DRAFT - NOT TO BE CITED

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This is an interim draft that has been completed prior to the implementation of demonstrations in cities and was finalised based on individual city reports (status as of 31 March 2021)

Working Paper: Impact Assessment - PASIG CITY

Background and context

The City of Pasig is one of the 17 cities and towns that comprise "Metro Manila." By virtue of the Republic Act 7829 ratified in 1994, Pasig was classified as a highly urbanized city (HUC). Highly urbanized cities are declared as autonomous from provinces and have a minimum population of 200,000 and an annual income of at least 50 million pesos. It has a population of 755 thousand which is about 5% of the total population of Metro Manila, according to the 2015 National Census. It is home to Ortigas Centre, one of National Capital Region's (NCR) premier financial districts, as well as several commercial, manufacturing, and residential zones. In addition, the City's location in the urban realm is highly centralized.

Geography and the social/urban context
Location

Pasig City is located in the Metro Manila which is situated in the centre of the Island of Luzon in the Philippines.

Topography

Pasig is generally flat, characterized by level to undulating slopes with gradients ranging from 0-5%. All barangays (smallest unit of government) have 0-2 percent slope, except Bagong Ilog, Pineda, Kapitolyo, and Oranbo (Pasig City Government, 2015). The elevation of Pasig City is approximately 1.00 meter below mean sea level. In some cases, invert elevation of drainage system is lower than the sea level. A back flow of waters is being experienced in the Poblacion especially during the rainy season.

Climate

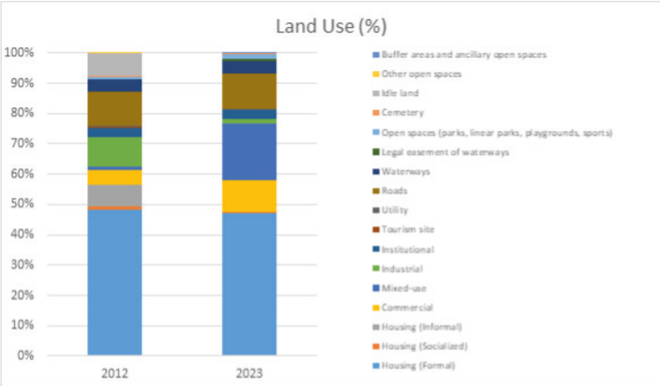
The City of Pasig generally falls under Type III category of the Modified Coronas Classification that has no very pronounced maximum rain period with a dry season lasting only from 1 to 3 months either from December to February or from March to May.

Population

Pasig City's population was registered at 755 million in 2015 and had grown at an annual rate of 3.81% per year in the period 2010-2015 (second highest population growth rate in Metro Manila's 17 cities). The weighted average population density is calculated to be at 65 thousand people per square kilometre in 2015 (or 658 people per hectare). Some barangays have witnessed immense growth rates in population between 2000-2015 (up to 11% annual growth rate).

Land Use

The existing Comprehensive Land and Water Use Plan (CLWUP) of Pasig City estimates that at least 57% of the land area of the city is dedicated to housing in 2012. Five percent (5%) of the land was allocated to commercial purposes, 10% for industrial areas, 11% for roads, and 1% for mixed use. A fundamental shift towards mixed use areas has been outlined by the said plan, which aims to increase mixed use areas to 17% by 2023.



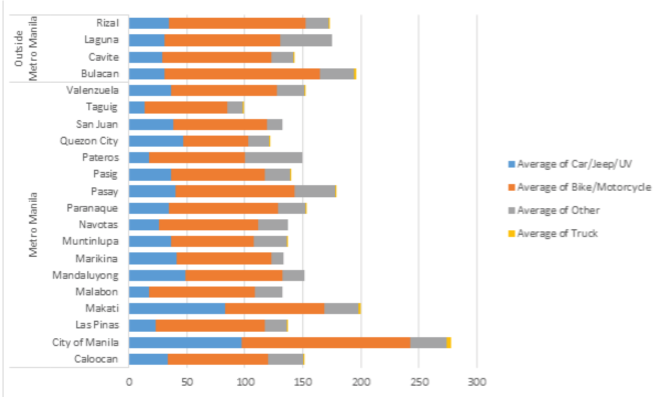
Economy

The economy of the City is primarily composed of activities within the secondary (Manufacturing; construction; mining and quarrying; electricity, gas, water generation; light and heavy manufacturing) and tertiary (Wholesale and retail trade; financial and insurance related activities; transportation and communications; personal and community services; warehousing and storage; real estate; food provision; accommodation services; tourism services) economic sectors:

In terms of competitiveness, Pasig ranked 6th out of 145 cities in the 2018 Cities and Municipalities Competitiveness Index. It ranked 4th in terms of taxes collection among the cities in the country. The City also ranks 5th in terms of assets owned, and ranked 4th in total expenses (2017).

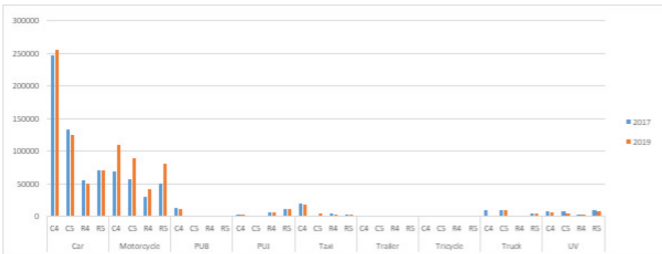
Urban transport
Motorization

The Japan International Cooperation Agency (2015) estimated that there are about 140 registered vehicles per 1000 people in the City of Pasig. This is slightly lower than the overall average in Metro Manila (163 vehicles/ 1000 people). Sixty percent of the vehicles owned are motorcycles.



While there is no official city-specific vehicle registration data available in the Philippines, the official vehicle registration data for Metro Manila provides us insights on the overall trends. The data from the Land Transportation Office shows significant growth in the motorcycle population in Metro Manila. From 2015-2020, the motorcycle fleet has grown at an average of 19% per annum, as compared to 1% growth in cars, and 9% growth in SUVs. The new motorcycle registrations had grown an astonishing rate of 37% per annum within that period. The drastic rise in motorcycle ownership is potentially driven by factors relating to increased economic capacities and access towards owning such vehicles, the low quality of service levels and connectivity of public transport modes, and the glaring comparative advantage of motorcycles in traversing the heavily congested transportation network in the Metropolis.

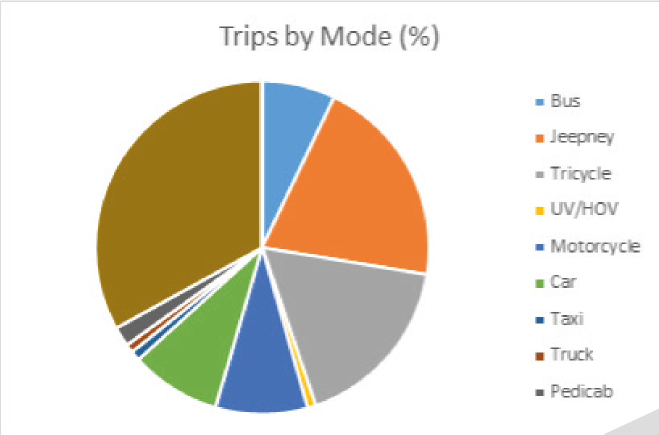
Similarly, the vehicle traffic observation data (annual average daily traffic) in points located within the City of Pasig shows the rapid increase in the motorcycle activity.



Source: MMDA (n.d.)

Mode shares

There are no available studies that readily provide the mode share of trips within the city of Pasig. However, a study that was done by JICA (2015) estimates the following distribution of trips by mode for the Mega Manila area (consisting of Metro Manila and adjacent provinces).



The same study estimates (through Mega Manila-wide household surveys) that the trip generation rate per capita is 2.24 trips/day. Using projections based on the previous Philippine Census data, in combination with the trip rates, it is estimated that roughly 1.7 million trips per day had been generated in Pasig in 2019. This figure is estimated to increase to around 2 million per day in 2030.

Public Transportation Services

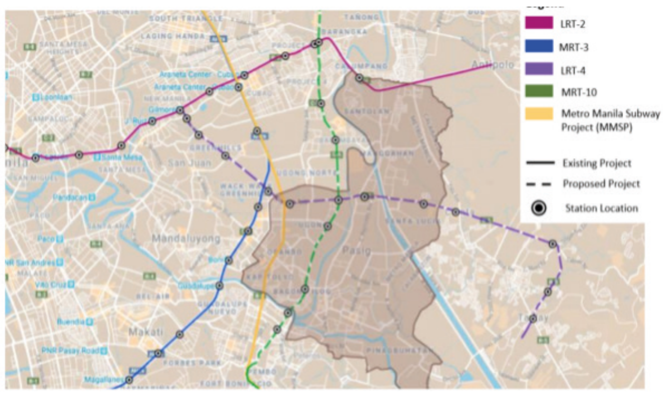
Based on a recent report of Systra Philippines (2019), there are over 16 thousand public transportation vehicles that are operating in the Pasig area:

Public Transport Mode	Intra-City	Inter-City
UV Express	775	128
Public utility jeepneys	3,271	866
Public utility buses	8	260
Tricycles	11,367	
Total	15,421	1,254

Two major urban rail transport lines are near the City: Manila Metro Rail Transit Line 3 (MRT-3) and Light Rail Transit Line 2 (LRT-2). MRT-3 is a high-capacity rapid transit system serving the corridor of Epifanio delos Santos Avenue (EDSA) while the LRT-2 is likewise a major high-capacity rapid transit line that serves the north eastern side of the City.

There are also proposed mass transport projects that are meant to traverse the City of Pasig:

- The Metro Manila Subway is an approved 36-kilometre underground rapid transit line which is expected to finish by 2026 (estimated to partially open by 2022). It will run from the North to South of Metro Manila, traversing 5 Cities including the city of Pasig.
- The LRT 4 is a national government approved monorail rapid transit line project (18 kilometres in total) that traverses Metro Manila from East to West. Five of the proposed stations for LRT 4 are located within Pasig.
- MRT 10 is the proposed rapid transit line whose proposed alignment is also partially located in Pasig.



Source: Systra (2019)

Urban Freight

Urban goods movement is a topic that has yet to gain the attention of policymakers, as well as the academia (among other stakeholders) in the Philippines. The available studies – particularly those that had been implemented as part of the project development cycle for large infrastructure initiatives – are primarily looking into truck traffic. In case of Pasig, the City is estimated to generate around 5% of truck traffic in the MUCEP (Metro Manila and adjacent cities) area (15 thousand truck trips per day). Providing increased attention to urban freight should become more of a priority, particularly with the continued increase in e-commerce in the country as depicted in the table below:

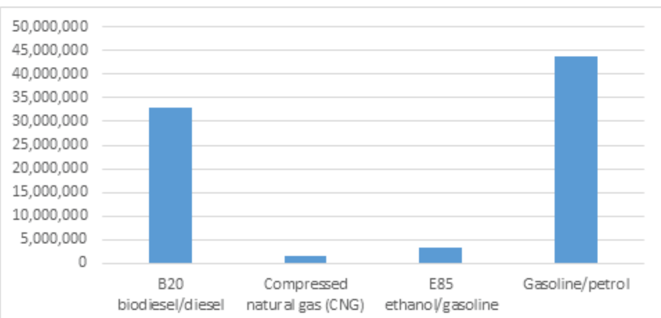
Total number of people purchasing consumer goods via e-commerce	47.30 million	+3.5%
Value of consumer goods e-commerce market	840 million USD	+22%
Average annual revenue per user of consumer goods e-commerce	18 USD	+18%

Source: Businesswire (2019)

Another significant trend to is that private entities (including individuals) are being tapped to provide delivery services for major e-commerce companies, without significant requirements (no experience, basic vehicle requirements) embedded into the approval process.

Identification of main problems
Emissions and Air Pollution

The City of Pasig, supported by the Ambitious City Project, has drafted a community-level GHG inventory for the year 2017. The study estimates that 170,948 tons of CO2e were emitted by on-road transportation in 2017 (12% of community-level GHG emissions). The estimate was based on fuel sales data from fuel station operators as shown below:



Source: Pasig City, ICLEI (2019)

It must be noted that the methodology used does not distinguish whether the fuel was burnt (and thus, emissions released) inside the Pasig City boundaries, and what type of vehicle consumed the fuel.

Congestion
A recent self-evaluation survey with local government units (LGUs) in Metro Manila, facilitated by the Metropolitan Manila Development Authority (MMDA) reveals that Pasig City has more than 30 traffic bottleneck locations (Laurel, 2019). It must be noted though, that the management of road traffic in the cities in Metro Manila is complicated, as the LGUs, MMDA, and the police are all involved in the process. Metro Manila has been regarded as one of the most congested cities in the world. For example, ADB (2019) estimated that Metro Manila ranked number one in congestion across 278 cities in Asia (Business World, 2019).

Passenger transport services

The provision of integrated, high quality urban public transport services in Philippine cities has proven to be quite a challenge that is underlined by various factors (e.g. multitude of modes, complex governance structures, high penetration of informality, lax regulations and enforcement, lack of integration in planning, among others).

Public transportation services may not necessarily be able to meet demand that considers the temporal and geographical nature of the activities that people need to make. It is not uncommon to see demand not served by the supply at peak hours, and to see almost empty public transport vehicle fleets running at non-peak hours.

Image by Alvin Mejia

In Pasig, for example, CTDMO has mentioned that there are specific areas that are experiencing heavy discrepancies in terms of the supply and demand for last-mile services (e.g. tricycles) particularly in the late hours of the evening. This might be driven by the higher numbers of employees performing night shifts (e.g. business outsourcing platforms). Commuting through public transport is almost impossible for many vulnerable users, particularly those that have major physical constraints. There had been recent programs by the national government (such as the Public Utility Vehicle Modernisation Program) that aims at transforming the public transport sector, but these still need to be fully realised.

Urban mobility is also challenged heavily by institutional matters. The Philippines is currently transitioning towards more substantial involvement of the local governments in mobility planning (i.e. the determination of public transport routes). Historically, cities had only been tasked to regulate and govern their local tricycle sectors. Pasig, for example, instituted a Tricycle Replacement Program that led into the elimination of old 2-stroke tricycles in the city. They are now looking into supporting the transition towards e-tricycles as well.

Freight transport services (if applicable)

As mentioned in section 1.1.2. there is not much data, nor existing studies focusing on urban freight in the Philippines. The lack of such does not curtail the importance of addressing the challenges that are normally associated with urban freight. Freight trucks, for example, have been implicated as key sources of on-road emissions in various parts of the globe. Their contributions to environmental pollution are magnified if these large trucks operate in carriageways which are not primarily designed to handle large vehicles. Loading and unloading activities, as well as manoeuvring of large trucks can cause bottlenecks, which can then exacerbate pollution. They can also pose safety concerns for other users of the roads.

Photos by Dorothy

As with passenger transport, the urban freight transport scene in the Philippines (like in many developing countries) feature different vehicles. While there are those vehicles that are registered for use in cargo movement, this process is now being blurred by new mechanisms that enable private citizens to engage in urban freight deliveries, as contractors to e-commerce companies.

Description of demonstration project

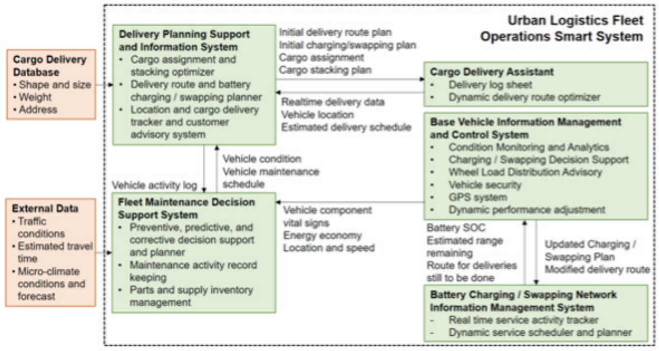
The demonstration in Pasig will focus on integrated and shared urban logistics solutions, as well as investigate the potential for public charging solutions. The activities on-the-ground will also include those that aim at improving the enabling conditions for e-mobility, and enhancing local capacities related to e-mobility.

Locally Developed/Assembled E-Quadricycles
The SOL+ demo will aim at producing and testing multi-purpose urban electric quadricycles that are suited to the local conditions.

These quadricycles combine the nimbleness of smaller vehicles and the carrying capacity of larger vehicles that are currently being used in conducting urban deliveries in Pasig (e.g. motorcycles, cargo tricycles, and mini vans). An example of a small L6 cargo quadricycle is provided on the picture on the right.

The quadricycle will also be designed to have a base that can carry different types of cargo, as well as passengers.

The SOL+ vehicle is intended to feature a base vehicle information management and control system which will provide information needed for condition monitoring and analytics, charging/swapping decision support, wheel load distribution advisory, vehicle security, GPS system and dynamic performance adjustment. The vehicle will track real-time monitoring of the vital signs, key components and operational parameters which will be sent periodically to a Fleet Maintenance Decision Support System which is envisioned to integrate machine learning features to better understand its performance, specifically energy consumption and parts degradation, vis a vis various operational conditions including traffic conditions, vehicle load wheel distribution, climate conditions and driver behaviour. The information will also be processed continuously by the tool to prompt the driver for any urgent technical intervention to prevent further technical damage and operational disturbance. Wheel loads will be monitored by the system and prompts the driver whenever load distribution goes beyond acceptable ranges for good energy economy and vehicle stability. It shall also provide the driver intervention recommendations in including cargo stacking and/or wheelbase adjustments. The system will also be responsible for sending the initial delivery route plan at the start of a working day and real-time location, battery SOC and estimated remaining range to the Battery Charging/Swapping Network Information Management System. The system will have the option to automatically adjust vehicle performance as needed to extend battery range as needed. This module will automatically prepare a battery / charging swapping strategy at the start of the delivery day for each unit based on the forwarded initial delivery route plan and considering charging and swapping station locations and the battery module inventory. It will make further necessary changes on the strategies of the vehicles based on real-time operational status and technical considerations (e.g. SOC, remaining battery range, delivery status). The system therefore consolidates charging / swapping demand and supply capability and intelligently generates dynamic charging / swapping strategies for each unit.



A "shared vehicle use" concept will be investigated for feasibility in the Pasig pilot. This concept would centre on the shared use system that would feature the use of the vehicles by PHLPost, the Pasig City Government, and by other private entities. The specific modalities by which the vehicles would be shared are being investigated.

Flexible Electric Van

SOL+ will also be supporting a proposal being led by the De Lasalle University to a funding mechanism of the Department of Science and Technology to develop a "flexible electric van" (FLEV proposal) which features a chassis that can be used for multiple purposes (e.g. passenger/ cargo). Essentially, the vision is to make the FLEV also compatible for handling the cargo boxes to be used in the SOL+ quadricycles. SOL+ can provide a couple of units of the Valeo motors to the FLEV proposal. The use of the FLEVs within the Pasig City Government, PHLPost, and other private entities are currently being investigated. In the case of Pasig City, the FLEVs can be suited for the operations of the General Services Office (GSO) and the medical depot.

Relevant stakeholders and user needs

A user needs assessment process was recently conducted to gain insights regarding the aims and needs of relevant stakeholders in Pasig City, including local and national level entities.

Institution	Short Name	Category
Philippine Postal Corporation1	PHLPost	Project partner/ Government-owned and controlled postal services provider; end-users
Department of Energy	DOE	National government
Department of Environment and Natural Resources	DENR	National government
Department of Transport - UNDP Low Carbon Transport Project	DOTR-UNDP LCT	Development agency
City Transportation Development and Management Office	CTDMO	Project partner/ City government
City Environment and Natural Resources Office	CENRO	City government
General Services Office	GSO	City government
Medical Depot		City government
Tricycle Operation and Regulation Office	TORO	City government
Medical depot		City government
Clean Air Asia	CAA	Civil society organisation
Senior Citizens' Association – Barangay Sta. Lucia		Other; end users
Tricycle Operators and Drivers' Association – Driver	TODA	Other; end users
Commuters		Other; end users

Online Survey

The online survey conducted with the relevant stakeholders reveal the following insights:

Dimension	Description
User and user acceptance of e-vehicles	The top scoring goal related to "usage and user acceptance" of e-vehicles are (1.77): to study the acceptance and perceptions of e-vehicle services"; and to increase the share made with public transport. These are also quite related to the second highest goals relating to the analysis of costs of implementation, and increasing the trips made by e-vehicles.
Mobility patterns	In terms of influencing mobility patterns, the respondents, rated the provision of stable transport services as the highest aim, on average (1.85).

City environment	The reduction in CO_2 emissions is rated as the top aim in relation to the city environment (1.85). This closely followed by the aim towards developing road infrastructure for e-vehicles (1.62).
Quality of life in the city	Improving public health was rated as the highest in terms of aims relating to the quality of life in the City (1.92), followed by improving the liveability of the city in general (1.85).
Target use case for e-vehicles	The results of the survey shows that the respondents expect or are envisioning the penetration of e-vehicles in different use cases: passenger (yes = 13); goods (yes = 10, with 9 respondents stating yes to last mile deliveries). Two respondents mentioned that e-vehicles would be used for the conduct of local government services/operations.
Areas of operation	Twelve (12) out of the 13 respondents expect that e-vehicles would be operating within the city centre. Five of them envision that e-vehicles will be used in subur-ban areas. Two (2) respondents expect that they would also be used in rural are-as, and 1 respondent say that e-vehicles would be used in all the three area types.
E-passenger transport: target user groups	Majority of the respondents think that e-mobility should target all citizens in the city (10 of 13).
Passenger transport: Types of Trips	All the respondents agree that e-vehicles will be adopted in the conduct of commuting trips. Twelve (12) respondents agree that e-vehicles will also impact job-related trips, and 10 respondents believe that e-vehicles will also impact school trips. One respondent mentions that tourism trips would also be influenced.
E-goods transport: user groups	Eleven (11) of the respondents expects that the city government would be using e-vehicles in its own goods distribution-related tasks.
Service operator	The respondents were asked about their sentiments as to which type of organisation should be the main service operator of e-vehicles. Eight (8) respondents chose the “city government”, and “other private service operators” respectively.
Obstacles, limitations, and barriers	The top challenges that hinder implementation of e-mobility initiative are infrastructure investments needed (12), followed by (11) the low acceptance of e-vehicles by actors (e.g. transport service operators, drivers, authorities).

Expert Interviews

The interviews were asked about the aims that their institutions have in relation to e-mobility, as well as the expectations that they have in relation to the SOL+ project (e.g. demonstration components such as the e-vehicles and charging solutions), and e-mobility in general. The following are the key points that had been mentioned by the interviewees:

Aims

- e-mobility to support their initiatives towards mitigating the negative externalities of urban transport in the City
- understanding the feasibility of transformations that can be brought about by e-mobility
- understanding the financial implications of e-vehicles if integrated into operations
- e-mobility can support wider initiatives towards reducing emissions from road trans-

port, alleviating heavy reliance on imported petrol, and contribute towards wider transport systems transformation

Expectations

SOL+ Demo

- demo to act as a testbed for viable e-mobility solutions
- open opportunities for generating private sector support
- find synergistic opportunities to cooperate with other initiatives

Vehicles

- compatible with current commercial electric vehicle technology standards
- use of lithium-ion batteries

- cheap to maintain
- energy efficient
- provision of maintenance support, and after sales service
- can be used for different purposes
- flood resistant

Charging

- centralized common charging stations be explored
- fast charging solutions to be explored
- accessibility to charging stations to be given priority
- consider proper user interfaces
- explore battery swapping
- consider importance of proper space allocation and practical design considerations

Regulations/Policies

- Pasig City is updating guidance on bicycle-related ordinances and active transport to consider e-bikes, electric kick/standing scooters, and other similar light electric vehicles
- CENRO shared that the City of Pasig has implemented a Tricycle Upgrading Ordinance (2016) which eliminated the 2-stroke tricycles in the City.
- The City is also looking into potential options for incorporating e-mobility considerations (e.g. provision of charging facilities) into its Green Building Ordinance (2016).
- The DoTr is currently implementing the PUVMP which sets standards for public transport vehicles (as well as their operations).
- The draft "Administrative Order on the Registration and Recording of Electric Vehicles" of the Land Transportation Office (LTO) which is still officially under review is a critical regulation to monitor.
- Department of Finance's Bureau of Internal Revenue (BIR) has begun using DENR certification in 2018 to determine whether the EVs qualify for tax exemptions following the issuance of BIR Revenue Regulations (RR) No. 24-2018 in November 2018.
- The DOE has issued Department Circular Number DC2020-10-0023 and is scheduled for publication soonest. The DC prescribes the policy framework for the fuel economy rating, fuel economy performance, and related energy efficiency and conservation policies for the transport sector and other support infrastructures.
- Used lead acid batteries are just among the hazardous wastes being regulated by the Department Administrative Order 2013-22.

Obstacles, Limitations, Barriers

- Proving the financial viability of integrating e-mobility solutions
- Perceptions of vehicle users on the performance/reliability of e-vehicles (including range anxiety, battery safety)
- Lack of clarity in the registration process for e-vehicles
- Lack of charging infrastructure
- high acquisition costs of EVs
- limited knowledge on the sustainability of EV operations
- recovery of costs and sustainability of operations
- lack of supporting policy and budget, red tape, lack of institutional buy-in

Sustainability of the e-Mobility solutions to be implemented

- use components that are of high quality to ensure longevity of the hardware
- after sales service is critical
- engaging key stakeholders is critical
- provision of supportive policies from

the LGU, as well as budget, capacity building and infrastructure support

Impact on Existing Business Models

- vehicle range would play a key role in determining how the e-quads can be integrated into the operations
- the charging modality is key (e.g. minimizing vehicle down time during operations due to charging)
- need to be creative in designing possible revenue streams
- At a wider level, e-mobility will generate new jobs in the design, manufacturing, assembly, repair, and maintenance of electric vehicles, and charging stations. Such a transition would require skills upgrading of workers to be able to meet the demands of the industry.
- mobility can deliver business benefits through the enhancement of the safety and quality of services, and the company's image

Implications for Planning and Urban Development

- The SOL+ demonstration can build momentum for e-mobility by showing people that everyday e-mobility applications extending beyond simple private ownership can be built in the Philippines.
- Introducing charging, e-vehicle sharing and business use of e-vehicles into the landscape of possibility, it would help make large steps towards higher e-vehicle adoption.
- There is a need to integrate e-mobility into relevant local plans such as the comprehensive land use plan, GHG management plans, and green route plans

Key Performance Indicators (KPIs)

Prioritization of KPIs addressing the specific city needs

As explained in 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 organized in relation to the user needs analysis. The procedure described in Section 2.1.4 was followed for 6 stakeholders, representing 3 stakeholder groups (refer to Section 5.1.5). The Pasig City team is still in the process

Level 1	Level 2	Level 3	PASIG
Effect on project finances	Financial viability	NPV (Net present value)	2.71
		IRR (Internal Rate of Return)	2.75
		Payback period	3.39
	Availability of finance	Ease of raising external funding	9.03
Effect on institutional framework	Coherence with plans/goals	Coherence with national plans/goals	5.63
	Alignment with legislation	Alignment with legislation	5.52
	Ease of implementation	Ease of implementation	6.35
Effect on climate	Effect on GHG emissions	Effect on GHG emissions	15.99
Effect on environment	Effect on air pollutants	Effect on NOx emissions	2.86
		Effect on PM2.5 emissions	3.07
	Effect on noise	Effect on noise	4.80
	Effect on resource use	Effect on recycled resources	5.52
Effect on society	Effect on accessibility	Effect on accessibility (passengers)	1.02
		Effect on accessibility (freight)	1.10
	Effect on affordability	Effect on affordability	2.15
	Effect on travel time	Effect on travel time (passengers)	0.81
		Effect on travel time (freight)	0.91
	Effect on road safety	Effect on major accidents	0.62
		Effect on minor accidents	0.59
		Effect on near accidents	0.59
	Effect on charging safety	Effect on charging safety incidents	1.96
	Effect on security	Effect on security incidents	1.75
	Effect on well-being	Effect on well-being (active travel)	1.92
	Effect on service quality	Suitability for climate changes	0.28
		Perceived comfort	0.26
		Perceived drivability (prof. drivers)	0.27
		Perceived drivability (end users)	0.27
		Perceived chargeability	0.28
		Perceived safety	0.28
		Perceived personal security	0.24
		Perceived transhipment quality	0.24
Effect on wider economy	Effect on budget	Effect on budget	6.17
	Effect on external trade	Effect on fossil fuel imports	2.83
		Effect on other imports	2.38
	Effect on employment	Effect on jobs	2.76
		Effect on wages	2.69

of getting more stakeholders to take part in the KPI weighting.

KPI estimation methods and data needs

The table below depicts the data needs that would be relate towards the estimation of the KPIs, and the intended methods for collecting these data.

Baseline scenario

This section describes a baseline scenario for road transportation in the City of Pasig. The scenario primarily reflects a continuation of the status quo, but also considers further improvements and policies (e.g. evolving emission standards, etc…). These initial estimates are generated primarily by using the Emobility calculator of the UNEP. Historical data that have been collated by international organisations (e.g. IMF, UN), as well as those collected by national government agencies (e.g. Department of Transportation, Department of Energy) were utilized when deemed necessary. Other figures needed for running the calculations were taken from existing studies (e.g. JICA, 2015; Mejia, 2016; Mitsubishi, forthcoming).

Socio-Economic

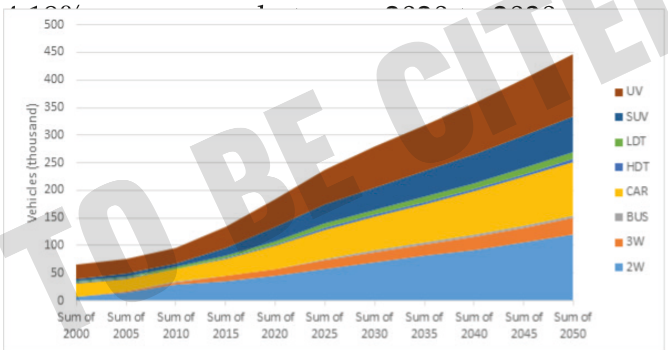
Country level GDP and population projections were used as primary input into the UNEP E-mobility calculator which enables the quick assessment of orders of future vehicle fleet numbers, energy consumption and emissions impacts.

	GDP (PPP USD Billions)	Population
2000	261	77,652
2005	367	85,821
2010	514	93,444
2015	744	101,803
2020	1,147	110,404
2025	1,299	119,219
2030	1,534	127,797
2035	1,768	135,919
2040	2,002	143,516
2045	2,236	150,591
2050	2,470	157,118

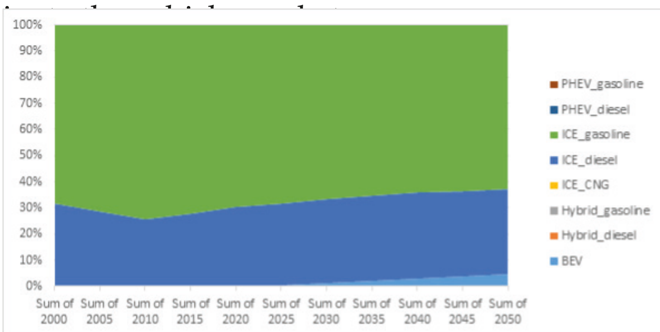
Existing trends in passenger/freight transport

Vehicle Fleet

Estimates for vehicle registration (and sales) were calculated by downscaling registration numbers for Metro Manila to Pasig City using multipliers that were calculated through the JICA (2015) study. The estimates suggests that vehicle registrations will grow at roughly

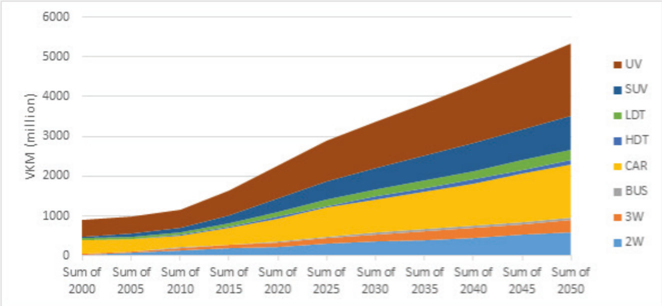


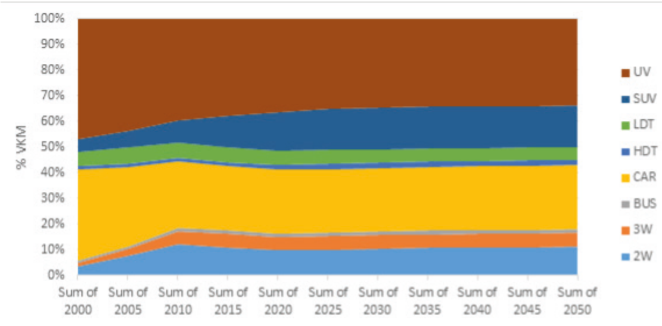
The baseline scenario adopted in this exercise reflects low levels of support towards emobility transformation, and thus it is assumed that ICE petrol and diesel vehicles will continue to dom-



Vehicle Activity

The vehicle-kilometers (VKM) estimates for 2020-2030 period show similar trends with the vehicle stock estimates and are expected to increase by 4.07% per annum during the period. The SUV segment is estimated to have more significant contributions to the VKM shares due to the strong increase in sales in the recent past.

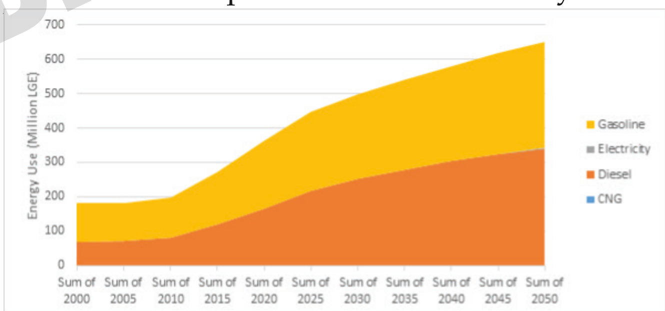




Baseline values

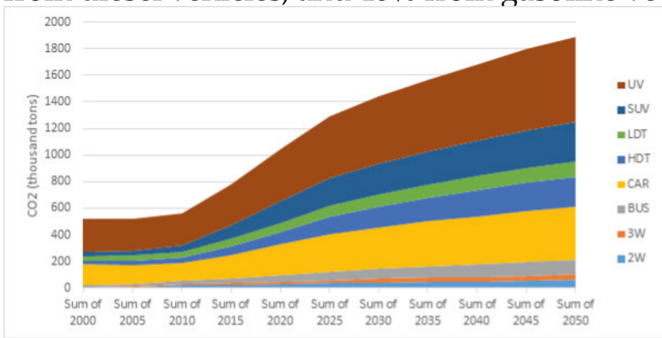
Energy Use

Energy use from road transport is estimated to grow at an annual average of 3.23% between 2020-2030 (362 to 498million LGE). Less than 1% of the consumption will be from electricity due to the low penetration of emobility in the

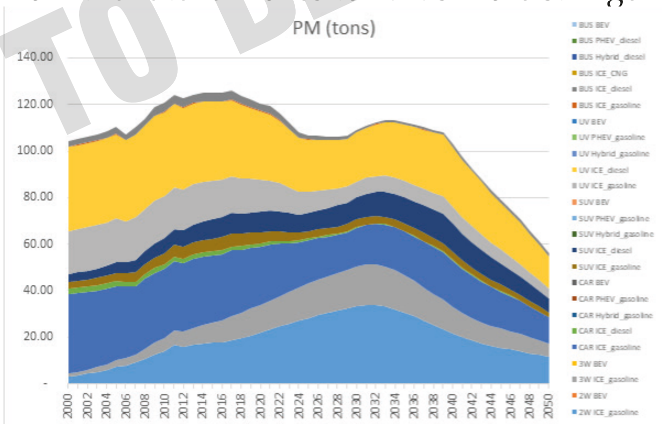


CO2 Emissions

As CO2 emissions are primarily a function of complete combustion (also considering that the baseline scenario is primarily a fossil-fuel based scenario), the general trends follow those of energy use. CO2 emissions are expected to grow at 3.27% between 2020-2030. In 2020, the estimated CO2 emissions is at 1 million tons, and will grow to 1.4 million tons by 2030. Fifty-two (52%) percent of the emissions would be from diesel vehicles, and 48% from gasoline ve-

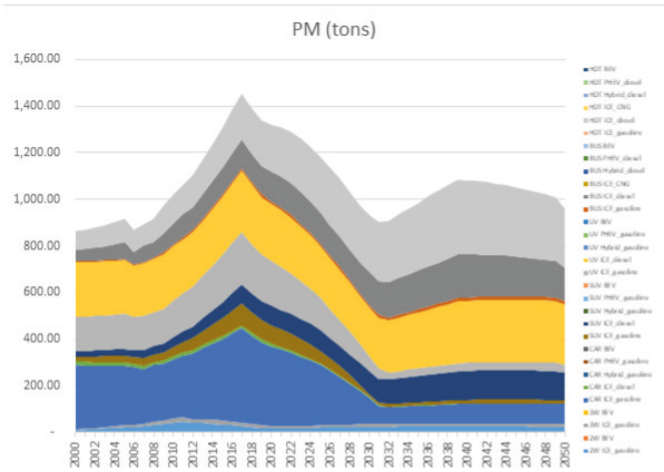


Particulate matter emissions are estimated to decrease by 1.3% per year between 2020 and 2030, and further decrease at 3.1% between 2030 and 2050. These are primarily the benefits from the future moves towards more stringent



NOx Emissions

NOx emissions are estimated to decrease at an annual rate of 3.5% between 2020-2030, but will again increase on average, between 2030-2050.



Ex-ante assessment of the SOL+ demonstration project

Expected Output

The direct outputs of the Pasig demonstration projects are:

- Up to 2 prototype units and 15 pre-production units of multi-purpose e-quadricycle (L6) vehicles
- Fleet and operations monitoring and decision support system
- Accompanying system that enables "sharing" of the e-quads

The basic functional requirements of the project components are the following:

- Vehicles to comply with applicable local laws and regulations (operations, vehicle classification, safety, environmental)
- Size must enable it to navigate through limited street widths with ease
- Power must be sufficient to allow it operate in areas with high inclination angles
- Customizable rear portion for accommodating both urban freight and passenger transport tasks
- Passenger vehicle configuration must consider PWD accessibility
- Maximum speed should be below 40 kmph (slow urban operations)
- Loading capacity should be able to handle operational requirements both as a passenger and urban freight vehicle (at least 300 kg payload)

- Battery capacity should be able to accommodate intended daily routine and activities (~70 kilometers per day as a passenger and an urban freight vehicle)
- Appropriate vehicle performance monitoring system needs to be integrated in order to aid data collection and optimize vehicle performance
- Similarly, a fleet maintenance decision support system that will aid preventive and corrective maintenance is also needed
- Security features to be embedded into the vehicles.
- Charging system to include an information management system and interface is needed to aid charging management
- Charging system to comply (at the minimum) with applicable local standards and regulations
- A ride hailing application (and associated services such as payment and routing) is needed in order to facilitate the booking of trips

Vehicle

Vehicle class	eL6 (electric quadcycle)
Drive system	full electric central drive
Peak speed	30 kilometres per hour
Vehicle dimensions	2,600 mm x 1,200 mm x 1,600 mm
Curb weight	130 kg
Load capacity	270 kg
Gross weight	400 kg
Load volume	max 1.5 cubic meter
Chassis built	steel ladder type
Body material	ABS/FRP composite
Climbing capacity	8- 12 degrees
Suspension	combination of coil-type suspension and leaf spring
Transmission	direct drive

Motor

Make	Valeo
Model	e-Access
Rated power	2 kW
Peak torque	550-1100 Nm
Rated speed	3000 rpm
Weight	22 kg
Lifetime	>10000 hrs
Maintenance	3,500 hrs
Motor max efficiency	95.1%

Battery

Chemistry	Lithium ion
Battery cell type	Prismatic
Charger rate	3 kW or 6 kW
Energy storage capacity	6.5 kWh
Battery module voltage	48 V 70 Ah or 48V 140 Ah or 60V 70Ah
Cooling	Air cooled
Cell weight	1.55 kg
Impedance	≤0.7mΩ

Cell dimensions	36.2 mm x 115.2 mm x 200 mm

Aside from the e-quadricycles, the demonstration will also feature the FLEVs which are to be produced under the DOST FLEV project. These vehicles are to feature 48V motors from Valeo. The testing of the FLEVs will be done in cooperation with the SOL+ local team in Pasig. The assessment, however, will not be included in SOL+, but will be handled through the DOST project.

Planned Input

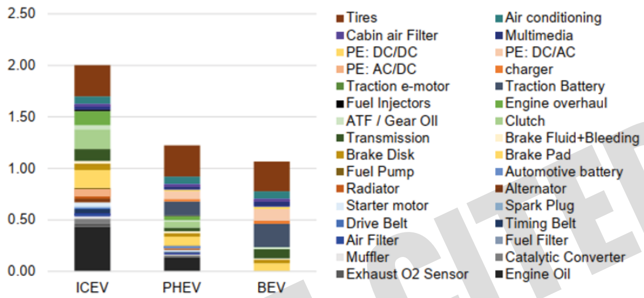
The inputs required for the demonstration are broadly defined in the table below:

Category	Description
Human resources	Cooperation with the various targeted user entities is required. The local SME which will be engaged will also play a crucial role, particularly in the development of the vehicle, and ensuring that these would align with the needs of the users and are optimized to fulfil the tasks as required by the user cases (passenger, cargo, utility).
Fixed assets	Land and facilities (i.e. Pasig City Government, target users)
Capital goods	Equipment and tools

Expected impacts

Financial Impacts

The e-quads are expected to deliver lower operating costs as compared to the other existing alternatives, particularly in comparison with ICE vehicles. The simulations considering local drive cycles, estimate that the e-quadricycle would achieve an average efficiency of 14 km/kwh (loaded). With an assumption (based on existing prices) of 6 PHP/kwh, the costs (PHP) per vkm is 0.43 cents. This is significantly lower than comparable alternatives (e.g. minivan is at 4.3 PHP/vkm; conventional tricycle is at 1.23 PHP/vkm). Maintenance costs are also expected to be lower due to the intrinsic advantage of e-vehicles having significantly fewer parts than ICE vehicles as shown in the figure below (Mitsubishi, forthcoming). The investment costs are still yet to be determined.



Source: Mitsubishi et al. (forthcoming)

The financial feasibility will also be influenced by changes in the operations that are expected to result from the use of the quadricycles. While these changes are expected to be different for each type of application, these would primarily be brought about by the change in vehicle capacities, ease of loading/unloading, increase in the utilization periods of the vehicles, reduced downtimes, and the supporting smart system modules.

- Socio-economic

The pilot project can potentially demonstrate how the use of such solutions can potentially lead to wider socio-economic benefits, particularly if significant levels of scaling-up is achieved.

Economic

The potential economic impacts of a strong push for a localized e-mobility industry have been estimated by Mitsubishi (2019), with the key points summarized below:

- Effect on budget - A strong shift towards local production of e-vehicles would lead to decreased tax revenues in total (as opposed to an importing model). However, collections could be improved if EV production is also localised.
- Effect on external trade – The scenario that reflects high importation rates results in expected increases in trade (export-import)

of the country and would negate the effects of reductions in fuel imports. The localisation of battery assembly and sourcing is expected to result in significant reductions in trade deficits.

- Effect on employment – Currently, the value of jobs associated with the supply, sales, and operations of ICEVs (internal combustion engine vehicles) is higher as compared to those associated with BEVs (battery electric vehicles) and PHEV (plugin hybrid electric vehicles). The manpower requirements for maintenance and fuel services are also higher for the ICEVs. However, the local production of EVs, and batteries are expected to boost job generation with value higher than the current estimates for the supply chain of ICEVs.

Social Impacts

The potential social impacts of the demonstration project are summarized below:

- Effect on accessibility – The demonstration project can improve overall accessibility as these are also intended to be used as shared, on-demand passenger vehicles which can: serve areas which have lower levels of access to public transport; vulnerable users (e.g. elderly and persons with disabilities – as the design is to be made PWD-friendly); serve as vehicles for night-time passenger transport services.
- Effect on affordability – While the overall affordability is yet to be determined (as part of the demo), the overall aim is to provide services to the final users which are comparable in terms of cost (if not lower) than the existing alternatives.
- Effect on travel time – The effect of utilizing the SOL+ vehicles in terms of travel time will heavily depend on the alternative that it is to be compared to. They are at a disadvantage – say, against minivans - if maximum speeds are to be considered, as they are to be designed as low speed vehicles. On the other hand, they are nimbler and can better traverse areas with narrow roads. As compared to motorcycles, the e-quads would be at a disadvantage, if we compare average speeds. However, if we consider the totality of the transport tasks to be done, the overall time required for completing such tasks might be significantly lower for the e-quad due to the advantage in capacity. Aside from travel time, benefits in terms of lowering loading times (for cargo applications) and waiting time (for passenger applications) will also be investigated.
- Effect on road safety – It is expected that the e-quads would present low risks on the road, primarily due to them being low speed vehicles. They would also be fitted with instruments that would ensure that they are safe to be operated on the roads, and safe for other road users to interact with them.
- Effect on charging safety – While the final charging modality is still being decided (battery swapping or using fast charging batteries). Safety will be ensured by adhering to standards and safety protocols. If successful, the demonstration can significantly lead to transformative insights that can address the concerns of existing EV users related to charging.
- Effect on service quality - The e-quads are expected to improve the provision of transportation services, particularly for vulnerable commuters through the provision of easily accessible transport services and safe journeys. The e-quads are also expected to result in improvements in the transport of goods by providing opportunities to improve overall operations, management, and monitoring.

- Environmental

Preliminary Calculations were conducted for estimating the potential direct impacts of the SOL+ quadricycles in Pasig City.

Urban Goods Movement

A theoretical total amount of daily maximum amount of cargo load was calculated based on the estimated capacity (cubic inches) of the quadricycles, average on-road speed, number of operating hours per day and average trip length as summarised in the table below.

Number of vehicles	15
Loading dimension (inches) - Length	60
Loading dimension (inches) - Width	40
Loading dimension (inches) - Height	35
Average speed (km/h)	10
Average operating hours per day	7
Average round trip length (km)	10

Max km per day/vehicle	70
Max trips per day/vehicle	7

The calculation exercise takes on the following assumptions to simplify the calculation of the potential impacts: the delivery tasks are to be done in a hypothetical setting wherein the average round trip is 10 kilometres; no delivery chains are reflected in the calculation; loads are simply treated in terms of total cubic inches (not number of parcels, etc…). The vehicle efficiencies are also static (average), and no dynamic projections of the emission factors were included in the analysis.

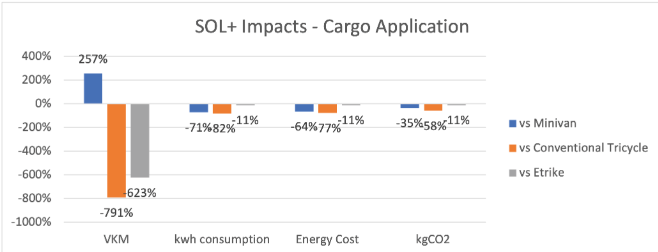
The resulting maximum load per day (SOL+ quad fleet) is 8.8 million cubic inches (84,000 per vehicle per trip). This same "demand" is used as a reference for calculating the impacts of the SOL+ quads. Essentially, the exercise asks what it would look like in terms of what the scenario might look like in case the SOL+ e-quads are not put in place. Three initial alternatives were taken into consideration:

- Gasoline minivan – In the case of PHLPost, for example, they utilize an old Japanese minivan for transporting cargo that would not fit into their motorcycle fleets;
- Gasoline three-wheeler – An illustrative example chosen as the use of three wheelers for moving urban goods is also a common practice in the Philippines;
- Electric three-wheeler – An illustrative example considering the developments in the use of electric three-wheelers in cargo delivery.

The changes in the vehicle activity (vehicle trips, vehicle kilometres), energy consumption, energy costs and CO2 emissions are brought about by the different characteristics of the vehicles used, primarily the vehicle capacity (as a function of vehicle dimension), fuel/energy efficiencies, unit cost of energy (e.g. electricity or gasoline). The number of vehicles under the demo baseline scenarios reflect the number of vehicles that would have been needed to perform the same amount of task to be done by the SOL+ fleet. Naturally, the minivans are bigger, and therefore, a lower number of these vehicles are needed to perform the same amount of task. On the other hand, the conventional and electric three wheelers (similar in capacity) are smaller than the equad, and therefore, more vehicles are needed to perform the same amount of task.

	SOL+	Minivan	Conventional 3W	Electric 3W
Loading dimension (inches) - Length	60	100	45	45
Loading dimension (inches) - Width	40	50	35	35
Loading dimension (inches) - Height	35	60	35	35
Fuel type	electric	gasoline	gasoline	electric
Efficiency (km/litre or km/kwh)	14	10	35	17
Number of vehicles	15	5	23	23

A multiplier of 330 (days in operation per year) was used to scale the daily figures into yearly figures.Please note that the activity levels used in the calculation processes reflect levels that are towards the maximum levels (to reflect maximum potential). The results of the exercise are visualized below in the graph below.



	SOL+	Minivan	Conventional 3W	Electric 3W
VKM	346,500	97,020	528,000	475,200
Vehicle trips	34,650	9,702	52,800	52,800
Total amount delivered (cubic inches)	2,910, 600,000	2,910, 600,000	2,910, 600,000	2,910, 600,000
kwh consumption	24,750	86,348	134,263	27,953
Energy cost (PHP)	148,500	417,186	648,686	167,718
kgCO2	14,603	22,315	34,697	16,492
Grams PM10	1,758	12,015	5,872	1,986

Grams PM2.5	1,031	10,772	4,339	1,165
Grams NOx	17,629	84,733	216,269	19,910
Grams CO	14,656	275,810	4,811,468	16,553
Grams SOx	27,616	281	507	31,190

Vehicle Kilometres
The total vehicle kilometres (VKM) are expected to increase by more than 2.5x against the minivan scenario. This is because the daily tasks (to be done by the 5 quadricycles) can theoretically be conducted using two minivans (which can carry approximately 2.5 times the load per trip than the SOL+ e-quad). While he e-quads fleet needs a total of 35 vehicle trips to deliver everything, the minivan fleet (2) only needs a total of 10 trips.

On the other hand, the SOL+ e-quad provides more capacity than the tricycles (approximately 1.5 times). It is estimated that at least 8 tricycles are needed to complete the assigned daily delivery amounts, corresponding to 53 vehicle trips per day.

Energy Consumption
The resulting gasoline figures (i.e. for the minivan and the gasoline tricycle) were converted into kwh using a conversion factor of 8.9 (NRCAN, n.d.) which enables direct comparison of the energy consumption figures for the different alternatives. Up to 109 MWh can be saved against the conventional tricycle, while 61 MWh can be saved against the minivan scenario. Three (3) MWh can still be saved as opposed to using e-tricycles.

Cost of Energy Consumed
The costs of electricity and gasoline were pegged at 6 PHP/kwh (business rates), and 43 PHP/ litre of gasoline. The magnitude of impacts in terms of energy costs are similar to the energy consumption. Up to 8,500 Euros/year would be saved compared to the scenario where conventional tricycles are used and the savings are around 4,500 Euros/year against the minivan. The e-tricycle alternative is quite similar in terms of energy costs, but positive savings of around 300 Euros/year is estimated.

Financial Impacts
Detailed estimations of the potential financial impacts of utilizing such e-quads in cargo operations would be needed. However, in the case of PHLPost, for example, the utilization of such e-quads can potentially transform their operations, as they can now cater towards servicing last mile parcel delivery. Currently, their urban operations (including in Pasig) are primarily relegated towards delivering letters. These e-quads would enable the company to engage in parcel delivery, due to the capacity, features, and low costs of operations.

Social Impacts
To follow.

Air Pollution Impacts
Default emission factors (translated into grams/kwh) were taken from Mejia (2016) for relevant vehicle types that reflect the defined baseline scenarios as shown in the table below.

	SOL+	Minivan	Conventional 3W	Electric 3W
PM10	0.071	0.139	0.044	0.071
PM2.5	0.042	0.125	0.032	0.042
NOx	0.712	0.981	1.611	0.712
CO	0.592	3.194	35.836	0.592
SOx	1.116	0.003	0.004	1.116

These emission factors were multiplied with the calculated energy consumption for each of the scenario. The table below shows the estimated amount of total emissions by pollutant (grams/year).

Significant air pollutant emissions savings can potentially result in the implementation of the demonstration project. However, it is noted that there potentially can be significant negative impacts in terms of the SOx emissions. This is due to the recent reduction in the amount of sulphur in the fuels sold for road transportation services (50 ppm sulphur) which is reflected in the baseline. The project scenario assumes low levels of emission control strategies in the fossil-based power plants (as a conservative approach). This also highlights the need towards integrated strategies that would involve electricity generation sector.

CO2 Emissions

The calculation of the CO2 emissions impacts uses a simple conversion factor of 2.3 kgCO2 per litre of gasoline (NRCAN, 2014). The calculation shows that the SOL+ e-quads can potentially reduce up to 58% CO2 against conventional tricycles (20 tons/year), and 35% against the minivan fleet (7.7 tons/year). The savings against the e-tricycle scenario is 11% (1.9 tons).

Urban Passenger Transport

A theoretical total amount of daily maximum amount of passenger transport tasks was calculated based on the estimated capacity of the quadricycles, average on-road speed, number of operating hours per day and average trip length as summarised in the table below.

Number of vehicles	15
Max occupancy	4
Average speed (km/h)	11.55
Average operating hours per day	7
Average round trip length (km)	5
Max km per day/vehicle	115.5
Max trips per day/vehicle	23

The calculation exercise takes on the following assumptions in order to simplify the calculation of the potential impacts: The e-quads are to be used on average, 7 hours per day, and that the average round trip lengths are 5 km/trip. The vehicle efficiencies are also static (average), and no dynamic projections of the emission factors were included in the analysis.

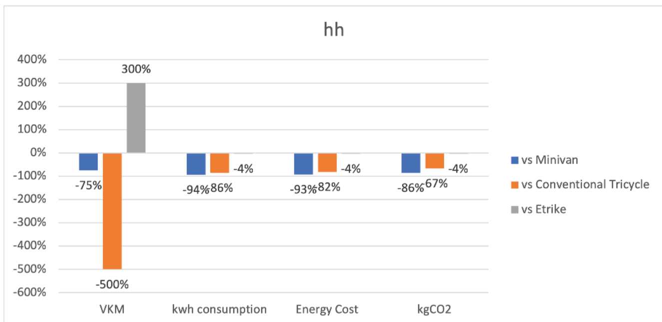
The resulting maximum pax per day (SOL+ quad fleet) is 64 passengers per vehicle. This same "demand" is used as a reference for calculating the impacts of the SOL+ quads. Essentially, the exercise asks what it would look like in terms of what the scenario might look like in case the SOL+ e-quads are not put in place. Three initial alternatives were taken into consideration:

- Gasoline Motorcycle – As this is a popular mode (both as privately owned, or through ride hailing mechanisms);
- Gasoline three-wheeler – The common first/last mile public transport mode in the city;
- Electric three-wheeler – An illustrative example considering the developments in the use of electric three-wheelers in cargo delivery.

The changes in the vehicle activity (vehicle trips, vehicle kilometres), energy consumption, energy costs and CO2 emissions are brought about by the different characteristics of the vehicles used, primarily the vehicle capacity (as a function of vehicle dimension), fuel/energy efficiencies, unit cost of energy (e.g. electricity or gasoline). The number of vehicles under the demo baseline scenarios reflect the number of vehicles that would have been needed to perform the same amount of task to be done by the SOL+ fleet. The capacities of the vehicles play a role in determining the number of trips that are required to perform the passenger transport tasks, and thus, the resulting energy consumed (and costs), as well as the emissions.

	SOL+	Motorcycle	Conventional 3W	Electric 3W
Max passengers	4	100	3	5
Fuel type	electric	gasoline	gasoline	electric
Efficiency (km/litre or km/kwh)	14	30	24	10.8
Number of vehicles	15	24	20	12
Average speed	11.55	21	11.55	11.55

A multiplier of 330 (days in operation per year) was used to scale the daily figures into yearly figures.Please note that the activity levels used in the calculation processes reflect levels that are towards the maximum levels (to reflect maximum potential). The results of the exercise are visualized below in the graph below.



	SOL+	Motorcycle	Conventional 3W	Electric 3W
VKM	396,000	1,584,000	528,000	316,800
Vehicle trips	79,200	316,800	105,600	63,360
Total amount delivered (cubic inches)	316,800	316,800	316,800	316,800
kwh consumption	28,286	469,920	195,800	29,333
Energy cost (PHP)	169,714	2,270,400	946,000	176,000
kgCO2	16,689	121,440	50,600	17,307
Grams PM10	2,010	6,692	8,563	2,084
Grams PM2.5	1,178	4,947	6,328	1,222
Grams NOx	20,147	461,132	315,393	20,894
Grams CO	16,750	11,829,747	7,016,724	17,370
Grams SOx	31,561	1,439	740	32,730

Vehicle Kilometres

The total vehicle kilometres (VKM) from the use of the e-quads are calculated to be higher than the other electric three-wheelers, as we had taken the bigger models as a base (5 occupants per trip). The motorcycle scenario is significantly higher in total VKM as the needed vehicle trips are substantially higher due to the low capacity (1 pax/vehicle trip).

Energy Consumption

The resulting gasoline figures (i.e. for the motorcycle and the gasoline tricycle) were converted into kwh using a conversion factor of 8.9 (NRCAN, n.d.) which enables direct comparison of the energy consumption figures for the different alternatives. The motorcycle scenario ended up with the highest energy consumption figures, again due to the discrepancy in the passenger capacity. The e-quads also faired significantly better than the conventional tricycle but was comparable in consumption (4% better) to the bigger e-tricycle.

Cost of Energy Consumed

The costs of electricity and gasoline were pegged at 6 PHP/kwh (business rates), and 43 PHP/ litre of gasoline. The magnitude of impacts in terms of energy costs are similar to the energy consumption.

Social Impacts

To follow

Air Pollution Impacts

Default emission factors (translated into grams/ kwh) were taken from Mejia (2016) for relevant vehicle types that reflect the defined baseline scenarios as shown in the table below.

	SOL+	MC	Conventional 3W	Electric 3W
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SOx	1.116	0.003	0.004	1.116

These emission factors were multiplied with the calculated energy consumption for each of the scenario.

Significant air pollutant emissions savings can potentially result in the implementation of the demonstration project. However, it is noted that there potentially can be significant negative impacts in terms of the SOx emissions. This is due to the recent reduction in the amount of sulphur in the fuels sold for road transportation services (50 ppm sulphur) which is reflected in the baseline. The project scenario assumes low levels of emission control strategies in the fossil-based power plants (as a conservative approach). This also highlights the need towards integrated strategies that would involve electricity generation sector.

CO2 Emissions

The calculation of the CO2 emissions impacts uses a simple conversion factor of 2.3 kgCO2 per litre of gasoline (NRCAN, 2014). The calculation shows that the SOL+ e-quads can potentially reduce up to 67% CO2 against conventional tricycles, and 86% against the minivan fleet (7.7 tons/year). The savings against the e-tricycle scenario is 4%.

Discussion

The figures and estimates that are contained in this report are to be treated as preliminary. For example, the baseline values (city-level) have yet to be validated, and compared with other estimates. The ex-ante impact estimates are also to be treated as preliminary.

The estimation methodologies are to be enhanced, and the values are to be updated as the team moves towards the implementation of the pilot in Pasig, and as more data are collected.

DRAFT - NOT TO BE CITED

This is an interim draft that has been completed prior to the implementation of demonstrations in cities and was finalised based on individual city reports (status as of 31 March 2021)

solutions plus

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