quadricycle was not in the optimal state due to performance issues. The said issues were found out to be caused by incompatibility of the imported motors and the battery. Because of this, the e-quadricycles only recorded a 35km per day VKT instead of its indicated range of 40km in the specifications.

Despite limited number of available vehicles and limited data gathered, preliminary assessment of the e-quads was conducted. The e-quadricycles are compared directly to the city government's existing APV, currently used for transporting medical supplies and personnel.

Overall, the impact assessment results show that the e-quadricycle is more cost-effective and has less impact to environment due to its low emissions and less

[9] Worldbank 2022 report Country Climate and Development Report: Philippines

perceived noise. The financial assessment showed that the e-quadricycle is easily the more cost-effective with a CER-VKT value of 55.76 pesos/vkt compared to the 75.07 pesos/vkt of the APV. In terms of impact to environment, replacing the APV with an e-quad provides an emissions mitigation of 2.2368 tonnes CO2/yr. More precisely, one single unit of APV produces 2.674 tonnes CO2/yr while one e-quad has 0.4375 tonnes CO2/yr.

Assessments of the social indicators show that e-quad received mixed feedback from end-users and stakeholders. The e-quad was seen favorably in terms of being less noisy, being relatively safe and thereby improving road safety, easier to drive by non-professional drivers, more suitable for city-driving within Pasig city, and the more effective vehicle for first-and last-mile passenger and freight transport. These were based on interviews from stakeholders including experts, as well as end-users such as drivers and passengers of the e-quadricycles. Understandably, the open design of the e-quad was a factor that made it seem less favorable in some social indicators including comfort (preference to air-conditioned units in a tropical climate), adaptability for adverse weather conditions (e.g. flooding issues) and safety (due to build and open design increasing risks to riders), among others.

To materialize a significant emissions reduction from transport sector in cities like Pasig, it will require a full replacement of public transport tricycles to electric vehicles[10]. And the pilot demonstration vehicles, e-quadricycle, is a good electric vehicle candidate for replacing the existing ICE public transport tricycles. As demonstrated in the emissions model, a significant reductions potential is seen in the scenario where public transport ICE tricycles are electrified.

[10] Based on own estimations calculations using LEAP-IBC, see Assessment of scaled up KPIs for discussion

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