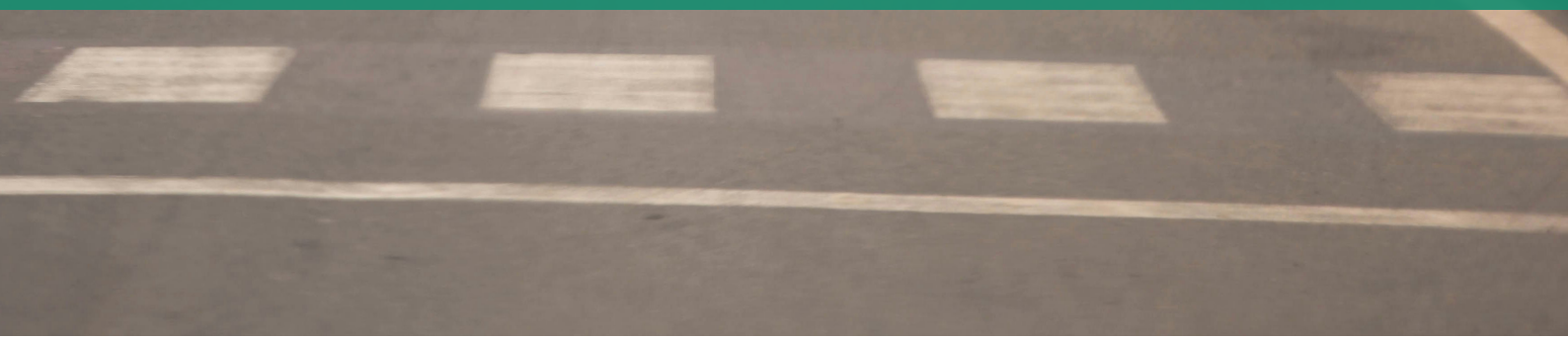
D1.6 IMPACT ASSESSMENT RESULTS

VOLUME 5: KIGALI, RWANDA



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PROJECT PARTNERS

ABOUT

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SOLUTIONSplus Impact Assessment Results

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EXECUTIVE SUMMARY

This report details the activities carried out by the SOLUTIONSplus project to assess the effect of the Kigali demonstration action. Only actions that were finished by April 2024 are included in the report. The ex-post implications of the e-bicycle bikeshare deployment are not covered in the report as the demonstration is still being implemented. An addendum including this information will be appended to the report by the project's conclusion.

Assessment of the Kigali demonstration project

Motivation and objectives

In Kigali, with rapid urbanisation and growth in income, the demand for private vehicles increases, straining the city's available public transport services in the city and causing several externalities.

The SOLUTIONSplus demonstration action supports various forms of electric mobility to address the main mobility and transportation-related problems identified in the city. The first component focuses on electric mobility for last-mile connectivity, in the form of light electric two-wheeled vehicles. The demonstration project supports electric motorcycle taxis, used for commercial services (taxi), and shared pedal-assist electric bicycles. Completing this activity on light electric vehicles, the project decisively supported the transition to electric public transport through a pilot of electric buses, aimed at collecting data and supporting the development of a Kigali E-Bus Master Plan. The project provides financial and technical support to selected companies, as well as policy and regulatory advice to public authorities, including institutional support via the creation of the E-Mobility Technical Committee.

Electric motorcycles

The project supported the development of robust electric motorcycles, with vehicles and batteries locally designed and assembled, an innovative re-energising model of battery swapping adapted to local needs and conditions, and technical support for scale and industrialisation. 24 e-motos were supported through the project. In addition, the project proactively used the transition to increase the involvement of women in the provision of transport services, by handing over the e-motos to trained women and sharing learnings and recommendations to a large regional and international audience.

Electric bicycles

To facilitate the integration of feeder services with the public transport system, a bike share system with 80 conventional bicycles was deployed on two corridors connecting to bus stations in 2021, with the aim to introduce pedal-assist electric bicycles in the shared fleet. 50 electric bicycles were planned to be introduced, but the implementation is delayed due to various company and ecosystem-based challenges described in this document.

Electric buses

A pilot enabled the introduction of four electric buses in December 2023, with an innovative leasing model helping operators face current challenges in accessing rolling stock. This pilot provided input into the E-Bus Charging Master Plan initiated

by the City of Kigali and ITDP in the second half of 2023. The master plan will focus on establishing the electric energy required to charge the fleet for the pilot e-buses, the location and technology of the chargers, the set of routes that and the most suitable business models for the city.

Policy and institutional e-mobility framework

The City of Kigali initiated the E-mobility Technical Coordination Committee as part of SOLUTIONSplus, providing a well-recognised platform for information sharing and alignment between public and private organisations.

SOLUTIONSplus provided multidimensional policy support to deploy an EV charging infrastructure, recommendations for fiscal conditions for pedal-assist electric bicycles, and a City roadmap on electric mobility. Planning support was provided by the Technical University of Berlin through a Design Studio in 2022 and 2023, focusing on the development of three speculative design solutions for public transportation, e-mobility, and road safety.

User needs analysis

With 6 responses to our online survey and 9 interviews with stakeholders in Kigali, the user needs analysis succeeded in obtaining the necessary feedback. Stakeholders were grouped into public/paratransit companies; national, regional and local authorities; passengers and individual travellers; service providers; OEMs, associations, importers and exporters; academic and research organisations; and finally, foundations and funders.

Stakeholder priorities

Among the findings, the following are worth noting: (i) the highest priorities were given to the impact the demonstration will have on climate and the environment, (ii) the next highest priority was allocated to available finance and financial viability of the projects (iii) the third highest priority was allocated to effect on institutional frameworks, where the ease of implementation of the project was accorded a very high priority.

Financial viability

For the e-motos, the company provides the e-motos to the drivers at a unity cost of USD 1284 in 2021, available through various financial models such as lease-to-own, rental or outright purchase. The company owns the batteries and provides the charged batteries and uses a battery-swapping model. The drivers pay a charging price of 1.84 USD per charge as of 2021. The company did not provide information on their capital and operating costs for operating the battery swapping system. Therefore, the financial analysis is from the theoretical perspective of a driver achieving the average minimum salary level found in Rwanda. The revenue per day for e-motos is 13.50 USD and after accounting for all costs she can earn a net revenue of 1.11 USD. The pretax internal rate of return is 42%, which can be considered very good from drivers' perspective.

Availability of financial resources

The score for this indicator for both e-motos and e-bicycles was 3.3. There were mixed responses to the question on the availability of government funds to support the project for both interventions, but all the stakeholders felt that international

donors strongly intended to fund similar projects. More stakeholders felt that the commercial bank was not yet prepared to support such initiatives, especially the e-moto intervention.

Institutional issues

Both interventions are fully coherent with the national and sub-national policies and development goals, that is government of Rwanda's program to retrofit electric motorcycles and National Transport Policy and Strategy, 2021. Likewise, these are also fully aligned with the city level plans and policies to enhance the last mile connectivity. There was a lack of clarity as to whether the interventions were fully consistent and aligned with environment policies at the national level, as the stakeholder gave a mixed response here. Overall, all the stakeholders felt that the interventions were fully aligned with the energy and transport policies at the national level and city level policies, and with the overarching policies at the national level like the National Development Plans, Climate Action Plans, NDCs etc.

Alignment with supra-national/national/city legislation & regulations was a bit more uncertain compared to alignment with national plans and development goals. Both e-motos and e-bicycles are fully compliant with the vehicle standards and regulations; however, as the electric vehicle policy is not detailed, alignment to electric vehicle standards and charging infrastructure standards was a bit uncertain. Likewise, alignment with charging operations, user-consumer protection (for electric vehicles) and environmental regulations was also a bit uncertain.

All the stakeholders opined that both e-motos and e-bicycles projects face no administrative barriers as the institutional bodies are in place, policies are in place or are being formed, and, most importantly, the government has strong buy-in for the projects. However, e-bicycles do face relatively higher financial barriers since they are not included in fiscal incentives provided by government for EVs.

Climate change and environmental aspects

In Kigali, as the e-motos (Kigali) replace the old ICE vehicles, they result in a significant GHG emission reduction of 73% from the base case technology in the base year. Over the life span, the CO2 emission reductions will be 71.8% lower in comparison with the ICE-motos. The CO2 reductions from eBuses are even higher than e-motos and 93% lower in comparison with diesel buses in the base year. Likewise, there is also a significant air pollution reduction as these vehicles have no tailpipe emissions. The effect on noise has not been considered in the project, but there is no noise from the e-motos, and their introduction is expected to reduce noise pollution.

Effect on society

As the routes and operation of e-motos remain the same, accessibility levels remain the same; with e-bicycles integrated with public transport, personal accessibility is likely to increase substantially, with 78% population coverage. As the fares don't change, there is no change in the affordability of the end users. As the routes don't change, the effect on travel time is also expected to remain the same. However, most e-motos users felt that travel on e-motos was marginally faster compared to ICE motorcycle, possibly due to higher acceleration and better navigation possibilities compared to traditional ICE engines.

KPI Defined with stakeholder input	Entering into evaluation	Absolute Weight	Normalised Weight	KPI Score		Scale
				E-Motos	E-Bikes*	
A1. IRR (Internal Rate of Return)		8.70	11.06	17.48%		%
A2. Ease of raising external funding		9.00	11.44	3.5	3.5	5 point
B1. Coherence with national plans/goals		5.48	6.97	4.50	5	5 point
B2. Alignment with legislation		3.91	4.97	3	3	5 point
B3. Ease of implementation		6.01	7.64	5	5	5 point
C1. Effect on GHG emissions		18.40	23.39	71.80%		%
D1. Effect on NOx emissions		3.75	4.77	100.00%		%
D2. Effect on PM2.5 emissions		3.81	4.84	100.00%		%
D3. Effect on noise	No	5.69	0			
D4. Effect on recycled resources		5.25	6.68	3.50	3.5	5 point
E1. Effect on accessibility (passengers)		1.92	2.44	3	4.5	5 point
E2. Effect on affordability		2.16	2.75	3.00		5 point
E3. Effect on travel time (passengers)		2.04	2.59	3.5		5 point
E4. Effect on major accidents (road safety in general)		0.81	1.03	3		5 point
E5. Effect on minor accidents (sverity of road accidents)		0.50	0.64	3		5 point
E6. Effect on near accidents (road safety of vulnerable groups)		0.56	0.71	4		5 point

KPI Defined with stakeholder input	Entering into evaluation	Absolute Weight	Normalised Weight	KPI Score		Scale
				E-Motos	E-Bikes*	
E7. Effect on charging safety incidents	No	1.50	0			
E8. Effect on security incidents	No	1.56	0			
E9. Effect on well-being (active travel)		1.94	2.47	3		5 point
E10. Suitability for climate changes		0.40	0.51	3.21		5 point
E11. Perceived comfort		0.25	0.32	2.93		5 point
E12. Perceived drivability (prof. drivers)	No	0.27	0.34			
E13. Perceived drivability (end users)	No	0.25	0.32			
E14. Perceived chargeability		0.28	0.36			
E15. Perceived safety		0.26	0.33	2.98		5 point
E16. Perceived personal security		0.24	0.31	3.19		5 point
E17. Perceived transhipment quality	No	0.27	0.34			
F1. Effect on budget	No	5.02	0			
F2. Effect on fossil fuel imports		2.98	3.79	4%		%
F3. Effect on other imports	No	2.19	0			
F4. Effect on jobs	No	2.24	0			
F5. Effect on wages	No	2.38	0			

*All KPI cells in yellow could not be evaluated since the demonstration could not take place during project implementation period

Road safety

Most of the users also felt that changing to e-motos from ICE motorcycles had no impact on the overall safety situation in the city or on an increase or decrease in the severity of road accidents. However, more than half respondents who used e-motos users felt that e-motos significantly increased the safety of vulnerable road users, even though one would expect the opposite because of increase acceleration and no noise from e-motos. This response could be because of the feel-good factor about e-motos, or their having better breaking response. The fact that responses were collected from users who are e-moto enthusiasts can be also responsible for this.

Charging safety

The risk of accidents related to the charging of EVs is expected to grow with the development of e-mobility. The lack of institutionalised standards in the country can aggravate this risk. As batteries are not charged by e-motos drivers or by the end users, this indicator could not be tested in the absence of input from the company.

Effect on service quality

The results show that the e-moto users have rated all the service level indicators a little above average. Users perceive e-motos as more secure, help in the continuity of travel which can be linked to response on journeys taking less time, so they can improve connectivity. Otherwise, there should be no change in the connectivity levels as the routes remain same. The respondents also felt the e-motos help reduce noise levels and are more suitable in adverse weather conditions.

Effect on employment

Inputs from Ampersand providing the motorcycle were requested on the job creation through e-motos. This information was requested for the specialities relating to EVs: (i) EV technicians involved in the construction and mainly maintenance of the vehicles, (ii) battery swapping attendants (iii) EV design engineers involved in the design or remodelling of vehicles, and (iv) IT analysts or other Industry experts. However, no information could be obtained.

Scaled-up project

The National Transport and Policy Strategy for Rwanda (2021) had extremely ambitious targets for EVs (p.49). It targeted 30% of the new vehicles to be electric by 2023/2024, and by 2034/35, 70% could be electric. We have, therefore, considered this as a target for e-motos as well and quantified the impacts of the same on the wider economy, climate, and environment. The e-motos can result in substantial fuel savings from the BAU scenario where-motos run on gasoline. However, since-motos only account for 8.8% of overall demand for petroleum products the cumulative fuel savings (2020-50) at a national level will be only around 4% from the BAU scenario.

Overall assessment

E-motos being a cleaner alternative to ICE-motos aligned well with user expectations and the demo has contributed to building momentum for e-motos in Kigali. Ampersand was able to leverage significant funding beyond SOLUTIONSplus for the e-motos. The project has provided positive results with regards to KPIs, pace of uptake of e-motos during the lifetime of SOLUTIONSplus (from about 30 vehicles in 2020 to 1,350 motorcycle taxis and 10 swapping stations as of late 2023). In addition, the

project included a successful gender-inclusive component, with 35 women trained as e-moto drivers and 24 women e-moto drivers receiving the electric motorcycles. Challenges remain, such as the facility to recruit trained engineers and mechanics, or the need to complete the regulatory landscape with clear standards and guidelines on the process to deploy charging infrastructure. Yet, the component of e-motos seems on a positive path to scale.

The component of e-bicycles is more challenging, as it faced large delays in the roll-out of the demonstration action. These challenges are related to barriers found on the side of the e-mobility company (impact of Covid on supply chains, challenges of Asia-based imports of parts, iterations from the initial model, lack of communication and reporting skills, lack of funding alongside SOLUTIONSplus and the lack of an enabling environment (regulatory challenges in the partnership between the company and the City, absence of subsidies, pedal-assist electric bicycles not exempted from taxes, unlike larger electric vehicles). SOLUTIONSplus partners are in the process of identifying conditions for a viable system in the future.

CONTENTS

1 BACKGROUND AND CONTEXT

Kigali is the capital and largest city of Rwanda. It is divided into three administrative districts, known as administrative units. These units are divided into sectors and cells for effective governance and service delivery. Gasabo is one of the three districts of Kigali. It is located in the northeastern part of the city and is the most populous district. Gasabo District is composed of several sectors, including Kimihurura, Gatsata, Kacyiru, Kinyinya, Gikondo, Remera, Jali, Bumbogo, Kabeza, Gisozi, Kacyiru, and Gatenga. Nyarugenge is another district of Kigali, located in the central part of the city. It is the historical and commercial heart of Kigali. Nyarugenge District is made up of sectors such as Nyamirambo, Kigali sector, Gitega, Muhima, Nyakabanda, and Cyahafi. Kicukiro is the third district of Kigali, situated in the southeastern part of the city. It is known for its residential neighbourhoods, educational institutions, and commercial activities. Kicukiro District comprises sectors like Kicukiro, Gatenga, Kigarama, Kanombe, Kagarama, Niboye, Gahanga, and Masaka. These administrative units play a crucial role in local governance, service provision, and development planning within the city of Kigali, ensuring effective administration and coordination of various sectors.

In 2020, Rwanda's GDP was approximately $10.2 billion, according to the World Bank. Kigali, as the capital and largest city of Rwanda, plays a crucial role in the country's economy. It serves as the political, economic, and cultural centre of Rwanda. Kigali is home to numerous government institutions, businesses, industries, and international organisations. The city has experienced significant growth and development, attracting investments and contributing to Rwanda's overall economic progress.

Rwanda has limited domestic fossil fuel resources, which has driven the country to focus on alternative energy options. Rwanda's primary electricity sources are hydroelectric power and thermal power plants. Hydroelectric power is the largest contributor to the country's electricity generation, taking advantage of Rwanda's numerous rivers and lakes. Rwanda has also been exploring other renewable energy sources, such as solar and geothermal energy. The government has implemented various initiatives and programs to encourage the use of renewable energy and increase energy efficiency throughout the country. These efforts are in line with Rwanda's commitment to sustainability and the global shift towards clean energy. Rwanda's Natinally Determined Contribution outlines the need and the ambition to promote electric mobility in country and Rwanda has set out to scale up electric mobility initiatives. The government has established a comprehensive electric mobility policy framework to promote the adoption of EVs in various sectors, including public transportation, logistics, and personal vehicles.

1.1 THE GEOGRAPHY AND SOCIAL/URBAN CONTEXT

Location and Geography

Kigali City (Figure 1), the capital of Rwanda, is situated almost in the centre of the country. Its geographical position is at latitude 1° 57'S, and longitude 30° 04'E. Kigali is situated in the natural region called Bwanacyambwe within the Nyabugogo river basin's proximity, between Mount Kigali (1852 m high) and Mount Jali. The city is built on interlocking hills, which progressively converge and are separated by large valleys giving them oval shapes. Originally the city occupied the hills of Nyarugenge and Nyamirambo, which covered about 200 hectares at the time of independence

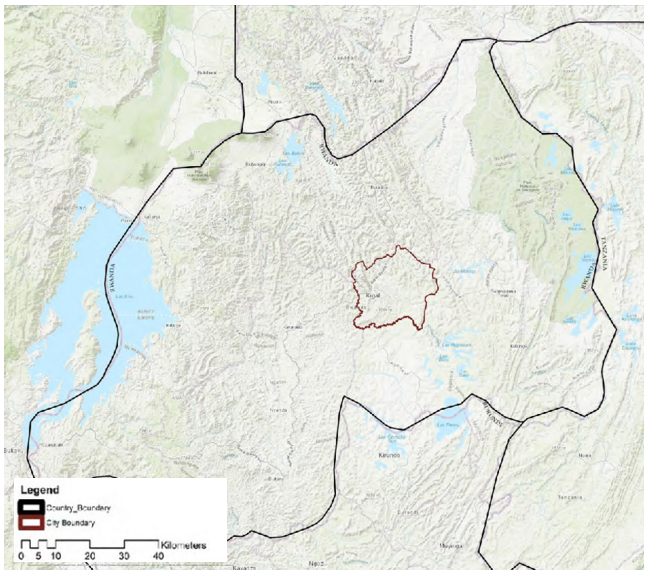


Figure 1: The city of Kigali 2018 (City of Kigali 2020)

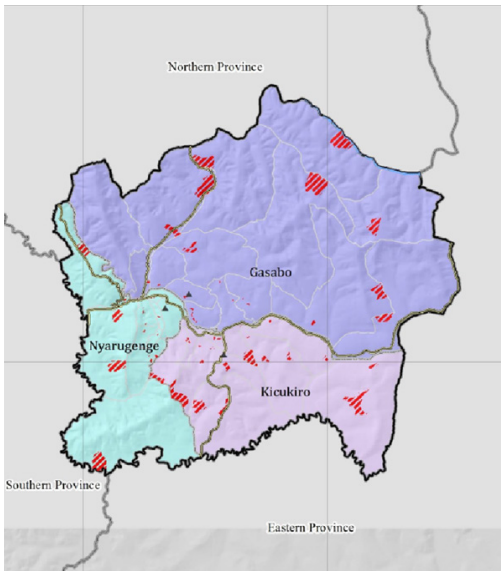


Figure 2: Kigali Districts (RDHS district chart handbook city of Kigali)

(Niyonsenga 2012, City of Kigali 2013). The city is ringed towards the north and west by higher hills. The highest of these is Mt. Kigali, with an elevation of 1 850 metres ASL. The southern reaches of the district is defined by the Nyabarongo River, which forms the marshes of Kigali. Within Rwanda, Kigali province shares borders with three other provinces (East, North and South); the West province forms Rwanda's borders with Lake Kivu to the west and the North and South provinces to the east (City of Kigali 2020).

The city stretches from the centre to include, towards the east, the hills of Kacyiru, Kimihurura, Mburabuturo, Nyarutarama, Remera and Kanombe, towards the south over the slope of mount Nyarutarama, towards the west over the slope of mount Kigali, on slopes of Kabusunzu hills, Kimisagara and Butamwaowards, and towards the north over the slopes of mount Jali and hills of Gisozi, Gaculiro, Kagugu and Kibagabaga (SPEA Engineering 2019). The city of Kigali has an area of 730 sq. km, of which 33.2% is developable, and 17% is built upon.

As shown in figure 2, the city of Kigali has three districts: Nyarugenge, Gasabo and Kicukiro. The city has 35 sectors, 10 sectors in Nyarugenge, 15 in Gasabo and 10 in Kicukiro. Nyarugenge is 134 sq. km and has a population of around 0.35 million; Gasabo is 430 sq. km and has a population of around 0.6 million, and Kicukiro is 167 sq. km area and has a population of 0.35 million (SPEA Engineering 2019).

Climate

Kigali has two main seasons: a dry season and a rainy season. The dry season typically occurs from June to September and December to February, while the rainy season occurs from March to May and October to November. During the dry season, Kigali experiences mild temperatures with average highs ranging from 23 to 27 degrees Celsius (73 to 81 degrees Fahrenheit). Nights can be cooler, with average lows ranging from 12 to 15 degrees Celsius (54 to 59 degrees Fahrenheit).In contrast, the rainy season in Kigali is characterised by increased precipitation. Rainfall is heaviest during the months of April and May, with average precipitation ranging from 100 to 200 millimetres (4 to 8 inches) per month. Temperatures during the rainy season are slightly cooler, with average highs ranging from 22 to 25 degrees Celsius (72 to 77

degrees Fahrenheit) and average lows ranging from 11 to 14 degrees Celsius (52 to 57 degrees Fahrenheit).

Overall, Kigali's climate is considered relatively mild and pleasant throughout the year, with temperatures rarely exceeding 30 degrees Celsius (86 degrees Fahrenheit). The city's higher elevation and mountainous surroundings contribute to its cooler temperatures compared to other parts of Rwanda and the surrounding region.

Population and urbanisation

As the country's commercial and administrative hub, Kigali is rapidly urbanizing due to a growing population and increasing economic activities (World Population Review, 2019). In Rwanda in 1991, only 6% of its population lived in urban areas, which changed to 12 % in 1999 and 17% in 2018. Consequently, the estimated city population in 2013 was around 1.3 million (City of Kigali 2013), which was estimated to be 1.5 million in 2018 (Sudmant, Kalisa et al. 2019). The 2013 city master plan projects the city population to be around 3.8 million by the year 2050. The 2018 population density (people per hectare) is shown in Figure 3. As one would expect the areas with the highest population density is in the centre of Kigali. The average population density for Kigali is approximately 25 people per hectare.

The total employment in the city in 2011 was 0.5 million, which is projected to be around 2.3 million by 2040. The central business district of Muhima, agricultural farmlands in Gasabo and Kicukiro, and free trade zone in Gasabo are the major contributors to Kigali's growing economy. Little more than 60% of the total employed population works in the services sector and around 35% for the employed work in the industrial sector and rest which is around 5% work in the agriculture sector. According to the Kigali economic development strategy report, around 37% of total employed

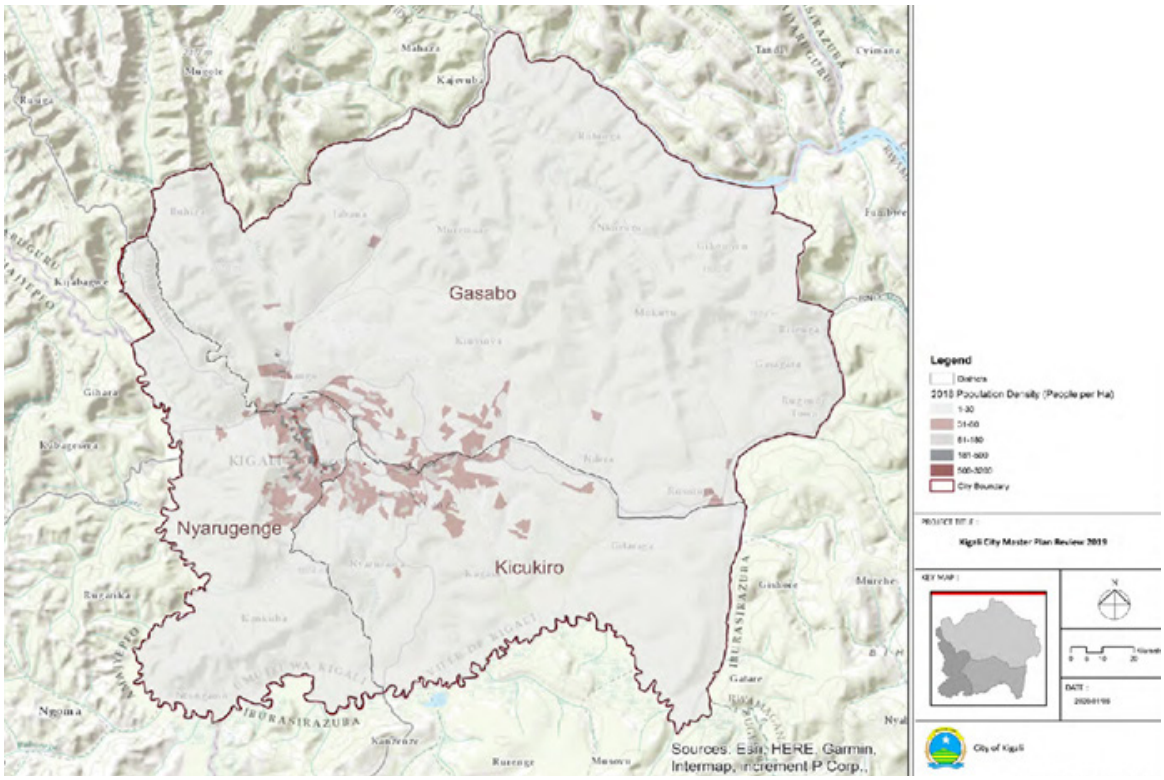
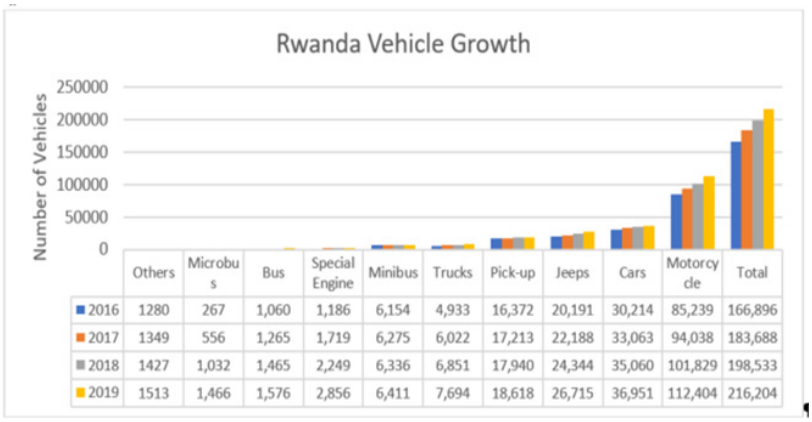


Figure 3: Population Density (People per Ha) in 2018 (City of Kigali 2020)

are in agro-husbandry, 23% in the informal sector, 13% in the public sector, 8% in the private sector, 5% in the commercial sector and 14% in other sectors (Niyonsenga 2012, SPEA Engineering 2019).

According to the Kigali master plan document, this surge in city population has led to spontaneous, uncontrolled, and haphazard development of the city of Kigali. As the city has been sprawling, it also has a very low development density, with only 20 housing units per hectare. Consequently, 19% of the urban area of Kigali encroaches upon land unsuitable for development, for example, areas with steep slopes and wetlands (City of Kigali 2013).

The city's major economic sectors are challenged with issues ranging from congestion, pollution, and deteriorating infrastructure. The transport and energy sectors, especially, have become stressed over the years, thus, prompting major reforms. The city master plan has plans to support the vibrant and developing economy of Kigali city and its estimated 2.3 million jobs with the allocation of land for industries, commercial space and for housing purposes. The master plan strategies include a hierarchy of commercial spaces, strategic industrial zones, and low, medium and high-density residential land uses. These are supported by the development of community spaces, social infrastructure and health facilities. Thus, the Kigali master plan aims for decentralized nodes, transit-oriented development to support public transport (buses including dedicated bus lanes and BRT) and non-motorized transport (City of Kigali 2020).



	Others	Microbus	Bus	Special Engine	Minibus	Trucks	Pick-up	Jeeps	Cars	Motorcycle	Total
2016	1280	267	1,060	1,186	6,154	4,933	16,372	20,191	30,214	85,239	166,896
2017	1349	556	1,265	1,719	6,275	6,022	17,213	22,188	33,063	94,038	183,688
2018	1427	1,032	1,465	2,249	6,336	6,851	17,940	24,344	35,060	101,829	198,533
2019	1513	1,466	1,576	2,856	6,411	7,694	18,618	26,715	36,951	112,404	216,204

Figure 4: Rwanda Vehicle Growth (Republic of Rwanda, Statistical Handbook, 2019)

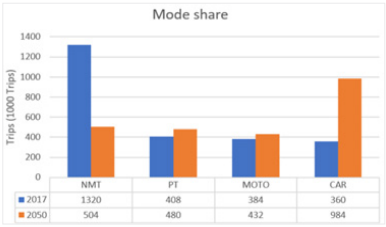


Figure 5: Mode Share (SPEA Engineering 2019)

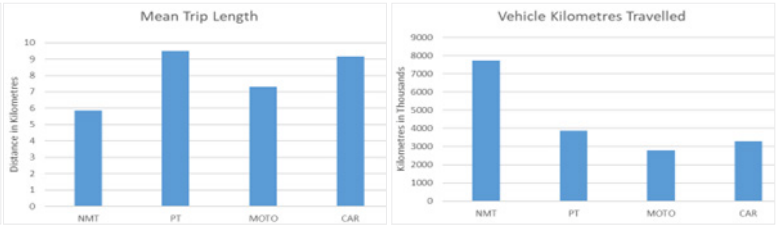


Figure 6: Mean trip Length and Vehicle Kilometres Travelled/Modes (SPEA Engineering 2019)

Urban Transport

The road network in Kigali, especially in the core, is continuously being improved. However, they need a good upgrade. In 2018 Rwanda had 216 thousand registered vehicles consisting of 52% motorcycles and 38% passenger vehicles, of which at least

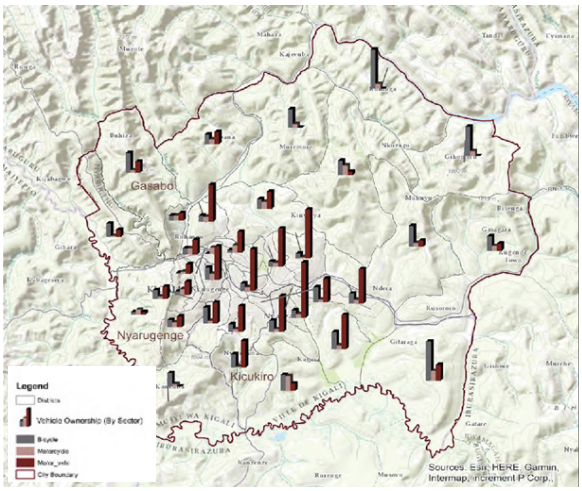


Figure 7: 2018 Number of households per sector that own at least one bicycle, one motorcycle and/ or one motor vehicle (City of Kigali 2020)

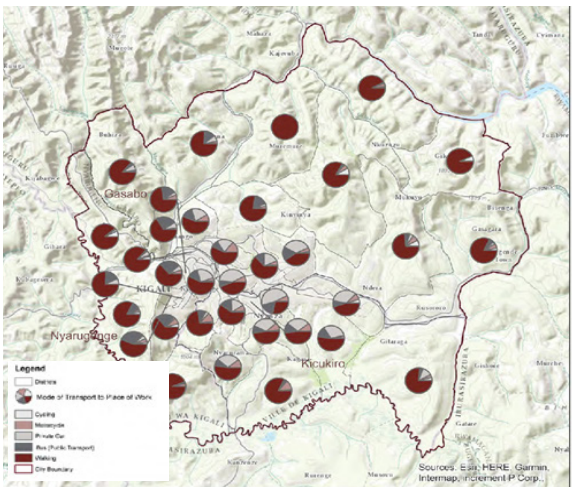


Figure 8: Mode choice commute to work (City of Kigali 2020)

30,000 are in Kigali (The number of vehicles is increasing rapidly (almost 12% per year)).

Figure 7 from City of Kigali (2020) shows the number of households within a sector that own at least one bicycle, at least one motorcycle and/ or at least one motor vehicle. For example, some households might own more than one bicycle/ motorcycle/motor vehicle. Also, one household might own both cars and bicycles.

In 2017 the total trips made in Kigali around 2.4 million trips were made in Kigali, with an average trip rate of 1.8 trips/hh/day. As shown in figure 6.6, more than half (around 52%) of these trips are undertaken using non-motorized modes, 17% by public transport modes, 16% by moto-taxis and the rest that is around 15% trips are performed by cars. In a BAU scenario projected by SPEA Engineering (2019) share of total trips made using a car is likely to increase to 41%, whereas NMT trips are likely to reduce to around 21% (SPEA Engineering 2019).

The mean trip length in Kigali is around 7.4 km, and the mean trip length by each mode is shown in figure 6. As one would typically expect Kigali residents to travel while using a car or using public transport as a mode, the average trip length with NMT modes is around 5.8, which is relatively high compared to other similar cities in the World. Kigali residents travel around 17.5 million kilometres each day, of which around 10 million kilometres of travel with motorized modes of travel.

Figure 8 from the City of Kigali (2020) shows the modes of transport that residents of Kigali use to commute to their place of work. These values correspond with the figures in Figures 6, as most employed citizens use walking as a mode of transport to their place of work. The City of Kigali (2020) also states that areas where people earn a higher income use private cars for commute purposes.

Transport infrastructure, including coverage of public transport

The road network of Kigali city consists of around 2851 km of roads, of which only 16 per cent are paved. Kigali is also well connected with other parts of Rwanda by a network of national roads. In Kigali, the central business district (CBD) from the centre of the radial road network of paved roads(AfDB 2013).

The public transport system in Kigali is composed of bus, car taxi, moto taxi, and

taxi bicycles (non-motorized). Licensed operators provide all motorized public transport services; however, tariffs are only regulated for the taxi-cars and bus services. This changed in August 2020, when Rwanda Utilities Regulatory Authority (RURA) announced tariff regulation for motorcycle transport services effective from 15 Aug 2020 . Services are not operated on a pre-defined timetable, and there is some degree of flexibility accorded to bus operators concerning the routes, stops and buses operating on each route. Thus the public transport services operation in Kigali accords flexibility according to the demand.

The bus transport network in Kigali can be divided into four zones (figure 9), and operators need to sign a single contract with RURA; contracts have been awarded to three bus companies that is, Kigali Business Services (Zone 1), Royal Express (Zone 2) and Rwanda Federation of Transport Cooperation RFTC (Zones 3 and 4). These zones have been shown in figure 9. The RTDA Annual Report for 2016- 2017 shows there were 865.5 km of scheduled bus routes in the City of Kigali which was much higher than the RTDA Annual Report target of 330 km for 2017.

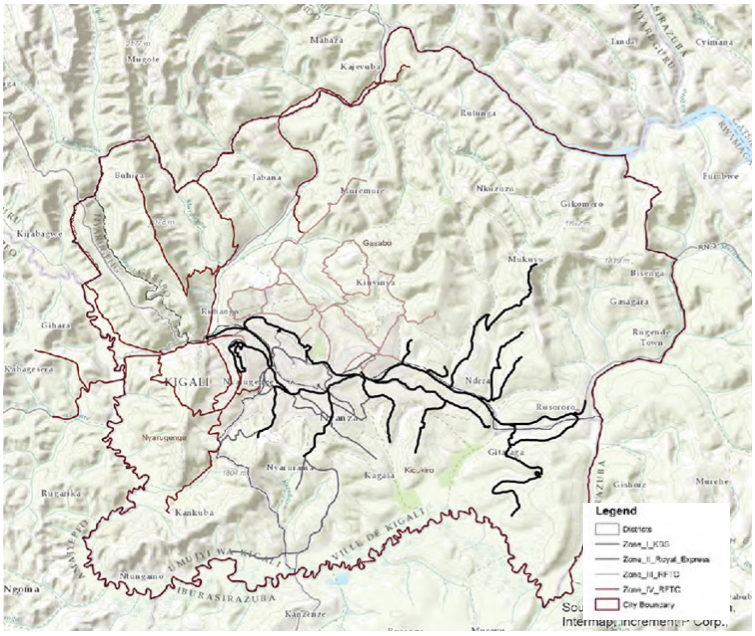


Figure 9: Public Transport in Kigali (City of Kigali 2020)

1.2 IDENTIFICATION OF MAIN PROBLEMS

With rapid urbanisation and growth in income, the demand for private vehicles increases, straining the city's available public transport services in the city and causing several externalities.

Emissions and air pollution

Kigali, the capital city of Rwanda, has been struggling with emission and air pollution problems in recent years. The city's rapid urbanisation, population growth, and increased industrial activities have contributed to the deterioration of air quality. One of the major sources of emissions and air pollution in Kigali is the transportation sector. The city has experienced a significant increase in the number of vehicles (Figure 4), particularly motorcycles and cars, leading to higher levels of exhaust emissions. Many vehicles on the road are old and poorly maintained, further exacerbating the pollution problem. Moreover, industrial activities, such as manufacturing and construction,

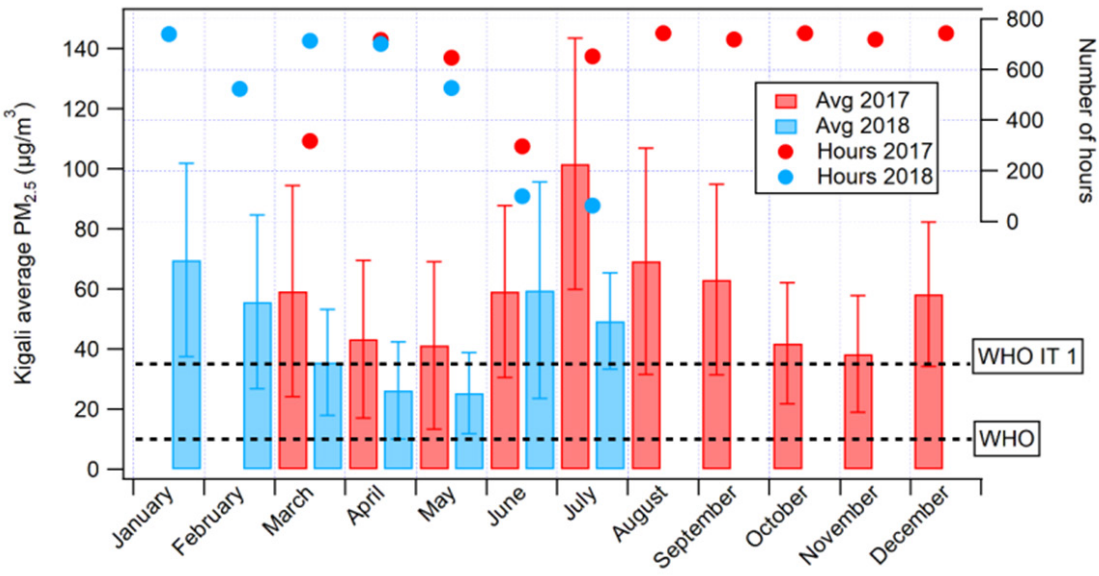


Figure 10: Monthly average PM2.5 measured in Kigali (Subramanian, R., et. al., 2020)

also contribute to air pollution in Kigali. These industries release pollutants such as particulate matter, sulfur dioxide, and nitrogen oxides, which can have adverse effects on air quality and human health.

In response to the air pollution challenge, the government of Rwanda has taken several measures to address emissions and improve air quality in Kigali. One notable initiative is the introduction of environmentally friendly public transportation systems its support for electric mobility.

The issues related to the transportation sector were highlighted in the Kigali Transport Master Plan, 2020 and they are summarised and listed in the Table 1.

1.3 DEMO DESCRIPTION

The SOLUTIONSplus demonstration action in Kigali supported various forms of electric mobility to address the main mobility and transportation-related problems identified in the city, in order to reduce air pollution and carbon emissions, decrease fossil fuel imports, and increase economic benefits for transport operators.

A first project component focused on electric mobility for last-mile connectivity. The demonstration supported light electric two-wheeled vehicles in the form of electric motorcycle taxis and electric bicycles. A first area of intervention tackled the transition from fossil-fuel to electric motorcycles used for commercial purpose (taxis), with a strong gender-inclusive focus. Supporting the shift to electric motorcycles is relevant in a context where motorcycle taxi services play a significant role in Kigali's urban mobility (16% of trips in 2017, forecasted to significantly increase). In addition, to facilitate the integration of feeder services with the public transport system, a bike share system with conventional bicycles was deployed along the most widely used bus corridors, with the aim to introduce pedal-assist electric bicycles in the shard fleet.

Completing this activity on light electric vehicles, the project decisively supported preparing the transition to electric public transport. Leaning on diverse capacity-building formats addressing public transport electrification, a pilot enabled the introduction of electric buses in Kigali with support from city authorities, transport operators and bus companies. The project enabled the collection of data to assess

Table 1. Issues highlighted in the 2020 Kigali Transport Master Plan

CAT.		PLANNING	ENGINEERING	DEVELOPMENT
PASSENGER TRANSPORT SERVICES	PUBLIC TRANSPORT NETWORK	Limited integration between public transport modes Limited bus accessibility (unpaved roads, steep gradients); limited spatial coverage of the bus network Limited space and government owned land for PT infrastructure Limited shelters No additional right of way for the BRT planned yet in the design for the new international airport PT link	Limited consideration of universal accessibility in the design of PT systems	
	GREEN TRANSPORT	Dedicated pedestrian and cycle routes only provided in the city centre Lack of continuity: disconnected non-motorized transport routes Challenge of cycling because of hilly terrain (more than 5%)	Special needs not accommodated through universal access design	
FREIGHT TRANSPORT SERVICES	FREIGHT NETWORK	Road freight: limited access for larger, heavier vehicles due to steep gradients; challenge of potential increase of e-commerce and traffic induced by deliveries Rail freight: uncertainty over viability of rail freight to airport; technical and financial challenges of rail because of mountainous terrain; risk of creating a physical barrier if deploying a rail line in the city center		

OVERARCHING	ROAD NETWORK	Inconsistent road hierarchy, no classification system for local roads Fragmented development Many unpaved road Road congestion, e.g. KN5 Road (International Airport) Limited road capacity Challenge of hilly topography	No formal guidelines to standardize the design of roads (no application of the EAC left-hand drive standards), road markings and signs Problematic maintenance because of multiple traffic signals manufacturers Poor design of traffic calming measures Limited intersection control (only few traffic signals, no signal optimization) Gradients not always considered in land-use developments/road access	Parking provision not systematically enforced throughout Kigali Moto-taxi parking not included in planning
	TRANSPORT POLICY	Fragmentation of policy; gaps in responsibility Lack of custodianship of the official city multi-modal transport model Unclear hierarchy of transport plans No centralized and updated transport database collating all survey data	No guidelines for Traffic Impact Assessments for new developments No thresholds and guidelines for pedestrian bridges	Buildings approved in areas where space for transport systems are required

the feasibility to move towards scaled public transport electrification in Kigali and supported the development of a Kigali E-Bus Master Plan.

The project is a good precursor to public transport electrification in Kigali, supporting e-moto and e-bicycle companies in developing business models, provided technical advice on vehicle and battery design, and corresponding policy and regulatory advice to public authorities

Electric Motorcycles

In Kigali, the project is supporting first—and last-mile connectivity by promoting electric two-wheelers used for commercial purpose (taxis), completing the public transport system which presents limitation in terms of geographical coverage and accessibility. This takes first of all the form of electric motorcycle taxis. The project supported the development of robust electric motorcycles, with vehicles and batteries locally designed and assembled, an innovative re-energising model of battery swapping adapted to local needs and conditions, and to support scale and industrialisation.

Multidimensional financial and technical support was provided to Ampersand over the course of four years. Seed funding was granted by UN-Habitat to support a cohort

of women in getting access to electric motorcycles. Technical advice support was provided by EU companies – consortium members of SOLUTIONSplus or external companies selected through EU matchmaking calls – on various aspects such as battery sizing, battery design, drivetrain, and industrialisation strategy. Key support was provided by the German company PEM Motion, selected through SOLUTIONSplus' second EU matchmaking call to review both The company's new battery design and The company's battery industrialization strategy to establish a new assembly line. This EU-local cooperation holds significant promise, as Ampersand experiences rapid expansion with a fleet and leads the transition to electric motorcycles in East Africa with 1,350 motorcycle taxis and more than 10 swapping stations in Kigali (Rwanda) and Nairobi (Kenya).

In addition, proactively using the transition to increase the involvement of women in the provision of transport services was a critical component of the project, achieved through the support for women to become drivers of electric motorcycle taxis. A total of 35 women were trained to become drivers of e-motorcycle taxis; among them, 24 obtained their driving license, representing a success rate of circa 70%, unprecedented in Kigali. In the presence of government officials and the City of Kigali, 24 electric motorcycles from Ampersand financed by SOLUTIONSplus were handed over to the women who had passed the exam. Learnings from the pilot and recommendations for scale-up projects were summarised in a practical Checklist, which has received large regional and international exposure.

Electric bicycles

To facilitate the integration of feeder services with the public transport system, a bike share system composed of 12 stations and 80 conventional bicycles was deployed on two corridors in 2021, connecting to bus stations and hubs in the eastern neighbourhood near a major bus terminal, and in the central business district.

Financial support was provided by the SOLUTIONSplus partner UN-Habitat to Guraride, a company collaborating with the City of Kigali through an MoU to deploy a bike share system. Technical advice was provided to the company deploying the system by the Urban Electric Mobility Initiative (UEMI), ITDP Africa, Goodmoovs on various aspects of bikeshare systems. This included large peer-to-peer training activities on bikeshare system involving pedal-assist electric bicycles involving more than eight cities worldwide in 2022, technical support on market options to charge the batteries, and on modalities for the redistribution of bicycles.

As of April 2024, the integration of electric bicycles in the bikeshare system was not feasible due to a combination of barriers faced, both on the side of the e-mobility company (impact of Covid on supply chains, challenges of Asia-based imports, iterations of the initial model, communication issues) and the lack of an enabling environment (regulatory challenges in the partnership between the company Guraride and the City, absence of subsidies, pedal-assist electric bicycles not exempted from taxes, unlike larger electric vehicles). Subsequently, key learnings are gathered to identify conditions for a viable system in the future.

In addition to the bike share system, cycling and intermodality in the city was supported through 80 bike racks deployed at strategic locations in July 2022.

Electric Buses

The third area of intervention addresses electric buses. A pilot allowed the introduction of four buses deployed by BasiGo in December 2023, providing an innovative leasing

model helping operators face current challenges in accessing rolling stock in Kigali. This pilot provided input into the E-Bus Charging Master Plan initiated by the City of Kigali and ITDP in the second half of 2023. The master plan focuses on establishing the electric energy required to charge the fleet for the pilot e-buses, the location and technology of the chargers, and the set of routes that could be considered in the pilot phase. The study also identify the most suitable business models for the city.

MaaS Application

The project assessed the possibility of introducing a Mobility-as-a-Service (MaaS) application in Kigali offering smart services for fleet management including an integrated electronic payment system. Following preliminary results, the implementation of MaaS application has been subsequently excluded from the scope of SOLUTIONSplus.

Policy and institutional e-mobility framework

The City of Kigali initiated the E-mobility Technical Coordination Committee as part of SOLUTIONSplus, providing a well-recognised platform for information sharing and alignment between public and private organisations.

SOLUTIONSplus provided multidimensional policy support to deploy an EV charging infrastructure, recommendations for fiscal conditions for pedal-assist electric bicycles, and a City roadmap on electric mobility. Planning support was provided with support from a dedicated master module at the Technical University of Berlin realized between 2022 and 2023, focusing on the development of three speculative design solutions for public transportation, e-mobility, and road safety.

1.4 INITIAL IDENTIFICATION OF RELEVANT STAKEHOLDERS AND USER NEEDS

At the inception of the project, the SOLUTIONSplus Kigali team identified 36 experts under eight main stakeholder groups for the initial user needs assessment (UNA). Interviews were arranged and conducted with 9 of these experts (completed in October 2020). An online survey was also circulated among the stakeholders. Table 2 presents the organisations that were contacted by group and UNA activity. This section summarises the key findings of the user needs assessment. For a comprehensive discussion, refer to D 1.3 (Initial identification of stakeholder and User Needs Assessments) and the Kigali User Needs Assessment – City Report. There was no e-mobility policy nor where specific regulation in place when the user needs assessment was done.

Aims of the city to transform urban mobility

Most stakeholders identified a plurality of goals pursued via e-mobility, including reduced carbon emissions, reduced air pollution, the introduction of innovative mobility options such as e-bikes (bicycles), as well as fuel reduction imports.

Reduce air and noise pollution, and help decarbonise transportation. All interviewed stakeholders highlighted the environmental advantages of electric mobility, especially in reducing air and noise pollution. Stakeholders observed that the introduction of e-mobility in the city centre and peri-urban areas would improve air quality - against the background of pollution of internal combustion engine (ICE) motorcycles not being controlled -, and that the introduction of e-buses would help to decarbonise transport in Kigali. Stakeholders also mentioned that e-mobility in Rwanda would help the country reduce imports of old vehicles that harm the environment. The interviewee

STAKEHOLDER GROUPS	STAKEHOLDER	UNA ACTIVITY	
		ONLINE SURVEY	INTER-VIEW & KPI WEIGHTS
Public/Para Transport Companies	JALI Transport (RFTC)		✓
National / Regional / Local Authorities	Rwanda Utilities and Regulatory Authority (RURA)		✓
	City of Kigali	✓	
	Rwanda Transport Development Authority	✓	
	Rwanda Environment Management Authority	✓	
Service providers (private and small-scale operators,, energy companies)	Ampersand (motorcycle taxis)		✓
	Gura Ride (e-bicycles)		✓
OEMs (i.e. vehicle companies, maintenance)	Volkswagen Mobility Solutions Rwanda	✓	✓
Associations	Fédération Rwandaise des Conducteurs des Taxi Motos (FERWACOTAMO)		✓
Academia/ Research	University of Rwanda	✓	✓
Foundation/Funders	Shell Foundation	✓	✓
	GGGI		✓

Table 2. Kigali Stakeholders

with the regulatory authority felt that most developed countries are shifting from ICE vehicles to EVs, so the authorities intend to act as soon as possible so that Rwanda does not lag with old ICE vehicles.

Decrease fossil fuel import. Most stakeholders also opined that the introduction of e-mobility solutions in Kigali would reduce fossil fuel imports, and the adoption of EVs would reduce dependence on imported fuel. Stakeholders also felt that e-mobility would help the transport sector increase its reliance on locally produced energy

rather than imported fuel.

Lower operating costs, economic benefits and comfortability. It is expected that the introduction of e-mobility will reduce operating costs and also increase comfort levels. Most stakeholders expect economic benefits via e-mobility in the form of increased electricity demand, spurred local production and reduced tariffs. On the positive side, with increased electricity demand, Rwanda has moved away from dependence on heavy fuel oil power plants to new electric supply sources and has also negotiated better tariffs with power producers. This will continue as the demand for electricity increases in future. The interviewees also stated that electric motorcycles are better in terms of speed and comfort than ICE motorcycles, and the interviewee is hopeful that the uptake of the new technology will be high.).

Regulations

At the time of the interviews, there were no e-mobility policied nor specific regulations in place, but the government was planning to promote EVs in Rwanda and was in the process of drafting supporting measures fitting into the national transport policy. Despite the absence of policies at this time, several stakeholders highlighted the strong governmental support for e-mobility. Stakeholders were eager to see policies adopted. Several of them hoped that they would be all-encompassing and will come with bold measures, including the provision of financial incentives and non-fiscal measures, such as allowing EVs to use bus lanes, free license plates, and special green license plates for EVs.

The interviewees also felt that the present challenge is the newness of the e-mobility technology, leading all stakeholders to learn along the way while upscaling, as well as a limited knowledge on e-mobility policies. They felt that the e-mobility landscape is very dynamic, and there is a need for testing policies before they are implemented at a large scale. Policies will have to consider that solutions may need to be differentiated for various vehicle types. For example, a good solution for a two-wheeler might not work as well for cars.

After 2020, when the user needs assessment was done, the Government of Rwanda adopted a wide range of fiscal and non-fiscal incentives for EVs, such as full custom duty and VAT exemption for EVs, charging infrastructure, battery and parts, reduction of electricity tariffs etc . In addition, several projects have been launched by the government to support electric mobility, which includes the retrofit electric motorcycle project and the NAMA support project on e-motos.

SOLUTIONSplus project expectations

Stakeholders identified several types of support that SOLUTIONSplus could bring in.

This included financial support to deploy additional EVs, financial support to extend the moto driver typology from men only to women and lastly, material support from the SOLUTIONS+ expert network (e.g. powertrains from EU industry partners). Stakeholders also expected that the SOLUTIONS+ project will increase EVs' visibility, translating into easier adoption of e-bikes in the long run, will support policymaking on sustainable mobility (e.g., bike lanes integrated with the planned BRT system) and bring in financial and technical support for e-mobility providers, not only for demonstration action but also to scale-up. The opportunity for SOLUTIONS+ to improve coordination between the multiple e-mobility projects and stakeholders, improving the image of non-motorized transport via the support to e-bikes, and facilitating access to funding, was also mentioned

Finally, respondents expected SOLUTIONS+ project to bring advanced solutions to ease maintenance of e-motorcycles, for instance, via an e-motorcycle demonstrator and training to local maintenance operators at local stations and garages. Further areas of support could include training in business operations and road safety.

Obstacles, limitations and barriers for EVs

Stakeholders highlighted several factors that can challenge the successful implementation of e-mobility in Kigali.

Charging stations

Lack of charging facilities and increased charging time for buses was felt as a potential limitation. An interviewee from the motorcycle-taxi sectors also mentioned that more charging stations would be required for e-moto taxi implementation.

Standards

The absence of charging standards could lead to safety issues, according to one interviewee. There is currently no clear masterplan, guideline, regulation related to the installation and operation of electrical charging stations for e-mobility. Stakeholders feel that policy will be needed on how the new charging infrastructure will be provided, including existing fuel stations.

Financial resources/upfront cost

Most stakeholders feel that investment in the sector is required, however access to finance (debt and equity) was a significant barrier. The upfront cost of buses, poses financial challenges that can affect e-mobility solutions' uptake.

Electricity tariffs

Although, as stated earlier, there is hope that the tariff will come down eventually, most stakeholders felt that the current high electricity tariffs would be the most significant challenge affecting the financial viability of e-mobility initiatives. Yet, although some interviewees stated that even with currently high tariffs, the shift to electricity is still financially attractive.

Supply chain and importations

Quality issues are also faced with supply chains and products from China, although incremental improvements have been achieved. EVs is a new technology, therefore switching from ICE engines to EVs will need many changes in the value chain. Regarding import policies, there are currently no particular regulations and guidelines on how EVs will be imported. However, the barrier of high import duties seems to have been partially resolved according to some stakeholders and service providers who received tax exemptions.

EV adaptation to topography

Several interviewees stressed the hilly terrain in Kigali, pointing out the necessity to assess the adaptability of EVs to this topography and impacts on operations.

Lack of technical expertise

There is concern about the availability of skills and knowledge to support the new technology, especially on e-buses, and maintenance of EVs in general.

Grid capacity

Views are disputed on this being a challenge. An interviewee with the public transport

sector had concerns among stakeholders about electricity availability and felt that more electricity would be required for e-buses while other electricity-dependent services such as industries and residential are also growing. Nevertheless, this was not shared by other interviewees, including one respondent having led a study on e-buses, stating that its grid analysis showed that grid capacity was not an issue, except for large charging depots for buses in certain areas of the city, and one respondent providing e-moto services. The interviewee stressed that electricity is in surplus, though electricity distribution is not equitable.

More disputed: knowledge and awareness on EVs

As this technology is new, there is no information about e-buses, e-motos and e-bikes, which are not operating or operating to a limited extent in Rwanda. Some stakeholders also felt that there could also be behavioural barriers because people's mindset set to traditional ICE vehicles, making the switch to EVs difficult. Yet, this was not shared by e-bikes and e-motos service providers, stressing enthusiastic feedback on the vehicles.

Interpretation of interviews: the main challenges with regard to SOLUTIONSplus project implementation

As the policy environment seems to evolve rapidly with expected measures on e-mobility, some of the main barriers could be lifted in the near future, such as high electricity tariffs. The political support for e-mobility solutions is a further facilitating factor, having led to flexible resolution of issues (e.g. importation duties) in the past. Yet, some context elements could turn as challenges for the implementation of the SOLUTIONSPLUS demonstration action, such as the lack of coordination between initiatives and the absence of clarity on the involvement of the city authorities, as opposed to Mininfra. For the upscaling phase of the Kigali demonstration action, access to finance seems a persisting hurdle which should be addressed early, in coordination with other stakeholders. Generally, it seems that e-motos and e-bikes are well supported and with some positive results already (e-motos), while the amount of hurdles and uncertainties faced by electric buses seems much higher, especially on the financial side. Lastly, the lack of technical knowledge and of information on pertinent policies does not appear as a barrier, but as an opportunity for SOLUTIONSPLUS to fill a gap and answer well-expressed needs.

Business models

Regarding public transport, financed by private operators (nb. interviews done before the start of subsidization in the context of Covid), a shift from ICE to electric buses could be difficult unless there is financial support from the public sector. On the side of motorcycle-taxis, stakeholders mentioned the lower costs of e-motorcycles in terms of maintenance and transport energy, compared with regular motorcycles using fuel. The interviewee with the e-motos service provider (e-motos) stressed the positive impact of electric mobility on ICE moto drivers' revenues, citing figures of USD 1.84 per charge, 91 km range per battery swap, enabling a 108% percentage net benefit to drivers (informunication communicated during a conference in February 2020). The interviewee from the moto-taxi federation also mentioned that e-motorcycles under test in cooperation with one e-moto service provider are on the good stage of profitability. The business case and pricing structure for shared e-bikes were more uncertain, mostly detailing offers for students (100 RWF , i.e. about 10 cents USD, for 30 minutes, allowing them to cover a few kilometers). The interviewee from the e-bikes service provider claimed that shared e-bikes will be a cheaper alternative to moto-taxis (about 300/400 RWF, i.e., US $0.30-0.40, for sometimes 500m to 1km).

More generally, some stakeholders found it challenging to identify the impact on users and business models without addressing costs for owning and operating EVs. Spare parts for EVs are prohibitive due to taxes, yet this seems to be changing via bilateral exemptions granted to service providers. The taxation and classification for e-bikes was unclear, possibly resulting in higher custom duties.

Finally, a need to incentivize the provision of charging infrastructure was identified, as well as work on recommendations on the building code to introduce charging at public buildings (green building minimum compliance standards).

Implications for Planning and Urban Development

Public transport planning. Stakeholders mentioned that there is a strong focus on the use of public transport and transit-oriented development in Kigali. The master plan encourages high commercial and residential density along mass rapid transit corridors. The interviewee from the OEM stressed that in Rwanda, many people still walk for about 20 minutes to access public transport. He feels that e-mobility solutions will have to be integrated mobility options (e.g. e-shuttles) catering for the last mile connectivity, all hinting towards a transit-oriented development.

Infrastructure planning. The need for an integrated approach was mentioned by several interviewees, alongside the need to understand better consumer behaviour and needs for charging. In addition, there is a consideration that data stemming from e-mobility may support better urban planning. The need to upscale the number of charging stations for e-motorcycle operations was mentioned by the interviewee from the moto-taxi federation - mentioned that current e-motorcycle operations are limited in Kigali due to a few number of swapping stations - and to include these in urban planning documents. In addition, the interviewee from the e-motos service provider mentioned the need to incorporate the additional space for infrastructure needed for electricity distribution and charging in urban plans.

Finally, parking is a topic with mixed views: the parking function was considered vital for charging by some interviewees, also mentioning that parking management will also be essential in a city where there is very little space. Yet, the policy context should be taken into consideration, with the 2020 Kigali Transport Master Plan stressing the need to reduce parking demand to limit the growth of private motorization.

2 KEY PERFORMANCE INDICATORS (KPIS)

2.1 PRIORITIZATION OF KPIS ADDRESSING THE SPECIFIC CITY NEEDS

As explained earlier, the stakeholders' priorities are determined by assigning weights to the selected Key Performance Indicators (KPI's). The KPI weighing activity in Kigali was conducted alongside the stakeholder interviews, the procedure for which has been described in section 2.1.4. Overall, nine interviews were conducted with six stakeholder groups (academic, government, service providers, public transport, foundations, and manufacturers).

Figure 11 shows the mean values of the weights received from the stakeholders for the level 1, level 2 and level 3 KPIs. Each box shows KPI values in black text (relative weights) and red text (cumulative weights). Relative weights indicate stakeholder priorities within a family and sum to 1. Cumulative weights at each level are determined by

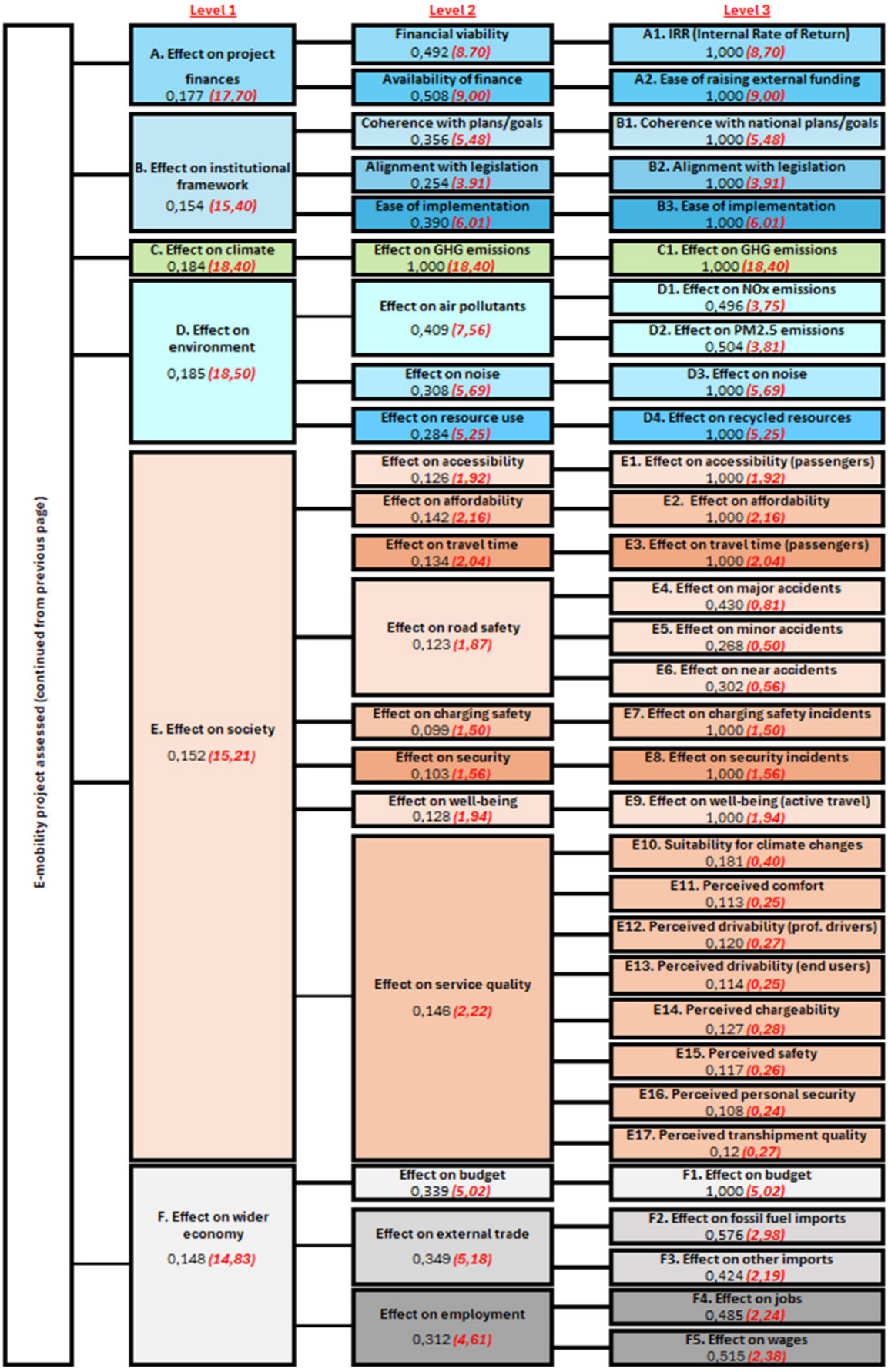


Figure 11. Attribute weights indicated by the Kigali stakeholders

applying the relative weights of that level to the parent attribute's cumulative weight. The sum of all cumulative weights at each level is set to 100, and the cumulative weights of Level 1 KPIs are identical to the corresponding relative ones, only expressed at a different scale.

Effect on the environment and effect on the climate, with a cumulative weight of 18.55 and 18.40, respectively, appear as the stakeholders' main priority, apparently reflecting the importance of electric mobility for both the environment and climate change mitigation. Project finance is the third-highest priority, underlying the importance of finance in supporting electric mobility initiatives. As also in the user needs analysis, institutions play an important role in the indicator weighting for Kigali institutional framework, which has been rated marginally higher when compared to the effect on society with a very small difference in weight (0.24). The stakeholders give the effects on the wider economy (14.83) the lowest priority.

Among the level 2 indicators, some interesting observations can be made. Air pollution is accorded higher priority among the three 'effects on the environment level 2 indicators. Followed by noise pollution and environmental resources resulting from implementing the electric mobility project has the lowest priority among the environmental indicators. Among the institutional framework, ease of implementation is considered as most important by the stakeholders. Likewise, coherence with plans/ goals is also given very high importance by stakeholders. Thus, with the pending electric mobility policy in Kigali, there is a lot of hope that it will ease the implementation and help the city achieve its sustainable development goals. Among the effects on society indicators, quality of service, affordability and travel time come out as the parameters considered most important by the stakeholders. Highlighting the need for good quality, affordable service which improves accessibility by reducing travel time in Kigali.

In relation to the level 3 attributes, the importance accorded to climate again gets reflected in the high score (0.40) given to suitability for climate change among service quality indicators. Also, service quality, safety, and personal security are given high importance among the service quality indicators. Level 3 attributes of safety accord high importance to need to reduce major accidents.

With only eight stakeholders from six stakeholder groups presenting KPI results diss aggregated by stakeholders presented in figure 12 needs to be addressed with caution, the further discussion on indicator weight by stakeholder groups should be considered tentatively.

The foundation and OEM stakeholders assign high importance to finance, that is 23.4 and 20.5, respectively. These values are way more than the average 17.71 for the indicator. Comparatively, the national authority gives less importance to the financial viability of electric mobility projects. For the government, it seems that electric mobility projects are essential for the other benefits they carry, which out-weight the need for these projects to be financially viable.

- OEM and the stakeholder from academia accorded the institutional issues high importance. With scores of 14.3, 15 and 15.6, service providers and the national authority gave relatively less priority to the institutional issues over other dimensions.
- Even though the economic indicator has the lowest overall score, economic issues are accorded very high importance by the national authority with a very high score of 22.2, underlining the national authority's importance.

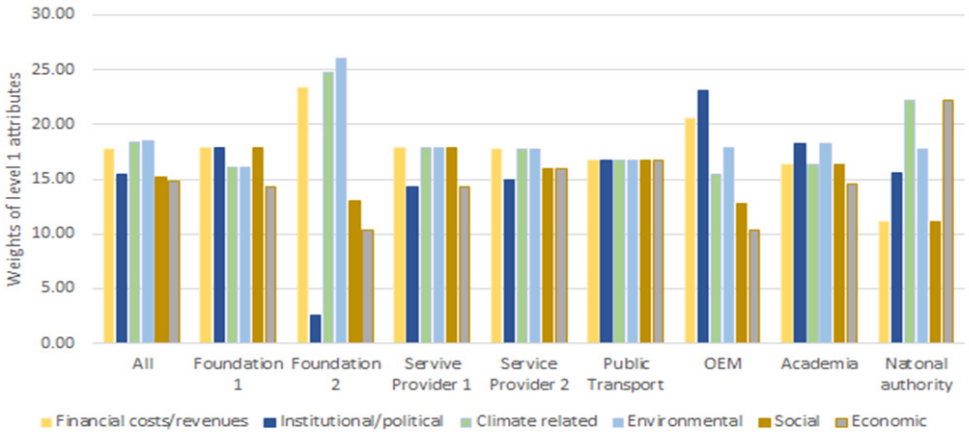


Figure 12: Level 1 Weights by stakeholder groups

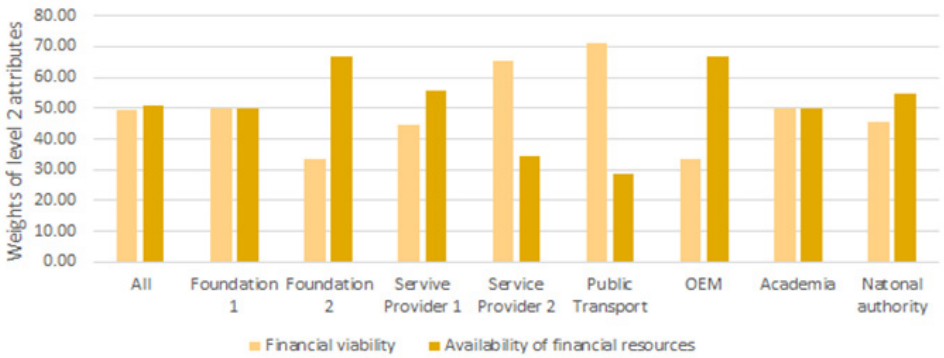


Figure 13 : Level 2 Weights by stakeholder groups - Financial cost/revenues

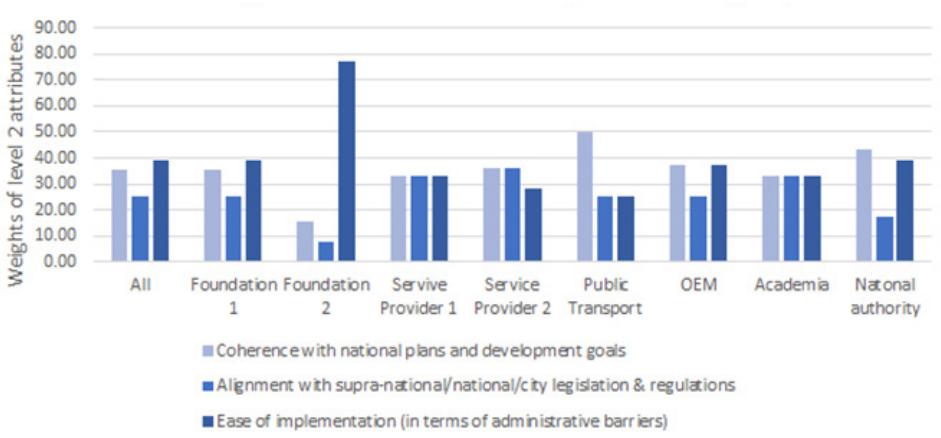


Figure 14: Level 2 Weights by stakeholder groups- Institutional Issues

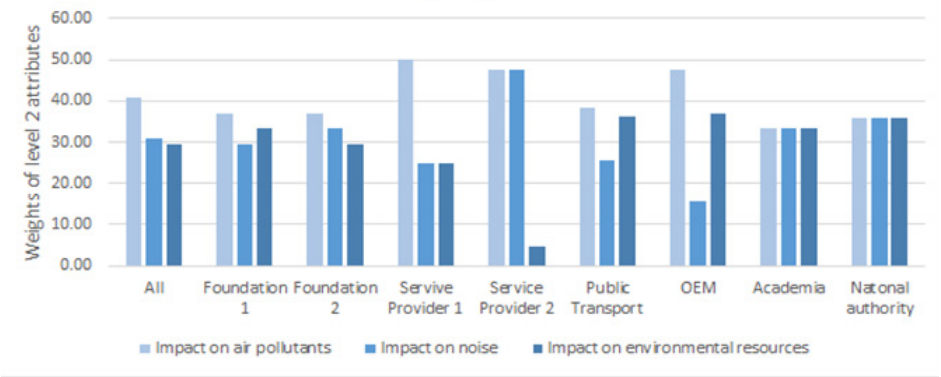


Figure 15 : Level 2 Weights by stakeholder groups - Environmental attributes

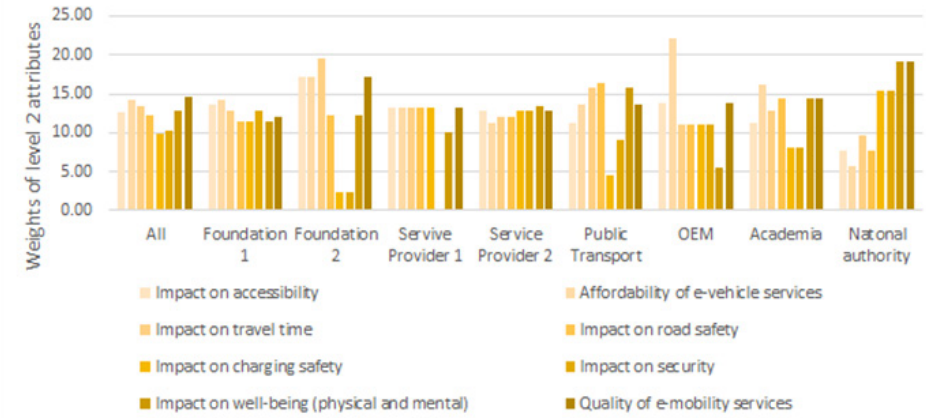


Figure 16: Level 2 Weights by stakeholder groups- Societal attributes

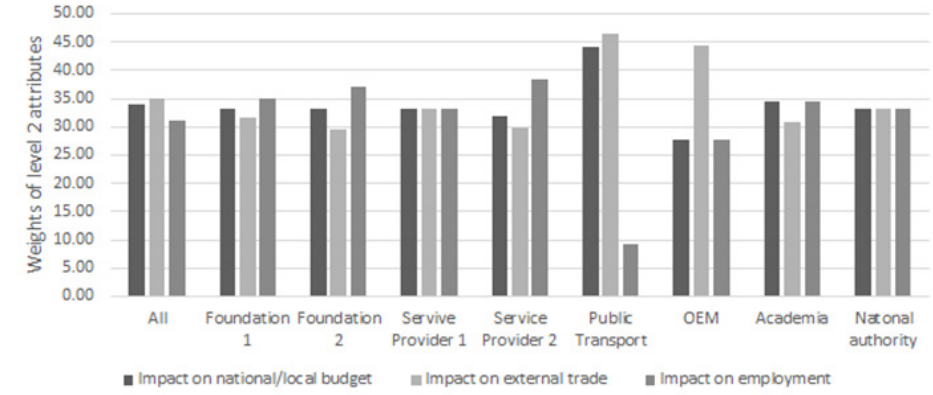


Figure 17: Level 2 Weights by stakeholder groups- Economic attributes

- For climate and environmental KPI's high importance is given by the foundation and the national authority. For the national authority, the need to mitigate climate change is as important as the economy with both having a score of 22.2. Foundation 2, is a research foundation, and, naturally, they consider climate change and the environment as the two most important issues with high scores of 24.7 and 26.
- Because the national authority and foundation 2 have given high importance to other issues, their scores for social KPI's are relatively low.

Figure 13 shows that service provider 2 and the public transport operator give significantly high importance to the projects' financial viability within finance. Foundation 2, OEM operator, and national authority consider both financial viability and availability of financial resources to be essential but accord higher importance to the availability of financial resources.

Foundation 2, which gives high importance to climate and environment KPI's, also gives a very high score to ease of implementation among institutional KPIs, as shown in Figure 14. The stakeholder from academics and service provider 1 thinks that all three institutional issues are of equal importance. The public transport provider and national authority consider coherence with national plans and development goals to be slightly more important than needed for easy implementation of electric mobility projects.

The stakeholders from academia and the national authority gave equal weight to all environmental attributes. As shown in Figure 15, all other stakeholders consider the impact on air quality as the essential environmental level 2 KPI. Surprising public transport operators and OEMs gave relatively low weight to noise pollution and thought the impact on environmental resources was more critical in comparison.

Foundation 2 and the national authority gave very high scores to the quality of e-mobility services. Foundation 2, OEM, and stakeholders from academia gave high scores to the affordability of e-mobility services; OEM stakeholder score was exceptionally high at 22.2. Foundation 2 and the public transport operation also considered the impact on travel time should have high weightage. Interestingly, for public transport operators, travel time has a direct link with patronage. Public transport operators also considered safety and well-being indicators more critical than other societal indicators like security and charging safety.

National authority, as stated earlier, gave high importance to economic KPIs, but at level 2, they accord equal importance to all three KPIs. OEM operators and public transport operators consider the impact on external trade more important compared to other indicators. Likewise, service provider 2 and both foundations consider that impact on employment should have marginally higher weightage compared to other level 2 KPIs.

2.1.1 KPI estimation methods and data needs

Data requirements are determined by the KPIs selected for the impact assessment in conjunction with the methods to be deployed in their estimation. Table 2 briefly presents the Level 2 KPIs and the corresponding estimation methods and data needs. Note that a distinction is provided for the estimation method, depending on whether the assessment concerns the demonstration project/component or the corresponding scaled-up project. The absence of a demo entry in the estimation column signifies no expected effect at the demonstration level. Some indicative data sources are provided in Table 3.

Table 3:. KPI estimation method and data needs

KEY PERFORMANCE INDICATORS		ESTIMATION METHOD	DATA NEEDS
LEVEL 1	LEVEL 2		
Effect on project finances	Financial viability	Scaled-up: The NPV, IRR, CER and payback indices will be calculated via specialised financial assessment tools calibrated for the specific applications. The total cost of ownership (TCO) calculations of the UNEP eMob model can also be used. Demo: No need to go beyond TCO estimates, as the purpose is to collect the data required for assessing the financial viability of the scaled-up project. Possible economies and diseconomies of scale effects need to be considered in applying demo figures on the scaled-up project.	Detailed capital, operating and maintenance costs on an annual basis for all project vehicles and for the duration of their expected lifespan One-time project preparation (if applicable) and residual values Cost structure of the corresponding baseline solutions (to be replaced by the proposed ones) Expected revenues of the executing agency Both costs and revenues are estimated on the basis of the corresponding volume figures and unit prices
	Availability of finance	Scaled-up: Direct rating (Likert scale)	Available private, government and donor funds, credit lines, etc. to be used for the scaled-up project in case external funding is required
Effect on institutional framework	Coherence with national plans/ goals	Scaled up: Direct rating (Likert scale)	National plans and development goals in relation to SDGs, climate change, energy policies, transport policies, environmental protection policies, etc. Similar plans and goals at regional/ city level
	Alignment with legislation	Scaled up: Direct rating (Likert scale)	National legislation concerning manufacturing, conversion, licensing, operation and decommissioning of urban transport vehicles with emphasis on EVs Similar regulations at regional/city level Technical standards for EV manufacturing and charging infrastructure

KEY PERFORMANCE INDICATORS		ESTIMATION METHOD	DATA NEEDS
LEVEL 1	LEVEL 2		
	Ease of implementation	Scaled up: Direct rating (Likert scale)	Implementation of existing legislation Enforcement mechanisms Administrative barriers
Effect on climate	Effect on GHG emissions	Scaled up: Application of the UNEP eMob model Demo: Calculation of the GHG emissions abated by comparing the EV carbon emissions (if any) to those of the do-nothing practice	Socio-economic data (population, regional GDP, expected GDP growth rate until target year) Composition of relevant fleets (existing vehicle stock, projected sales until target year, composition of sales by technology) Emission standards by year of introduction Fuel quality standards by year of introduction Existing and projected charging infrastructure Fuel economy of vehicles involved Operational characteristics (annual mileage, load factor, expected lifespan) The default emission figures provided by the UNEP eMob model for the vehicles involved might be sufficient for the demo components
Effect on environment	Effect on air pollutants	Scaled up: Application of the UNEP eMob model Demo: Calculation of the NOx and PM2.5 emissions abated by comparing the EV corresponding emissions (if any) to those of the do-nothing practice	Ibid
	Effect on noise	Scaled up: Expected reduction in noise due to the electric drive as reported in literature. Demo: Ibid	Considered positive for e-motos.

KEY PERFORMANCE INDICATORS		ESTIMATION METHOD	DATA NEEDS
LEVEL 1	LEVEL 2		
	Effect on resource use	Scaled up: Quantification of mechanical parts and batteries recycled. Demo: Ibid	Weight of recycled parts (due to conversion) as a percentage of the total weight Battery recycling infrastructure Volume of recycled batteries generated by project activities
Effect on society	Effect on accessibility	Scaled up: Effect is possible only in case of substantial cost savings due to the conversion of old diesel buses to e-buses	Pricing policy
	Effect on affordability	Scaled up: No effect on travel time is expected by the planned SOLUTIONplus initiates	Delays due to malfunctions of diesel buses Technical reliability of e-buses vs. diesel buses
	Effect on travel time	Scaled up: Comparison of EVs with traditional vehicles with respect to road accidents per vkm Demo: Monitoring and reporting of safety incidents during the demo period	Official annual national/regional/city statistics on road accidents by type (fatalities/major injuries, minor injuries/material damages, near misses) Official annual statistics of road accidents by gender Official annual statistics of road accidents involving VRUs Official statistics of accidents involving EVs
	Effect on road safety	Scaled up: Comparison of EVs with traditional vehicles with respect to charging safety incidents per thousand recharging/refuelling operations Demo: Monitoring and reporting of charging safety incidents during demo period	Official national/regional/city statistics on safety incidents during refuelling operations Official statistics on safety incidents during recharging operations of EVs

KEY PERFORMANCE INDICATORS		ESTIMATION METHOD	DATA NEEDS
LEVEL 1	LEVEL 2		
Effect on wider economy	Effect on charging safety	Effect on security Scaled up: Comparison of EVs with traditional vehicles concerning security incidents per vkm Demo: Monitoring and reporting of security incidents during demo period	Official national/regional/city statistics on safety incidents during refuelling operations Official statistics on safety incidents during recharging operations of EVs
	Effect on security	Scaled up: Comparison of EVs with traditional vehicles concerning security incidents per vkm Demo: Monitoring and reporting of security incidents during demo period	N/A
	Effect on well-being	Scaled up: No effect on accessibility is expected by the planned SOLUTIONSplus initiatives	N/A
	Effect on service quality	Scaled up: Direct rating (Likert scale)	User perceptions on suitability for climate changes, comfort, drivability (by professional drivers), chargeability, safety, personal security and transshipment quality
	Effect on budget	Scaled up: Comparison of required investment to the annual budget of the executing agency	Annual budget of the executing agency
	Effect on external trade	Scaled up: Expected reduction in imported values due to lower fossil fuel quantities and the conversion activities	Reduction of fossil fuel consumption due to the introduction of EVs Reduction of import value due to converting existing buses
	Effect on employment	Scaled up: Expected effects on jobs and technical skills due to the introduced e-mobility activities on the basis of published information and input requirements observed during demo	Effects on employment due to the introduction of e-mobility reported in Nepal and abroad Human resources required for the conversion activity Availability of necessary skills

The present version of the document has only shown the data needed for the UNEP eMobility calculator that has been used to estimate Climate and Air Pollution KPIs. In terms of other KPIs e.g., road safety, environmental resources, national / local budget, etc. the data needed will be mapped after a formal definition for KPI is done.

To analyze the baseline scenario to project energy use, greenhouse gas and pollutant emissions , the tool developed by UNEP' e-mobility (eMOB) calculator' is used. The required input data for the model includes Socio-economic data (GDP and population), vehicle stock and sales, vehicle technology shares, economic growth and techno-economic vehicle parameters. Stakeholders and local institutions are expected to be involved in data provision and collection are listed in Table 6.1 by type of data needs. Incase of lack of exact data, assumptions were made.

2.1.2 Value functions

As explained in the methodology section of D1.6 – Vol.1 (Section 2.1.3.2), the KPI values estimated as described in Section 2.2 need to be transformed into star values to become compatible. This is done through value functions, which, in the case of Kigali, were constructed together with partners involved in the project and through an online call on 21 March 2024.

There are KPIs that do not require a value function. They fall into two categories. The first one concerns the KPIs that use a 5-point scale for scoring through direct rating, in which case the KPI value is identical to the corresponding star-value. The following indicators belong to this category:5

- Easeof raising external funding (A2),
- all three institutional/political KPIs (B1, B2, and B3),
- effect on noise (D3),
- effect on recycled resources (D4),
- effect on accessibility (E1)
- effect on affordability (E2)
- effect on travel time (E3)
- all KPIs related to road safety (E4-E6)
- KPI related to charging safety (E7)
- KPI related to security (E8)
- Effect on well beng (active travel) (E9)
- all KPIs related to service quality excluding drivability as perceived by end users (E10-E17)

The value functions of the remaining KPIs are presented below:

Financial viability

IRR, NPV and payback period are the indicators used for profit maximising operations, among which, the first two are considered more formal and are usually required by the financing institutions. Compared to NPV, IRR exhibits the advantage of being independent from the size of the investment. It was, thus, decided to construct a value function only for this indicator. The suggested function transforming the IRR (expressed in %) into a star value as required by the evaluation framework is shown in Table 4.

Table 4: Value function for the IRR

STAR	IRR RANGE	RATIONALE
1★	IRR ≤ 0%	Absolute loss
2★	0% < IRR ≤ 7.5%	IRR below risk free rate set by Central Bank
3★	7.5% < IRR ≤ 16%	IRR below lending rate to set by Banks
4★	16% < IRR ≤ 20%	IRR expected higher for EVs2 due to higher capital costs, risks with technology (battery swapping) and small volumes
5★	IRR > 20%	Profitable

Effect on GHG emissions

Table 5: Value function on GHG emissions

STAR	C1 RANGE	RATIONALE
1★	C1≤ 0%	EV can have higher CO2 emissions than a ICE if electricity is coming from coal
2★	0% < C1 ≤ 10%	
3★	10% < C1 ≤ 18%	% Reductions achieved due to fuel shift CNG/ LPG
4★	18% < C1 ≤ 28%	% Reductions achieved due to shift to EV when electricity is produced using Natural Gas
5★	C1 > 28%	Increasing electricity from renewables

This KPI is defined as the percentage change in the absolute mass of GHG emissions resulting from the new e-mobility solution under consideration in comparison to the baseline scenario (defined by the type of services/vehicles relevant to the scaled-up project components). It concerns well-to-wheel CO2 emissions accumulated over the entire assessment period (2019 to 2030). The value function needed to transform the percentage change of CO2 emissions into a star value appears in Table 5. The reductions rationale is mainly related to well-to-wheel emission reductions possible from different vehicle technologies based on a review of literature available in the IPCC Sixth assessment.

Effect on NOx emissions

This KPI is defined as the percentage change in the absolute mass of NOx emissions resulting from the new e-mobility solution under consideration in comparison to the

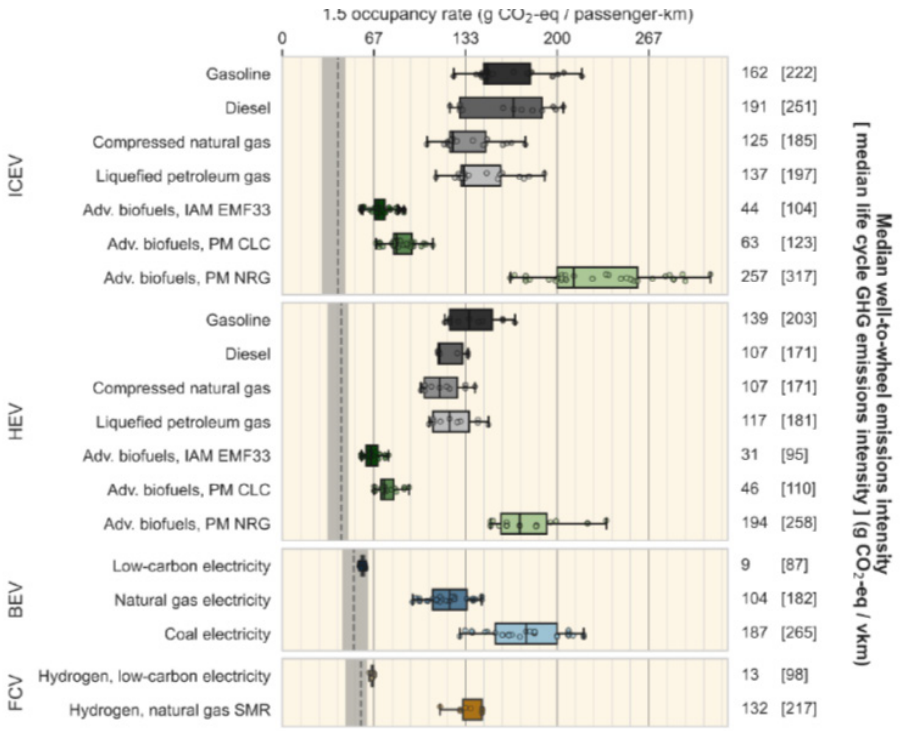


Figure 18: GHG emissions well-to-wheel from different light duty vehicles (Median and inter-quartile ranges) (Jaramillo, P. et al., 2022)

baseline scenario (defined by the type of services/vehicles relevant to the scaled-up project components). It concerns tank-to-wheel NOx emissions accumulated over the entire assessment period (2019 to 2030). The value function needed to transform the percentage change of NOx emissions into a star value were considered similar to C1 (Effect on CO2 emissions).

Effect on PM2.5 emissions

This KPI is defined as the percentage change in the absolute mass of PM2.5 emissions resulting from the new e-mobility solution under consideration in comparison to the baseline scenario (defined by the type of services/vehicles relevant to the scaled-up project components). It concerns tank-to-wheel PM2.5 emissions accumulated over the entire assessment period (2019 to 2030). The value function needed to transform the percentage change of NOx emissions into a star value were considered similar to C1 (Effect on CO2 emissions).

Effect on accessibility

In the case of e-motos they are simply substituting the ICE motos with no change in routes and stops and hence no change in accessibility is expected. For the e-bikes the value function will be defined once the demonstration is finalised.

Effect on affordability

Since the e-motos are simply substituting the ICE motos with no change in fares there will be no effect on affordability. For the e-bikes the value function will be defined once the demonstration is finalised.

Effect on travel time

In the case of e-motos, they are simply substituting the ICE motos with no change

in routes and stops. Further the driving speed will be also similar to ICE motos and hence no change in travel time is expected. However for e-Bikes the effect on travel time will be captured in a survey on a 5 point scale and would not require any value function.

Effect on national/local budget

Table 6: Value function on national/ local budget

STAR	ΔBUD RANGE	RATIONALE
1★	ΔBUD ≥ 1%	Very significant impact
2★	0.5% < ΔBUD ≤ 1%	
3★	0.2% < ΔBUD ≤ 0.5%	
4★	0.1% < ΔBUD ≤ 0.2%	
5★	ΔBUD ≤ 0.1%	Very small impact

This KPI is defined as the percentage change in the relevant (national/local) budget due to the scaled-up project. In case of funding from more than one public sources, the most burdensome effect among them will determine the KPI value (ΔBUD). ΔBUD measures the net effect as a percentage of baseline scenario budget. The value function needed to transform ΔBUD into a star value appears in Table 5.

Effect on fossil fuel and other imports

Table 7: Value function on fossil fuel or other imports

STAR	ΔFFI RANGE	RATIONALE
1★	ΔFFI ≤ 0.1%	Very small impact
2★	0.1% < ΔFFI ≤ 0.2%	
3★	0.2% < ΔFFI ≤ 0.5%	
4★	0.5% < ΔFFI ≤ 1%	
5★	ΔFFI ≥ 1 %	Very significant impact

This KPI is defined as the percentage change in fossil fuel imports (ΔFFI) within the project area and over the project duration. The value function needed to transform ΔFFI into a star value appears in Table 7.

Effect on employment

Table 8: Value function on fossil fuel or other imports

STAR	ΔJOB RANGE	RATIONALE
1★	ΔJOB ≤ 20	Very small impact
2★	20 < ΔJOB ≤ 50	
3★	50 < ΔJOB ≤ 100	
4★	100 < ΔJOB ≤ 250	
5★	ΔJOB ≥ 250	Very significant impact

This KPI is defined as the absolute number of net additional jobs (ΔJOB) expected to be generated by the e-mobility solution under consideration in comparison to the baseline scenario over the entire assessment period (2019 to 2030). The value function needed to transform ΔJOB into a star value appears in Table 8.

3 ASSESSMENT OF THE DEMONSTRATION PROJECT

The evaluation of the two demo projects, that is the e-bikes and e-motos is presented in the following sections (organised by KPI). In this detailed assessment we do not cover ebus demonstration since it happened towards the end of the project. A short note on the impact of eBus is provided at the end (sub section 3.6)

3.1 EFFECT ON PROJECT FINANCES

3.1.1 IRR

E-motos

The demo consisted of replacing 24 ICE motos (motorcycles) that are used to carry passengers on the back seat with 24 e-motos with no change in routes or fares charged. The demo was run by the company that provided the e-motos to drivers at a unit cost of USD 1284 in 2021 for which the drivers have various financial access modalities, including lease-to-own, rental or outright purchase. The company owns the batteries and provides the charged batteries (battery swapping model) to drivers and for which the drivers have to pay a per charging price of 1.84 USD per charge in 2021. The company did not provide information on their capital and operating costs for operating the battery swapping system. Therefore, the financial analysis is from the perspective of a driver for the theoretical case that this person would pay self a minimum Rwandan wage. The inputs used for financial assessment as provided below in the Table 9.

Table 9: Input values for assessing the e-motos (Drivers perspective)

PARAMETER	VALUE	UNITS	COMMENTS/ REFERENCE
Number of e-motos	24		
Discount Rate	10%		Bank Interest Rate + 2%
Battery type	Li-ion		
Battery size	3	KWh	
Range per charge at the start	91	km	
Motor	3	Kw	
Vehicle efficiency	30.3	km/Kwh	Efficiency depend on topography
	0.03	Kwh/km	
Battery life	2000	Cycles	Li Ion Batteries typically have a life between 1000 to 6000 cycles
Battery Useful Capacity at start	85%	%	
* Battery Useful Capacity at the start	2.55	KWh	
Battery Useful Capacity at the end	70%		
* Battery Useful Capacity at the end	2.1	KWh	
* Battery range at the start	77.35	km/charge	
* Battery range at the end	63.70	km/charge	
*Charging frequency per day	2.23	cycles/day	
* Battery life	2.88	years	
Total Capital cost	30,816	USD	For operating 24 e-motos
* Capex per year per moto	209	USD/year	
Purchase price per bike	1284	USD	Excluding Battery Cost
Expected useful life	10	years	
Residual value	100	USD	At end of life (based on scrap value)

PARAMETER	VALUE	UNITS	COMMENTS/ REFERENCE
* Capex for charging	0	USD/year	Charging being provided through battery swap model and included in operating costs
* Capex in replacement battery	32,640	USD	Linked to battery life. However not considered since batteries will be provided by The company
Replacement battery	1,360	USD /battery pack	
Depreciation schedule	0.10		
Route	Flexible		
Length of trip	8.6	km	
*Trips/day	18.3	trips/day	
Total distance/day	157.0	km/day	12-13 hours /day
Operating days/year	312	days/year	Assuming 6 days per week
*Total vehicle kms in a year	48984	pkm	
Total operating cost	87,728	USD/year	For operating 24 e-motos
* Fixed Operating Costs	4,786	USD/year	
- Insurance costs / moto	67	USD/year	
- Moto taxi registration / moto	103	USD/year	
- Helmet Cost	30	USD/year	
* Personnel cost	42,451	USD/year	
- Coordinator -1		USD/ Month	Considered part of charging cost
- IT Analyst -1		USD/ Month	Same as above -
- Driver -1	1,769	USD/Year	

PARAMETER	VALUE	UNITS	COMMENTS/ REFERENCE
- Mechanic -1		USD/ Month	Considered part of charging cost
* Charging Cost	30,672	USD/year	For charging 24 e-motos
- Battery swap cost	1.84	USD/ Charge	Cost of swapping battery (including electricity price)
* Maintenance cost	9,820	USD/year	For 24 e-motos
- Maintenance cost	346.75	USD/year	From 2020 The company's slide deck: 0.95 USD/ day
- co-op fee per day	0.20	USD/day	
***Total revenues**	**101,088**	**USD/year**	**From 24 e-motos**
Revenues per e-moto	13.50	USD/day	

The financial analysis was done using an excel spreadsheet and yield a pre-tax IRR of 42.4% (See Annex for overview of revenues and costs).

3.1.2 Availability of financial resources

	E-Motos		E-Bikes	
	(+)	(-)	(+)	(-)
A. The availability of government/regional/city funds for supporting the project	3	2	2	1
B. The intention of international donors to get involved in funding e-mobility projects of the suggested nature	5	0	2	1
C. The preparedness of commercial banks to support projects concerning e-mobility in the project city through preferential interest rates	2	3	2	1
Overall Rating	**3.3**		**3.3**	

The availability of financial resources was assessed by the project team and was assessed by five experts, including one from the university, one from an NGO and one from the city government. The overall rating is computed by dividing all the positive scores with the total responses (positive + negative).

E-motos

The Government of Rwanda has adopted a wide range of fiscal and non-fiscal incentives, such as full custom duty and VAT exemption for EVs, charging infrastructure, batteries and parts, reduction of electricity tariffs etc. (Strategic Paper for E-Mobility Adaptation in Rwanda, https://www.mininfra.gov.rw/fileadmin/user_upload/Mininfra/Publications/Laws_Orders_and_Instructions/Transport/16062021_Strategic_Paper_for_e-mobility_adaptation_in_Rwanda-Final.pdf). These incentives apply to e-motos. There is however no direct financing.

In addition, various projects have been launched or are being prepared with the support from the Governement. This is for instance, the retrofit electric motorcycles project launched by the government of Rwanda and UNDP Rwanda (https://www.undp.org/rwanda/press-releases/government-rwanda-and-undp-rwanda-launch-retrofit-electric-motorcycles-project) or the NAMA Support Project (NSP), now MAF (Mitigation Action Facility) project on e-motos, pending final validation " (https://nama-facility.org/projects/rwanda-accelerating-the-deployment-of-electric-motorcycle-taxis-e-motos-and-e-buses/),

Given UNDP's involvement in retrofitted e-motos and the MAF proposal on e-motos been selected in Phase I, the support from and intention from international donors to get involved in funding e-mobility projects of the suggested nature in Rwanda is positive. It is however mostly negative for banks as getting funding from the banks for the project is not very easy. However, asset financing companies now support them, which can be extended private commercial entities in general.

E-Bikes

The City of Kigali does not subsidise a bike-share system. However, the gov is indirectly financially supporting the system by allowing them to deploy dock stations in public spaces, where they will also collect advertising revenues. So no direct funding is available from the Government for these projects.

There are initiatives like the SOLUTIONSPLUS, but the IFC commissioned a study which was critical of the financial feasibility of e-bikes with a doubtful hypothesis; another financial assessment is being done, but so far, there is very little or no engagement from international donors.

There is no information about the support of commerce banks for bike-share systems, as banks do not see potential in the e-mobility business, especially the bike-share system. However, as mentioned for e-motos, there is goodwill created by active support from the government. Also, many e-bike providers have sought non-banking financial options to support e-bike purchases.

3.2 EFFECT ON INSTITUTIONAL FRAMEWORK

Like availability of financial resources, effect on the framework was assessed by the project team and was assessed by five experts, including one from the university, one from an NGO and one from the city government. The overall rating is computed by dividing all the positive scores with the total responses (positive + negative) and rounding to 0.5.

3.2.1 Coherence with national plans and development goals

E-motos

This project is completely aligned with the country's policies, including Rwanda's

updated National Determined Contribution (https://unfccc.int/sites/default/files/NDC/2022-06/Rwanda_Updated_NDC_May_2020.pdf), the National Transport Policy and Strategy for Rwanda (https://www.mininfra.gov.rw/fileadmin/user_upload/Mininfra/Publications/Policies/Transport/NATIONAL_TRANSPORT_POLICY_AND_STRATEGY_APRIL_2021.pdf), and the Strategic Paper for E-Mobility Adaptation in Rwanda) (https://www.mininfra.gov.rw/fileadmin/user_upload/Mininfra/Publications/Laws_Orders_and_Instructions/Transport/16062021_Strategic_Paper_for_e-mobility_adaptation_in_Rwanda-Final.pdf), all three documents recognising the importance of EVs.

As stated earlier, the government of Rwanda is involved in further current and planned e-mobility projects (UNDP Rwanda on retrofitted e-moto project, and MAF project in preparing), showing their alignement on e-mobility.

E-Bikes

Like E-motos, the E-Bike projects are also completely aligned with country policies, including the National Transport Policy and Strategy 2021 and the energy policy. However, there is no information regarding alignment with environmental policy, so it is unclear if there is an alignment or not. Similarly to e-motos, the project aligns well with policies at the city level.

	E-Motos		E-Bikes	
	(+)	(-)	(+)	(-)
Alignment with transport policy at national or city level (e.g., National Transport Plan, City Master Plans, etc.)	5	0	3	0
Alignment with energy policy at national level (e.g., Energy Performance / Efficiency Standards, etc.)	3	2	2	1
Alignment with environment policy at national or city level (e.g., emission standards, waste and recycling policies, etc.)	5	0	3	0
Alignment with overarching policies at national level (e.g., National Development Plans, Climate Action Plans, NDCs, etc.)	5	0	3	0
Overall Rating	**4.5**		**4.6**	

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

E-motos

The project's compliance level to the applicable regulations and laws is to the vehicle standards and regulations – including applicable homologation regulations. E-motos are fully compliant to the applicable laws and regulations in Rwanda. These have been inspected by the Rwanda National Police (RNP) and RNP is using international technology at European standards (https://www.ktpress.rw/2020/11/rwanda-national-police-opens-new-automobile-inspection-centres/). However, there is a level of uncertainty as the regulations of electric vehicles are not present in the country.

About charging infrastructure and the end-of life for e-motos battery regulations are

uncertain, they follow common regulations concerning charging equipment and cell batteries but no particularity regarding e-motos.

As any new business has to go through the Rwanda Development Board, the project fully complies with the country's business regulations. E-motos are eligible to work in all areas of roads There are no restrictions on their movement, and they are treated similarly to ICE engine vehicles as far as traffic rules and regulations are concerned. As there are still no clear rules and regulations regarding e-vehicles and charging infrastructure, it is uncertain if what is implemented within this project follows charging rules and regulations, as vehicle standards and regulations for Kigali do not exist. Likewise, there is also uncertainty if the pilots are in full compliance with environmental regulations like battery recycling etc., as these specific ecological regulations do not exist.

E-Bikes

Like E-motos, there is a level of compliance of the project to the applicable regulations and laws to the vehicle standards and regulations. However, there is a level of uncertainty as the regulations of electric vehicles are not present in the country.

Like E-motos compliance to charging infrastructure and end-of-life for e-motos battery

What is the project's compliance level to the applicable regulations and laws?	E-Motos		E-Bikes	
	FC	UC	FC	UC
Vehicle standards and regulations – including applicable homologation regulations (if applicable)	3	2	1	2
Charging equipment and infrastructure – including relevant standards for charging equipment and infrastructure	2	3	1	2
Business regulations – would encompass regulations applicable to the set-up and the process of providing the services (e.g. competition regulations, regulations pertaining to the legal requirements for emergent business models	4	1	2	1
Traffic regulations – e.g. eligibility of the project vehicles to operate in the proposed area/ types of roads	5	0	2	1
Charging operations – e.g. regulations pertaining to the operations/provision of charging services.	2	3	1	2
User / consumer protection regulations – e.g. for shared schemes – data protection, fair pricing regulations	2	3	1	2
Environmental regulations – e.g. end-of-life regulations (battery recycling, etc.)	2	3	1	2
Overall Rating	**2.9**		**2.5**	

FC = Full Compliance UC=Uncertainty

regulations are uncertain, they are compliant with business regulations and traffic regulations. But in the absence of a clear e-mobility policy, there is uncertainty with regard to their compliance to applicable laws and regulations regarding charging, environment, etc.

3.2.3 Ease of implementation (in terms of administrative barriers)

How easy is it to implement the project from an institutional/political point of view?	E-Motos		E-Bikes	
	(+)	(-)	(+)	(-)
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	5	0	3	0
The political and institutional bodies needed to support the implementation of the project are in place	5	0	3	0
The existing national/city political and institutional bodies are (likely to be) supportive of the necessary actions required for the project implementation	5	0	3	0
Overall Rating	**5**		**5**	

E-motos

Several positives facilitate the implementation of the project, including the Government of Rwanda project to retrofit electric motorcycles and the MAF support project to accelerate the deployment of electric vehicles. This project only required a letter of participation from the City of Kigali. The project has also led to the creation of some supporting institution structures, e.g. the E-mobility technical committee. They are very supportive; high-level political demand to introduce electric mobility and phase out ICE-motos; strong policy measures in the NDC, National Transport Policy and Strategy, 2021 government incentives, and City of Kigali Strategic Paper. Therefore, the implantation of the project is easy from an institutional/political viewpoint. The local and national governments also fully support these initiatives.

E-Bikes

The situation of e-bikes in terms of ease of implementation is similar to e-motos.

3.3 EFFECT ON CLIMATE

3.3.1 Effect on GHG emissions

UNEP E-Mob calculator is used to analyse the impact of SOLUTIONSPLUS interventions on GHG emissions. The GHG emissions are calculated well-to-wheels (including CO2 emissions in electricity production); In Kigali, as the e-motos (Kigali) replace the old ICE vehicles, therefore, these result in significant GHG emission reduction of 73%, from the base case technology in the base year. However, over the life of e-motos (assumed as 10 years) the absolute CO2 emissions from 24 e-motos will reduce by 636 tons. The CO2 emission reductions will be 71.8% lower in comparison with the ICE-motos.

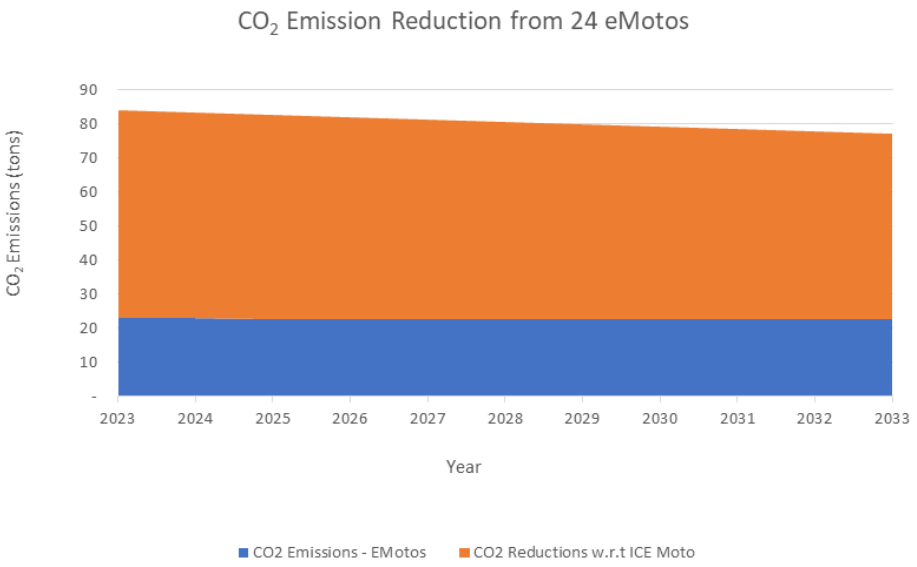


Figure 19: Impact of E-motos on CO2 reductions

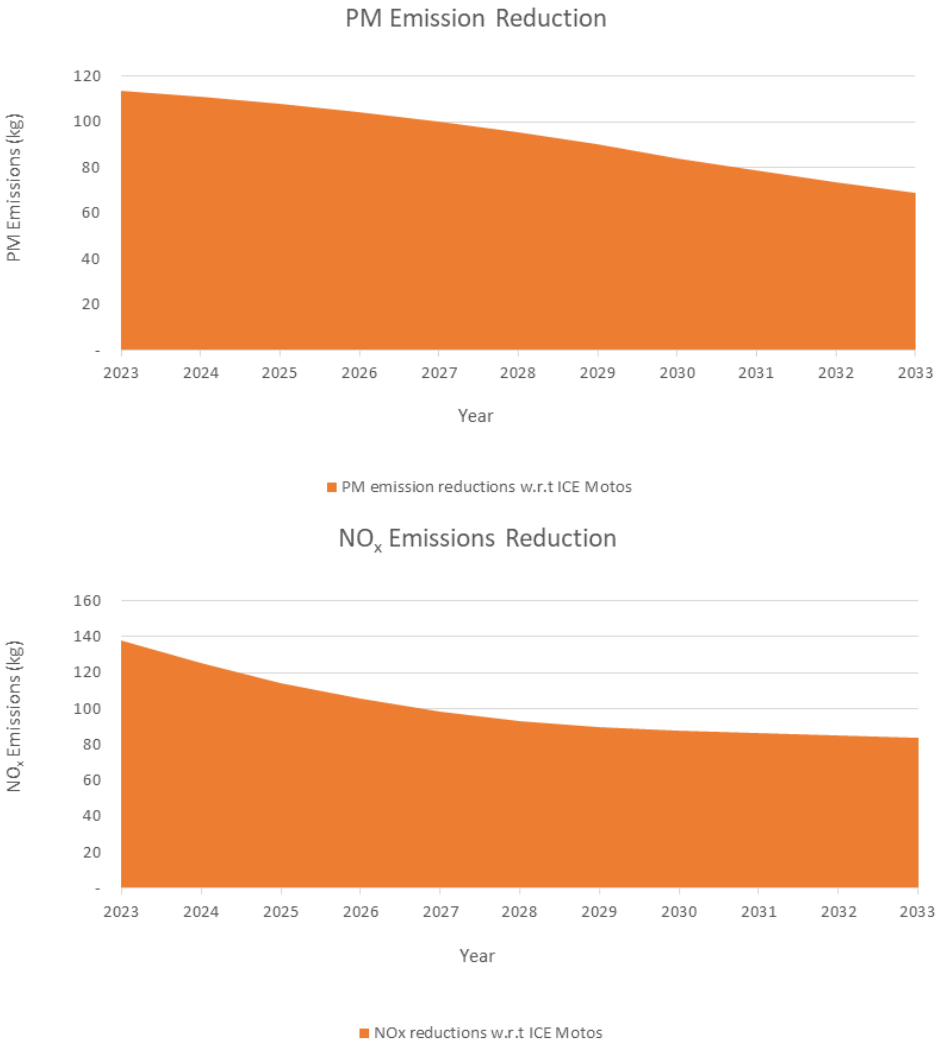


Figure 20: Impact PM and NOx emission reductions

3.4 EFFECT ON ENVIRONMENT

UNEP E-Mob calculator is used to analyse the impact of SOLUTIONSPLUS interventions on GHG pollution. The air pollution is calculated tank-to-wheels i.e., air pollution caused in the production of electricity is not included.

3.4.1 Effect on NOx and PM 2.5 emissions

There are significant air pollution reductions from e-motos since these vehicles have no tailpipe emissions. Over the life of 24 e-motos (assumed as 10 years) the absolute PM and NOX emissions from 24 e-motos will reduce by 1,029 kgs of PM and 1,106 kgs of NOX. The PM & NOx emissions will be 100% in comparison with the ICE-motos. However, the reductions reduce with time (Figure 20) since the ICE-motos emission performance also improves with time due to stricter emission standards.

3.4.2 Effect on noise

No significant impact on noise is expected from implementation of e-motos and neither was it found feasible to collect data on this KPI.

3.4.3 Effect on recycled resources

Does the project enhance/promote circular economy in the project city?	E-Motos		E-Bikes	
	(+)	(-)	(+)	(-)
Useful application of materials through recycling and recovering (e.g. incineration though energy recovery)	3	2	2	1
Smarter vehicle use and manufacturing through rethinking (making vehicle use more intensive) and reducing (increasing efficiency of vehicle manufacturing by consuming less natural resource)	4	1	2	1
Expanded lifespan of vehicles and their parts through reusing (using discarded vehicles) and repairing	4	1	2	1
Overall Rating	**3.5**		**3.5**	

E-motos

Even though the e-motos used in the demo project are new and do not have any recycled materials. The project is expected to enhance the circular economy by promoting the reuse of old motorcycles (retrofit electric motorcycles project launched by the government of Rwanda and UNDP Rwanda) . Given the policy on using recycled materials, in the long run it will definitely help reduce waste.

E-Bikes

Like e-motos, this project in the long run will lead to the reuse and transformation of old bicycles and, therefore, will have a positive or negative influence on promoting circular economy.

3.5 EFFECT ON SOCIETY

3.5.1 Effect on accessibility (passengers)

E-motos

As there is no change in the routes and operation of E-motos, there will be no change in accessibility levels. Therefore, a rating of 3 is taken.

3.5.2 Effect on affordability.

E-motos

The E-Moto fares for the end user have not changed so there is no effect on the affordability of the end users.

3.5.3 Effect on travel time (passengers)

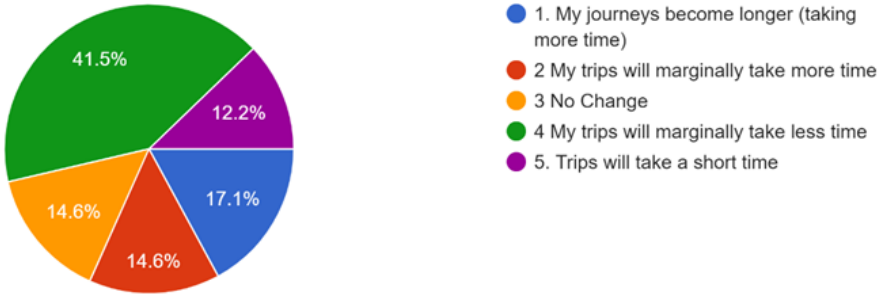


Figure 21: E-motos affect on travel time-user responses.

The effect on travel time is expected to remain the same. However, a survey of e-moto users was done to understand the perception the e-motos have on travel time-saving. A total of 46 e-moto users were surveyed. The respondents gave answers on issues related to travel time, safety, and their perception about service quality. The survey was only conducted for e-moto users as e-bikes was not implemented yet.

E-motos

As the routes of e-motos have remained the same, it is only that they have transited from ICE engine to electric engine, no apparent impact on the travel time for the end users is expected. However the end user were asked if using e-motos brings any changes in their travel time, the response is displaced in graph in Figure 20. Majority of the users indicated that the trips on e-motos was marginally faster compared to earlier modes, this might be because the e-motos have higher acceleration and better navigation possibilities compared to traditional ICE engines. A large portion of respondents (about 32%) felt that the trips took marginally longer line or a significantly higher time.

Overall rating 3.5

3.5.4 Safety (road safety situation in the area/city)

According to police data, Kigali City road-based accidents remain higher than the rest of Rwanda. In 2017, 71% of total registered road accidents involved motorcycles (moto-taxis), pedestrians and bicycles. As can be seen from figure 21 the main road and city circle junctions remain the hotspots for fatal accidents in Kigali, as determined from a study done from the police database. The information was extracted from the 2017

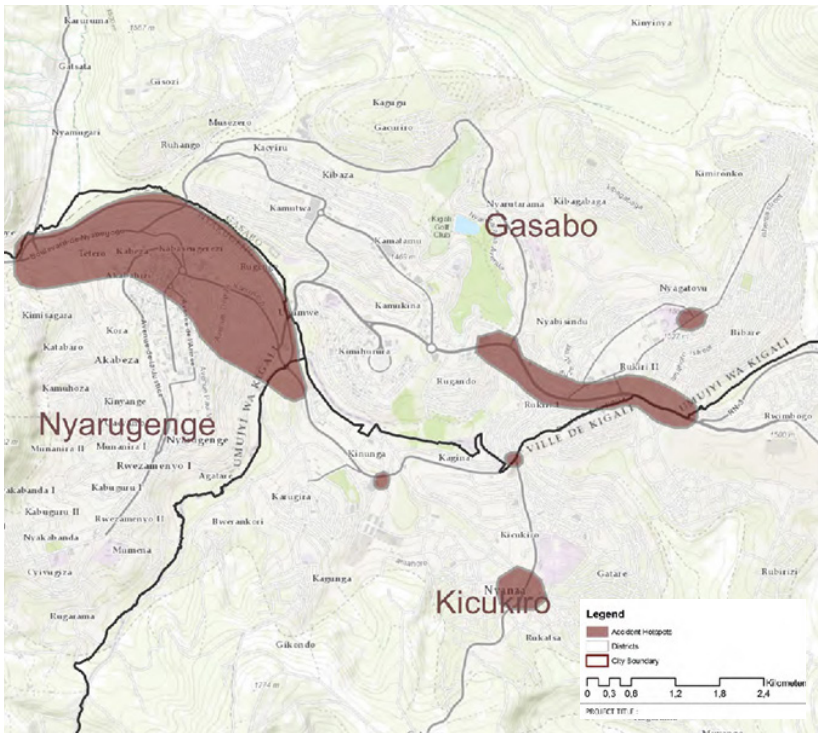


Figure 22: Fatal accidents hotspots(City of Kigali 2020)

Rwanda Statistical Yearbook. No data was available to distinguish between accidents involving pedestrian and cyclists. The government has continued to implement safer road programs to educate road users on the road's effective and safe usage. In 2017 the government reviewed laws on the road. As shown in Figure 6.25, motorcycles have the highest safety-related incidents, with both injuries at 55% share and fatalities at 37% share. They are followed by public transport vehicles. Solution+ project plans to promote both modes. Therefore it is essential that safety parameter are given careful consideration.

In figure 23 the users response to the question on how the introduction of e-motos has impacted the overall safety in Kigali city are displayed. The response was neutral on the impact on safety with slightly more respondents suggesting that the overall road safety is positively affected with the introduction of e-motos in Kigali.

E-motos

In figure 23 the users response to the question on how the introduction of e-motos has impacted the overall safety in Kigali city are displayed. The response was neutral on the impact on safety with slightly more respondents suggesting that the overall road safety is positively affected with the introduction of e-motos in Kigali.

Overall rating 3

3.5.5 Safety (increase/decrease in chances of road accidents)

E-motos

Figure 24 is the user response to the question on the impact of e-motos on an increase or decrease in the severity of road accidents. Very similar to the response on overall road safety, a majority of the respondents felt that there is no change, with a slightly higher share of respondants (about 39%) suggesting that the introduction of e-motos actually reduces the chance of severe accidents.

Overall rating 3

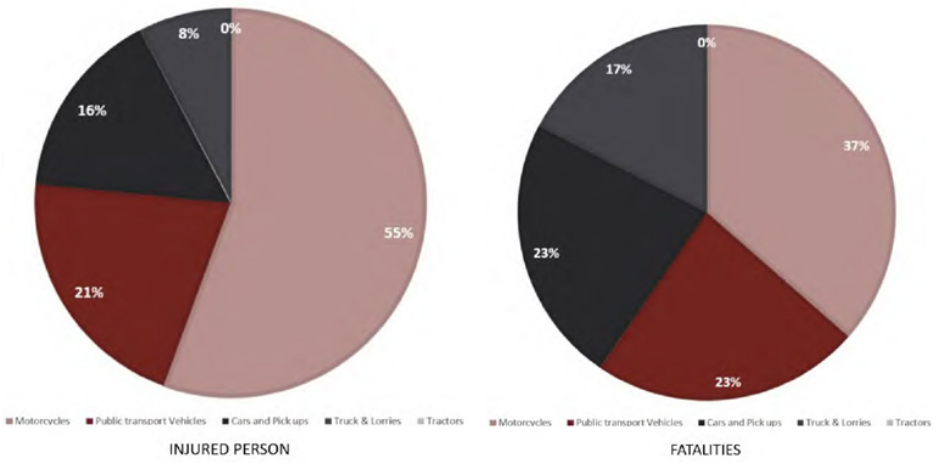


Figure 21: E-motos affect on travel time-user responses.

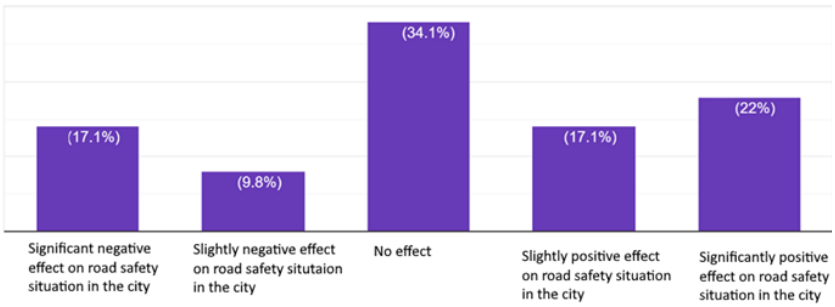


Figure 23: Injuries and Fatalities by Mode type

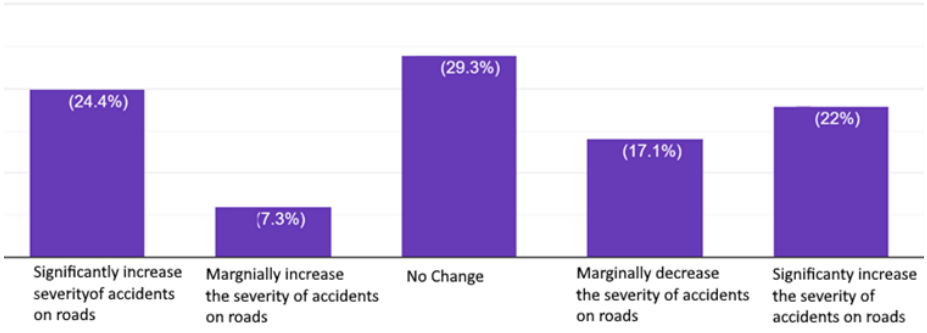


Figure 24: Impact of e-motos on road safety in general

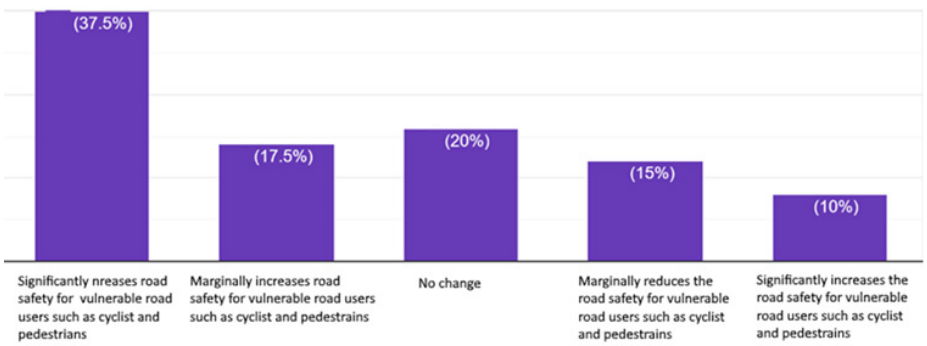


Figure 25: Impact of e-motos on increase/decrease in severity of road accidents

3.5.6 Safety (increase/decrease in road safety for vulnerable road users such as cyclists and pedestrians)

E-motos

Figure 25 shows the response to the question on the increase or decrease of road safety of vulnerable road users, like pedestrians and bicyclists, after the introduction of e-motos. Most respondents feel that there is a significant increase in road safety for vulnerable road users.

Overall rating 4

3.5.7 Effect on charging safety

Many of today's motorcycle repair shops lack tools, even meters, to recognise electricity failures (Sweco, 2019). Several actions need to be put in place before electric mobility can be scaled up and the number of vehicles increased. Further actions are needed, including that technical standards and regulations cover charging infrastructure design, safety and operational aspects and that pilots are used to learning and adjusting approaches. Charging infrastructure studies are needed for different vehicle categories, including testing charging strategies and assessing the feasibility of these solutions.

3.5.8 Effect on well-being (active travel)

E-motos

As the typical routes remain the same there is no impact expected on the active travel performed by users of e-motos. Hence a KPI score of 3 is considered.

3.5.9 Effect on service quality

Description	Suitability for adverse weather condition	Perceived comfort	Perceived safety	Perceived Security	Continuity of travel	Noise level
Old is much better than the new	3	7	5	3	4	8
Old is better than the new	8	10	12	7	8	5
There is no difference	14	12	9	17	10	7
New solution is better	11	13	11	11	9	6
The solution is much better	6	4	5	5	8	14
total	42	46	42	43	39	40
Overall Score	**3.21**	**2.93**	**2.98**	**3.19**	**3.23**	**3.33**
Overall Rating	**3.15**					

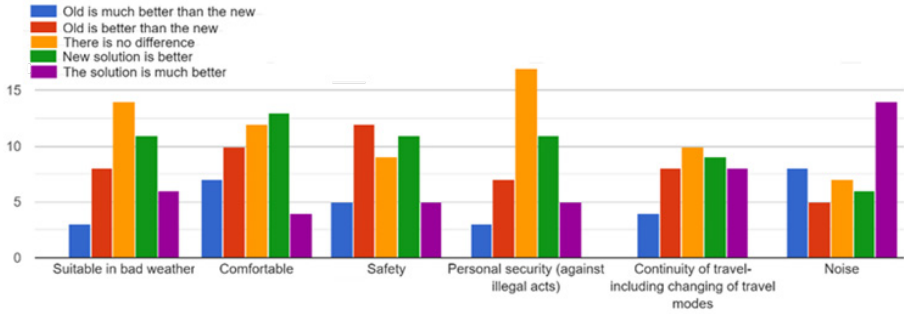


Figure 27: Perception on service quality

The relevant indicators in service quality are based on the responses from survey respondents. These are from e-moto users, as discussed earlier. A total of 46 responses were received. The responses received are shown in figure 26. The results show that user have rated all the service level indicators a little above average. User perceive e-motos are more secure, help in continuity of travel and also help reduce noise levels and are more suitable in adverse weather condition.

3.6 Effect of e-buses

The eBus pilot with four e-buses was run successfully over 3 months starting from December 2023. The e-bus pilot has been well aligned with the policies in the country and has already provided inputs for the "E-Bus Charging Master Plan" document for the city of Kigali, developed in the context of SOLUTIONSplus.

The e-buses were procured by BasiGo and leased to three bus operators in Kigali at a discounted price of 600 Rwandan francs per kilometer. The lease payments are automatically deducted from the fare payments, which simplifies the cash flow planning for the bus operators. The financial assessment from the standpoint of BasiGo could not be undertaken since full data on capital and operating costs was not available (only energy costs provided). However, given that BasisGo is moving ahead with scaling up of e-bus leasing in Rwanda (142 e-bus reservations made, 10 bus operators having expressed interest), it can be assumed that they have a financially viable model. From an operator's perspective, the demo shows that on average each operator is earning more than 162,859 RWF per day which is close to the monthly average salary for a driver in Rwanda.

Average daily revenue generated per bus	259,009 RWF
Average daily lease rental per bus	96,150 RWF
Average daily income for operator per bus	162,859 RWF

The eBus pilot will contribute significantly towards the reduction of CO2 emissions and over a ten-year period the cumulative CO2 reduction on a well-to-wheel basis from the 4 e-buses will be 2.3 thousand tCO2 and around 93% lower than diesel buses. However, the CO2 reduction will decline with time since in the BAU we consider more efficient diesel buses would come over time and replace inefficient buses and thereby reduce the efficient advantage of e-buses. The analysis assumed a constant CO2 intensity of 0.46 KgCO2 per kWh for electricity.

The PM and NOx emission reductions from e-bus implementation are significant to start with. However, they are projected to decline (Figure 29) due to the assumption that by 2030 Rwanda would adopt the Euro V and by 2040 Euro VI emission standards. The decline is more significant for PM as compared to NOx emissions.

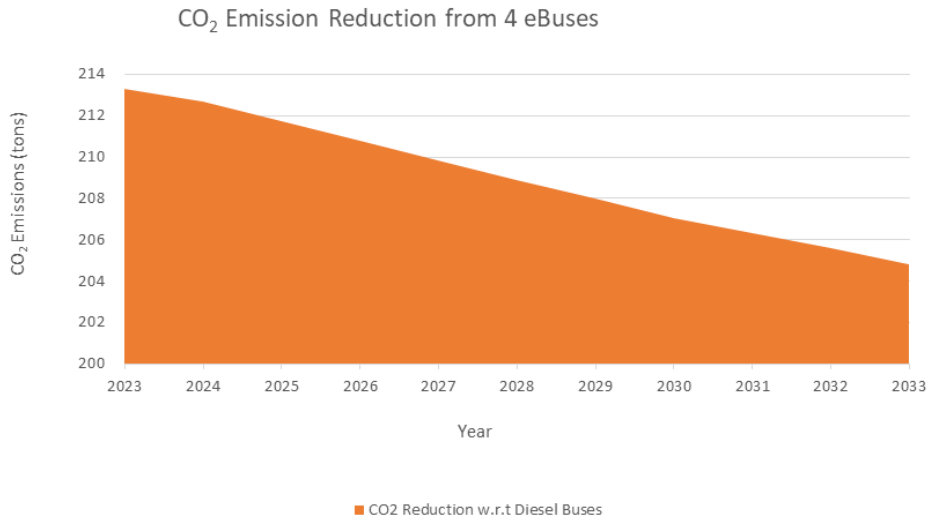
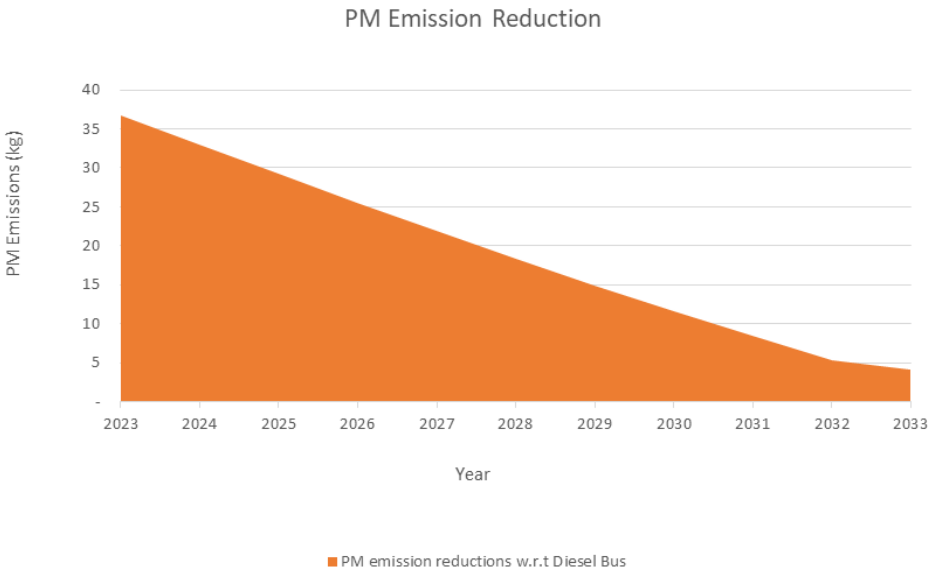


Figure 28: CO2 Emission Reduction from 4 eBuses



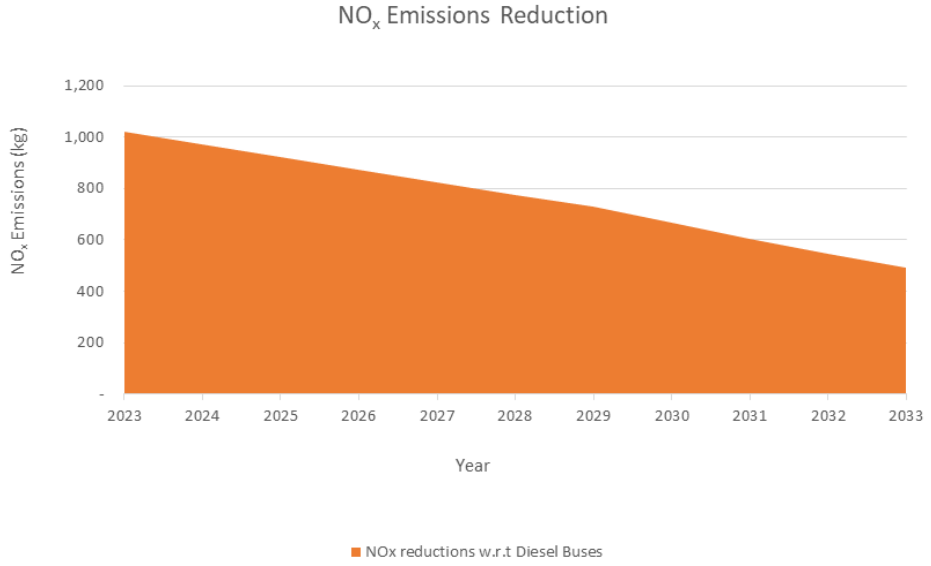


Figure 29: PM and NOx Emission Reduction from 4 eBuses

4 SCALED UP PROJECT FOR E-MOTOS

The National Transport and Policy Strategy for Rwanda (2021) had extremely ambitious targets for EVs (p.49) and targeted 30% of the new vehicles to be electric by 2023/2024 and by 2034/35 70% for could be electric. We have therefore considered this as a target for e-motos as well and quantify the impacts of the same for wider economy and also climate and environment.

4.1 BASELINE SCENARIO

Motorcycles that run on gasoline are used as a means of public transport. The motorcycle stock in Kigali was around 30,000 in 2019 and has been increasing with time and by 2050 this is expected to go to around 70,000 motorcycles in line with past trends (Figure 27). We have however assumed that as per capita incomes go beyond 10,000 USD that growth in motorcycles will slow down and therefore an elasticity with income of 0.7 is considered.

In the baseline scenario it is expected that electric motorcycles will take some share from gasoline ICE motor-cycles. In the baseline scenario we have assumed a modest share of 15% in sales for electric motorcycles. The eMob can model the stock of e-motos and for this we consider a lifetime of 10 years for both ICE and electric motorcycles.

The energy, GHG emissions and local pollutants for the motorcycles are projected upto the year 2050 using the eMOB calculator. The average fuel consumption of ICE motorcycles was estimated as 2.4 Liters of gasoline per 100 km and they run on an average 48,984 km in a year.

4.1.1 Energy and GHG emissions

Sine the gasoline ICE technology is considered to dominate the share of motorcycles, the energy mix is expected to be dominated by gasoline (Figure 28). The eMob calculator assumes a continuous improvement in energy efficiency (0.9% per annum) since older vehicles will be retired and newer more efficient vehicles are expected to replace them. Therefore, growth in energy demand will be slower than growth in motorcycle population e.g., though motorcycle population doubles between 2020 and 2050 the growth in energy is less than double.

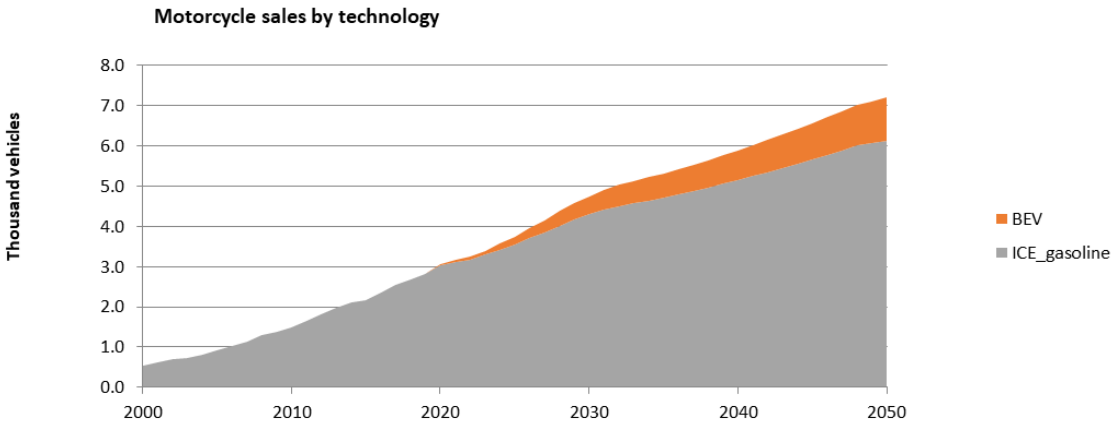
The eMob calculator based on use of fossil fuels calculate the CO2 emissions using CO2 emission coefficients from IPCC. Accordingly, the growth CO2 emissions follows a trajectory like growth in gasoline demand. The eMob calculator also allocates the emissions from electricity production and for this it uses the grid emission factors. In case of Rwanda since a large part of electricity is hydro the grid emission factor of 0.46 Kg CO2 per kwh is taken. On account of the higher energy efficiency and low grid emission factor the GHG emissions of e-motos is quite small.

4.1.2 PM and NOx emissions

In contrast to CO2 emissions the PM and NOx emissions start decoupling from energy demand and this is largely due to the assumption that by 2030 Rwanda would adopt the Euro V and by 2040 Euro VI emission standards. Electrification of motorcycles will also help in this regard since they have zero tail pipe emissions.

4.2 KPIS FOR ASSESSING SCALED UP PROJECT

All KPIs of Figure 6-10 enter the assessment of the scaled-up project. The indicators



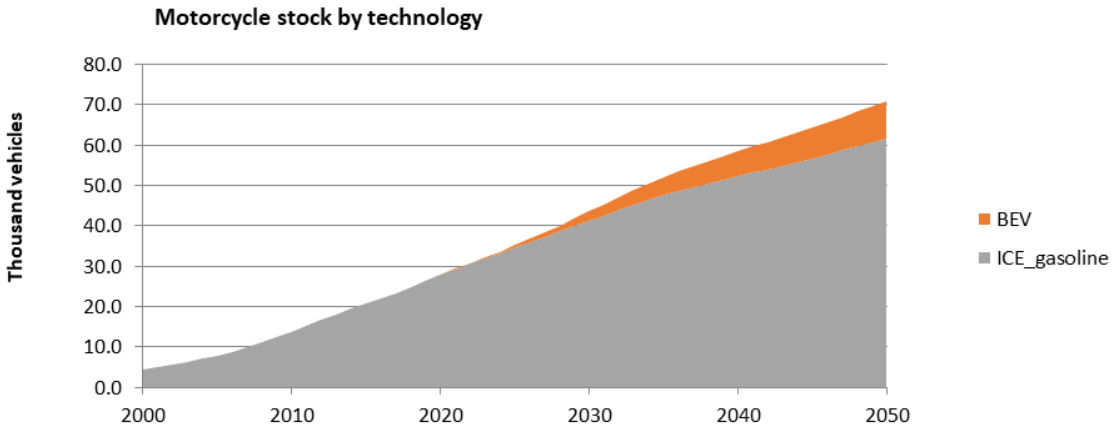


Figure 30: Motorcycle sales and stock by technology (projections)

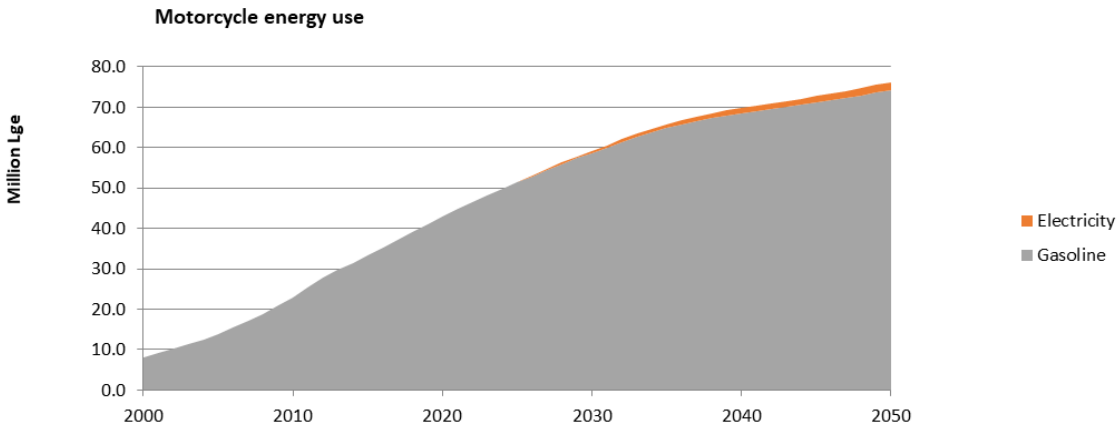


Figure 31: Energy use Motorcycle

concerning the effect of the project on the wider economy should, thus, be added to those already assessed for the Demo. These additional indicators relate to the effect on budget, external trade, and employment. Since e-motos are being implemented through private sector players and there is no impacts on city or national budget the effect was found to be not relevant. Lack of data also lead to abandoning the KPI on the effect on 'other imports,' restricting external trade consideration to merely fossil fuel imports. The wider economy effects were reduced to impacts on fossil fuel imports, employment through job creation and technical skill requirements, which are presented in the following headings

4.2.1 Effect on fossil fuel imports

If the e-motos achieve the vehicle shares proposed in the National Transport and Policy Strategy for Rwanda then progressively there will be a decrease in demand for gasoline and an increase in electricity demand. The decline in demand for gasoline will be far greater than the increase in demand for electricity. In terms of overall energy, the cumulative energy savings till 2050 will be 666 million lge (Figure 35), however the gasoline savings over the same period will be 805 million lge (Table 9).

In 2021 Rwanda imported 16,908 TJ of oil products (UN Statistics). However, the total gasoline consumption for motorcycles in 2021 was 44.4 million lge or 1486 TJ i.e., 8.8% of overall oil imports. The gasoline demand for motos is expected to increase to 74.1 million lge by 2050 and the cumulative demand for gasoline over the period 2020-50 will be 1867.2 million lge (Table 10). The savings in gasoline in eMob scenario will be 43% compared to BAU scenario however in relation to the overall petroleum exports the reduction will be 4%.

Table 10: Fuel Savings from scaled up implementation of e-motos

	2020-2025	2025-2030	2030-2035	2035-2040	2040-2045	2045-2050	Total savings
BAU Gasoline Demand (Million l) for Motos	239.3	274.9	308.6	333.0	348.6	362.8	1867.2
Gasoline Savings	10.6	49.5	113.8	171.6	211.7	247.7	804.9
% Savings w.r.t BAU Demand for Motos							43%
% Savings of Oil* Imports							4%

*Assuming that imports of oil products will happen at same rate as in 2021 and the share of motorcycles in oil demand remains same

4.2.2 Effect on jobs

EVs offer a significant opportunity for job creation. There will be job losses in

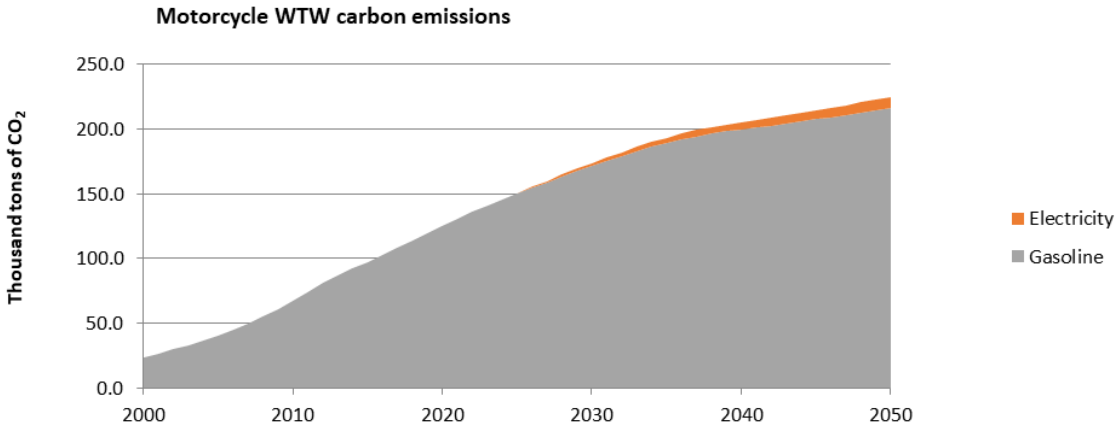


Figure 32: Motorcycle WTW carbon emissions

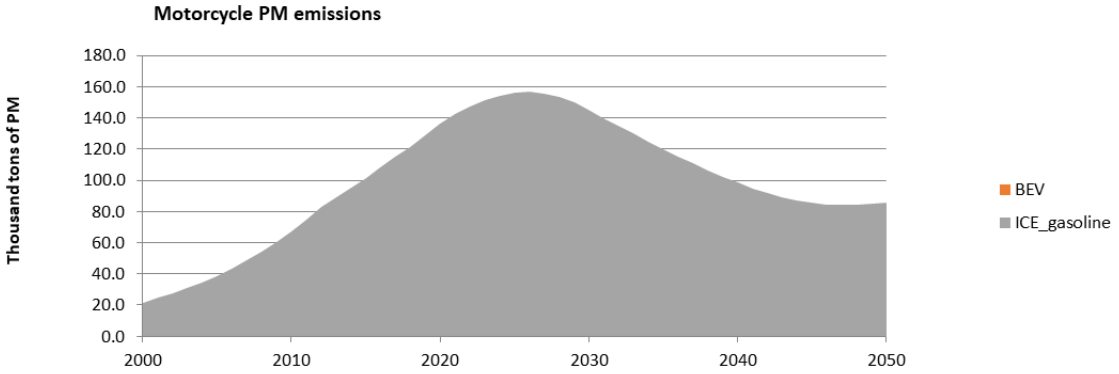


Figure 33: Motorcycle PM Emissions

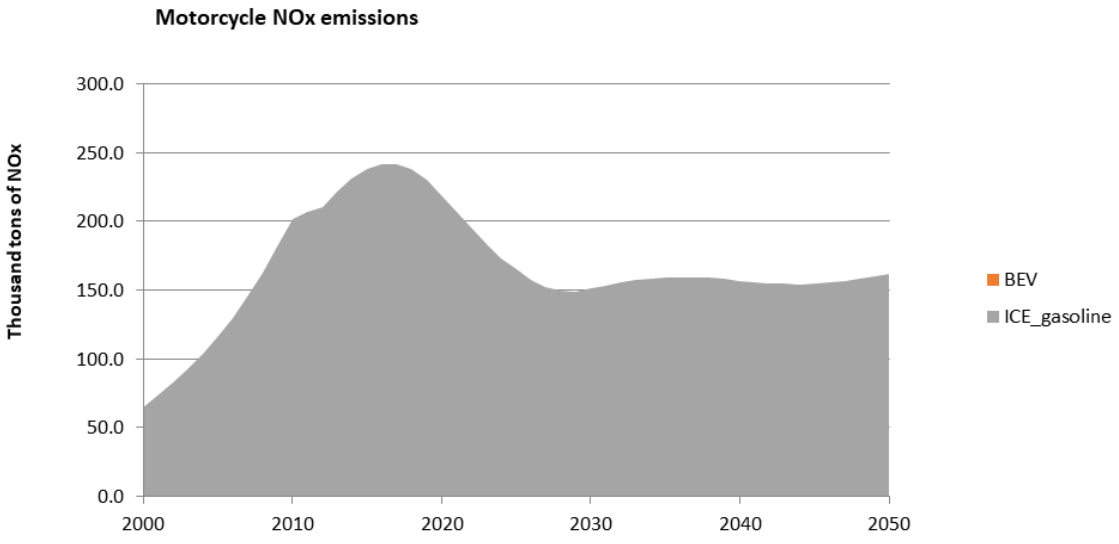


Figure 34: Motorcycle NOx emissions

conventional vehicles that use petrol / diesel, however, overall the impacts will be positive. For example, in China, the previous 10-year plan aimed at creating 1.2 million jobs engaged in producing 1.67 million new EVs annually during the decade 2010–2020.

Inputs from Ampersand were taken on the job creation through e-motos. This information was collected for the specialties relating to EVs: (i) EV technicians involved in the construction and mainly maintenance of the vehicles, (ii) EV design engineers involved in the design or remodeling of vehicles, and (iii) IT analysts or other Industry experts The responses received are summarised in Table 11. Ampersand was also provide an estimate about the jobs lost in each of the categories.

Table 11: Job Creation through e-motos

Job Types	Unit	Jobs +/-
Technicians		
New Jobs	No.	
Job Losses	No.	
Net Jobs	No.	
Engineers		
New Jobs	No.	
Job Losses	No.	
Net Jobs	No.	
IT Analystt & other experts		
New Jobs	No.	
Job Losses	No.	
Net Jobs	No.	
Total Net Jobs Added	No.	

5 DISCUSSION

This section discusses the work performed until April 2024 in relation to the impact assessment of the Kigali part of SOLUTIONSplus. The discussion is structured along two central themes: the assessment of the Kigali demo activities, and the assessment methodology itself

5.1 ASSESSMENT OF DEMO ACTIVITIES

The Kigali demo involved two different vehicle types (components) the e-motos and ebicycles. E-motos are supposed to either replace or add to existing motorcyles that run on petrol. In contrast, the e-bicycles involves the deployment of a public bike sharing scheme, initiated in 2021. To understand the user needs an online survey and interviews of 9 stakeholders were undertaken. Most stakeholders identified a

plurality of goals pursued via e-mobility, including reduced carbon emissions, reduced air pollution, the introduction of innovative mobility options such as e-bikes (bicycles), as well as fuel reduction imports.

E-motos being a cleaner alternative to ICE-motos aligned well with user expectations and the demo has contributed to building a momentum for e-motos in Kigali. Ampersand was able to leverage significant funding beyond SOLUTIONSplus for the e-motos. The project has provided positive results with regards to KPIs, pace of uptake of e-motos during the lifetime of SOLUTIONSplus (from about 30 vehicles in 2020 to 1,350 motorcycle taxis and 10 swapping stations as of late2023). In addition, the project included a successful gender-inclusive component, with 35 women trained as e-moto drivers and 24 e-motos successfully passing their exam and receiving the electric motorcycles.

Challenges remain, such as the facility to recruit trained engineers and mechanics, or the need to complete the regulatory landscape with clear standards and guidelines on the process to deploy charging infrastructure. Yet, the component of e-motos seems on a positive path to scale.

The component of e-bicycles is more challenging, as it faced large delays in the roll-out of the demonstration action. These challenges are related to barriers found on the side of the e-mobility company (impact of Covid on supply chains, challenges of Asia-based imports of parts, iterations from the initial model, lack of communication and reporting skills, lack of funding alongside SOLUTIONSplus) and the lack of an enabling environment (regulatory challenges in the partnership between the company and the City, absence of subsidies, pedal-assist electric bicycles not exempted from taxes, unlike larger electric vehicles). SOLUTIONSplus partners are in the process of identiy key learnings and recommandations to identify conditions for a viable system in the future.

The stakeholder provided inputs on the KPI weights at the beginning of the process and these revealed the stakeholder priorities. Effect on environment emerged as the highest priority for stakeholders, followed by effect on climate and effect on project finances. Stakeholder inputs were also collected to score a number of KPIs, where direct rating on a scale of 1 to 5 was used These stakeholder inputs were collected ex-ante and covered both e-motos and ebikes. Ex-post (after the emoto demo started) a survey was used to collect inputs from users on the KPIs related to service quality and safety.

5.2 Assessment of Methodology

From the long list of KPIs in the evaluation framework during stakeholder interviews 36 KPIs at Level 3 were shortlisted for the Kigali demo (Refer Table 13 put in the Annex). However subsequently when we started to assess the KPIs four KPIs were reduced. These KPIs were reduced under two categories a) Financial costs/revenues and b) social. The 32 KPIs that define the evaluation for Kigali are provided in Table 12.

The financial costs / revenues initially had three level 3 KPIs namely IRR, NPV and Payback period. Since Payback period ignores the time value of money the choice was then between NPV and IRR which take this into account,. NPV values are not comparable across projects whereas IRR values allow comparison and therefore it was decided to use only IRR value for assessing the financial viability.

Under social there were KPIs to measure travel time savings and accessibility and there was a KPI for passenger and freight for each under this category. Since there is no freight component in the Kigali demo it was decided to remove these two KPIs

Table 12: Input values for assessing the e-motos (Drivers perspective)

KPI Defined with stakeholder input	Entering into evaluation	Absolute Weight	Normalised Weight	KPI Score		Scale
				E-Motos	E-Bikes*	
A1. IRR (Internal Rate of Return)		8.70	11.06	17.48%		%
A2. Ease of raising external funding		9.00	11.44	3.5	3.5	5 point
B1. Coherence with national plans/goals		5.48	6.97	4.50	5	5 point
B2. Alignment with legislation		3.91	4.97	3	3	5 point
B3. Ease of implementation		6.01	7.64	5	5	5 point
C1. Effect on GHG emissions		18.40	23.39	71.80%		%
D1. Effect on NOx emissions		3.75	4.77	100.00%		%
D2. Effect on PM2.5 emissions		3.81	4.84	100.00%		%
D3. Effect on noise	No	5.69	0			
D4. Effect on recycled resources		5.25	6.68	3.50	3.5	5 point
E1. Effect on accessibility (passengers)		1.92	2.44	3	4.5	5 point
E2. Effect on affordability		2.16	2.75	3.00		5 point
E3. Effect on travel time (passengers)		2.04	2.59	3.5		5 point
E4. Effect on major accidents (road safety in general)		0.81	1.03	3		5 point
E5. Effect on minor accidents (sverity of road accidents)		0.50	0.64	3		5 point
E6. Effect on near accidents (road safety of vulnerable groups)		0.56	0.71	4		5 point

KPI Defined with stakeholder input	Entering into evaluation	Absolute Weight	Normalised Weight	KPI Score		Scale
				E-Motos	E-Bikes*	
E7. Effect on charging safety incidents	No	1.50	0			
E8. Effect on security incidents	No	1.56	0			
E9. Effect on well-being (active travel)		1.94	2.47	3		5 point
E10. Suitability for climate changes		0.40	0.51	3.21		5 point
E11. Perceived comfort		0.25	0.32	2.93		5 point
E12. Perceived drivability (prof. drivers)	No	0.27	0.34			
E13. Perceived drivability (end users)	No	0.25	0.32			
E14. Perceived chargeability		0.28	0.36			
E15. Perceived safety		0.26	0.33	2.98		5 point
E16. Perceived personal security		0.24	0.31	3.19		5 point
E17. Perceived transhipment quality	No	0.27	0.34			
F1. Effect on budget	No	5.02	0			
F2. Effect on fossil fuel imports		2.98	3.79	4%		%
F3. Effect on other imports	No	2.19	0			
F4. Effect on jobs	No	2.24	0			
F5. Effect on wages	No	2.38	0			

*All KPI cells in yellow could not be evaluated since the demonstration could not take place during project implementation period

related to freight from the demo.

During the course of evaluation a number of KPIs could not be assessed. In most cases this was due to lack of data and these KPIs therefore are not entering the evaluation and their weight is therefore normalised into remaining KPIs (Table 12).

Lastly the three safety KPIs were slightly modified to make them more understandable and relevant for the Kigali use case and therefore instead of major, minor and near accidents now look at safety in general, increased severity of accidents and road safety of vulnerable groups. The last KPI also addresses the comment from project officer.

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7 ANNEX

Table 13: Key Performance Indicators (First Short List for Kigali)

KPI - Level 1	KPI - Level 2	KPI - Level 3
Financial costs/ revenues	Financial viability	NPV (Net present value)
		IRR (Internal Rate of Return)
		Payback period
	Availability of financial resources	Ease of raising external funding
Institutional/ political	Coherence with national plans and development goals	
	Alignment with supra-national/national/city legislation & regulations	
	Ease of implementation (in terms of administrative barriers)	
Climate related	Impact on GHG emissions	Amount of carbon avoided (% change compared to baseline)
Environmental	Impact on air pollutants	NOx emissions avoided
		PM2.5 emissions avoided
	Impact on noise	Perception of the impact of the demo EVs on noise level
	Impact on environmental resources	Resources saved due to recycling (kg)
Social	Impact on accessibility	Access to jobs, opportunities and services (personal travel)
		Access to pickup/delivery locations (freight)
	Affordability of e-vehicle services	
	Impact on travel time	Change in travel times due to e-mobility services (personal travel)
		Change in travel times due to e-mobility services (freight)
	Impact on road safety	(Annual) Number of road accidents with fatalities/serious injuries

KPI - Level 1	KPI - Level 2	KPI - Level 3
		(Annual) Number of road accidents with minor injuries/material damage
		(Annual) Number of traffic related near accidents/dangerous situations
	Impact on charging safety	(Annual) Number of charging related safety incidents
	Impact on security	(Annual) Number of vandalism/theft incidents
	Impact on well-being (physical and mental)	Change in well-being due to changes in active travel
	Quality of e-mobility services	Suitability of e-vehicles in changing climate conditions [Likert scale]
		User perception of comfort of e-vehicles [Likert scale]
		Ease of driving e-vehicles - professional drivers [Likert scale]
		Ease of driving e-vehicles - other users [Likert scale]
		Ease of charging the e-vehicle [Likert scale]
		Perception of safety [Likert scale]
		Perception of personal security [Likert scale]
		User perception of continuity of journey chains, incl. modal interchange from/to e-vehicles [Likert]
Economic	Impact on national/local budget	Required public investment as % of relevant national/local budget
	Impact on external trade	Abated fossil fuel imports as % of total imports
		Abated other imports as % of total imports
	Impact on employment	Number of additional jobs
		Expected increase (%) in the average wage

Table 14: Financial Analysis for 24 e-motos

Year	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Investment	-30,816										
Residual Value											
Annual Revenues		101,088	101,088	101,088	101,088	101,088	101,088	101,088	101,088	101,088	101,088
Annual Operating & Maintenance Costs	-87,728	-87,728	-87,728	-87,728	-87,728	-87,728	-87,728	-87,728	-87,728	-87,728	-87,728
Net pre-tax cash flow	-30,816	13,360	13,360	13,360	13,360	13,360	13,360	13,360	13,360	13,360	13,360
Cummulative pre-tax cash flow	-30,816	-17,456	-4,097	9,263	22,622	35,982	49,341	62,701	76,060	89,420	102,779
Pre-tax NPV	**55,990**										
Pre-tax IRR	**42.47%**										

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