E-Motion Country Intervention Strategy Peru

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Abbreviations

AC	Air Conditioning
AECID	Spanish Agency for International Development Cooperation
AFD	French Development Agency (Agence Française de Développement)
APN	National Port Authority
AssetCo	Special Purpose Company (SPV / SPE / SPC)
ATU	Urban Transportation Authority for Lima and Callao
BAU	Business as Usual
BCRP	Central Reserve Bank of Peru - (Banco Central de Reserva del Perú)
BEB	Battery Electric Buses
BEV	Battery electric vehicle
CAF	Andean Development Corporation (Corporación Andina de Fomento)
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditure
CDM	Clean Development Mechanism
CF	Cash Flow
CFF	Cities Finance Facility
COFIDE	Development bank of the Peruvian State - Development Finance Corporation
CORPAC S. A.	Corporación Peruana de Aeropuertos y Aviación Comercial S.A.
DGEE	Directorate General of Energy Efficiency
EIRR	Economic Internal Rate of Return
ENAPU S. A.	Empresa Nacional de Puertos S.A.
EU	Executing Units
EV	Electric Vehicle
FA	Financial Assistance
FIRR	the Financial Internal Rate of Return
GHG	Greenhouse Gases
GIZ	German Cooperation Agency - GmbH (Deutsche Gesellschaft für Internationale Zusammenarbeit - GmbH)
GPAE	Policy and Economic Analysis Management
HEV	Plug-in hybrid electric vehicle
IADB	Inter-American Development Bank
ICCT	International Council on Clean Transportation
IEA	International Energy Agency
INEI	National Institute of Statistics and Informatics
ISC	Selective Consumption Tax
KfW	Reconstruction Loan Corporation (Kreditanstalt für Wieddiseraufbau)
LABMOB	Sustainable Mobility Lab
LCMR	low-cost/must-run
LCV	Light Commercial Vehicle
LULUCF	Land use, Land-use Change, and Forestry
MADS	Ministry of Environment and Sustainable Development
MINAM	Ministry of Environment
MINEM	Ministry of Energy and Mines - (Ministerio de Energía y Minas)
MINSA	Ministry of Health
MTC	Ministry of Transportation and Communications
NAMA	Nationally Appropriate Mitigation Action
NDC	Nationally Determined Contributions
NGV	Natural Gas Vehicles
OEM	Original Equipment Manufacturer

OPEX	Operational Expenditure
OPI	Programming and Investment Offices
OSITRÁ	Supervisory Body for Public Transportation Infrastructure Investment
P4G	Partnering for Green Growth and the Global Goals 2030
PHEV	Hybrid electric vehicle
PM	Particulate Matter
PNA	National Environmental Policy
PNUD	United Nations Development Programme
PPP	Public-Private Partnership
PRI	Principles for Responsible Investment
Promovilidad	National Programme for Sustainable Urban Transport - attached to the MTC
PROPARCO	Promotion and Participation for Economic Cooperation, part of AFD (Promotion et de Participation pour la Coopération Economique)
PTO	Public Transport Operator – usually a private company
SERPOST S. A.	Postal Services of Peru S.A. (Servicios Postales del Perú S. A.)
SETACA	Cab Service in Callao
SETAMETA	Metropolitan Taxi Service
SPV / SPE / SPC	Special Purpose Vehicle / Special Purpose Entity / Special Purpose Company.
SUTRANS	Superintendencia de Transporte Terrestre de Personas, Carga y Mercancías (Superintendence of Land Transportation of People, Cargo and Merchandise)
TA	Technical Assistance
TCO	Total cost of ownership
TTW	tank-to-wheel
UF	Formulation Units
UNEP	United Nations Environment Programme
USCUSS	Land use, land use change and forestry
WACC	Weighted Average Capital Cost
WB	World Bank
WTW	well-to-wheel
WWF	World Wildlife Fund
ZEBRA	Zero Emission Bus Rapid-Deployment Accelerator

Contents

1. Introduction

The country intervention strategy summarizes the results of the country diagnostic and the market assessment and adds the components of proposed project interventions (investment projects and technical assistance), proposed instruments and the direct plus indirect potential impact of the program.

2. Country Diagnostic[1]

2.1. General

Peru has an area of 1,285,215 square km and, according to the INEI in 2019 it had 32.5 million inhabitants. For 2030 the project population size is 35.8 million inhabitants (Ministry of Foreign Affairs, European Union and Cooperation, 2020). In terms of major cities, Lima tops the list with 9.7 million inhabitants, followed by Arequipa with 1.2 million and Callao with 1.1 million - the only three cities with more than 1 million inhabitants.

Real-time information on air quality is provided by the Ministry of Environment[2]. PM_{10} measurements in Lima show that the maximum value of 50 µg/m^3 is surpassed at most stations in most months[3]. The same holds true for $PM_{2.5}$. NO_x maximum threshold levels (100 µg/m^3 annual average) are in general not reached[4].

It is important to mention that national mobility statistics in Peru are somewhat deficient, the reader will find in this document that many of the conceptual and numerical references in this field are limited to the metropolitan area of Lima Callao.

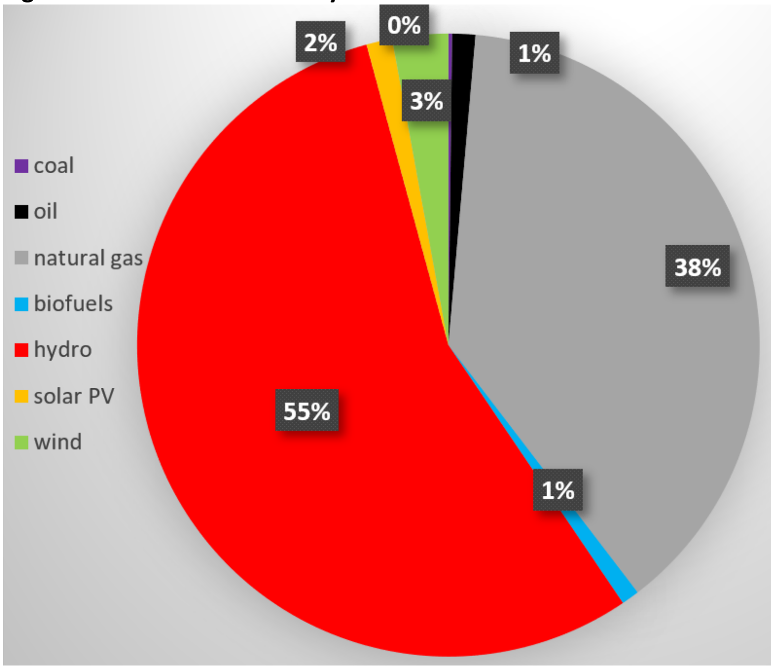
2.2. Climate and Energy Policies

Peru had in 2017 Greenhouse Gas (GHG) emissions of around 157 million tons (Climatewatch, 2019). The Nationally Determined Contribution (NDC) focuses on two fundamental issues: adaptation to change and mitigation of GHGs. In terms of GHG mitigation measures, Peru presents 62 measures to reduce emissions by 20% with respect to the business-as-usual scenario, and a further 10% depending on international collaboration. This shall limit GHG emissions to a maximum of 209 million tons in 2030, and in case of international support, the limit is fixed at 179 million tons (NDC, 2020). The NDC proposes the entry of 6,707 electric buses and 171,359 electric light-duty vehicles by 2030.

In 2019 60% of electricity was generated by renewables (see figure below). Based on MINEM Peru has a very large not yet exploited renewable energy potential basically for wind (>22,000 MW exploitable), geothermal (3,000 MW potential) and solar PV.

[1] See Report Grutter Consulting, 2021, Country Diagnostic Peru for further details.
[2] Conoce la calidad del aire en tiempo real a través de Infoaire Perú | Ministerio del Ambiente (minam.gob.pe)
[3] The WHO guideline stipulates that $PM_{2.5}$ not exceed 10 µg/m^3 annual mean, or 25 µg/m^3 24-hour mean; and that PM_{10} not exceed 20 µg/m^3 annual mean, or 50 µg/m^3 24-hour mean.
[4] INEI, 2019, Perú Anuario de Estadísticas Ambientales 2019

Figure 1: Power Generation by Source 2019



Source: IEA database

The carbon factor of the electricity grid of Peru is 0.223 $kgCO_2/kWh$[5].

2.3. Transport Sector

2019 nearly 6.7 million vehicles were operating in Peru. Since 04/2018 the emission standard Euro 4/IV is in force. Diesel fuel sold has 50ppm sulphur.

Road transport GHG emissions of Peru in 2019 are estimated at 28 million tCO_{2e}[6] based on a bottom-up transport model calibrated with top-down fuel consumption data. Buses represent 53% of emissions (especially due to a very large number of small buses), taxis 7% and LCVs 1%. Additionally a large number of 3-wheelers used as taxi or light commercial vehicles (LCVs) operate. Based on (DS 013-2005-EM) petrol has an ethanol share of 8% and diesel a biodiesel share of 5%. Assuming that biofuels have 0 GHG emissions the tank-to-wheel (TTW) GHG emissions would be 26.9 $MtCO_{2e}$ instead of 28.5 $MtCO_{2e}$.

GHG emission from the transport sector are expected to grow under a BAU scenario by around 32% reaching 38 million tCO_{2e} by 2030 (see table below).

[5] GHG emissions / net production; see (Grutter Consulting, 2021)

[6] Tank-to-wheel approach; well-to-wheel approach including Black Carbon: 38 $MtCO_{2e}$

Table 1: Projected 2030 Transport Emissions

Vehicle category	NO_x in tons	$PM_{2.5}$ in tons	CO_2 TTW in tons	CO_2 WTW in tons	Energy in TJ
Passenger car	5,736	243	7,456,266	9,306,824	108,195
Taxi	999	19	3,335,907	4,194,953	49,848
3-wheeler	0	0	2,014,630	2,397,409	29,071
Motorcycles	4,131	75	2,353,502	2,817,437	33,961
small bus	114,483	899	10,883,181	13,993,354	146,872
urban bus	5,140	40	1,327,550	1,713,018	18,732
coach	19,572	153	3,407,766	4,295,017	45,989
LCV	1,421	70	435,995	591,049	5,884
Truck < 7.5t	1,711	11	335,652	420,314	4,530
Truck 7.5-16t	4,146	25	772,664	967,378	10,427
Truck 16-32t	18,430	115	3,219,788	4,037,968	43,452
Truck >32t	11,607	67	2,013,703	2,522,403	27,175
Total	**187,377**	**1,717**	**37,556,603**	**47,257,127**	**524,136**

Source: (Grutter Consulting, 2021)

In Lima and Callao, about 22.3 million trips are made daily, of which 16.9 million are made with motor vehicles. The distribution of daily trips by collective means (traditional buses, Metropolitano, Metro de Lima and colectivos) is of 51%, followed by walking (24%) and finally private car and cab trips (18%) (Escorza, 2016). In the case of Arequipa, 68% of motorized trips are made by public transport and 32% by private transport, and the trends show a growth in private transport and a decrease in public transport. As for the Province of Piura, 68% of trips are made by public transportation, the main modes being bus with 29%, then motorcycle cab with 21% and collective cab with 13%.

Public transport in the aforementioned cities is characterized by low traffic speeds: less than 15 km/hour in urban roads, between 11 and 19 km/hour in Arequipa and 16 km/hour in Piura (Fundación Transitemos, 2018). In addition, it is made up of an old fleet in poor condition, predominance of low-capacity vehicles, unreliable service, and inadequate treatment of drivers and conductors.

In Lima's BRT, the Metropolitano, the construction of roads and bus stops was financed with public funds and the acquisition of buses was carried out by private companies financed through fare collection. The acquisition, operation and maintenance of the buses is done through a Public-Private Partnership (PPP) for a period of 12 years. In 2008, four concessionaires were chosen to operate feeder buses and trunk buses separately. 75% of the income generated by the system goes to the bus operators, 13% to the collector and the remainder to the State (León, 2012).

At present, there are no cab statistics available at the national level since their registration is distributed among 196 Provinces. Lima, in July 2019, had more than 200,000 cabs, of which, according to figures from Acceso Crediticio, 37% were operating informally, 47% were registered in the Metropolitan Taxi Service (SETAME) and 19% in the Taxi Service in Callao (SETACA) (Revista Gana Más, 2019). For Lima and Callao, the "Observance Report on the Situation of Public Transportation in Lima and Callao 2018" was made, in which it is evident that there is many vehicles operating informally.

2.4. EV Policies and Activities

To date, Peru does not have any regulation with the status of law that promotes and/or regulates the use of electric and hybrid vehicles. However, there are two Bills 2182/2017-CR and 3446/2018-CR, which have favourable opinions since 2018, the Congress of the Republic has not yet passed a "Law declaring of national interest and public necessity the promotion of the use of electric vehicles (EVs)", consequently, there is no legal framework to define a roadmap for the implementation of these technologies. In total only some 20 BEVs have been registered in 2019 and another 20 in 2020 (AAP, 2020). Various studies and reports have been made however for EVs including a study of the IDB on e-buses for Lima.

The Ministry of Energy and Mines (Minem) seeks to promote a more environmentally friendly energy source in the automotive sector, thus, Supreme Decree N° 022-2020 (August 21, 2020) establishes the provisions to implement the future charging and energy supply infrastructure for electric mobility (gob.pe, 2020). Among the objectives outlined in the Decree is to achieve 100,000 EVs by 2030.

The following table summarizes enabling factors and barriers towards the deployment of commercial EVs in Peru.

Table 2: Enabling Factors and Barriers to Commercial EVs in Peru

Enabling factors	• Lithium extraction potential: The Financial Times, in a report in November 2018, states that the Falchani lithium project is the first discovery of this type of material in the Andean country and would constitute as one of the 10 largest lithium-in-stone reserves in the world. • Manufacturers' interest in the market: Several pilot projects of companies such as Enel x, QEV Tech, Engie and BYD have been realized.
Barriers	**Political situation**: Electric mobility policy in Peru is only just being structured with a few isolated measures that need cohesion. • In 2018 the Supreme Decree No. 019-2018-MTC updated the National Vehicle Regulation to include vehicles with new technologies such as electric vehicles, additionally, the Supreme Decree No. 094-2018-EF increased taxes on fuels according to their degree of harmfulness. The purpose of the decree is to encourage consumers to choose less polluting options and thus reduce carbon emissions. The Supreme Decree N°012-2019 approved the Urban Transport Policy, Supreme Decree N° 027-2019-MTC that creates PROMOVILIDAD, Supreme Decree No. 181-2019-EF increased and standardized the Selective Consumption Tax rate for imported used vehicles to 40%, in order to have new and clean technologies, Supreme Decree No. 022-2020-EM approved the provisions to implement charging and energy supply infrastructure for electric mobility in order to encourage an alternative transportation system that is environmentally and public health friendly. • Atomized and mostly informal transport sector, without active scrapping regulation of obsolete diesel fleet (gasoline in private cars and taxis) hinders capital investment. Public transport structures in Peru need to be consolidated/formalized and reformed. This also inhibits viable business models and therefore higher CAPEX is an even greater challenge. • Production of cheaply priced gas for vehicle use **Technical capacity**: Public institutions in charge of leading and encouraging the electrification of transportation in each of the cities fall short in terms of knowledge (Osinergmin, 2019). The transition to electric transportation systems will be slowed down with the lack of trained staff. **Procurement policies**: Procurement policies are not in line with e-mobility requirements with more focus on initial investment costs and with too short concession contract periods in relation to the long payback periods of EVs. **Lack of domestic supply chain**: Currently there is no local supply chain for the manufacture and assembly of electric vehicles, which generates a lack of availability of spare parts in the country. This results in higher maintenance and repair costs of EVs (Osinergmin, 2019). **Economic issues**: Although the price of electric cars has decreased thanks to technological advances, fossil cars continue to be economically more attractive. To reverse the balance, the Peruvian government needs to implement fiscal measures to promote the purchase of electric vehicles, such as special subsidies for certain low-cost vehicles or sales tax exemptions. • the cost of the initial investment in the EV and its financing conditions including the cost of the associated infrastructure (charging station). • the cost of electric energy compared to CNG. **Regulatory framework to exploit lithium**: Peru does not have a regulatory framework for the exploitation and export of lithium and uranium (Osinergmin, 2019).

3. Actor Mapping

The **Ministry of Transportation and Communications** is the entity in charge of integrating air, water and land transportation routes, as well as telecommunications networks and postal services. In order to fulfil its mission, the Ministry of Transportation and Communication works hand in hand with several affiliated agencies.

Ministry of the Environment formulates, plans, directs, executes, supervises and evaluates the National Environmental Policy, focusing its actions towards a clean, natural and inclusive Peru by promoting the environmental sphere in government policies and programs.

Ministry of Energy and Mines oversees formulating and evaluating national policies for mining and energy activities that reduce the environmental impact, safeguarding the rational use of natural resources.

National Public Investment System It is an administrative system that certifies the quality of Public Investment Projects (PIP) and is aimed at improving the provision of public services by the state. This is achieved through sustainable projects.

COFIDE is committed to the sustainable development of the country. Its objective is to raise financial resources from domestic banks, foreign banks and the market in order to channel them to individuals and legal entities through intermediary financial institutions.

Integra Transportation (SIT City of Arequipa) is an operator in the city of Arequipa with a 10-year route concession and is currently operating a BYD 12-meter electric bus. Based on this experience they wish to acquire 77 additional 12-meter electric buses.

Cruz del Sur Transportation is a transport company which operates long routes of national transportation and personnel transportation. It currently has an agreement with ENGIE to operate an electric bus for personnel transportation at the Cerro Verde mine in Arequipa and based on this experience it is interested in initially acquiring a fleet of 30 electric buses for personnel transportation and preparing to bid for future tenders for the new urban transportation systems in Lima.

Lima International Bus are Peruvian operators associated with the SI 18 Group, and SI 98, which are operators of Transmilenio, and currently operate the Lima Metropolitan BRT. It also operates in association with its Perun partners in Cartagena de Indias. Lima Bus currently operates 78 articulated buses and 40 12-metre buses, all CNG buses, which are more than 10 years old and are due for refurbishment and a commitment to expand to 90 articulated buses.

AFD is currently working on transport, tram and metro systems; **AFD** have the possibility of working with credit access or private banks (via **Proparco**) to finance the conversion to electric taxis or buses. In the private sector, the **AFD** group, through **Proparco**, financed a credit access for the conversion to natural gas of taxis in Lima and Callao, through the Cofigas programme.

The **German Cooperation Agency – GIZ** implemented the "Sustainable Urban Transport in Intermediate Cities (DKTI)" in cooperation with the Ministry of Transport and Communications (MTC) and selected local municipalities. It includes the creation of the National Program for Sustainable Urban Transport 2019 (Promovilidad), which supports medium-sized cities in the development of sustainable and lower-emission urban transport systems. The project offers expert advice on mobility planning and works closely with Peruvian and German universities. On the other hand, the Peruvian government, under the leadership of the Ministry of Transport and Communications (MTC), developed TRANSPerú, a set of Nationally Appropriate Mitigation Actions (NAMA) consisting of more than 50 measures aimed at reducing GHG emissions related to transport and urban mobility.

Engie has delivered pilot electric buses to Lima and Arequipa to show interest in this system.

UNEP active **GEF** Technical Assistance "Enabling policies", study of new business models to facilitate electric mobility. This programme has not yet started.

The **WRI,** in 2014, awarded Peru an allocation of more than USD 11 million to finance Peru's urban transport NAMA, known as T-NAMA, an ambitious package of infrastructure investments, new climate-friendly regulations and institutional reforms that aims to reduce Peruvian GHG emissions from the transport sector by 4 MtCO2e over the next decade. The Peru T-NAMA has been jointly developed by the Peruvian Ministries of Environment and Transport, with the support of GIZ-Transfer, the World Resources Institute (WRI), the Global Alliance for Low Emission Development Strategies (LEDS-GP), the Pontificia Universidad Católica del Perú (PUC), Transitemos and other local partners.

With the **IADB** Lima is currently implementing a pilot-test to evaluate different variables to consider when adapting a fleet of electric buses. This program is a joint effort between the Inter-American Development Bank (IADB), the government and the private sector. In 2020, the IDB published a study, coordinated with the Ministry of Energy, in which it analyzes the business models and financing mechanisms for electric buses in Lima. The project is financed with US$40 million, of which US$20 million is from the Clean Technology Fund (CTF) and the other US$20 million from the IDB loan. The program will have access to long-term financing for private EV projects (replacement of internal combustion engine vehicles with EVs and electric stations preferably powered by renewable energy), and the resources will be provided by the National Development Bank of Peru (COFIDE). This financial approach will have funds not only for EV investment, but also for complementary EV activities such as: awareness raising and capacity building, development of financial models and improvement of the regulatory framework.

4. EV Deployment Scenarios

4 different EV scenarios have been constructed which are contrasted with a 0-EV scenario:

- EV30@30: The EV30@30 scenario of IEA has as target that 30% of all vehicles sold in 2030 are electric. The scenario is built on newly purchased vehicles (and not the stock of vehicles) in line with IEA scenarios (IEA, 2019). In addition to the IEA also motorcycles and trucks <7.5t are included with the same EV penetration rates.
- EV15@30: The moderate EV scenario is based on the "EV new policies scenario" which has as target for 2030 15% instead of 30% EV share. The same approach is used as for EV30@30.
- EV scenario based on targets of Peru (MINEM targets).
- EV “high growth” scenario focusing on the potential for commercial vehicles targeted by the e-mobility fund with an EV target of 100% of new registered vehicles for these categories by 2030. In all other vehicle categories the maximum of the 3 other scenarios has been chosen.

The following table shows the results in terms of GHG reduction against the BAU scenario of no EVs as well as the additional electricity consumption due to EVs with the different scenarios.

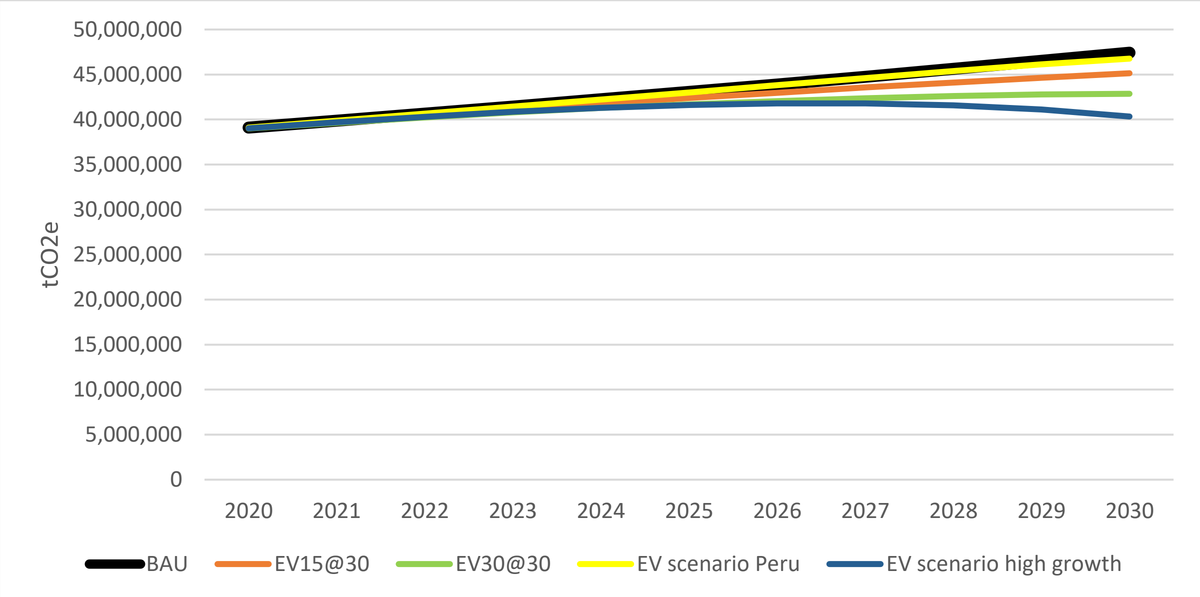
Table 3: Scenario Results

Impact	Scenario	By 2025	By 2030
GHG reduction WTW in tCO_{2e} per annum	IEA 15@30	680,000	2,270,000
	IEA30@30	1,360,000	4,540,000
	Peru scenario	50,000	650,000
	"High growth" scenario	1,450,000	7,020,000
Electricity demand of EVs in GWh per annum	IEA 15@30	860	2,830
	IEA30@30	1,730	5,660
	Peru scenario	60	660
	"High growth" scenario	1,040	7,660

Source: (Grutter Consulting, 2021)

The figure below shows the slow reaction of GHG emission reductions of the sector due to long permanence of vehicles once purchased. The introduction of EVs takes a long time to reduce in absolute terms GHG emissions of the transport sector as vehicle growth still occurs and as vehicle replacement rates are relatively low i.e. it takes time to achieve a large stock and therefore large impact of EVs. This highlights the importance of early actions. Waiting 5-10 years more until the market has evolved without support will result in a 5-10-year time lag of GHG reductions and thus non-attainment of climate targets.

Figure 2: Projected GHG Transport Emissions Peru BAU with no EVs and with EV Scenarios (WTW)



Source: Grutter Consulting

The 2030 projected electricity demand of EVs represents 10% of same year electricity generation for the highest EV growth scenario. The electricity demand increase resulting from EVs is very gradual and thus leaves enough time to the country to plan a potential production expansion.

The Perun grid system has a not very pronounced peak in the early evening (6-8PM). Electric buses can avoid using these peaks for charging. This is true for overnight charged buses as well as intermediate or opportunity fast charged buses. Taxi fast charging could basically be done outside the peak as well and fast chargers could apply significant differential pricing to avoid peak charging. Passenger cars and LCVs are basically charged overnight which minimises the need for incremental electricity generation capacity and investment in distribution infrastructure upgrades.

The connection of charging sites with a capacity up to 500 kW may be feasible without many issues. However, charging sites with more than 500 kW load may require quite some network reinforcements, which time to complete. Although the number of outages in Lima is reasonable, the average duration of the outages is pretty long (more than 3 hours). Furthermore, the voltage quality is of concern, but this may need to be reconfirmed by additional measurements.

5. Market Analysis[7]

5.1. Current EV Market

In total only some 20 electric vehicles have been registered in 2019 and another 20 in 2020 (AAP, 2020). Only pilot vehicles are operational for buses and taxis.

5.2. Current Commercial EV Financial Viability

5.2.1. Introduction

The financial assessment is made per vehicle type with local data. Following parameters are assessed:

- Total cost of ownership (TCO) per kilometre comparing the fossil with the electric unit: The TCO is calculated in financial and economic terms; values are not discounted for the TCO.
- Incremental upfront capital investment required and incremental equity capital required with current financing schemes.
- Profitability of investing in an EV instead of a fossil vehicle by calculating the Financial Internal Rate of Return (FIRR) of the incremental capital expenditure: the FIRR is compared to the Weighted Average Capital Cost (WACC) calculated at 9.8%[8];
- Differential cash flow;
- Discounted payback time of differential investment (using the WACC as discount rate).

The financial analysis is a comparison of investment options. It does not assess the financial viability of operating the specific vehicle (as example in public transport diesel buses could be operating at a loss and e-buses could continue to be operated at a loss) nor the financial soundness and creditworthiness of an enterprise. For latter other factors need to be contemplated such as revenues, debt and equity levels etc. The financial analysis is a comparison of investing pari passu in electric instead of fossil units. All calculations are performed in constant real 2020 USD.

5.2.2. Electric buses

The following table summarizes the financial assessment of BEBs (fast as well as overnight charged BEBs were assessed). The standard bus considered in the analysis is a 12m urban bus with AC. To comply with operating conditions in Peru an overnight charged bus would require a battery set of 310 kWh whilst a fast-charged unit could be equipped with a 200-kWh battery set and 300 kW chargers (on average 1 per 10 buses)[9].

[7] See also for further details Grutter Consulting, 2021, Assessment of Commercial EV Demand in Peru
[8] see (Grutter Consulting, 2021a) for details of calculations.
[9] For details see report 2

Table 4: Summary Financial Assessment 12m BEBs Peru

Criteria	Result	Assessment
TCO	0.96 – 1.10 USD/km for BEBs versus 0.77 USD/km for CNG and 0.82 USD/km for diesel bus[10]	Non-discounted the cumulated lifetime costs for BEBs are higher than CNG or diesel buses.
Capital investment	340-420,000 USD for BEB[11]; 120- 160,000 for diesel respectively CNG bus	Significantly higher capital requirement incl. higher loan demand; negative impact on debt to equity ratio
Equity investment	110-120,000 for BEB[12] versus 30,000 for fossil bus	Significantly higher equity demand which might overstretch the capabilities of small and medium enterprises
Profitability[13]	Negative FIRR	Investment in e-buses is not profitable.
Discounted Payback	Incremental investment is not recovered with savings during asset lifetime (20yrs)	The investment in e-buses is not profitable and the payback time is extremely long, even going beyond the asset lifetime. This indicates a high risk profile of the investment.
Cash Flow (CF)	Negative cumulative CF entire lifespan (due also to replacement batteries and chargers in year 8 and 10)	The investment in BEBs will affect the liquidity position of the companies in a negative manner and will affect negatively the solvency ratio and at least for the loan period the working capital ratio.

Source: (Grutter Consulting, 2021a): see Annex 3 for details including assumptions

The investment in BEBs with the current financial conditions and business models is not profitable, a high risk, requires a significant increase in owners capital and results in potentially serious liquidity problems. The main problem for BEBs in Peru is the very low CNG prices combined with relatively high electricity prices resulting in CNG buses having a lower energy cost than BEBs.

5.2.3. Electric Taxis

The following table summarizes the financial assessment of e-taxis. The comparison is based on a standard CNG taxi versus a Nissan Leaf or BAIC e-taxi with a 60kWh battery set.

Table 5: Summary Financial Assessment E-Taxis Peru

Criteria	Result	Assessment
TCO[14]	0.12 USD/km for e-taxis versus 0.08 USD for CNG unit	Non-discounted the cumulated lifetime costs for e-taxis are significantly higher than for a fossil unit
Capital investment	32,000 USD for e-taxi versus 14,000 USD for CNG unit	Significantly higher capital requirement incl. higher loan demand
Equity investment	6,000 USD for e-taxi versus 3,000 USD for CNG unit	Significantly higher equity demand which might overstretch the capabilities of taxi owners
Profitability[15]	Negative FIRR	Investment in e-taxis is not profitable
Discounted Payback	Incremental investment is not recovered	The payback time is longer than the asset lifespan. This indicates a high risk profile of the investment.

[10] TCO includes only CAPEX (including battery replacement, including bus, charging infrastructure, grid connection, bus depot upgrades), energy, maintenance, insurance, and financial cost but not driver or management overhead. Calculated for 20-year lifespan.

[11] Includes bus, charging infrastructure, grid connection, bus depot upgrades. Prices of BEBs have considerable variations between countries and depend on factors such as vehicle specifications, number of units purchased, battery size etc. The price quoted is sourced from (IDB, 2020) figure 27 and includes 16% IGV as well as 2% sales tax. In comparison with other countries the price is considered to be on the higher end but could be due to certain bus specifications.

[12] Banks only finance 80% of BEB but not of charging infrastructure, grid connection and depot upgrades due to not being collateral.

[13] FIRR of incremental investment compared to CNG bus.

[14] Includes CAPEX, energy, maintenance and finance costs; does not include other costs such as the driver which are independent of the technology chosen.

[15] FIRR of incremental investment compared to gasoline taxi.

Cash Flow	Negative cumulative CF entire lifespan	The investment in e-taxis will affect the liquidity position of the taxi owner in a negative manner and will affect negatively the solvency ratio.

Source: (Grutter Consulting, 2021a); see Annex 3 for details including assumptions

Summarized the investment in e-taxis with current financial conditions and business models is not profitable. CNG taxis have lower energy costs than e-taxis. Also CNG conversion of gasoline units is low-cost and can be done also of used units. Many small, low-cost gasoline or CNG units are available on the market which is not the case for electric vehicles. Another major risk is that revenues will be lower when using an e-taxi. The average daily driving range is thereby not the only parameter to consider as peak days have much higher mileage (and much higher income). Taxis are also driven during weekends (Friday to Sunday) or on special days with double shifts or 24 hours as this is the most profitable period. During such days the driving range of the e-taxi will be insufficient without re-charging. Home-charging takes 6-8 hours and is too slow. Also public chargers available are in general too slow. A fast-charging urban network is required to ensure that e-taxi owners do not lose a significant part of their revenues.

5.2.4. Electric LCVs

The following table summarizes the financial assessment of e-LCVs. The comparison is based on a Suzuki APV versus a Maxus E-deliver, with a battery set of 35 kWh which is sufficient due to relatively low daily mileage of LCVs in urban settings.

Table 6: Summary Financial Assessment e-LCVs Peru

Criteria	Result	Assessment
TCO[16]	0.21 USD/km for e-LCVs versus 0.20 USD/km for fossil unit	Non-discounted the cumulated lifetime costs for e-LCVs is comparable to a fossil unit
Capital investment	33,000 USD for e-LCV versus 18,000 USD for fossil unit	Significantly higher capital requirement incl. higher loan demand
Equity investment	7,000 USD for e-LCV versus 4,000 USD for fossil unit	Slightly higher equity demand
Profitability[17]	FIRR of 3%	Investment in e-LCVs is not profitable
Discounted Payback	Incremental investment is not recovered with savings	The payback time is longer than the asset lifetime. This indicates a high risk profile of the investment.
Cash Flow	Cumulative negative CF until year 5	The investment in e-LCVs results in a negative liquidity impact until the fifth year

Source: (Grutter Consulting, 2021a); see Annex 3 for details including assumptions

Summarized the investment in e-LCVs with current financial conditions and business models is not profitable, has a high risk and a very long payback time.

5.3. Sensitivity of Commercial EVs to Change of Finance Conditions

5.3.1. Introduction

Variations have been conducted by using concessional loan conditions and investment subsidies to assess their impact on the core financial parameters. The following table lists the base assumptions

[16] Includes CAPEX, energy, maintenance and finance costs; does not include other costs such as the driver which are independent of the technology chosen.
[17] FIRR of incremental investment compared to gasoline LCV.

used for calculations. All values are tentative used as modelling assumptions. Project specific conditions will depend on a variety of factors such as risk rate or borrower status.

Table 7: Assumed Concessional Conditions for USD Loan

Parameter	Value	Source
GCF loan conditions	1.25% (0.75% interest rate + 0.5% service fee)	GCF conditions public sector non-vulnerable countries; GCF/B09/08
AFD loan conditions non-sovereign public sector	5.5%	AFD
Assumed shares	30% GCF and 70% AFD	
Bank spread for on-lending	1.5%	Assumed
Resultant minimum loan rate for buses if based on project finance with public lender e.g. municipality	4.2%	Calculated based on above data
Resultant minimum loan rate for LCVs and taxis based on lending through public banks	5.7%	
Lending rates for buses, LCVs and taxis	80% maximum	
Loan tenure	12 years buses 7 years taxis & LCVs	

5.3.2. E-Buses

Concessional finance would result in an interest rate of 4.2% instead of 10.5% available currently. The level of concessionallity would be dependent if the recipient is a public body e.g. municipality or public bank. An 80% lending rate on the total CAPEX is also assumed. The concessional loan helps to resolve liquidity issues and results in an improvement of the investment profitability but risks very remain high with an unsatisfactory payback and a negative profit rate. It is clear that concessional loan conditions are an important feature but are not sufficient to tilt an investors decision with the current risk profile of BEBs in the country. Even including a 20% grant the FIRR remains negative, the investment is not recovered during the asset lifespan and the CF remains negative. With current energy pricing policies BEBs do not make commercial sense in Peru. In chapter 5.4. the assessment will be made with the expected e-bus price decrease under a Business-as-Usual scenario to see if there is a future option to get towards commercial e-buses.

5.3.3. E-Taxis

For taxis, the assumption is that a fast-charging infrastructure would be established to eliminate the barrier of reduced revenues. The charging infrastructure would be managed by a 3rd party (e.g. electric utility) and would be partially grant and concessional loan financed. Taxis are privately owned and managed. The assumed business model geos through loans managed by public banks (idem to the current loan structure) which would receive the concessional conditions of the Program. The on-lending interest rate would drop from currently 10.5% to 5.7%.

However, as is the case for buses, even with concessional loans and 20% upfront grant electric taxis are commercially not viable in Peru. In chapter 5.4 future market price development of e-taxis will be modelled to assess the future viability.

5.3.4. E-LCVs

LCVs are privately owned and managed. The assumed business model is through loans managed by public banks (idem to the current loan structure) which would receive the concessional conditions of the Program. An analysis of the usage of these loans shows that these are not sufficient to move towards commercial viability. Combined with a 20% upfront grant electric LCVs are viable at least in certain segments. However, currently there is no demand from investors to electrify their LCV fleet.

5.4. BAU versus Project EV Market Deployment

5.4.1. Approach

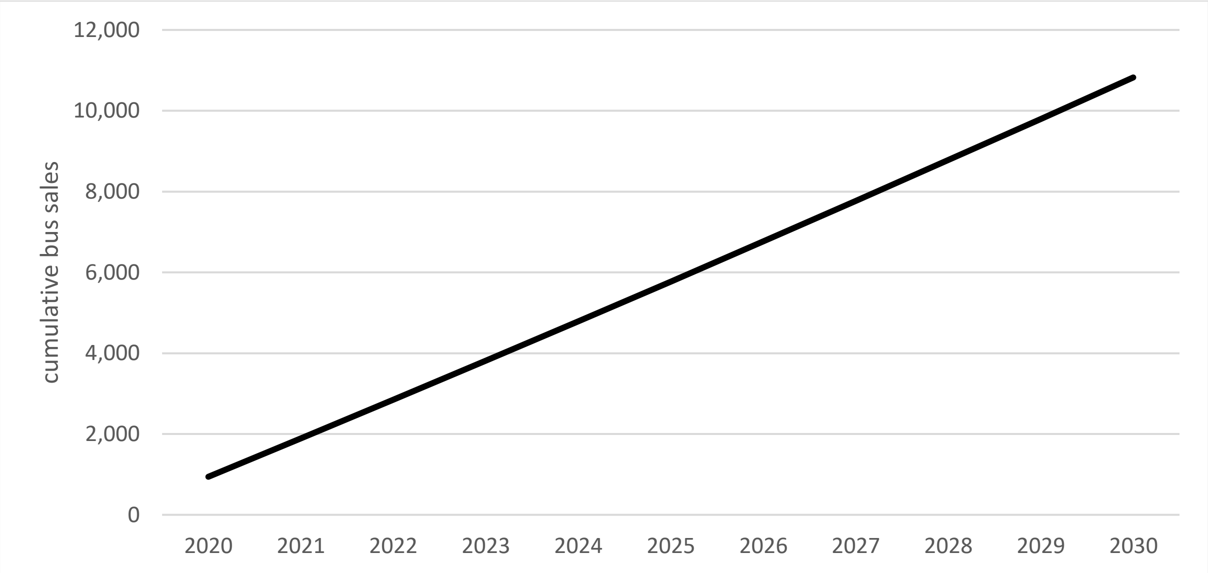
Under a BAU scenario EVs will pick up without commercial support. The question is when and how much. The following chapters will model the BAU deployment expected for the different commercial EV technologies due to decreasing EV prices and therefore increasing financial profitability of latter and the scenario of commercial EV deployment with program activities. This allows to model the with and without program scenario and the potential impact of the program beyond the singular fleet investments.

5.4.2. E-Buses

Market Demand for Urban Buses

The initial graph shows the total projected cumulative demand for urban buses in Peru based on vehicle replacement and market growth rates.

Figure 3: Total Projected Cumulative Market Demand Urban Buses Peru



Source: (Grutter Consulting, 2021)

Projected BAU Demand for E-Buses

The BAU e-bus demand is based on comparing the FIRR with the WACC taking the decision rule that the investment is realized if the FIRR is higher than the WACC. The required WACC is adjusted for a risk rate based on being a new technology using the following criteria:

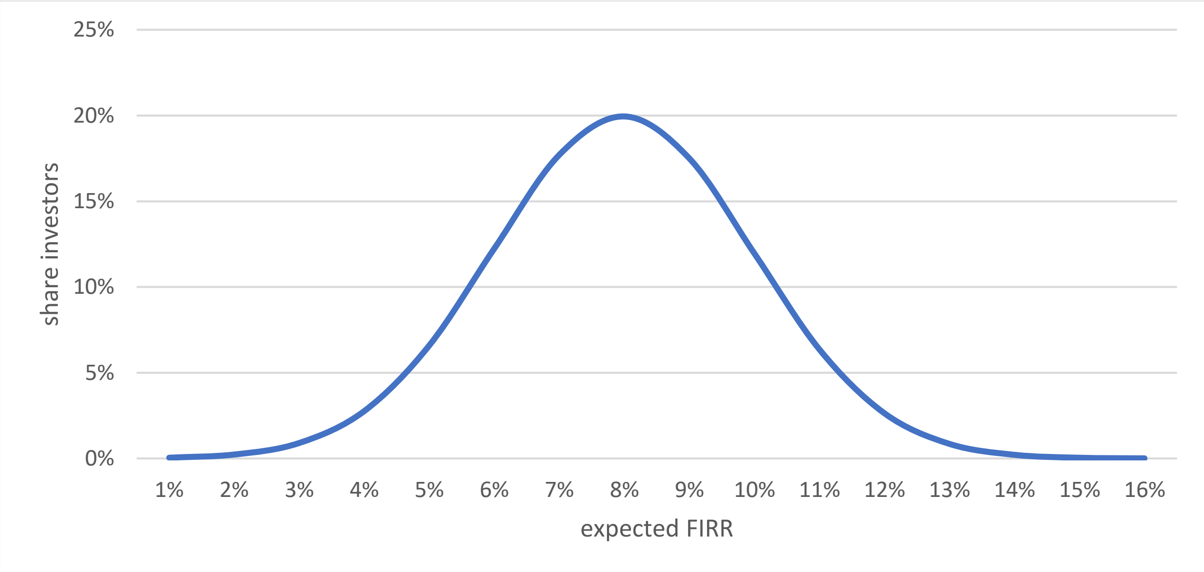
- Performance risk of BEBs with higher-than-expected energy costs (due to increasing electricity prices, more charging during high-cost periods and/or higher than expected energy consumption of buses). The medium risk rate is modelled around 30%.
- Performance risk of e-bus maintenance costs. Whilst e-buses do require less maintenance of liquids and engine, their tyre usage is higher and spare parts are more expensive. Also maintenance savings might not materialize except for large fleets as only latter will allow for

re-structuring the maintenance department and reducing for example workforce in this area. The medium risk rate is modelled around BEBs having 20% higher maintenance costs than expected.

- Risk of battery costs not decreasing as fast as expected. Whilst the standard model assumes battery prices to decrease by 50% the risk-model assumes a decrease of on average only 10%. This is also based on the fact that cell prices are decreasing fast but battery package prices not as much. Also, BEBs might require new battery management systems with an additional investment in 8 years.

Not all investors have the same risk appetite. The modelling assumes normal distributed risk propensities i.e. we have the same share of persons being risk averse and risk takers. The risk propensity distribution is used to calculate a normal distribution of risk factors, which is added to the WACC and allows to determine for each year the share of investors which are willing to invest in e-buses at the given CAPEX of that year. The figure below shows the assumed distribution of investors based on a normal distribution of investors around the base risk-free WACC of 8.0%.

Figure 4: Expected FIRR of Investors



Source Grutter Consulting

Even with projected decreasing bus prices until 2030 under a BAU scenario no BEBs will be purchased as the risk adjusted FIRR remains negative (see figure below).

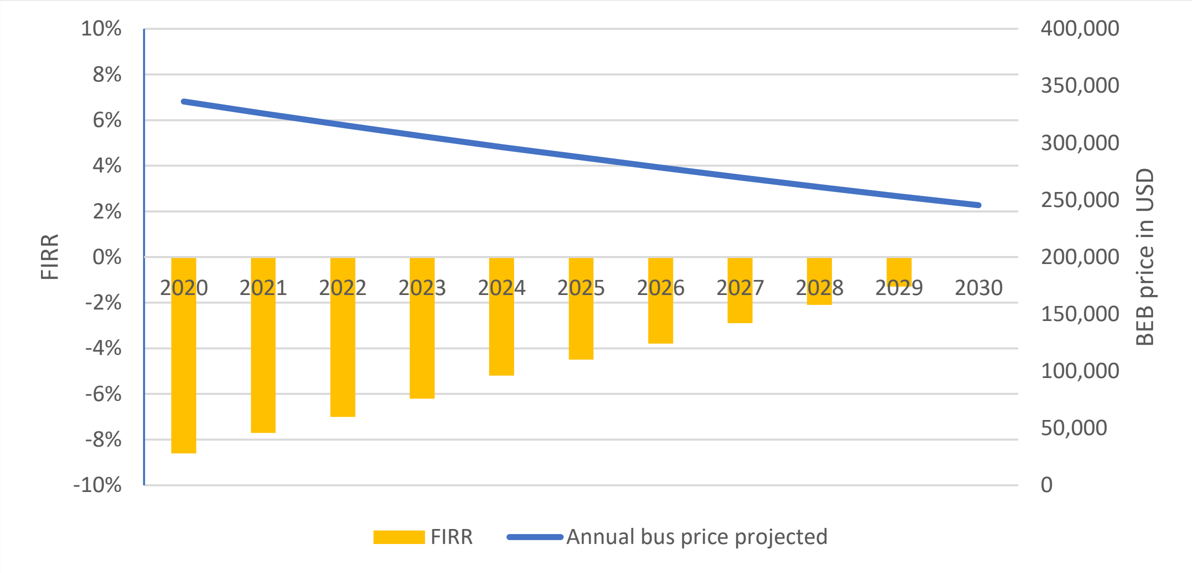
Projected with-Project Demand for E-Buses

The EV project has as basic function to accelerate EV deployment. It uses financial assistance (FA) to deploy an initial at-scale fleet. This initial fleet is used to reduce the performance risk perception of future investors by having actual performance data of large-scale fleet application, by reducing risks and costs of new market entrants, by having appropriate maintenance facilities in place and by having new business models in place (if so required). Technical assistance (TA) is used to reduce entry barriers e.g. the length of concessions for e-buses, asset turn-over contracts and new business models e.g. based on leasing. At the same time capacity building and training reduce the performance risks.

The projected BEB demand with project is therefore based on reduced risk rates due to the initial fleet financed by the program and due to reduced performance risks. Even with this, risks are not assumed to be reduced to 0 immediately. A gradual risk rate reduction relative to BAU from 2024 to 2027 is assumed. The projected EV demand is then modelled with the changed risk rates, whilst taking the same BAU EV price development.

The following rate shows that even without risk rate the FIRR remains negative even the expected decreasing e-bus prices.

Figure 5: FIRR and Expected BEB Price



Source: Grutter Consulting based on 3% decreasing BEB prices annually based on battery cost decrease see BNEF[18] based on constant real USD; no real price changes except BEB price; differential FIRR (profitability of investing incremental sum of capital into BEB instead of investing in CNG bus)

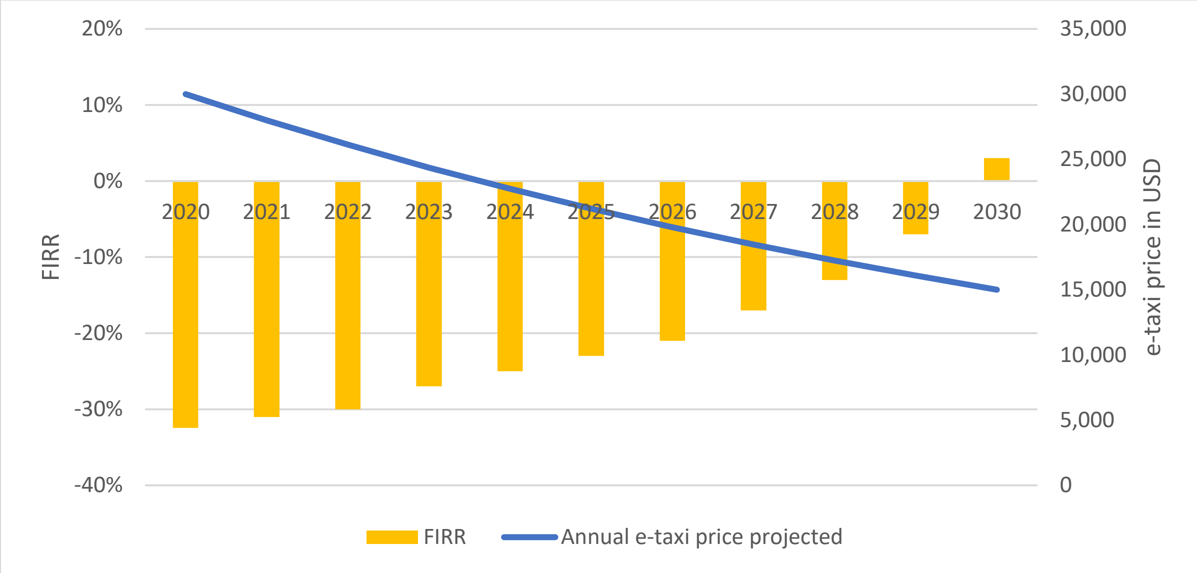
Comparing the with and without project scenario we can state that only the directly financed BEBs will be implemented. As long as CNG prices do not increase significantly, no induced or independent uptake of BEBs will take place in areas with CNG access. Despite national commitments to reduce carbon emissions by 40% by 2030 government would not feel enough pressure to realize such a change, given the vast gas reserves of Peru and the economic advantage of using gas domestically instead of exporting liquefied gas. No indirect impact is expected from the program in Peru for buses. For now, the thought of massively funding e-buses under these circumstances would be a one-shot endeavor without having a structural and sustained change. It is therefore recommended to not engage in e-buses in Peru in areas where CNG is available, but it is possible to consider cities where CNG pipelines do not have access, Arequipa, Cusco, Piura and Ayacucho are good candidates at this time.

5.4.3. E-Taxis

Similar as for buses the e-taxi price decrease will not be sufficient to make e-taxis commercially viable with current CNG prices (see figure below). The conclusion is thus as with e-buses that it is not considered useful at the moment to intervene with electric taxi investment projects in the country.

[18] https://www.sustainable-bus.com/news/electric-vehicle-outlook-2020-bnef-electric-buses/#:~:text=With%20regards%20to%20electric%20bus,needed%20to%20keep%20prices%20falling%C2%BB.&text=But%20by%202030%20demand%20grows%20almost%2014%2Dfold%20to%201%2C755GWh

Figure 6: FIRR and Expected e-Taxi Price



Source: Grutter Consulting based on 7% decreasing e-taxi prices annually based on cost parity with gasoline version by 2030 (Electric vehicle trends | Deloitte Insights)

5.4.4. E-LCVs

Due to the limited mid-term commercial financial viability of e-LCVs this area is not included in the investment projects for Peru and thus also no BAU and with-project scenario is developed.

6. Commercial Potential of BEBs in Areas without CNG

6.1. Context

In various areas CNG is neither currently nor in the medium term (next decade) available due to lack of a pipeline. This includes large cities as Arequipa and Cuzco. In these cities the relevant reference bus is a diesel unit and not a CNG unit. Calculations will thus be performed to realize an assessment if in such cities it would be viable to foster BEBs. Arequipa as well as Cusco also have interest in promoting BEBs due to significant air pollution caused by diesel units especially $PM_{2.5}$ emissions of diesel buses are much higher than of CNG units. This situation is aggravated with the high altitude of these 2 cities which reduce efficiency of diesel engines resulting in higher emissions and also reduces significantly power available of diesel engines thus resulting in engines being stressed further (especially if not sufficiently high powered resulting in excessive particle emissions and a higher fuel consumption.

6.2. Sensitivity of BEBs versus Diesel Buses to Concessional Conditions

Concessional finance conditions assumed for BEBs are idem to the ones assumed previously i.e. 20% grant finance of total CAPEX plus 80% concessionary loan of total CAPEX. The following table shows the results of this exercise.

Table 8: BEBs versus Diesel Bus with Concessional Finance

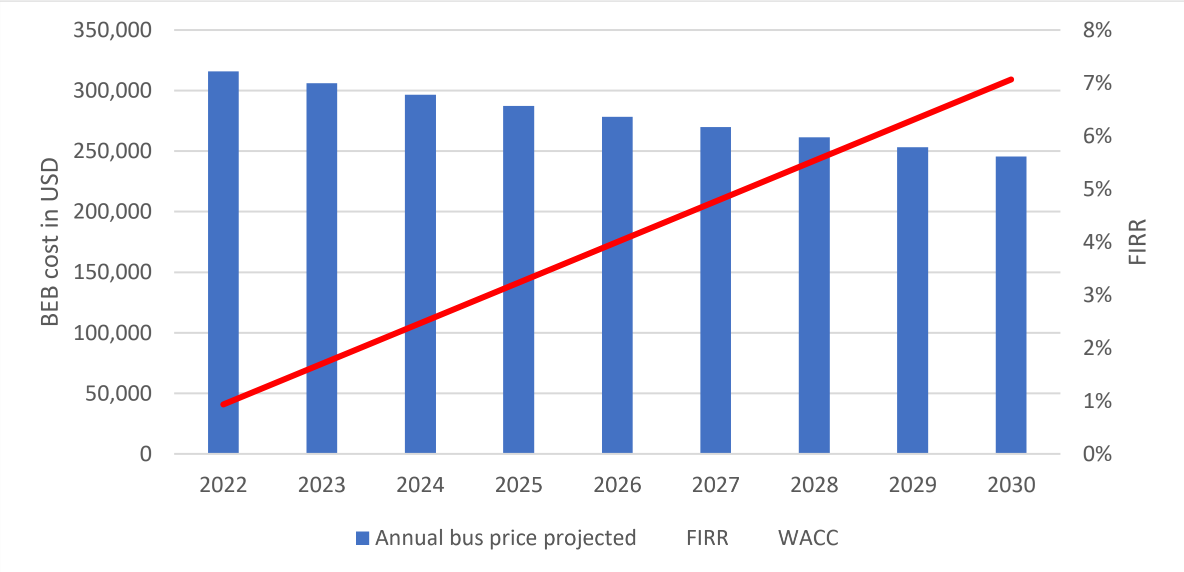
Parameter	BEB	Diesel Bus
TCO	0.82-0.91 USD/km (lower value for fast-charged and higher value for overnight charged BEB	0.82 USD/km
Differential FIRR	-1.9% to 3.6% (higher value fast-charged BEB) i.e. fast charged BEBs are comparable to diesel units (WACC 4.4%)	
Payback time	Differential invstment is not recovered in lifetime of equipment	

Concessional finance can make BEBs, especially fast-charged units, comparable to diesel units in financial terms whilst reducing emissions.

6.3. Commercial Deployment of BEBs relative to Diesel Units

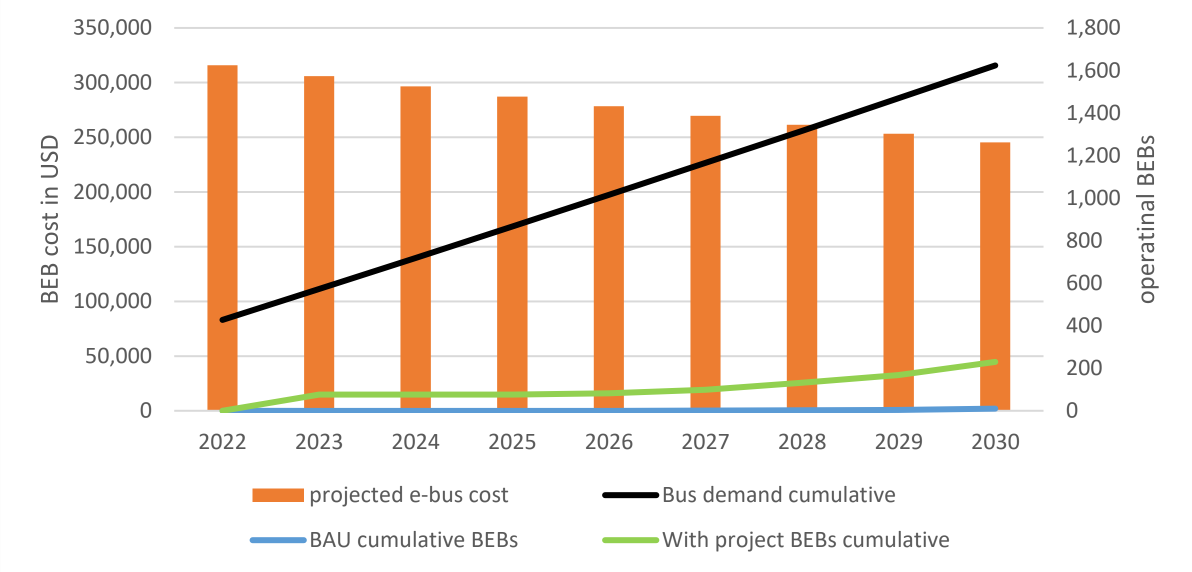
The price development and relative profitability of BEBs versus diesel buses in Peru has been assessed to deem when such units could potentially become attractive. The figure below shows the relative FIRR of BEBs for the incremental investment versus diesel units. Important in this aspect is also that diesel units will be getting in around 2 years more expensive due to requiring Euro V/VI standards. Based on risk-neutrality of BEBs (see BAU market deployment below for inclusion of risk into FIRR) latter get commercially viable around 2027.

Figure 7: Expected BEB Price Development and Relative FIRR BEB versus Diesel Units in Peru



Source: Grutter Consulting

Figure 8: BAU and with-Project Projected BEB Uptake in Peru in Arease without CNG and Price Trend of BEBs



Source: Grutter Consulting

Comparing the with and without project scenario we can state that under a BAU no commercial uptake of BEBs occurs whilst with the project a commercial uptake occurs around 2027 (2023 an initial fleet is launched). This impact continues during the entire period due to vehicles being kept in operations for a long period. Thus the project has a decisive impact on accelerating climate friendly technologies. Compared with the BAU scenario this results by 2030 in the following impact (based on lifetime impact of cumulative incremental fleet operating by 2030):

- Additional 290,000 tons of CO_2 reduced;
- Additional 9 tons of $PM_{2.5}$ avoided;
- Additional 1,100 tons of NO_x avoided;
- Additional economic savings of 13 MUSD.

6.4. Conclusions Concerning Viability of BEBs in Zones of Peru with Diesel Buses

BEBs are more viable in Peru in areas with diesel buses i.e. where natural gas is not used. Together with concessional finance it is feasible to implement an initial lot of BEBs. Due to risk reduction measures medium-term commercial uptake of BEBs is feasible in this area. Therefore it is recommended to focus on these areas and to realize an ongoing investment project for BEBs in Arequipa and to additionally consider cities such as Ayacucho Cusco and, additionally, Piura.

7. Potential Investment Projects

7.1. Urban Buses

7.1.1. Barriers and Interventions Options

The following table summarizes main barriers towards massive e-bus deployment in Peru. The barrier source gives an indication of what type of changes are required from an institutional perspective and the barrier elements which concrete aspects need to be altered.

Table 9: Barriers towards e-Bus Deployment in Peru

Barrier Type	Concrete Aspects
Atomized market structure of bus operators	Public transport structures in Peru need to be consolidated/formalised and reformed. This also inhibits viable business models and therefore higher CAPEX is an even greater challenge.
Financially weak operators	The fragility of balance sheets experienced by operators is unclear. Commercial banks have expressed their disinterest in financing vehicle fleets due to the instability of transport systems and their difficulties. In most cities there is no injection of additional resources to partially subsidise OPEX.
Procurement policies:	These are not in line with e-mobility requirements with more focus on initial investment costs and with too short concession contract periods in relation to the long payback periods of EVs.
Financial barriers	EBs are not profitable. The current FIRR is negative[19]. The investment in BEBs will affect the liquidity position of companies negatively and will negatively affect the solvency ratio and, at least for the period of the loan, the working capital ratio.

Source: Grutter Consulting

E-buses have significant environmental and social benefits that translate into a high positive environmental and health impact. Although the total cost of ownership of e-buses is slightly lower than that of diesel units, the CAPEX is a major disincentive for investors. This, combined with market conditions (atomized bus ownership) and a policy/contractual framework that hinders the deployment of e-buses, means that e-buses are barely present in Lima, Callao and Arequipa.

The atomized structure of the market means that very small quantities of buses are purchased. This results in loss of economies of scale which means medium and large businesses. In addition, operators lack knowledge of e-bus technologies and are therefore at the mercy of suppliers. Relatively large-scale procurement would address these issues. This can be based on different organisational models.

Technical assistance can be useful to further develop appropriate bulk-purchase business models and link them with concessional financial instruments.

The weakness of the credit subjects will result in a problem of access to loans and favourable loan conditions. Separating bus ownership from operation and collection, as has been done successfully in e.g. Santiago de Chile or Bogotá, brings in other financially stronger actors who can provide the necessary capital for the business on more favourable terms. This could also be done with the municipality or government buying buses and then leasing or renting them to operators, as is done, for example, in several cities including Medellín. This operation scheme can be replicated in intermediate cities to encourage the transition to electromobility. Technical assistance supports these new systems in cities with limited institutional capacities. Relying solely on financial assistance would be inefficient as it would require much more support resources and maintain an inefficient public transport system.

Peru is an important producer of gas, fuel which is cheap for vehicle operation as long as the environmental effects of its use are not recognised. Emphasising this point in a technical assistance programme is essential, both for public officials and the private sector. Much of the country is covered by an efficient distribution network for this fuel with the exception of the cities of Arequipa and Cuzco, among the most important and significant cities for electric mobility purposes, making them ideal for starting initial projects.

[19] See Figure 5 and
Table **4**

While some operators report experience in obtaining credit, including from international banks, concessional loans and investment grants are key to minimising this type of risk and creating an attractive financial framework. This includes longer loan terms, concessional interest rates, higher loan rates, payment guarantees and upfront investment grants for a significant value of the total investment, allowing a third party or bus operator to invest in e-buses receiving an adequate return on investment, an acceptable payback period, limiting their capital investment and financial exposure to a rate comparable to fossil buses and allowing a positive cash flow.

7.1.2. Possible Business Models

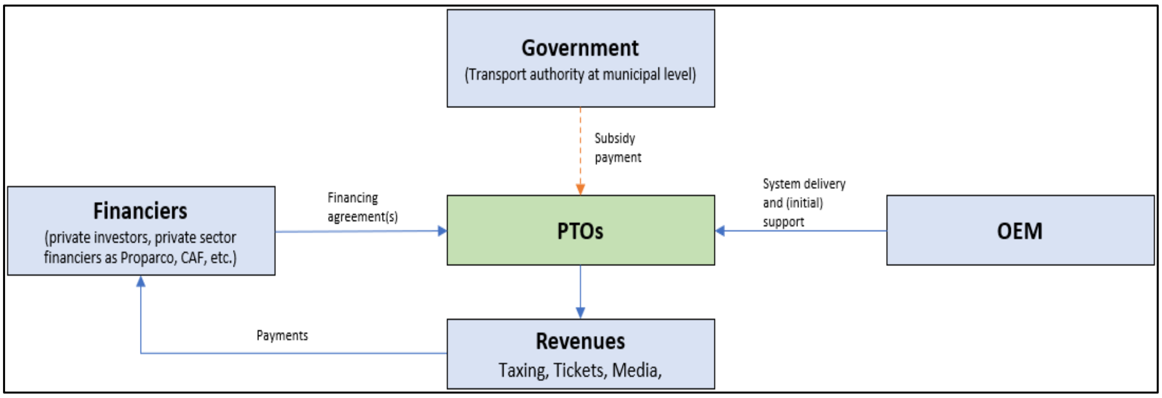
The typical structures that could be followed in the case of Peru are:

- Public Transport Operator (PTO)-led delivery.
- Private sector-led (“PPP”); and
- Public sector-led;

Option 1: Public Transport Operator (PTO)-led delivery

Public Transport Operator (PTO)-led delivery is highlighted in the figure below.

Figure 9: PTO-led Delivery



Source: Grutter Consulting based on Grutter Consulting / RebelGroup report for IFC, 2021

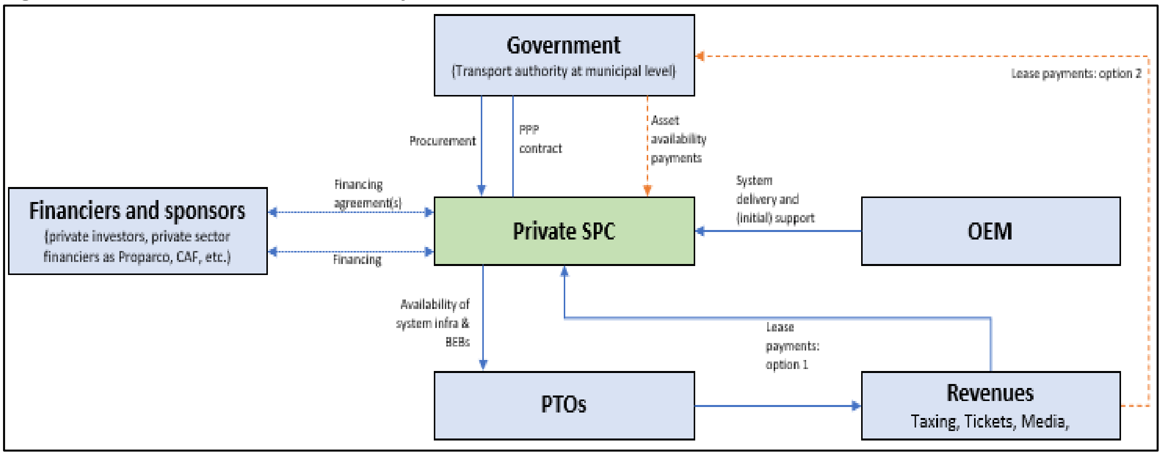
In this structure, PTOs:

- Procure the BEB fleet and charging infrastructure assets (including initial maintenance training, spare parts, etc.) from a selected OEM;
- Raise the necessary financing for this, possibly in combination with the procurement of the assets themselves; and
- Receive a subsidy from the government to neutralize the difference between the capital cost and operating cost of diesel bus operations versus BEB-FC operations over the life of the concession (which is presumably shorter than the break-even period).
- Receive a pass-through guarantee from the government that ensures that subsequent concession holders will take over the assets and financial obligations if the PTO concession is discontinued. Funders may require a direct guarantee to the same extent.

Option 2: Private Sector-led Delivery

Private sector-led delivery is highlighted in the figure below.

Figure 10: Private Sector-led Delivery



Source: Grutter Consulting based on Grutter Consulting / RebelGroup report for IFC, 2021

In this structure:

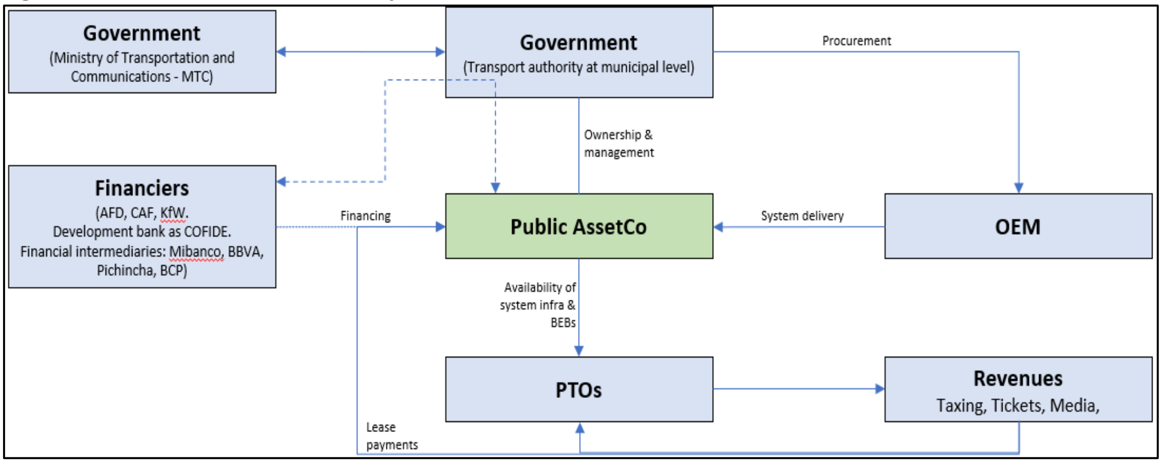
- Government (central government or municipalities) procures a “PPP” for a consortium to deliver and finance the BEB fleet and charging infrastructure assets.
- The winning consortium sets up a private sector AssetCo (Special Purpose Vehicle or SPV) which:
    - Structures and raises financing from selected financiers and investors.
    - Procures the buses and charging equipment assets from an OEM.
    - Ensures the availability to PTOs of buses and charging equipment.
    - Provides maintenance training and additional spare parts inventory,
    - The assets are held and/or managed by the SPC, which is the ultimate legal owner.
    - The PTOs are obliged to use BEB-FC's assets as they are made available by SPC and are contractually bound to a care and maintenance obligation, as well as an obligation to transfer the assets to subsequent concessionaires in case a PTO loses its concession.
    - In addition, PTOs will either
        - pay the lease fees directly to the SPC - however, as the overall cost of use of the assets must be at most equal to that of the existing diesel buses, in this case the government must pay an "additional" payment stream for the availability of the assets to the SPC.
        - or pay the same lease fees to the government, which in turn pays a "fully loaded" asset availability payment stream to SPC.
        - it is expected that several enhancements (not shown in the figure) will be necessary to enable this structure, as financiers are likely to require.
        - a guarantee from the government[20] if SPC defaults on its funding obligations (or, at a minimum, if PTOs default on their lease payment obligations)

Option 3: Public Sector-led Delivery

Public sector-led delivery is highlighted in the figure below.

[20] This can be provided by entities such as COFIDE

Figure 11: Public Sector-led Delivery



Source: Grutter Consulting based on Grutter Consulting / RebelGroup report for IFC, 2021

In this structure:

- Government (Ministry of Transportation and Communications – MTC – and/or municipalities) procures financing infrastructure, stations and/or workshop yards, and in no case acquire fleet or fare collection equipment.
- Thee funding agreements are with the government (public funding from, for example, a multilateral development bank such as AFD or a development bank such as COFIDE) and the government passes the funding through AssetCo.
- COFIDE, as a development bank, does not lend directly, but through intermediary banks, COFIDE is the entity authorised to take on loans on behalf of the Peruvian state.
- The figure of a trust fund could be used, fed by the resources of the tariff and governmental resources, which guarantees the payment to the financier regardless of the variation in income due to factors such as a reduction in demand.
- Supply and deliver contracts (including an initial service & support agreement for maintenance training, initial spare parts, etc.) may be signed by the OEM with the government counterpart or with the AssetCo directly.
- The assets are held and/or managed in the AssetCo with government remaining the final legal owner; and
- PTOs are required to lease the BEBs from the AssetCo and are contractually bound to pay lease fees to the AssetCo, keep to a care and maintenance obligation, as well as a handover obligation for transfer of assets to subsequent concession holders should a PTO lose its concession.

A number of improvements (not shown in the figure) are expected to be necessary to enable this structure:

- Regardless of the exact nature of the funders and the financing arrangements, it is expected that funders will require:
  - PCG/PRI or similar on government loan repayment obligations if the structure involves direct private sector financing; and/or,
  - Pledge/first claim on bus and fare infrastructure assets in case of default on debt service obligations.

- Government and/or AssetCo may require a PTO direct guarantee vis-à-vis the obligations of duty and care of the bus and charging assets, particularly concerning the state of asset maintenance at hand-over to any successor concessionaire.
- Financing agreements are either with the government (public financing sourced e.g. from eMotion) and the government passing the financing through into the AssetCo, or directly with the AssetCo – with government guarantee in case the borrowing entity is not the Ministry of Finance providing the credit signature;
- Supply and deliver contracts (including an initial service & support agreement for maintenance training, initial spare parts, etc.) may be signed by the OEM with the government counterpart or with the AssetCo directly;
- The assets are held and/or managed in the AssetCo with government remaining the final legal owner; and
- PTOs are required to lease the BEBs from the AssetCo and are contractually bound to pay lease fees to the AssetCo, keep to a care and maintenance obligation, as well as a handover obligation for transfer of assets to subsequent concession holders should a PTO lose its concession.

Financiers are expected to require pledge/first claim on bus and charging infrastructure assets in case of default on debt service obligations. Government and/or AssetCo may require a PTO direct guarantee vis-à-vis the obligations of duty and care of the bus and charging assets, in particular concerning the state of asset maintenance at hand-over to any successor concessionaire.

7.1.3. Potential Investment Project

Various potential e-bus investment projects have been identified. However, as CNG prices make a sustainable commercial uptake of BEBs difficult in Peru the focus is laid on areas without natural gas. The identified project is therefore the purchase of BEBs in Arequipa.

Table 10: Potential E-Bus Investment Project

Item	Description
Project contents	Purchase of 76 12m BEBs including charging infrastructure in Arequipa; the private concessionaire has the obligation to use BEBs
Project owner	Integra Peru S.A. (private concessionaire)
Total investment	29 MUSD
Loan components	20 MUSD for 70% of the CAPEX @ 4.2% for 12 years tenure of which 9 MUSD from the GCF
Subsidy	20% of total CAPEX equal to 6 MUSD
Environmental impact	100,000 tCO_{2e} reduced, 3 tons of $PM_{2.5}$ avoided and 375 tons of NO_x avoided cumulative over the lifespan of units (16 years)

Source: Grutter Consulting

The proposed project in Arequipa is an important intervention to launch a process of change towards electromobility. It is a decisive moment to demonstrate the advantages of new technologies over gas, commonly used in Peru.

With a development that follows the current inertial trend, barriers to e-buses will be reinforced rather than resolved and e-bus fleets will only be able to start operating in Peru at a much later stage as current market conditions are not conducive to adopting this type of equipment at this time, mainly those associated with social and corporate imaginaries accustomed to maintaining the status quo. Breaking down this barrier requires a strong focus on technical assistance and information for the main actors involved in transport systems, decision-makers, public officials, investors, project evaluators, policy makers, and others.

In addition, there are the variables associated with the pandemic that has affected public transport operators. However, the latter can also be seen as an opportunity to restructure and consolidate the sector if strategic measures are taken to break the relative advantages of fossil fuel vehicles.

8. Proposed Financial and Technical Assistance

8.1. Financial Assistance Instruments

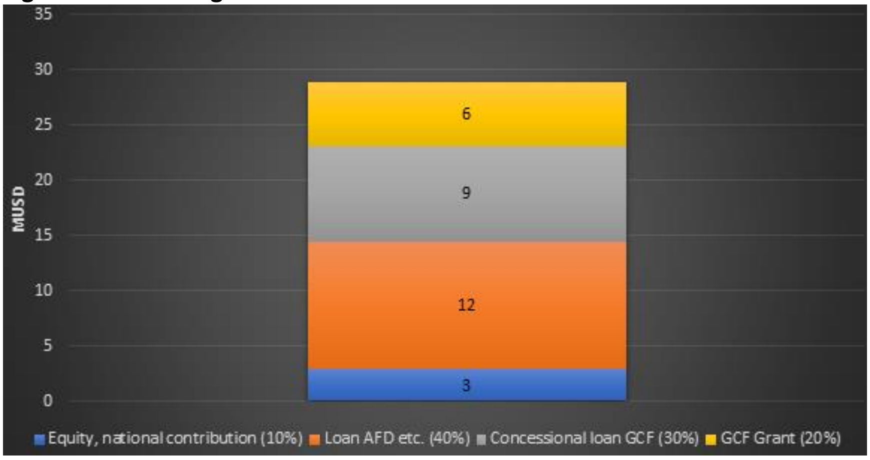
The following table summarizes financial intervention instruments proposed for commercial EV deployment in Peru.

Table 11: Financial Assistance GCF

Instrument	e-buses
Loans	30% of total CAPEX
Grants	20% of total CAPEX

Concessional loans from the GCF are blended with ADF and co-finance and have a long tenure (12 years or longer). GCF loan conditions have been estimated at 0.75% annual interest rate.

Figure 12: Financing Structure e-Buses



Note: Numbers are indicative based on 76 e-buses including bus, charger, grid connection, depot upgrade
Source: Grutter Consulting

The following table summarizes the FA proposed.

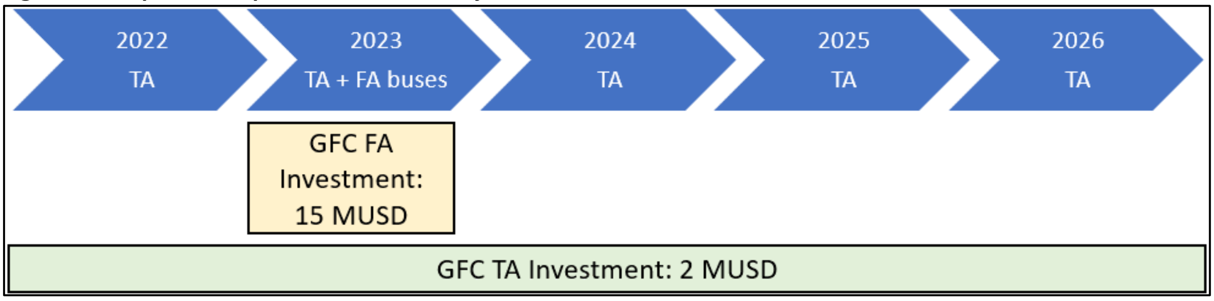
Table 12: FA Potential Project Peru (MUSD)

Parameter	e-buses
Total CAPEX	29
Total loan	24
Co-finance loan	*12*
GCF loan	*9*
Equity and other co-finance	3
GCF grant	6

The delivery channel or business models for buses is based on a private operator with a concession contract from the municipality.

The total GCF contribution for Peru from the GCF is estimated at 17 MUSD of which 9 MUSD concessional loan, 6 MUSD grant for FA and 2 MUSD TA grant. The following chart shows when investments are expected.

Figure 13: Expected Implementation of Projects



Source: Grutter Consulting

8.2. Technical Assistance Instruments

The following technical assistance activities to be managed through GIZ are deemed important to create favourable market conditions for mass deployment of commercial EVs, see annex 1:

- Institutional training for the different sectors involved in electromobility for an adequate adoption of the technology.
- Training in the financial sector for the development of capacities focused on electromobility financing mechanisms within the framework of international mechanisms generated for environmental finance and green finance.
- Technical assistance to generate charging infrastructure standards.
- Support in the structuring and execution of pilot programmes focused on the second life of batteries used in electromobility.
- Support in the structuring and knowledge of the actors involved in the operation contracts that allow the inclusion of third parties in public transport systems that adopt electromobility.
- Training on the appropriate vehicle operating conditions in terms of the durability of battery autonomy, recharging and maintenance services.
- Training on business models for adequate stakeholder participation in the energy chain and the establishment of the electricity supply market for electromobility.
- Technical assistance to generate guidelines for the correct deployment of recharging infrastructure, considering the particularities of the distribution network.

TA for preparation/ feasibility assessment of the projects worth 0.5 MUSD is managed and paid directly by the financing agent whilst the other TA activities are executed by GIZ.

The annex 1 includes a detailed TA for the Program.

9. Impact Assessment

The impact of the proposed FA and TA is assessed at 2 levels:

- Direct impact based on the emission reductions of the vehicles financed by the FA of the program.

- Indirect impact based of the program due to the kick-start of mass deployment of EVs initiated through the investment projects combined with the barrier reduction and the reduced performance risk of EV investments. This is reflected in the incremental amount of deployed EVs until 2030 versus the BAU development as shown in chapter 5. The lifetime impact of the incremental number of EVs is the base of calculations of the indirect program impact.

The following table shows the core indicators and the estimated direct and indirect impact in Peru of the EV program.

Table 13: Program Impact

Parameter	Direct impact	Total impact
GHG reduction lifetime vehicles cumulative in tons	99,000	290,000
$PM_{2.5}$ reduction lifetime vehicles cumulative in tons	3	9
NO_x reduction lifetime vehicles cumulative in tons	380	1,090
Energy savings cumulative lifetime vehicles in TJ	1,000	3,700
Fossil fuel savings cumulative lifetime vehicles in Ml	35	101
Economic savings cumulative in MUSD	5	13

The following table shows the main financial indicators related to the GCF investment.

Table 14: GCF Financial Indicators

Parameter	Direct impact	Total Impact
Total CAPEX investment	29 MUSD	
GCF Loan	9 MUSD	
GCF Grant FA	6 MUSD	
GCF Grant TA	2 MUSD	
Total GCF	**17 MUSD**	
Co-finance ration	**46%**	
GCF investment cost per tCO_2 reduced	**170 USD/tCO_2**	**59 USD/tCO_2**
Total investment cost per tCO_2 reduced	**316 USD/tCO_2**	**109 USD/tCO_2**

Bibliography

ADB. (2018). *Low-Carbon Buses in the People's Republic of China.*

Escorza, M. A. (2016). *Transporte Urbano: ¿cómo resolver la movilidad en Lima y Callao?* Lima.

Fundación Transitemos. (2018). *Transporte Urbano Lima y Callao - 2018.* Lima.

gob.pe. (2020, Agosto 28). *Minem busca fomentar el cambio de matriz energética en el sector automotriz migrando a la electricidad*. From https://www.gob.pe/institucion/minem/noticias/296830-minem-busca-fomentar-el-cambio-de-matriz-energetica-en-el-sector-automotriz-migrando-a-la-electricidad

Grutter Consulting. (2021). *Country Diagnostic Peru.*

Grutter Consulting. (2021a). *Assessment of Commercial EV Demand in Peru.*

ICCT. (2018). *Effects of battery manufacturing on electric vehicle life-cycle greenhouse gas emissions.*

IEA. (2019). *Global EV Outlook 2019.*

León, O. P. (2012). *Los retos del dearrollo de infraestructura de transporte en Lima Metropolitana a través de asociaciones público - privadas.* Lima: Universidad del Pacífico.

OSITRAN. (2018). *Nosotros*. From https://www.ositran.gob.pe/

Revista Gana Más. (2019, Julio 4). *El 37% del parque de taxis en Lima opera en la informalidad*. From https://revistaganamas.com.pe/el-37-del-parque-de-taxis-opera-en-la-informalidad/

UNFCCC. (2019). *CDM Methodological Tool Investment Analysis Version 10.0.*

Annex 1: TA Project for Peru

OUTPUT 1: Establishment of an e-mobility conducive national ecosystem

Through the Ministry of Energy and Mines (Minem), Peru seeks to promote a more environmentally friendly energy source in the automotive sector. Among the objectives set at the national level is to reach 100,000 electric vehicles by 2030. In addition, this target is expected to reduce greenhouse gas emissions, fossil fuel consumption and, consequently, damage to public welfare and the environment.

The **activities in this Work package** are to *strengthen institutions, ministries and the legal framework in order to massively deploy e-buses, e-taxis and e-LCVs*.

- To elaborate together with the Ministry of Environment, Ministry of Energy and Mines and other stakeholders to homologate standards for recharging infrastructure, considering the national context and the plans for technology transition at national level.
- Structuring investment mechanisms for the acquisition of e-cabs including analysis of third party inclusion and leasing schemes. This component should include the legal structuring of such mechanisms and the distribution of responsibilities. In addition, it should consider vehicle renewal and scrappage programs.
- Develop together with the Ministry of Environment the identification of actors, e.g. hazardous waste recyclers and a battery disposal strategy. This includes an identification of best practices and accompaniment to implement a pilot programme for the use of second life batteries.
- Capacity building for insurance companies, drivers, mechanical workshops and first response staff (firefighters, police, paramedics)
- Evaluate the technological alternatives in electromobility available on the international market and their applicability to Peru
- Capacity building in public financial institutions to generate financing mechanisms to facilitate the adoption of electromobility.
- Capacity building in public institutions focused on access to international funding sources with an emphasis on green and environmental mechanisms, as well as on the distribution of resources at the local level to obtain competitive interest rates for the end-user.
- Elaborate the diagnosis of the energy distribution network to adopt electromobility. This activity should give preference to small and medium-sized cities that have institutional capacity difficulties. It will be developed with municipalities and utilities.
- Design a smart fast charging public network for e-vehicles and policies to encourage off peak charging together with the utilities.
- Support to governance and coordination mechanisms

OUTPUT 2: Establishment of an e-mobility conducive local ecosystem

Through the Ministry of Energy and Mines (Minem), Peru seeks to promote a more environmentally friendly energy source in the automotive sector. Among the objectives set at the national level is to reach 100,000 electric vehicles by 2030. In addition, this target is expected to reduce greenhouse gas emissions, fossil fuel consumption and, consequently, damage to public welfare and the environment.

The activities in this Work package are to strengthen institutions, ministries and the legal framework in order to massively deploy e-buses, e-taxis and e-LCVs.

Activities:

- Preparation of financial, economic and environmental pre-feasibility studies of public transport systems that shall be financed under the program.
- To structure, together with the Ministry of Transport and Communications, appropriate concession contracts and concession conditions in medium and small cities geared towards e-bus deployment, including the duration of the concession, fare structuring, guarantees, etc. Close co-operation with legislators is required. Legal advice will be provided through subcontractors. Generate business models that allow for third party participation and sharing of responsibility for e-buses.
- To design, structuring and provide support in the implementation of electric urban transport systems. This activity should prioritise systems that wish to adopt electromobility and do not currently have electric fleets.
- Capacity building in public transport system operators interested in to adopt electric vehicles, in operational conditions such as proper driving, recharging and maintenance processes of units and infrastructure.

OUTPUT 3: Establishment of an e-mobility conducive regional ecosystem:

It is necessary to have a functional and attractive smart charging infrastructure in terms of speed and price due to its low impact on the grid, considering that Peru has set an ambitious electric fleet target for 2030.

- Information and outreach events in the areas of buses, taxis and LCVs to inform about advantages of EVs.
- Dissemination focused on successful models implemented.
- Preparation of knowledge materials including publications, webinars, benchmark and best-practice studies.
- MRV Guidelines & Training.
- Preparation of Capacity Building guidelines.
- Dialogue with EV suppliers.

Annex 2: List of Interviewed Persons and Institutions

Organización	Nombre	Apellido	Departamento	E-Mail
GIZ	Klas	Heising	Oficina Peru	klas.heising@giz.de
CAF	Paloma	Ruiz Gonzales	Vicepresidencia de Infraestructura	PRUIZ@caf.com
	Claudio	Higa	Sector Publico	chiga@caf.com
	Andres	Alcala	Dirección de Análisis y Evaluación Técnica de Infraestructura	aalcala@caf.com
AFD	Heduen	Estrella	Oficina Peru	estrellah@afd.fr
	Priscille	De Coninck	Oficina Peru	deconinckp@afd.fr
	Dominique	De Longevialle	Oficina Paris	delongevialled@afd.fr
Transporte Cruz de Sur	Luis	Ramirez	Alta Direccion	lramirez@gibarcena.com.pe
Linea 1 del Metro de Lima - AENZA	Manuel	Wu	Concesiones de Transporte	mwu@aenza.com.pe
Linea 1 del Metro de Lima - AENZA	Blanca	Sarria	Concesiones de Transporte	blanca.sarria@gym.com.pe
Calac +	Adrian	Montalvo	Swisscontact Oficina Peru	adrian.montalvo@swisscontact.org
Lima Bus International / El Metropolitano	Jose Luis	Diaz Leon	Gerencia	jldiaz@limabus.com.pe
Miniterio de Transporte / Promovilidad	Ismael	Sutta	MTC PROMOVILIDAD	isutta@mtc.gob.pe
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Miniterio de Transporte / Promovilidad	Luis	Chacon	MTC PROMOVILIDAD	lchaconm@mtc.gob.pe
Miniterio de Transporte / Promovilidad	Pamela	Livano	MTC PROMOVILIDAD	plivano@mtc.gob.pe
Miniterio de Transporte / Promovilidad	Juan	Quispe	MTC PROMOVILIDAD	jquispem@mtc.gob.pe
Miniterio de Transporte / Promovilidad	Karen	Guerrero	MTC PROMOVILIDAD	kguerrero@mtc.gob.pe

Organización	Nombre	Apellido	Departamento	E-Mail
COES (Coordinador de Operaciones Electricas del Sistema Interconectado)	Jesus	Tamayo	Directorio	jrtamayop@hotmail.com
Integra Peru SAC	Ruben Dario	Velez Arredondo	Gerencia	rvelez@integra.com.co
Lima Vías Express S.A. - Grupo Express del Perú SAC	Otto	Sarmiento Garcés	Gerencia	osarmiento@lvesa.pe
Transporte Metropolitano de Trujillo	Gladis	Tantalean	Gerencia	gerenciageneral@tmt.gob.pe
COFIDE (Banca de 2do Piso)	Carlos	Linares Peñaloza	Alta Direccion	clinaresp@cofide.com.pe
Municipalidad de Arequipa	Omar	Candia	Alcaldia	omarcandiape@yahoo.com.mx
Acceso Crediticio	Jose	Hidaldo Caceres	Alta Direccion	jose.hidalgo@acceso.com.pe
AAP Asociacion Automotriz del Peru	Armando	Negri	Presidente	anegrip@gmail.com
Transportes Transmar	Yonel	Vitor	Alta Direccion	yondenn@icloud.com
Transporte Consorcio Arequipa S.A (Concesionario de Transporte Arequipa)	Luis	Moran Marquez	Alta Direccion	lmoran@ctarequipa.net

Annex 3: Details Financial Calculations

General Parameters			
Parameter	**Value**	**Unit**	**Source**
NCV of diesel	43	MJ/kg	IPCC, 2006, table 1.2
CO_2 emission factor of diesel	74.1	gCO_2/MJ	IPCC, 2006, table 1.4
Density of diesel	0.844	kg/l	IEA, 2005
Well-to-tank mark-up factor diesel	23%		UNFCCC, 2014, Table 3
NCV of CNG	48	MJ/kg	IPCC, 2006, table 1.2
CO_2 emission factor of CNG	56.1	gCO_2/MJ	IPCC, 2006, table 1.4
Density of NG	0.714	kg/m^3	IGU, 2012
Well-to-tank mark-up factor CNG	18%		UNFCCC, 2014, Table 3
Methane slip as % of NG consumption TTW	1.1%		Average low and high value of ICCT, 2015, table 4 for crankcase and tailpipe
Methane slip as % of NG consumption WTW	3.4%		Average low and high value of ICCT, 2015, table 4 for well-to-pump and fuelling station plus TTW slip
NCV of gasoline	44.3	MJ/kg	IPCC, 2006, table 1.2
CO_2 emission factor of gasoline	69.3	gCO_2/MJ	IPCC, 2006, table 1.4
Density of gasoline	0.741	kg/l	IEA, 2005
Well-to-tank mark-up factor gasoline	19%		UNFCCC, 2014, Table 3
GWP_{100} of BC	900		Bond, 2013; see also IPCC, 2013, Table 8.A.6
GWP_{100} of CH_4	28		IPCC, 2013, Table 8.A.
BC fraction Euro 2 gasoline passenger car and LCV	25%		EEA, 2020, tabla 3-92
BC fraction Euro 4 gasoline passenger car and LCV	15%		
BC fraction Euro 2 diesel passenger car and LCV	80%		
BC fraction Euro 4 diesel passenger car and LCV	87%		
BC fraction Euro II HDV	65%		
BC fraction Euro IV HDV	75%		
BC fraction Euro 1 Motorcycle	25%		
BC fraction Euro 2 Mot	25%		
Conversion kWh to MJ	3.6	MJ per kWh	https://home.uni-leipzig.de/energy/energy-fundamentals/03.htm#:~:text=Power%20units%20can%20be%20converted,%3D%203.6%20MJ%20%5B
Battery manufacturing emissions	110	$kgCO_2$/kWh	ICCT, 2018, table 1 (per kWh battery set); average value not taking into account 2nd life usage of batteries

TCO 12m Bus

Parameter	Value	Unit	Source
Distance driven per bus per annum	57,000	km	Corredores complementarios; BID, 2020, figure 34
Workday distance driven daily	163	km	calcualted based on 95% availability and 10% above average for workday
Specific electicity usage	1.1	kWh/km	Chinese average; ADB, 2018; includes AC but not heating
Diesel usage	50	l/100km	operator value reported in IDB, 2020, figure 50
CNG usage	48	kg/100km	operator value reported in IDB, 2020, figure 50
maintenance cost CNG bus incl. labor and tyres	0.38	USD/km	operator value reported in IDB, 2020, figure 50
Maintenance cost diesel bus incl. labor and tyres	0.25	USD/km	operator value reported in IDB, 2020, figure 50
CNG cost	0.29	USD/kg	operator value reported in IDB, 2020, figure 50
Insurance diesel / CNG as % of CAPEX	1.4%		operator value reported in IDB, 2020, figure 50
insurance e-bus as % of CAPEX	2.2%		operator value reported in IDB, 2020, figure 50
Lifespan bus diesel	14	years	IDB, 2020 see e.g. Figure 71
Lifespan bus electric	16	years	max based on battery age; can be 20% more than diesel
Lifespan battery @ 80% SOC	8	years	current guarantee levels

Financial defaults

Parameter	Value	Unit	Source
CAPEX diesel bus	118,000	USD	IDB, 2020, figure 44 incl. taxes
CAPEX CNG bus	157,000	USD	IDB, 2020, figure 44 incl. taxes
CAPEX overnight charged e-bus	377,600	USD	IDB, 2020, figure 27 based on Yutong with 320 kWh battery base price plus 16% IGV and 2% ISC tax;
CAPEX slow-charged batteries	200	USD/kWh	LFP batteries
CAPEX fast-charged BEB	295,000	USD	Based on standard fast-charged bus incl. taxes
CAPEX batteries fast-charged	250	USD/kWh	NMC batteries
Reduction battery cost in 8 years	50%		US DOE projections, 2017 have a decrease of 12% per annum; applied to 5 years; https://energy.gov/sites/prod/files/2017/02/f34/67089%20EERE%20LIB%20cost%20vs%20price%20m
CAPEX charger excl. Installation per kW	120	USD/kW	Standard chinese chargers, 2 nozzles
CAPEX charger installations civil works	2,500	USD/bus	Civil works for chargers; 2 buses per charger; 5,000 USD per unit
Cost per bus depot upgrade	7,500	USD/bus	Coverage of bus and chargers with roof, no paving, includes labour (20m2 per bus, 250 USD/m2 material and 125 USD/m2 labour)
Cost grid connection of chargers	30,000	USD/bus	Compact sub-stations for groups of chargers; 20kV cables from connection substation to the compact substation, 400V cables from compact substation to chagers; costs not born by electric utility
Maintenance & repair cost of e-buses incl. labour	0.15	USD/km	Based on experience in PR China; ADB, 2018; 10% higher tyre costs; 40% lower maintenance staff and
Lifetime chargers	10	years	standard value
Lifetime bus depot upgrades	20	years	standard value
Lifetime grid connection	20	years	standard value
Maintenance chargers, grid connection, depot	2%		of investment

Option A: Overnight Charging

Battery Size Determination overnight charging

Parameter	Unit	Value
Daily range workday (max)	km	163
Energy usage day	kWh	180
Risk ratio (higher energy consumption)		10%
Reserve ratio		20%
SOC loss year 8		20%
Battery size required year 8	**kWh**	**310**

Charging required at bus depot overnight

Parameter	Unit	Value
Battery capacity	kWh	310
Average daily consumption workday	kWh	180
Time available at depot night	hours	6
Power conversion efficiency of chargers		90%
Charging power required (incl. 1h reserve for slower charging last 20%)	kW	40

Option B: Fast Charging

Parameter	Unit	Value
Battery size	kWh	200
C-rate		0.65
Charging in 30 minutes	kWh	65
Average re-charge during day required with 20% reserve ratio	kWh	20
Average share of day electricity		11%
Fast-charger	kW	300
Power conversion efficiency of chargers		90%
Average required re-charge day with 300 kW charger	minutes	4
Number of buses per fast-charger	buses / charger	10
Night charger power		40

Other options are possible e.g. smaller battery and higher C-rate, buses per fast-charger based on max 12 units or time*2 for charging and 3 hour slot

TCO Buses

12m standard bus, USD 2019

Parameter	Diesel	CNG	BEB overnight	BEB fast
CAPEX bus	118,000	157,000	377,600	295,000
CAPEX charging infrastructure	0	0	7,300	11,150
CAPEX grid connection	0	0	30,000	30,000
CAPEX depot upgrade	0	0	7,500	7,500
Total CAPEX	118,000	157,000	422,400	343,650
Battery replacement yr 8	0	0	31,000	25,000
Energy cost yr 1	21,577	7,749	10,629	10,629
Maintenance cost bus yr 1	14,250	21,660	8,436	8,436
Insurance cost average	974	1,295	4,413	3,448
Maintenance cost infra yr 1	0	0	896	973
Finance cost average per year	2,807	3,735	10,048	8,175
Economic costs yr 1	5,187	4,906	959	959
TCO financial per km	0.82	0.77	1.10	0.96
TCO economic per km	0.93	0.87	1.12	0.98

timespan of calculation: lifespan of e-buses with replacement investment for fossil buses; end of life value proportional to remaining lifespan

TCO Taxis

Parameter	Value	Unit	Source
Average battery size	60	kWh	Nissan Leaf 2020; idem BAIC
Battery lifespan	10	years	idem to vehicle lifespan
Vehicle lifespan	10	years	
Annual mileage	53,000	km	
Daily mileage	171	km	Based on 310 working days
Charging at home average	70%		Assumption; only re-charge if above-average mileage or night shifts
Charging fast-chargers	30%		
CAPEX CNG taxis	14,000		1000 more than gasoline taxi
CAPEX e-taxi	30,000		Nissan LEAF large battery or BAIC
Capex home charger 7.4kW	2,000	USD	Nissan LEAF large battery or BAIC
CNG consumption	6.3	kg/100km	
Electricity consumption	0.16	kWh/km	Nissan LEAF https://ev-database.org/car/1106/Nissan-Leaf
Charger lifespan	10	years	
Maintenance cost CNG	0.033	USD/km	excludes tyres
Maintenance cost total e-taxi	0.017	USD/km	50% lower than cng
Loan tenure taxi	7	years	Bank conditions
Loan share taxi	80%		

CNG versus e-taxi

Parameter	CNG	e-taxi
CAPEX vehicle	14,000	30,000
CAPEX charger	0	2,000
Total CAPEX	14,000	32,000
Energy cost	954	1,654
Maintenance cost	1,749	875
Finance cost average per loan year	333	761
Economic costs yr 1	492	76
Lifespan in years	10	10
TCO financial per km	0.08	0.12
TCO economic per km	0.09	0.12

LCVs

1. Petrol Van

Parameter	Value	Unit	explanation
CAPEX van	17,500	USD	https://autos.suzuki.com.pe/auto/apv-van
Petrol fuel consumption	8.5	l/100km	https://www.carsguide.com.au/suzuki/apv; Automercados indicates 9l/100km
Maintenance cost	0.04	USD/km	excludes tyres and repairs;
Lifespan	15	years	Based on annual mileage
Daily distance driven	70	km	Automercados; commensurate with annual mileage
Annual distance	20,000	km	95% usage

2. E-Van

Parameter	Value	Unit	explanation
CAPEX e-van	31,000	USD	Maxus E-Deliver (see https://saicmaxus.co.uk/edeliver3/); 4.8 m3 cargo volume; short-wheel base; small battery
Range WLTP	222	km	https://saicmaxus.co.uk/edeliver3
Battery size	35	kWh	
Cost battery	7,000	USD	Based on 200 USD/kWh per battery
electricity consumption	0.15	kWh/km	WLTP
Maintenance cost	0.02	USD/m	50% of fossil (as only engine maintenance is included; no tyres, no repairs)
Lifespan van	15	years	assumed same as fossil
Lifespan battery	8	years	
Capex home charger 7.4kW	2,000	USD	
Lifespan charger	10	years	
Charging at home average	90%		Assumption
Charging fast-chargers	10%		Exceptional if long distances were made

fossil versus e-van

Parameter	petrol	e-van
CAPEX vehicle	17,500	31,000
CAPEX charger	0	2,000
Total CAPEX	17,500	33,000
Energy cost	1,615	495
Maintenance cost	850	425
Finance cost average per year	833	1,570
Economic costs yr 1	187	27
Lifespan in years	15	15
TCO financial per km	0.20	0.21
TCO economic per km	0.21	0.21