grütter consulting

Country Diagnostic Peru

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Abbreviations

AC	Air Conditioning
AFD	French Development Agency (Agence Française de Développement)
APN	National Port Authority
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
CF	Cash Flow
CDM	Clean Development Mechanism
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
IEA	International Energy Agency
INEI	National Institute of Statistics and Informatics
ISC	Selective Consumption Tax
KfW	Reconstruction Loan Corporation (Kreditanstalt für Wieddiseraufbau)
LCMR	low-cost/must-run
LCV	Light Commercial Vehicle
LULUCF	Land use, Land-use Change, and Forestry
MINAM	Ministry of Environment
MINEM	Ministry of Energy and Mines - (Ministerio de Energía y Minas)
MINSA	Ministry of Health
NDC	Nationally Determined Contributions
NGV	Natural Gas Vehicles
OPEX	Operational Expenditure
OPI	Programming and Investment Offices
OSITRÁ	Supervisory Body for Public Transportation Infrastructure Investment
PHEV	Hybrid electric vehicle
PNA	National Environmental Policy
PROPARCO	Promotion and Participation for Economic Cooperation, part of AFD (Promotion et de Participation pour la Coopération Economique)
SERPOST S. A.	Postal Services of Peru S.A. (Servicios Postales del Perú S. A.)
SETACA	Cab Service in Callao
SETAMETA	Metropolitan Taxi Service

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

1. Country Brief

Peru has an area of 1,285,215 square km and, according to the National Institute of Statistics and Informatics (INEI) in 2019 it had 32.5 million inhabitants, and projected that in 2030 there will be 35.8 million inhabitants (Ministry of Foreign Affairs, European Union and Cooperation, 2020). Its territory presents three defined regions: Coast, Highlands and Jungle, which are divided into departments.

Table 1: Coastal zone population

Departamento	1995	2010	2020	2030
Total	**12 782 715**	**15 881 453**	**18 924 251**	**21 626 738**
Prov. Const. del Callao	704 064	927 153	1 129 854	1 319 706
Ica	620 601	766 179	975 182	1 189 708
La Libertad	1 386 270	1 711 902	2 016 771	2 277 363
Lambayeque	1 013 016	1 160 034	1 310 785	1 419 648
Lima	7 001 163	8 864 719	10 628 470	12 214 119
Moquegua	139 967	168 636	192 740	211 157
Piura	1 505 035	1 764 979	2 047 954	2 277 711
Tacna	241 795	306 325	370 974	430 642
Tumbes	170 804	211 526	251 521	286 684

Source: National Institute of Statistics and Informatics, 2019

Table 2: Population of the Highlands

Departamento	1995	2010	2020	2030
Total	**9 239 780**	**10 109 389**	**10 584 763**	**10 699 573**
Áncash	1 036 065	1 098 254	1 180 638	1 216 561
Apurímac	416 711	429 378	430 736	414 184
Arequipa	1 006 567	1 224 189	1 497 438	1 755 684
Ayacucho	550 262	646 633	668 213	661 885
Cajamarca	1 368 052	1 429 490	1 453 711	1 417 012
Cusco	1 127 101	1 226 106	1 357 075	1 439 741
Huancavelica	425 733	441 097	365 317	290 010
Huánuco	719 741	774 475	760 267	715 363
Junín	1 159 999	1 279 658	1 361 467	1 388 418
Pasco	255 024	281 169	271 904	252 048
Puno	1 174 525	1 278 940	1 237 997	1 148 667

Source: National Institute of Statistics and Informatics, 2019

Table 3: Population jungle area

Departamento	1995	2010	2020	2030
Total	**2 220 105**	**2 702 073**	**3 116 934**	**3 465 768**
Amazonas	375 202	407 420	426 806	428 576
Loreto	789 261	930 554	1 027 559	1 087 623
Madre de Dios	77 878	123 528	173 811	234 432
San Martín	618 293	773 197	899 648	1 003 377
Ucayali	359 471	467 374	589 110	711 760

Source: National Institute of Statistics and Informatics, 2019

In terms of major cities, Lima tops the list with 10.6 million inhabitants, rising to 11.7 million in the metropolitan area it forms with Callao in a conurbation of these two cities.

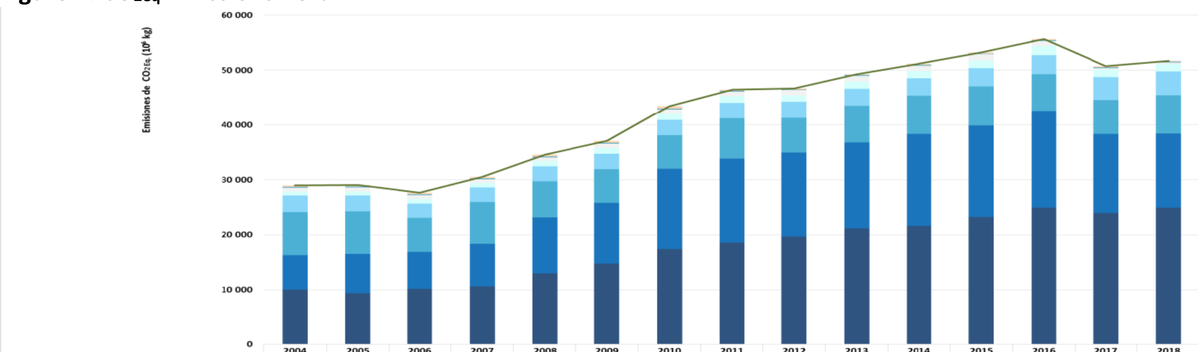
It is important to mention that national mobility statistics in Peru are somewhat deficient, the reader will find in this document that many of the conceptual and numerical references in this field are limited to the metropolitan area of Lima Callao.

2. Policy Framework

2.1. Climate Change / Environment

In the case of Peru, according to Ministry of Energy and Mines, National Energy Balance Sheet, around 51.7 million tons of CO_{2eq} were emitted in 2017[1].

Figure 1: CO_{2eq} Emissions Peru

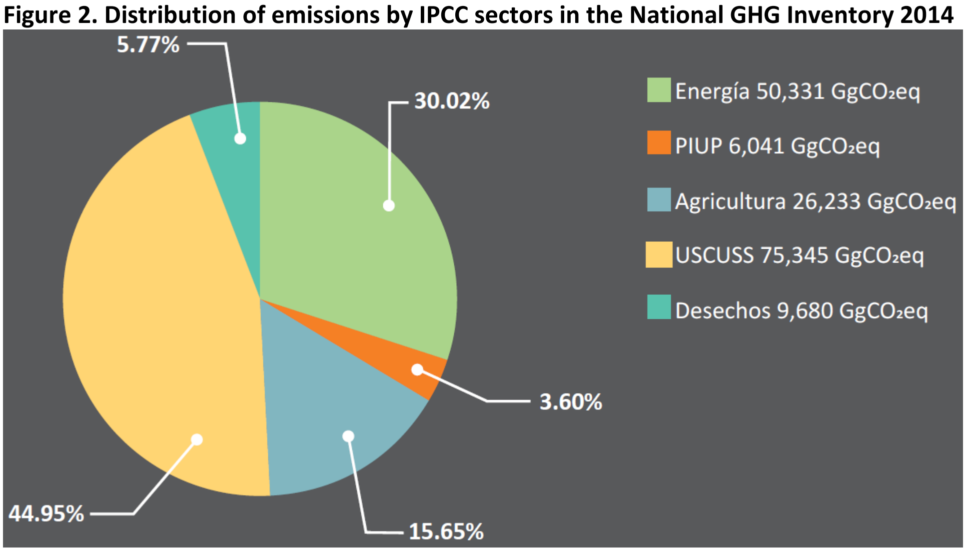


	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Pesca	286	269	291	284	317	365	474	228	217	179	218	191	213	199	123
Agropecuario	137	126	130	126	144	144	156	148	135	136	133	136	138	138	139
Público	656	756	720	675	679	821	833	811	896	1 013	1 009	1 132	902	275	326
Minero	724	731	811	838	1 002	995	1 137	1 256	1 229	1 323	1 279	1 442	1 672	1 335	1 281
Residencial y Comercial	3 068	2 877	2 571	2 614	2 707	2 809	2 807	2 855	2 994	3 115	3 202	3 301	3 441	4 192	4 400
Industria	7 764	7 764	6 226	7 614	6 522	6 100	6 127	7 414	6 370	6 816	7 065	7 205	6 701	6 325	7 006
Centro de Transformación / consumo propio	6 308	7 101	6 656	7 756	10 204	11 087	14 537	15 209	15 230	15 601	16 699	16 649	17 714	14 299	13 505
Transporte	10 035	9 413	10 235	10 618	12 980	14 754	17 432	18 613	19 684	21 156	21 632	23 232	24 900	24 001	24 940
Total emisiones de CO2 equivalente	28 978	29 038	27 639	30 525	34 554	37 075	43 503	46 533	46 756	49 339	51 238	53 289	55 683	50 764	51 721

Source: Ministry of Energy and Mines, National Energy Balance Sheet - 2018

USCUSS (see figure below) is the activity with the highest emissions, 75,345 $GgCO_{2e}$, followed by the energy sector with 50,331 $GgCO_{2e}$ and the agriculture sector with 26,233 $GgCO_{2e}$.

Figure 2. Distribution of emissions by IPCC sectors in the National GHG Inventory 2014



Source: Ministry of the Environment, Second Biennial Update Report to the United Nations, Framework Convention on Climate Change, 2019

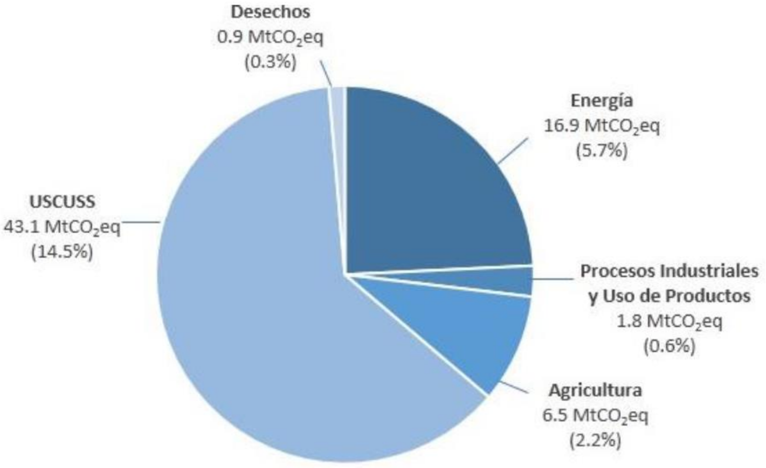
The Nationally Determined Contributions (NDCs) focuses on two fundamental issues: adaptation to change and mitigation of GHGs. In terms of GHG mitigation measures, Peru presents 62 measures to reduce emissions by 20% with respect to the business-as-usual scenario, and a further 10% depending

[1] Climatewatch estimates around 167 million tons of greenhouse gases emitted in 2017.

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).

To meet the goals, the State in accordance with the Peruvian Framework Law on Climate Change developed measures distributed in five sectors: 1) Energy, stationary and mobile combustion[2], 2) Industrial processes, 3) Agriculture, 4) Land use and forestry; and 5) Waste - solid waste disposal and wastewater treatment (NDC, 2020). The measures by sector are distributed as shown in the following graph.

Figure 3: Contribution of mitigation measures to GHG emission reductions by 2030, by IPCC sector



Source: Technical information to guide the implementation of the Nationally Determined Contributions (GTF-NDC) - final report, Dec 2018

In terms of transportation and electric vehicles, the NDC Peru mentions the following goals:

- Incorporation of light-duty, hybrid and electric vehicles at the national level: The NDC proposes the entry of 6,707 electric buses and 171,359 electric light-duty vehicles by 2030.
- Energy efficiency labelling for light-duty vehicles to influence the buyer's decision making. A 3.5% decrease in energy consumption by 2030 is expected.
- National Sustainable Urban Transport Program: The NDC considers the implementation of Mass Transport Systems based on buses powered by Compressed Natural Gas (CNG) in intermediate cities such as Piura, Chiclayo, Trujillo, Arequipa and Cusco.

2.2. Energy Policies

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

[2] Mitigation measures in this field are: Implementation of the complementary Corridors of the Integrated Transport System of Lima, Current operation of the Metropolitano and extensions, Implementation of Lines 1 and 2 of the Lima and Callao Metro, Promotion of Natural Gas Vehicle (NGV) for light vehicles, Promotion of the use of cleaner fuels, Promotion of electric vehicles at national level, Promotion of liquefied natural gas (LNG) for freight transport of the natural gas massification project, Efficient driving training for professional drivers, National Sustainable Urban Transport Programme, National Programme for Vehicle Scrappage and Renewal Energy efficiency labelling for light-duty vehicles, Project "Construction of the Trans-Andean Tunnel", Improvement of the railway transport service in the Tacna - Arica section, Integral rehabilitation of the Huancayo - Huancavelica railway line.

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 that the country's vehicle fleet reaches 100,000 electric vehicles by 2030, given that the energy efficiency of electric vehicles is 3 times higher than that of a fossil engine. In addition, this objective is expected to reduce GHG emissions, fossil fuel consumption and, consequently, reduce damage to public and environmental well-being.

For this purpose, the following provisions are established:

- Electric vehicle recharging facilities will operate in fuel service stations. In addition, private charging will be allowed, which implies the provision of charging points in homes, workplaces, public spaces and parking lots.
- Minem will have one year to set up and regulate the installation and operation of charging infrastructure.
- Minem will have 270 days to regulate the Efficient Energy Use Plan, which defines the actions on charging infrastructure and electric energy supply that will allow reaching the energy efficiency goals.
- The regulator, Orinergmin, will be in charge of supervising the quality of service and the municipalities will be responsible for the compliance with technical and safety conditions.

2.3. Transportation Policies

The initial exercise is embodied in Decree 64 of 2010, which created the General Directorate of Energy Efficiency and, although it is not specifically aimed at mobility, it constitutes the normative basis of reference to begin to consolidate a policy in this area. Since 2018, with Decree 019, concrete steps have been taken to include new vehicle technologies in Peruvian transport systems. Institutionally, discussions and incentives for electric mobility have been developed. As a consequence of those discussions on electric mobility, the following specific regulations have been produced so far:

- **Supreme Decree No. 064-2010-EM:** It creates the General Directorate of Energy Efficiency as an entity of the Ministry of Energy and Mines in order to coordinate national development policies including the energy sector. To this end, the National Energy Policy of Peru 2010-2040 is approved based on nine objectives:
  1. To have a diversified energy matrix, with emphasis on renewable sources and energy efficiency;
  2. Competitive energy supply;
  3. Universal access to energy supply;
  4. To have the highest efficiency in the production chain and in the use of energy;
  5. Achieving self-sufficiency in energy production;
  6. To develop an energy sector with minimal environmental impact and low carbon emissions;
  7. Develop the natural gas industry, and its use in household, transportation, commerce and industry;
  8. Strengthening the institutional framework of the energy sector;
  9. Integrate with the region's energy markets.
- **Supreme Decree No. 019-2018-MTC:** In 2018 the Peruvian government updated the National Vehicle Regulation in order to include vehicles with new technologies such as electric cars and pedal-assist bicycles, in addition, the decree requires a National Vehicle Homologation System

in order to know whether new vehicles imported or manufactured in the country comply with environmental safety standards, energy efficiency and safety standards (Osinergmin, 2019). Regarding cabs, the Decree requires that the electric vehicle must have a minimum range of 200 km with power no less than 80kW. In addition, it clarifies that the emissions required by DS No. 010-2017-MINAM do not apply to electric vehicles (Osinergmin, 2019).

- **Supreme Decree No. 094-2018-EF:** The Ministry of Economy and Finance, together with the Ministry of Environment, 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. On the other hand, this decree eliminated the Selective Consumption Tax (ISC) on new electric, gas and hybrid vehicles, in order to encourage the acquisition of vehicles with a lower carbon footprint.
- **Supreme Decree N°012-2019** approving the Urban Transport Policy.
- **Supreme Decree N° 027-2019-MTC** that creates PROMOVILIDAD.
- **Supreme Decree No. 181-2019-EF:** This decree 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:** With this Decree, the Ministry of Energy and Mines approves 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.
- **Directorial Resolution No. 266-2020-MTC/16** approving the Guide "Climate Change, Air Quality and Transport: Guide to quantify emissions of Greenhouse Gases (GHG) and Short-Lived Climate Pollutants (SLCP) in the transport sector".

2.4. Others

In Peru, additional advances have been made that do not focus on the legal framework but on agreements and projects that promote electromobility in the country. These are private and public companies that have materialized sustainable projects such as the following:

- **First fast charger:** In September 2018, ABB presented the first Terra 53 fast charger model for electric cars with a power of 50kW (Osinergmin, 2019).
- **First electric cabs in Lima:** In May 2019, the first electric cabs in Lima started working. With the company Taxi Directo and BYD it was possible to start providing services with two vehicles and 20 more by the end of the year (Osinergmin, 2019).
- **First green buses in Peru:** In September 2018, in the city of San Isidro, the first 100% electric public transport bus in the country starts working (Osinergmin, 2019).
- **First electric bus on commercial route:** Lima within the Corredor Rojo was the first to operate an electric bus with a BYD bus, supported by GSEP, Enel and Hydro-Québec, later this bus was transferred to the company ETUL 4. The bus is a K9G model with a capacity of 80 passengers (Osinergmin, 2019). The bus of the Municipality of San Isidro operated on a trial basis and was then re-exported to Costa Rica, as the bus was not purchased. MODASA, a Peruvian coachbuilder, has produced its first electric bus on a Volkswagen bus platform. In Arequipa, an electric bus is also operated by Integra Peru SAC, concessionaire of SIT Arequipa.
- **First electric bus for mining:** In April 2019, Engie launched the first all-electric bus for mining tasks. The vehicle is designed for travel between provinces and its function will be to transport people from the Cerro Corona mining project in the department of Cajamarca. The route will be Lima-Cajamarca, with stops in the cities of Chimbote and Trujillo (Osinergmin, 2019).

- **Electric chargers will pay less for energy:** The Ministry of Energy and Mines deems it appropriate that those who supply chargers be considered as free customers of the electricity market to promote the entry of these devices in the country. The cost will be paid by those who choose to charge energy.

2.5. Summary

In Peru, the development of e-mobility is limited. The main measures and policies are summarized in the following table.

Table 4: Main E-Mobility Policies of Peru

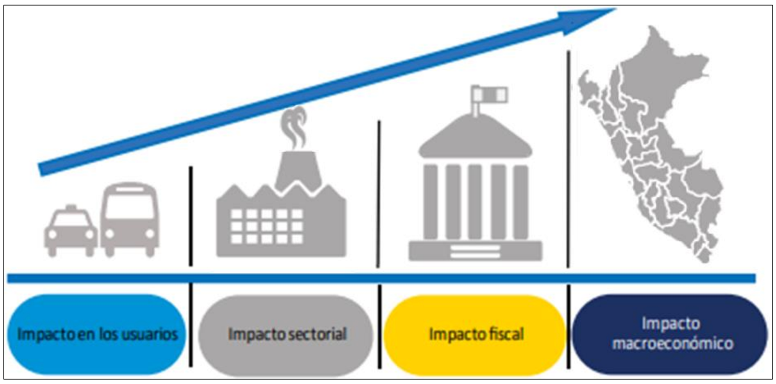
Policy	Main components
Directorial Resolution No. 266-2020-MTC/16	It approves the Guide "Climate Change, Air Quality and Transport: Guide to quantify emissions of Greenhouse Gases (GHG) and Short-Lived Climate Pollutants (SLCP) in the transport sector".
Supreme Decree N°012-2019	It approves the Urban Transport Policy.
Supreme Decree N° 027-2019-MTC	It creates PROMOVILIDAD.
Supreme Decree No. 064-2010-EM	It creates the General Directorate of Energy Efficiency to promote national policies in the energy sector.
Supreme Decree No. 094-2019-EF	The Ministry of Economy and Finance increases taxes on fuels according to their degree of harmfulness in order to encourage the purchase of less polluting vehicles.
Supreme Decree No. 181-2019-EF	The Selective Consumption Tax rate for imported used vehicles is increased and standardized in order to attract clean technologies.
Supreme Decree No. 019-2018-MTC	The government updates the National Vehicle Regulations to include vehicles with new technologies in the vehicle fleet.
Supreme Decree No. 022-2020-EM	The Ministry of Energy and Mines approved the implementation of charging and energy supply infrastructure.

Source: own elaboration

3. Macroeconomic Impact of E-mobility

As evidenced, the adoption of EVs is considered as one of the main options to reduce fuel use and GHG emissions. Therefore, the volume of EV sales will depend on consumer acceptance, technology development by the different sectors and regulatory changes in the country. (Osinergmin, 2019).

Figure 4: Impact Areas of E-Mobility



Source: (Osinergmin, 2019)

In the case of the user, the investment cost must be taken into account. At the sectoral level, the adoption of EVs is related to the energy sector, transportation sector, mining sector (due to copper requirements and potential lithium exploitation) and the hydrocarbon sector. Finally, at the fiscal level, the State will report lower tax revenues, will no longer receive income from selective consumption tax (ISC) on fuels, and is expected to spend less on health due to improved air quality. The following diagram shows the impacts on the different sectors.

Impact on users

To make a comparative analysis between the total cost of ownership (TCO) of an electric vehicle (EV) and an electric combustion engine vehicle (ICEV), the value of the investment and the value of the operation and maintenance costs over the life of the vehicle must be taken into account. Currently, the price of EVs is still above their internal combustion engine counterparts, however, operation and maintenance costs are typically lower (Osinergmin, 2020). In Peru, the energy cost (USD/km) of a battery electric vehicle (BEV) is three times lower than that of an ICEV and two times lower than that of a hybrid electric vehicle (HEV) (Osinergmin, 2019). The results of the economic analyses indicate that the lower operational costs, OPEX, obtained by BEVs do not sufficiently offset their higher purchase costs, CAPEX, although competitive, 15-year TCOs are too close for BEVs compared to fossil fuel technologies depending on the city and its specific circumstances.

Sectoral impacts

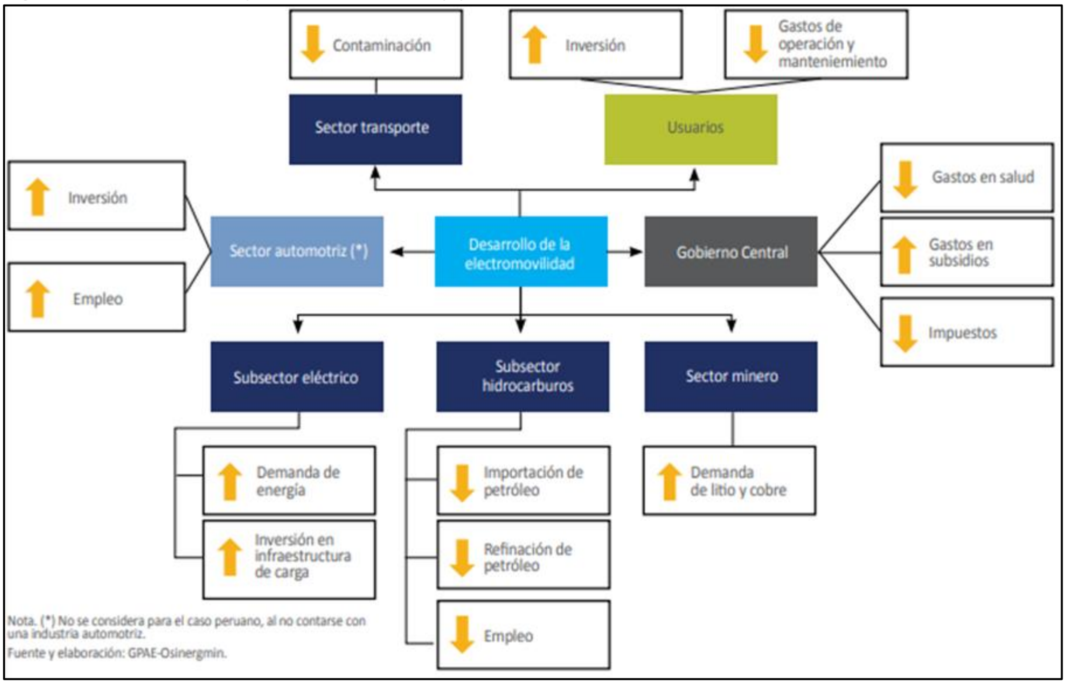
Automotive sector: The automotive industry in Peru is small and there are no manufacturers except for the assemblage of truck and bus chassis. For the development of an electric vehicle industry in the country, there should be a highly qualified and competitive labour supply, which the country does not have and therefore no benefits in terms of investment and increase in employment are expected in this sector (Osinergmin, 2019).

Electric sub-sector: electromobility benefits this sector by increasing the investment in infrastructure required for recharging electric vehicles. The increase in electricity consumption would also allow the integration of renewable energies (Osinergmin, 2019).

Hydrocarbon subsector: e-mobility leads to a decreasing demand for oil and its refining. In the case of Peru, which is an importing country, this represents a large economic benefit. In the case of the refining industry, the inclusion of EVs could accelerate the refining capacity crisis (Osinergmin, 2019).

Mining sub-sector: the demand for lithium used for EV production increased from 20% in 2014 to 49% in 2018, and is expected to increase to 90% by 2030[3]. In addition, the demand in copper is 3 times the amount required in a conventional vehicle, thus, electromobility is expected to have an impact on copper and lithium exports since Peru is the second largest copper producer worldwide and is seen as a potential lithium exporter by 2022 (year in which it expects to export 60,000 tons). These imports translate into revenues for the State (tax and non-tax). (Osinergmin, 2019). These production expectations for this essential mineral open up a favourable horizon for the mass use of electric mobility in Peru.

Figure 5: Economic Impacts of E-Mobility per Sector



Source: (Osinergmin, 2019)

[3] In 2018, the company Macusani Yellowcake, a subsidiary of the Canadian Plateau Energy, discovered a deposit with resources equivalent to 2.5 million tons of high grade lithium and significant amounts of uranium in Macusani, in the Puno region. This is not lithium in the form of salt flats as in the "lithium triangle" countries with average contents of 500 parts per million (ppm), but lithium in the form of rock, where the content is of higher concentration (an average of 2,000 ppm); this is what gives this deposit its importance. The development of new technologies and research will be required for its metallurgical processing, extraction and production by the uranium-lithium mineral association in rock. Various social organizations have highlighted the risks of conflict in a potential lithium megaproject, where redistributive, territorial, participatory, environmental and social disputes could arise. Mining in Peru is associated with environmental costs, especially for those who live nearby, with water or soil contamination and water scarcity. There are also economic and social problems, wealth that does not benefit the poorest local population and the migration of people who arrive in search of work. In this regard, the Peruvian government is preparing a draft law on the regulation and exploitation of uranium and lithium for "pre-publication" and discussion, but its scope is unknown.

Fiscal impacts

The factors can be grouped into local effects, vehicle imports, fuel sales and electricity sales and, of course, lithium and copper exports.

Macroeconomic impacts

GDP: The impact on the Gross Domestic Product derives from lower expenditures on oil imports and higher spending on vehicles (consumer prices increase and real income decreases, although operating costs decrease). For this reason, the long-term impact will depend on vehicle costs, batteries, the location of supply chains, among other factors. (Osinergmin, 2019).

Employment: since there is no automotive industry in the country, electromobility will have an impact on jobs in the hydrocarbon and mining sectors. Indirect impacts are expected if EVs have lower total costs as people spend the available extra income to a large extent on service goods with a higher employment impact.

4. Transport Sector

4.1. Actors in E-Mobility in the Transport Sector

Some of the most important actors related to mobility in Peru are listed below. This is not an exhaustive list but aims to cover the most important issues and aspects related to the e-motion programme.

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

Ministry of the Environment
This entity 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
This sector is in charge of formulating and evaluating national policies for mining and energy activities that reduce the environmental impact, safeguarding the rational use of natural resources.

Ministry of Economy and Finance
Contributes to the sustained economic growth of the country by promoting the economic growth of its inhabitants.

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.

Supervisory Body for Investment in Public Transportation Infrastructure (OSITRAN)
This agency is in charge of regulating, supervising and overseeing the transportation infrastructure under concession between the state and the private companies that manage those infrastructures and those managed by the companies CORPAC and ENAPU (OSITRAN, 2018)

COFIDE
Banco de Desarrollo del Perú; a financial institution 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.

Provias Nacional
It is a project with technical, administrative and financial autonomy and is in charge of projects of improvement, maintenance and construction of the National Road Network.

Urban Transport Authority for Lima and Callao (ATU)
The Authority of Urban Transport for Lima and Callao is a specialized technical organism of the Ministry of Transport and Communications, whose objective is to organise, implement and manage the Integrated System of Transport of Lima and Callao (SIT).

Integra Transportation (SIT City of Arequipa)
This 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.

Asociacion Automotriz del Perú (https://aap.org.pe)
The Asociación Automotriz del Perú, a private organisation, initially called the Asociación de Importadores de Automóviles del Perú, aims to look after the interests of its members and to develop the country's transport sector.

Acceso Crediticio (https://acceso.com.pe)
Es una compañía de financiamiento comercial orientada al sector transporte mediante la bancarización a través del crédito vehicular en la base de la pirámide.

SIGMA http://sigmasafi.pe/
Es una empresa privada dedicada a administrar fondos de inversión públicos y privados especializada en productos financieros como Leasing Operativo, e inversiones vía Private Equity en empresas dedicadas al desarrollo de Infraestructura, es una de las principales administradoras de fondos de inversión en el Perú respaldada por inversionistas institucionales y otras empresas privadas.

Integra Perú SAC www.integra.com.co
INTEGRA S. A. es un transportador privado conformada por las siete (7) empresas de transporte urbano colectivo agremiadas a ASEMTUR y por pequeños propietarios para participar en el Sistema de Transporte Masivo. INTEGRA PERÚ S. A. C. opera el Taxi Premium. This company operates in Arequipa and carries out inter-urban passenger transport.

PROMOVILIDAD
El Ministerio de Transportes y Comunicaciones (MTC) tiene como su principal lineamiento la generación de infraestructura al servicio de las personas. En ese sentido, lidera el trabajo a fin de contar con vías más seguras, formalizar los servicios de transportes, generar sistemas integrados, entre otros. Promovilidad es la respuesta institucional a esta situación, financiará sistemas de transporte, brindará acompañamiento a las municipalidades, convocará asistencia técnica de los cooperantes internacionales y del propio MTC.

Cruz del Sur Transportation
National Transportation 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 the city of 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. This company operates inter-urban passenger transport.

Transmar
It is a business group dedicated to passenger transport services. It has had organisational experience since 1985. Its long experience in seeking funds to finance its operations makes it an interesting candidate to enter more easily into the electric mobility business. This company operates inter-urban passenger transport.

Lima International Bus

Peruvian operators associated with the SI 18 Group, and SI 98, which are operators of Transmilenio, and currently operate the Metropolitano de Lima BRT. It also operates in association with its Colombian partners in Cartagena de Indias. Lima Bus currently operates 78 articulated buses and 40 12-meter buses, all of which run on CNG, which are more than 10 years old and must be renewed and meet the commitment to expand to 90 articulated buses.

Transportes Metropolitanos de Trujillo

Transportes Metropolitanos de Trujillo - TMT is a Decentralised Public Body of the Provincial Municipality of Trujillo, dependent on the Municipal Council. It is in charge of the projects related to the Urban and Inter-urban Public Transport system of the Province, including the study and execution phases. The aforementioned system also includes the complementary technological services and facilities. This company has expressed interest in purchasing electric buses, 40 to 50 in phase 1, to renew part of the current fleet.

Municipalities

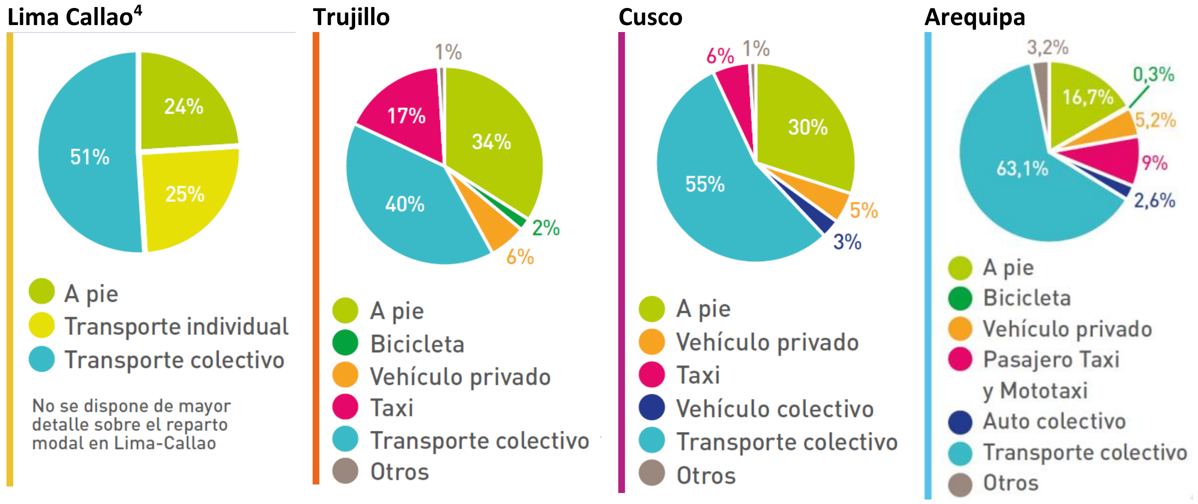
Municipalities play a major role in collective and individual public mobility decisions. They interact directly with private actors and are responsible for the contracts for the provision of these services. Arequipa and Trujillo, for example, have shown interest in further details on this new technology and have expressed interest in acquiring some vehicles to renew and increase their fleets.

4.2. Urban Mobility in Peru

Peru is a country that has different phases of growth throughout its territory, however, the inadequate transportation systems that move people are a characteristic among all its cities. Public policies together with citizen demands have been oriented towards strengthening the private automobile at the expense of weakening sustainable public transportation (Escorza, 2016). A clear example of this is the lack of information by public entities on urban transport to such an extent that it is limited to the cities of Lima and Callao, and to nationwide services.

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 (combis, coasters, 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).

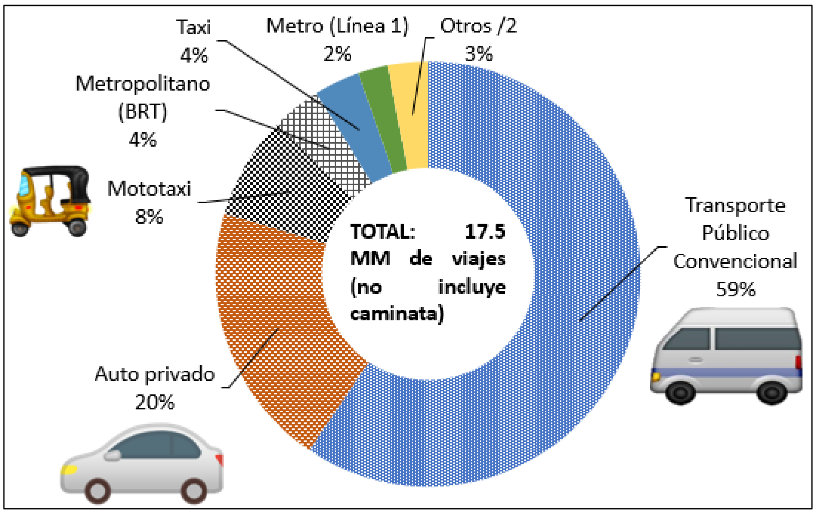
Figure 6: Mode Share in four cities



Source: AFD, CODATU, CEREMA MTC, Recomendaciones para lograr el cambio de paradigma - mayo 2018

For public transportation in Lima and Callao, the distribution of trips by mode is shown in the following figure. Cabs are the most common mode of transportation after regular transportation such as buses, combi, coaster (minibus) and motorcycle cabs.

Figure 7: Mode Share in Lima Callao



Source: ATU for Lima Callao - 2020

The top 25 urban transport companies in Lima Callao in 2019 are listed in Table 9.

Table 5. More important companies of urban transport in Lima Callao

N°	Company	Vehicle by type					
		Bus feederr	Bus articulated	Rural van	Microbus	Bbus	Tota
1	Emp.de trans. Y serv. Virgen de la puerta s.a.-vipusa				109	198	307
2	Empresa de transportes urbano linea 4 s.a.				1	289	290
3	**Consorcio allin group n° 2 javier prado - la marina - faucett**					**257**	**257**
4	Translima s.a.			43	147	48	238
5	E.t. santa rosa de jicamarca s.a.				173	51	224
6	E.t. sol de oro s.a.				83	118	201
7	E.t. la unidadde villa s.a.			124	37	33	194
8	E.t. unidos chama s.a.			10	80	100	190
9	E.t.s.guadulfo silva carbajal s.a.				84	106	190

[4] In Escorza's 2016 work for Lima Callao: public transport 47.8%, walking 24.3%, private car 15.2%, motorbike taxi 5.9%, taxi 2.6%, colectivo 1.5%, BRT 1.2%, motorbike, 0.5%, bicycle 0.3%, train 0.3%, other 0.2%.

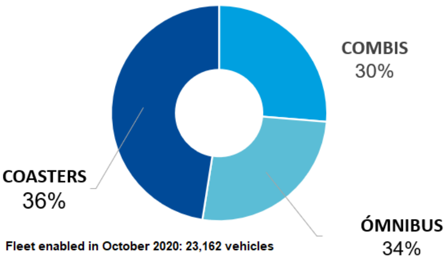
10	E.t. y serv. Elrapido s.a.					187	187
11	Comun. Integ.turis. Y serv. Urano tours s.a.			87	20	74	181
12	E.t serv. Mult. Nuevo peru s.a.			8	100	70	178
13	**Consorcio transporte arequipa n° 3 tacna garcilazo arequipa**					**157**	**157**
14	**Transvial lima sac 76 78**	**76**	**78**				**154**
15	E.t. urbanos los chinos s.a.					148	148
16	E.t. unidos de pasajeros s.a. (etupsa 73)					143	143
17	Transportes huascar s.a.				22	119	141
18	E.t. luis banchero rossi s.a.				72	68	140
19	E.t. serv.multi.san genaro s.a.			78	9	53	140
20	E.s.t. santa catalina s.a.				7	133	140
21	E.t. nor lima s.a. (etnolsa)				132	6	138
22	E.t. turismo huaycan s.a.			42	79	17	138
23	Transportes negociaciones santa anita s.a.				92	41	133
24	E.t. y serv. Nueva america s.a.			3	39	86	128
25	E.t. y serv. Salvador s.a.c.				10	117	127
	Total general	76	78	395	1,296	2,619	4,464

Note: companies 3, 13 and 14 are formal
Fuente: Municipalidad de Lima y Callao - CIDATT

In the case of Arequipa, 72% of motorized trips are made by public transport, included taxi, and 28% by other modes, and the trends show a growth in private transport and a decrease in public transport. As for Cusco, 64% of trips are made by public transportation, the main modes being bus with 55%, then taxi with 6% and collective cab with 3%.

It is also possible to segregate the fleet composition according to the type of bus (see the following table and pictures).

Figure 8: Composition of Bus Fleet in Lima and Callao – 2020



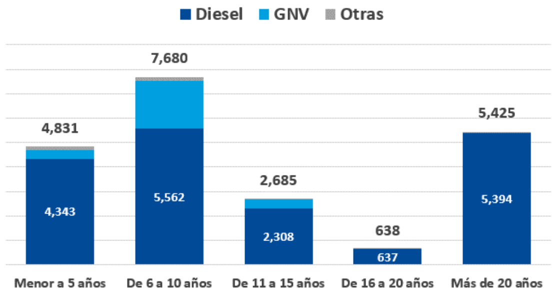
Source: ATU for Lima Callao - 2020

Photo 1: Bus, Coaster and Minibus in Lima/Callao

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. Additionally, the ownership of the vehicles is individual and they pay a membership fee to the companies for the use of the road, workers are not on the payroll and have no social benefits, and do not receive remuneration, but work, charges are collected for each unit and given to the owner of the unit, maintenance is individual, vehicles stay overnight at the home or property of the individual owner.

The average age of the public transport vehicle fleet in Lima and Callao as of 2018 is 12.5 years (Fundación Transitemos, 2018). Buses are the units with the lowest average age due to the renewal processes that took place between 2010 and 2014. 31% of buses and 59% of coasters are 15 years or older.

Figure 9. Fleet by fuel consumption



Other: Gasoline, Dual NGV, Dual LPG, among others.
Source: Register of vehicles authorised for regular transport service, Feb 2020.

Diesel is the most used type of fuel in the public fleet in Lima and Callao. Around 15% of units use CNG.

In Lima's BRT, the Metropolitano, the construction of the 10.2 km of roads and its 18 stations is being financed with public funds, and the procurement of the new buses was carried out by private companies financed through through fare collection. The system was implemented in two stages: 1) design and construction of infrastructure and 2) procurement of equipment and vehicles. The first was entirely financed by public funds while the buses were financed by private firms through operators who purchase and operate the buses, the yards, the control system and maintenance. (León, 2012). The construction of the infrastructure was contracted in the traditional way, where the State builds through a contractor and assumes the major construction risk. The acquisition, operation and maintenance of the buses is done through a 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). But it is also important to recognise that operators are not interested in credits of more than 10 years and are not looking to commit to payments longer than that.

There are two categories of companies in the bus transport sector: formal and informal.

In the former, the fleet is owned by the companies, workers are on the payroll and receive all social benefits, fare collection and vehicle maintenance is centralised, and vehicles spend the night in yards managed by the company.

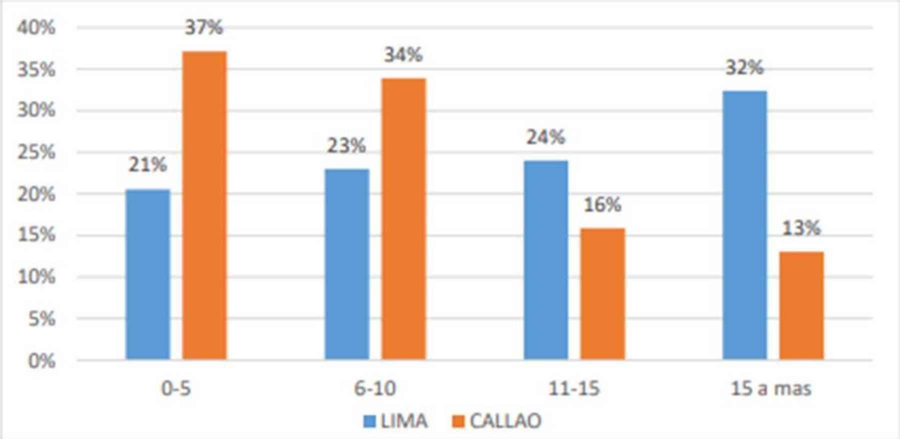
While in informal enterprises the ownership of vehicles is individual and they pay a membership fee to the companies for the use of the route, workers are not on the payroll and have no social benefits, and are not paid if they do not work, the collection is collected for each unit and given to the owner of the unit, maintenance is individual and the vehicles stay overnight in the house or property of the individual owner.

4.3. Taxis

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 the cities of 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 a large number of vehicles operating informally.

The average age of the formal taxi fleet is 10 years with 30% of units having more than 15 years (see the following figure).

Figure 10: Formal Taxi Age Structure in lima and Callao, 2018



Source: (Findación Transitemos, 2018)

There are three modalities of cabs in Lima and Callao denominated as follows: independent cab, cab station and cab remisse. The independent cab service is provided by natural persons with yellow cars, or with yellow and black stripes. Station cabs must be part of a minimum fleet of 10 authorized vehicles of a white color and with black and white stripes. Finally, remisse cabs must also be part of a company with a minimum fleet of 10 authorized vehicles. Although they are formal, they do not have any specific color and cannot pick up and drop off passengers on public roads (unlike independent and station cabs) since they obey a central office. Station and remisse cabs are more expensive than independent cabs. (Autofact, 2020).

On the other hand, on October 28, 2020, INDECOPI confirms that Uber is neither a cab company nor commits unfair competition [Resolution 0084-2020/SDC-Indecopi], and as a consequence may continue to operate in Peru. Likewise, the Chamber concluded that Uber is not a cab company in the terms established in Ordinance 1684 - Ordinance that regulates the provision of cab services in Metropolitan Lima. In this regard, such conclusion was based on the fact that the economic activity carried out through the digital platform Uber is not a cab company. Therefore, it is not up to Uber B.V. to prove the possession of the enabling title that entitles it to provide the cab service. The Court confirmed that the drivers themselves are governed by the provisions of the Urban Transportation Management of the Metropolitan Municipality of Lima and by Ordinance 1684.

The taxi transport sector is generally an individual business in which the ownership of the vehicles is individual and the companies receive a membership fee without providing the member with any kind of service, the drivers are not affiliated to any social security system, they receive no income if they do not work, the collection is made by the driver and a part is given to the owner of the unit, the maintenance is individual and the vehicles stay overnight at the individual owner's home.

4.4. Urban Cargo Vehicles

Despite the fact that there is no information on the fleet of urban light-duty vehicles, nor on the type of ownership and age the city of Lima has been working on their regulation. In fact, in Lima Mayor's Decree No. 011 of September 5, 2019, the regulation of the circulation of cargo and/or goods transport vehicles in Metropolitan Lima was established in order to contribute to traffic order and optimize the current road infrastructure.

The nation has some control over the census of heavy-duty vehicles operating on national roads, but light-duty delivery vehicles, the last mile vehicles, are not subject to such registration and there is no inventory of this fleet.

On the other hand, the chatarrización, valid for all categories of vehicles, has only had a massive and organized operation, but unfortunately this exercise has not been replicated recently and it can be said that this programme does not exist in practice. The Table 6 shows the volumes handled on that occasion.

Table 6. Scrapping by vehicle type as of 30/11/2014

Vehicle Type	Quantity	Economic Incentives[5]		%
		PEN	USD	
Rural Van	761	3,581,000	1,253,350	29%
Minibus	1,079	7,099,500	2,484,825	57%
Bus	201	1,730,000	605,500	14%
Total	2,041	12,410,500	4,343,675	100%

Source: Protransporte's Chatarreo Programme Database

[5] USD and PEN of 2014

5. E-Mobility in Peru

Peru does not (yet) have a roadmap for the use of electric vehicles. In total only some 20 BEVs have been registered in 2019 and 22 in 2020 (AAP, 2020).

Table 7. Sales of Light and Heavy Electric and Hybrid Vehicles (2019 - Oct 2020)

	2019	2020	Total
BEV	20	22	42
PHEV	7	6	13
HEV	339	388	727
TOTAL	366	416	782

Source: Automotive Statistics (Edition- November 2020, page N° 12)

The Ministry of Energy and Mines through its Energy NAMAs, developed in July 2017 the report "Diagnostic Study, Evaluation, Analysis and Proposal to Support the NAMA for the Preparation of the Energy Sector for the Transformation towards a Clean Energy Matrix through the use of Clean Transportation in Peru". The study considers several options for the replacement of the energy matrix used predominantly in transportation (gasoline, diesel, LPG, NGV), to electric and hybrid vehicles.

On the other hand, the Management of Policies and Economic Analysis (GPAE) in its monitoring of the main events and policy discussions in the energy and mining sectors, generated 2018 the Report "Electric vehicles in Peru: A look from the specialized literature and international experience". In the report, a Sectoral Economic Analysis Report is conducted on the industries regulated and supervised by Osinergmin (natural gas, liquid hydrocarbons, electricity and mining).

The Inter-American Development Bank provided technical assistance to the General Directorate of Energy Efficiency (DGEE) of the Ministry of Energy and Mines of Peru (MINEM) in June 2019 with the report "Analysis and design of business models and financing mechanisms for electric buses in Lima". This report, aims to evaluate the economic feasibility of the use of 12-meter electric buses, related to the remuneration mechanism of urban transportation systems and establish business models and financing mechanisms for the massification of the technology in the city of Lima, Peru.

Finally, Osinergmin's Management of Policies and Economic Analysis (GPAE) in 2019 developed the book "Electromobility: Concepts, Policies and Lessons Learned for Peru" with the aim of raising awareness among policy makers about the great opportunity that electromobility represents.

Public Chargers

Through the Supreme Decree N° 022-2020-EM, The Ministry of Energy and Mines (Minem) approved, on August 22, 2020, the provisions to implement the future charging and energy supply infrastructure for electric mobility. This regulation establishes that electric vehicle charging facilities will also operate in fuels service stations. It also opens the option of allowing the private charging of vehicles for non-commercial purposes, which implies setting up charging points in homes, workplaces, multi-family buildings, commercial premises and private parking lots. The goal set by the Minem for 2030 is that 5% of all light vehicles and buses operating in the country will use electric energy, and to this end the regulation will allow charging infrastructure establishments to access the free electricity market, obtaining competitive prices for their investment (see below).

Table 8: EV target 2030 of MINEM

Year	Total vehicles	Electric vehicles	Percentage of the fleet electrified
2019	1,262,940		0.0038%
2021	1,382,919	102	0.0074%
2021	1,514,296	214	0.0141%
2022	1,658,154	450	0.0271%
2023	1,815,679	946	0.0521%
2024	1,988,168	1,988	0.1000%
2025	2,177,043	4,179	0.1920%
2026	2,383,862	8,782	0.3684%
2027	2,610,328	18,458	0.7071%
2028	2,858,309	38,793	1.3572%
2029	3,129,847	81,533	2.6050%
2030	3,427,182	171,359	5.0000%

Source: Detailed design of the Clean Transportation NAMA, its respective Monitoring, Reporting and Verification System (MRV), training for its validation, operation and preparation of documentation to register the NAMA with MINAM and UNFCCC.

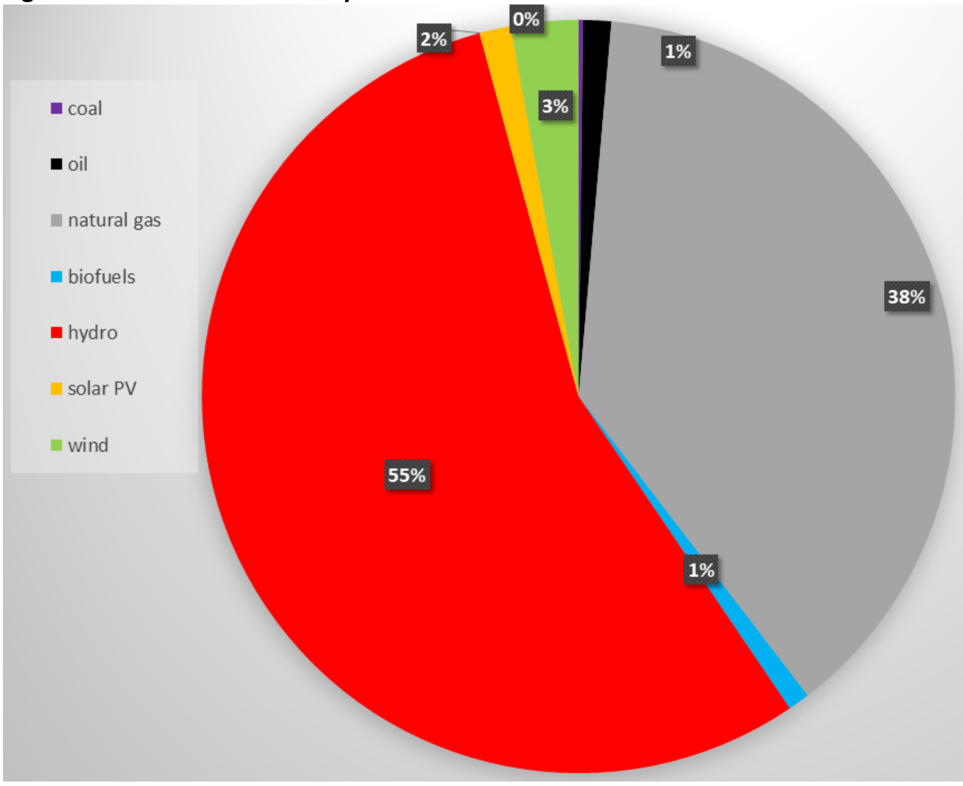
The regulation specifies that the price of the electric vehicle charging service must be established under competitive conditions. However, if Osinergmin observes that it lends itself to distortions, it may modify it, after a study developed by this agency and approved by the Minem, in order to guarantee that the service is provided in an efficient manner and ensures an equitable commercial character between the service provider and the users.

6. Energy Sector

6.1. Electricity Generation

In 2019 60% of electricity, of a total generation of 54,000 GWh, was generated by renewables (see figure below).

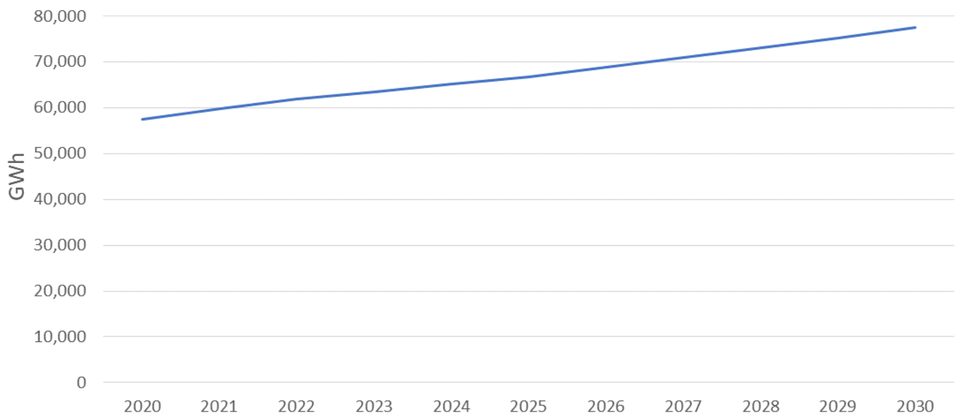
Figure 11: Power Generation by Source 2019



Source: IEA database

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 (The documents consulted on this topic mention some areas of the country, which are not exhaustive inventories, with 6.8 to 8.5 kWh/m^2). The average growth rate of energy consumption is 3% per year, see Figure 12.

Figure 12: Projected Electricity Consumption Peru (GWh)



Source: MINEM, Plan energetico nacional 2014-2025; used for data until 2025; same growth rate assumed by author from 2026 to 2030

6.2. Grid Factor

The carbon emission factor of the grid is calculated based on national data. The latest available grid factor is used. The actual grid factor is taken and not the grid factor used by UNFCCC methodologies based primarily on the Combined Margin (CM). The UNFCCC approach using the CM is not applied as former was designed primarily for renewable energy projects trying to capture what type of electricity would be displaced from more GHG intensive means[6]. It is a tool designed for energy supply and not energy demand projects. The CM does not reflect actual GHG emissions of the electric grid and in some cases can be far off actual emissions due (i) non-inclusion of low-cost/must-run (LCMR) and (ii) the non-inclusion of CDM projects in the CM. Especially the exclusion of LCMR resources result in misleading results.

Following values are used for the grid factor of Peru (all year 2018, IEA database):

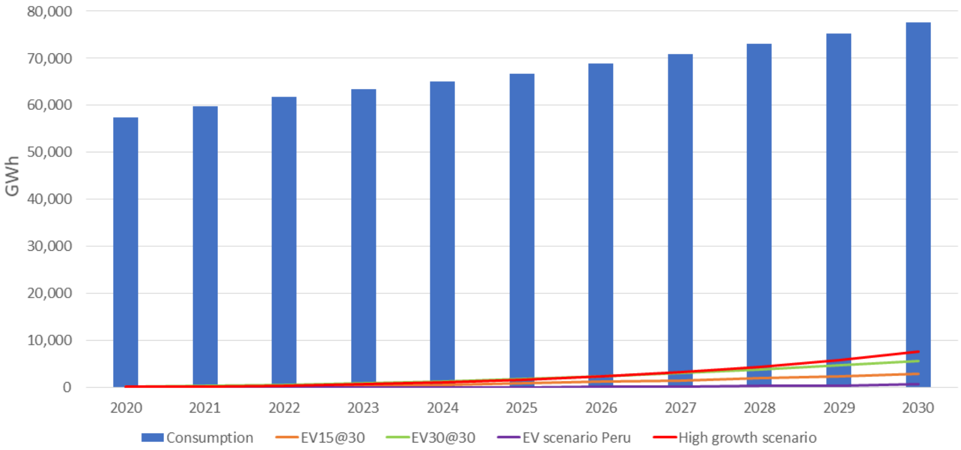
- Total electricity generation: 54,955 GWh
- Electricity losses: 5,966 GWh
- GHG emissions from electricity generation: 10,935,300 tCO_{2e}

The carbon factor of the electricity grid of Peru is therefore: **0.223 $kgCO_2$/kWh**[7].

6.3. Electricity Sector and EVs

The following figure shows the projected electricity demand from EVs based on the four scenarios (see following chapter) and the projected electricity consumption of Peru.

Figure 13: EV Electricity Demand versus Projected Electricity Consumption Peru 2020-2030



Source: Grutter Consulting based on EV scenarios and consumption in former figure

The 2030 electricity demand of EVs represents for the Peruvian EV target scenario 1% of the 2030 projected total consumption, for the EV15@30 4%, for the EV30@30 7%, and for the high growth scenario 10%. The demand increase is very gradual and thus leaves enough time to the country to plan a small production expansion required.

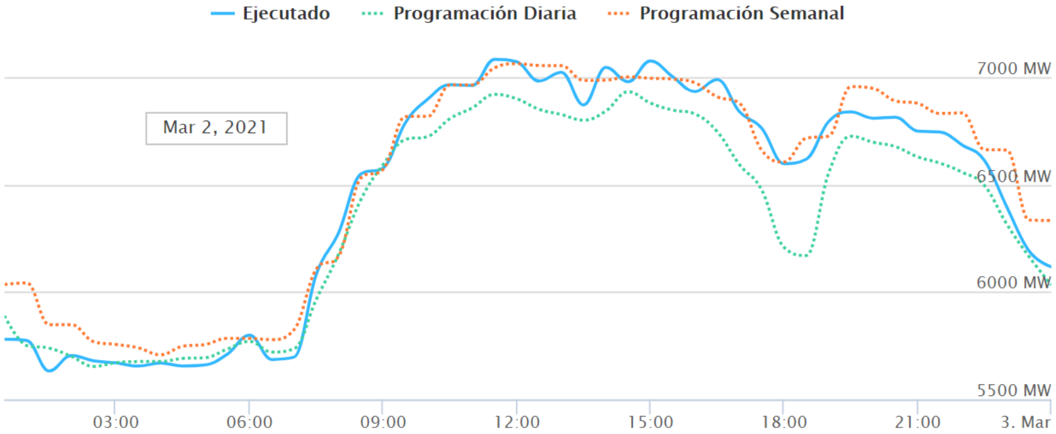
[6] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v6.pdf

[7] GHG emissions / net production

Running 100% EVs not only stresses the grid in terms of electricity production but also in terms of power demand. EV charging can have a sizeable impact on the loads applied to the grid at certain times and locations. The rise in the number of EVs can be accommodated fairly easily by power generation facilities as long as the vehicles are charged off peak. Faster charging during peak demand, however, can have a significant impact[8]. The extent on which EVs will impact the electricity networks will depend highly on technologies and charging modes used with the bulk of charging expected to occur in low-voltage distribution grids in residential or commercial areas (IEA, 2017). The management of the grid is considered critical rather than absolute capacities. Problems which can occur are increased peak loads and charging hotspots resulting in local network overloading. EV charging can have a sizeable impact on the loads applied to the grid at certain times and locations.

The following figure shows a typical demand curve in Peru.

Figure 14: Demand Curve, March 2 2021[9]



Source: https://www.coes.org.pe/Portal/portalinformacion/demanda?indicador=maxim

The curve looks quite "flat" from 10:00 to 17:00, consumption around 7,000 MW, declines at 18:00, 6,600 MW, rises at 19:00 to 6,800 MW and starts to decline again until 7:00 when it rises steeply until 10:00 going from 5,700 MW to 7,000 MW to close the cycle.

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. Intermediate fast charge buses charge 1-2 times per day, although it is difficult to match charging schedules to off-peak transport demand, and opportunity charge buses can easily be equipped with battery packs large enough to run for demand-adjusted periods of time with an effort to schedule the rotation of charging shifts so as not to disrupt service.

The first fast charging of the taxi could basically also take place outside the peak-hour, however, a second fast charging will necessarily have to take place during the peak hour at a full price, the sum of the recharging costs is favourable for the transporter. Passenger cars and LCVs are basically charged overnight which minimises the need for incremental electricity generation capacity and investment in distribution infrastructure upgrades. Plugging EVs to the grid too early i.e. before 10PM may however result in this additional demand coinciding with the evening peak electricity demand resulting in a

[8] Peak demand from a single EV using a top-of-the-range fast charger can be 80 times higher than the expected peak demand of a single typical household. See (McKinsey, 2018)

[9] The general profile of this curve is similar for other days in 2019 and 2020, as are the relative levels of consumption. No average curve has been found for the purpose of this work.

higher risk of overloading of the power distribution network ultimately requiring additional generation capacity and network upgrades. Especially LCVs and passenger cars, but also taxis could be prone to be charged too early as people return home and plug-in their vehicle. This will require smart management involving e.g. controlled charging and using Demand Side Management (DSM) instruments.

No special electricity price for EVs or for charging stations has yet been fixed. The table below shows average tariffs for residential and medium voltage industrial customers (relevant for bus operators) in Lima.

Table 9: Electricity Tariffs Lima January 2021

Sector	Tariff
Residential with consumption >100kWh/m	56 S/kWh (0.15 USD/kWh)
Industrial medium voltage MT2	Peak consumption: 32 S/kWh (0.09 USD/kWh) Off/peak consumption: 27 S/kWh (0.07 USD/kWh) Demand charge peak: 78 S/kW (21 USD/kW) Demand charge off-peak: 48 S/kW (13 USD/kW)

Peak hours are 18-23 Monday to Saturday
Source: Enel

6.4. Grid Assessment in Respect of Connecting Chargers of Commercial EVs

This section relates to the connection of charging sites for commercial electric vehicles[10] (EV) to the public electricity grid in urban areas of Peru, with the focus on the metropolitan area of Lima. In contrast to private EV, these EV will operate rather continuously during day-time and will be usually charged at sites with many chargers (e.g. depots) and/or by fast chargers with large power ratings. Consequently, the charging sites will require power connections in the range of typically 500kW to 5MW. This power range is usually connected directly or indirectly (via a dedicated transformer) to medium voltage (MV) networks. For that reason, this section's focus is on connecting to MV networks.

Electricity Network in Peru

The medium voltage (MV) networks in Lima are operated at a Voltage level of 10 kV. In older areas and areas with high load density (60% of the MV networks) the MV networks consist of underground cables. Overhead lines are typically used in peripheral and industrial areas (40% of the MV networks).

The MV lines and cables use a large variety of conductors resulting in a wide range of nominal capacities of the MV feeders. The underground MV feeders could typically accommodate a total load of up to approximately 5 MW[11], while the overhead lines can accommodate up to approximately 8 MW. Although the feeders with the highest capacity ratings may technically be able to facilitate charging sites in the 500 kW – 5 MW range, many feeders applied in Lima are a lot smaller and would only be able to facilitate charging sites at the lower end of the 500 kW – 5 MW range. It is further reported that the currently available capacity on existing MV feeder varies and that load on the MV networks is still increasing. In some areas MV feeders are fully loaded.

Typically, the network operator does not connect loads of more than about 500 kW[12] to the 10 kV network in Lima. For the charging sites considered in this section, this means that the MV network

[10] Commercial vehicles include urban buses, minibuses, taxis, light and medium trucks and public fleet etc.
[11] The MV feeders have a capacity of 3 MVA to more than 7MVA. Assuming that the feeders are operated up to 80% with a power factor of 0.9, the load per feeder should be in the range of 2-5 MW.
[12] The technical limit is 630 kVA. Taking into account a power factor this translates in loads of 500 to 600 kW.

would only facilitate the smallest sites. Larger sites may need to be connected directly to a 60 kV substation (see below).

The MV networks are usually powered from a substation in which High Voltage (HV, 60 kV) is transformed to MV (10 kV). The MV side of these substations typically connects several MV feeders. The MV network consists of both radial system and meshed systems. In meshed systems, feeders starting from one HV substations can be connected via switching actions to other feeders powered from the same or other HV substations. This has the advantage that in case of a power outage due to a fault in a feeder line or cable or a substation, the power supply can be restored via another route. In Lima, these are usually manual switching actions while in exceptional cased the operation is automated. Consequently, after a fault in a MV feeder of a meshed system or an HV/MV substation, the supply to all customers could be restored within typically a few hours. Supply restorations on radial system will take typically longer since the MV feeder needs to be repaired first.

On average, a customer in Lima was in 2016 without power 5.4 times per year (=SAIFI) and the average duration of an outage was 3 hour and 16 minutes (=CAIDI)[13]. It is reported that by 2020, these figures have been slightly improved. The technical standard for quality of electrical services[14] includes targets for the network quality: Customers at MV networks may expect 4 interruptions per semester (SAIFI = 8 interruptions per year) and a total of 7 hours without power per semester (SAIDI -14 hours/year).

In addition to these reliability targets, the technical standard for quality of electrical services also defines a target voltage quality, including limits for voltage level, harmonic distortion, and voltage dips in MV networks. The limits are in line with internationally applied standards (e.g. IEC) and should be sufficient to connect charging equipment without problems. The technical standard adds requirements on monitoring and reporting on these aspects of voltage quality, which are also in line with international standards (e.g. IEC-61000-4-30). In practice, only the voltage level in both MV and LV is monitored and reported[15]: approximately 10% of the measurements are outside the target range. It is further reported that in some areas and at certain load levels, also other voltage quality issues may appear.

In addition, the technical standard describes an extensive mechanism that provides the network operator with financial incentives to improve the both the reliability figures mentioned above and the voltage quality.

Connecting to the Electricity Network

The maximum load that can be connected to 10 kV networks in Lima is about 500 kW[16], which is at the lowest end of the 500 kW to 5 MW range that is assumed for charging sites for commercial EV. If the load of a charging site is higher, it will likely need to be connected to a 60 kV substation. There are tens of 60 kV substations in Lima which are typically 2 to 5 km apart[17]. Consequently, new MV feeders of up to 3 km are required to connect the charging sites larger than 500 kW. This is of course subject to available capacity in these 60 kV substation and the possibility to find direct cables routes.

[13] Source: OSINERGMIN. CAIDI is calculated by dividing SAIDI (17:42 hours/year) by SAIFI (5.4 times/year). The values indicated correspond to distribution systems that include MV/LV networks.
[14] La Norma Técnica de Calidad de los Servicios Eléctricos (NTCSE), Decreto Supremo Nº 020-97-EM (Actualizado al 13 de Setiembre de 2010 DS 020-1997- EM – Urbana), chapter 6 (responsibility of Osinergmin, an independent agency of the Ministry of Energy and Mines, which has supervisory and sanctioning powers to enforce compliance with the Technical Standard for the Quality of Services)
[15] Some power distribution companies also monitor other parameters, but they are not public.
[16] The technical limit is 630 kVA. Taking into account a power factor this translates in loads of 500 to 600 kW.
[17] Source: https://gisem.osinergmin.gob.pe/

Consequently, connecting charging sites may require quite some network reinforcements which take time for route finding, permitting and construction.

Summary and Conclusion

In summary, 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.

In general terms, for the purposes of e-motion, natural gas competes with some advantage since about 40% of the electricity produced in the country is generated by thermoelectric plants powered by this fuel, which means that the price of electricity to the consumer already includes the price of the fuel, its transformation and distribution. Peru has proven gas reserves for the next 20 years and continues to explore.

Natural gas is extracted directly from nature and, without undergoing any chemical transformation, reaches its point of consumption. It is cleaner than coal and oil, although, like oil, its chemical composition varies depending on where it is found. Natural gas generates minimal amounts of sulphur, mercury and other particulates, which is why it is considered the fossil fuel with the lowest environmental impact. Despite of these, natural gas is not ecologically perfect, because it has a much greater impact than carbon dioxide as a greenhouse gas, as each molecule radiates 21 times more than a molecule of carbon dioxide.

It is important to mention that most of the country is covered by a network of gas pipelines, with some exceptions such as Arequipa, Ayacucho and Cusco, cities where electromobility should be considered as a priority.

7. Emissions in the Transport Sector

7.1. Introduction

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. Real-time information on air quality is provided by the Ministry of Environment[18]. PM10 measurements in Lima show that the maximum value of 50 µg/m^3 is surpassed at most stations in most months. The same holds true for $PM_{2.5}$. NOx maximum threshold levels (100 µg/m^3 annual average) are in general not reached[19].

7.2. Road Transport Emissions

The following table shows registered vehicles of Peru in 2019.

Table 10: Vehicles Registered Peru 2019

Vehicle category	gasoline	diesel	CNG	total
Passenger car	1,354,816	348,987	230,000	1,933,803
Taxi	134,000		66,000	200,000
3-wheeler	1,082,741			1,082,741
Motorcycle	2,577,477			2,577,477
small bus		463,876		463,876
standard urban bus		12,800	3,200	16,000
coach		78,617		78,617
LCV		63,497		63,497
Truck < 7.5t		38,720		38,720
Truck 7.5-16t		38,720		38,720
Truck 16-32t		119,091		119,091
Truck >32t		62,315		62,315

Source: Superintendencia Nacional de los Registros Públicos; Passenger cars incl. station wagons and camionetas; CNG car numbers based on conversion numbers; no official taxi numbers as very large number of informal taxis: estimate of taxi number from : https://larepublica.pe/economia/2019/06/22/hay-mas-de-68-mil-taxis-informales-solo-en-lima/ (includes informal taxis); assumed that the share of taxis converted is 50% higher than average as lower operating cost; small bus incl. camioneta rural which is classified in public transport. Urban buses based on 2x bus number of Lima: fuel distribution based on Lima for 50% and rest of country for other 50%; coach buses based on rest of country fuel distribution; motorcycles and 3-wheelers based on Superintendencia Nacional de los Registros Públicos (SUNARP) for 2011 to 2018 and AAP sales 2019 based on registry cumulative since 2011

The number of taxis includes official and non-official units. Urban buses are basically standard 12m units. However, a very large share of minibuses operate in the country.

For 2019 emissions the average emission factor used for modelling purposes is Euro 2/II and for 2030 Euro 4/IV. The following table summarizes core assumptions on mileage and fuel consumption used for calculations[20].

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[18] Conoce la calidad del aire en tiempo real a través de Infoaire Perú | Ministerio del Ambiente (minam.gob.pe)
[19] INEI, 2019, Peru Anuario de Estadisticas Ambientales 2019
[20] Fuel consumption is the base for calculation of GHG emissions using for tank-to-wheel (TTW) calculations the fuel consumed, Net Calorific Value and the CO_2 Emissions factor and for well-to-wheel (WTW) calculations an upstream mark-up for fuel extraction, refinery and transport plus the GHG emissions caused by Black Carbon.

Table 11: Main Parameters Used for Emission Calculations 2019

Vehicle category	Fuel	Fuel consumption in g/km	Annual distance driven in km
Passenger Car	gasoline	66	11,500
	diesel	55	11,500
	CNG	63	15,000
Taxi	gasoline	66	50,000
	CNG	63	53,000
3-wheeler	gasoline	24	15,000
Motorcycle	gasoline	36	5,000
Small bus	diesel	152	44,000
Urban standard bus	diesel	405	60,000
	CNG	515	63,000
Coach bus	diesel	247	50,000
LCV	diesel	80	20,000
Truck < 7.5t	diesel	101	20,000
Truck 7.5-16t	diesel	155	30,000
Truck 16-32t	diesel	210	30,000
Truck >32t	diesel	251	30,000

Source: Passenger car size: small gasoline and large/SUV diesel; Fuel consumption values from (EEA, 2020) Tier 2 approach for vehicles > Euro 1/I; mileage calibrated with fuel consumption in Peru

The following table shows estimated 2019 road transport emissions for Peru. The model has been calibrated with actual gasoline consumed by Peru in 2019 with a difference between top-down actual and the modelled bottom-up consumption of 0.1-0.4%..

Table 12: Estimated 2018 Road 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	7,040	258	4,512,437	5,697,447	65,478
Taxi	1,904	19	2,018,848	2,541,053	30,167
3-wheeler	0	0	1,219,228	1,450,881	17,593
Motorcycles	4,085	45	1,424,309	1,705,077	20,553
small bus	18,451	3,327	9,879,983	14,098,626	133,333
urban bus	10,234	171	1,302,915	1,752,713	18,362
coach	35,181	649	3,093,642	4,184,605	41,750
LCV	189	149	323,713	505,146	4,369
Truck < 7.5t	2,703	47	249,211	334,164	3,363
Truck 7.5-16t	6,389	121	573,680	776,297	7,742
Truck 16-32t	28,260	554	2,390,596	3,264,390	32,262
Truck >32t	17,498	363	1,495,114	2,051,154	20,177
Total	**131,934**	**5,701**	**28,483,676**	**38,361,554**	**395,149**

Source: Grutter Consulting; for details of modelling data see Annex 1

Road transport GHG emissions of Peru TTW in 2019 were 28.5 million tCO_{2e}. WTW GHG emissions of 38 million tCO_{2e} reflect the GHG emissions caused directly and indirectly by the road transportation sector of Peru. 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 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 TTW GHG emissions would be 26.9 $MtCO_{2e}$ instead of 28.5 $MtCO_{2e}$.

7.3. Projected 2030 Transport Emissions

For 2030 projections an elasticity or growth factor per vehicle category was determined. The GDP growth rate 2020-2030 is based on IMF/WB projections and results in 2.8% average annual growth[21].

Table 13: Parameters for Projection of Vehicle Numbers and Emissions

Parameter	Value	Source/Explanation
CAGR population growth 2019-2030	0.9%	INEI
CAGR GDP real growth 2019-2030	2.8%	IMF/WB
CAGR GDP per capita growth 2019-2030	1.9%	Calculated from GDP and population growth rate
CAGR freight transport growth rate	2.7%	Freight intensity of 0.98[22] based on income per capita 2030 (PPP) of 8,600 USD using 2019 data from the World Bank and the real GDP growth rate
CAGR passenger transport except buses	4.7%	Based on Gomperz function with α of -5.3 and β of -0.00012 with a saturation level of 590 vehicles per 1,000 population[23];
CAGR bus passenger growth	0.9%	In line with population growth; trip number increse compensated with mode share decrease

Vehicle growth rates per vehicle category are used to model vehicle numbers for 2030. The average emission level assumed for 2030 is Euro 4/IV. The mileage of vehicles is kept constant. The following table shows projected 2030 road transport emissions of Peru.

Table 14: Estimated 2030 Road 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; for details of modelling data see Annex 1

TTW emission from the transport sector are expected to grow under a BAU scenario by around 32% reaching 38 million tCO_2 by 2030 (47 million tCO_{2e} with a WTW approach) – considering a constant share of biofuels the TTW emissions would be 35.5 $MtCO_{2e}$ by 2030.

[21] World Economic Outlook (October 2020) - Real GDP growth (imf.org)

[22] Freight intensity rates based on groupings realized by (OECD, 2017), table 2-4

[23] Saturation level based on Japanese pattern (Tian, 2014); parameters calculated by Grutter Consulting

8. EV Scenarios

4 different EV scenarios have been constructed which are contrasted with the BAU 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-motion program 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 number of vehicles to be newly registered per annum is the sum of additional vehicles (due to vehicle growth) and replacement vehicles. The following table shows the average lifespan of vehicles and the average annual replacement rate of the fleet as used for projections.

Table 15: Average Lifespan and Replacement Rate per Vehicle Category Peru

Vehicle category	lifespan in years	% replaced per annum
Passenger car	20	5%
Taxi	10	10%
Motorcycles	8	13%
3-wheeler	8	13%
small bus	25	4%
standard urban bus	20	5%
Coach	15	7%
LCV	14	7%
Truck < 7.5t	20	5%
Truck 7.5-16t	20	5%
Truck 16-32t	20	5%
Truck >32t	20	5%

Source: Grutter Consulting based on average ages per vehicle category based on Superintendencia Nacional de los Registros Públicos

EV 15@30 and 30@30 Scenarios

The following table shows the modelled share of EVs as total of new registered vehicles from 2019 to 2030.

Table 16: EV Rates of Newly registered Vehicles

Scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
EV15@30	3%	3%	4%	5%	7%	9%	10%	11%	12%	14%	15%
EV30@30	5%	6%	8%	11%	14%	18%	20%	22%	24%	27%	30%

Source: Grutter Consulting based on IEA scenarios

Scenario Peru

The targets are derived from MINEM. For passenger cars and buses the target is 5% of the vehicle stock in 2030. For all other vehicle categories no explicit targets are formulated. Targets were re-formulated based on vehicle groups and to determine EV replacement rates.

Table 17: EV Rates of Newly Registered Vehicles EV Scenario Peru

Category	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Passenger cars	0%	0%	0%	0%	0%	1%	2%	4%	8%	14%	28%
Passenger cars absolute	0	196	606	1,249	2,147	3,557	7,246	17,545	39,103	78,593	159,786
Urban buses plus coach bus	0%	1%	1%	2%	4%	6%	8%	10%	13%	17%	25%

Source: Grutter Consulting based on above cited targets

Scenarios are made for illustrative purposes to assess their impact on the EV stock, the electricity sector and the environmental impact. The table below shows an illustrative calculation of the electric passenger cars under the EV scenario Peru reaching the target of 5% electric cars as percentage of car stock in 2030.

Table 18: EV Car Scenario Peru

Passenger cars Peru scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all cars	2,024,139	2,118,696	2,217,670	2,321,267	2,429,703	2,543,206	2,662,010	2,786,364	2,916,528	3,052,772	3,195,380
Replacement cars	96,690	101,207	105,935	110,883	116,063	121,485	127,160	133,101	139,318	145,826	152,639
Additional new cars	90,336	94,557	98,974	103,597	108,437	113,502	118,804	124,354	130,163	136,244	142,608
EV car fleet new	0	196	410	643	898	1,410	3,689	10,298	21,559	39,490	81,193
EV car fleet stock	0	196	606	1,249	2,147	3,557	7,246	17,545	39,103	78,593	159,786
EV fleet as % of stock	0%	0%	0%	0%	0%	0%	0%	1%	1%	3%	5%
GHG reduction WTW in tons	0	453	1,400	2,888	4,965	8,225	16,757	40,572	90,426	181,745	369,503
Electricity demand GWh	0.0	0.4	1.3	2.6	4.4	7.4	15.0	36.3	80.9	162.7	330.8

Source: Grutter Consulting

EV High Growth Scenario

The share of newly registered EVs for the selected vehicle categories in the high growth scenario is shown below.

Table 19: Share of EVs of Newly Registered Vehicles "High Growth Scenario"

category	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Taxis	0%	1%	4%	8%	14%	22%	32%	45%	61%	79%	100%
Urban Buses	0%	5%	4%	8%	14%	22%	32%	45%	61%	79%	100%
Small buses	0%	0%	4%	8%	14%	22%	32%	45%	61%	79%	100%
LCVs	0%	0%	4%	8%	14%	22%	32%	45%	61%	79%	100%

Source: For urban buses, taxis and LCVs the target is 100% of new registered buses/taxis/LCVs in 2030 are electric; This takes into consideration that Evs in this segment should be cost-competitive by 2030. No early replacement of vehicles is made i.e. conventional vehicles could still be used till ending their lifespan. The growth curve towards 2030 is based on a power curve with the function y=0.0024*n^2.52 based on the curve of Norway for the last 10 years). Initial experiences are built and cost structures go down. Barriers are removed and financial equivalence will be achieved. The vehicle penetration rates increases then (for new vehicles)

For other vehicle categories no specific scenario is made but the highest value from the other 3 EV scenarios is taken.

Scenario Results

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 20: Scenario Results

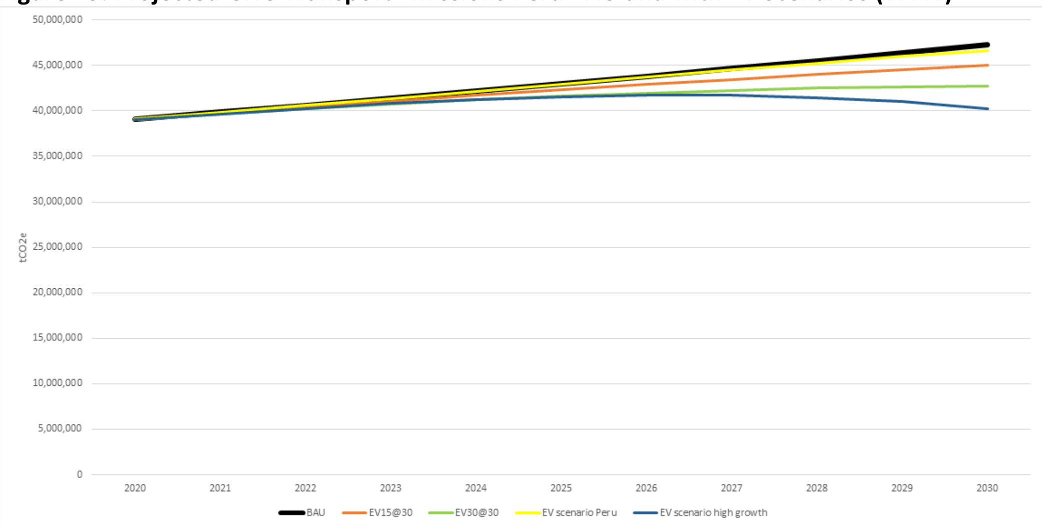
Impact	Scenario	By 2025	By 2030
GHG reduction WTW in tCO_{2e} per annum	IEA 15@30	680,000	2,270,000
	IEA30@30	1,360,000	4,540,000
	Peru scenario	50,000	650,000
	"High growth" scenario	1,450,000	7,020,000
Electricity demand of EVs in GWh per annum	IEA 15@30	860	2,830
	IEA30@30	1,730	5,660
	Peru scenario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

Source: Grutter Consulting, see Annex for further details

The growth of electricity demand is discussed in chapter 6.

The most ambitious scenario (EV potential scenario) would result in a 15% reduction of GHGs relative to the baseline. Only the "high growth" scenario result in a trend change in this period and only latter result in GHG transportation emissions in 2030 not being significantly higher than in 2019. 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 15: Projected GHG Transport Emissions Peru BAU and with EV Scenarios (WTW)



Source: Grutter Consulting

The following table shows the potential GHG reduction which is possible to achieve for the targeted vehicle sectors.

Table 21: Projected GHG reductions by vehicle type - "High growth scenario"

		2020	2022	2024	2026	2028	2030
Taxis	Stock all taxis	209,343	229,358	251,288	275,313	301,636	330,476
	Replacement taxis	20,000	21,912	24,007	26,303	28,817	31,573
	Additional new taxis	9,343	10,236	11,215	12,287	13,462	14,749
	EV taxi fleet new	0	1,229	4,880	12,483	25,765	46,322
	EV taxi fleet stock	0	1,429	8,967	29,537	73,596	155,087
	EV taxi as % of stock	0%	1%	4%	11%	24%	47%
	GHG reduction WTW in tons	0	14,372	90,153	296,975	739,953	1,559,292
	Electricity demand GWh	0	12.9	80.7	265.8	662.4	1395.8
Small bus	Stock all vehicles	467,972	476,273	484,722	493,320	502,071	510,977
	Replacement vehicles	18,555	18,884	19,219	19,560	19,907	20,260
	Additional new vehicles	4,096	4,169	4,243	4,318	4,395	4,473
	EV vehicle fleet new	0	882	3,251	7,724	14,809	24,733
	EV vehicle fleet stock	0	932	6,019	18,935	44,654	88,871
	EV fleet as % of stock	0%	0%	1%	4%	9%	17%
	GHG reduction WTW in tons	0	17,069	110,276	346,931	818,166	1,628,307
	Electricity demand GWh	0	23	148.3	466.6	1100.3	2189.8
Urban bus	Stock all vehicles	16,141	16,428	16,719	17,016	17,317	17,625
	Replacement vehicles	800	814	829	843	858	874
	Additional new vehicles	141	144	146	149	152	154
	EV vehicle fleet new	0	37	135	321	615	1,028
	EV vehicle fleet stock	0	87	298	835	1,904	3,741
	EV fleet as % of stock	0%	1%	2%	5%	11%	21%
	GHG reduction WTW in tons	0	6,567	22,592	63,278	144,295	283,578
	Electricity demand GWh	0	5.2	17.9	50.1	114.2	224.5
LCV	Stock all vehicles	65,239	68,869	72,700	76,745	81,014	85,521
	Replacement vehicles	4,536	4,788	5,054	5,335	5,632	5,946
	Additional new vehicles	1,742	1,839	1,942	2,050	2,164	2,284
	EV vehicle fleet new	0	253	969	2,389	4,751	8,230
	EV vehicle fleet stock	0	257	1,764	5,730	13,917	28,512
	EV fleet as % of stock	0%	0%	2%	7%	17%	33%
	GHG reduction WTW in tons	0	1,087	7,453	24,207	58,795	120,455
	Electricity demand GWh	0	1	7.1	22.9	55.7	114

Source: Grutter Consulting

The following table shows key figures for the potential EV scenario in terms of number of electric vehicles, the GHG impact and the vehicle investment volume.

Table 22: Key Figures Commercial Vehicles EV "Potential Scenario"

Parameter	Taxis	Small Buses	Urban Buses	LCVs	Total
EV stock 2025 (% of all vehicles)	17,000 (6%)	11,000 (2%)	500 (3%)	3,300 (4%)	**32,000**
EV Stock 2030 (% of all vehicles)	155,000 (47%)	89,000 (17%)	3,700 (21%)	29,000 (33%)	**276,000**

GHG impact 2025	171,000	205,000	39,000	14,000	**430,000**
GHG impact 2030	1,559,000	1,628,000	284,000	120,000	**3,592,000**
$PM_{2.5}$ reduction 2030 (tons)	9	156	9	23	**197**
NO_x reduction 2030 (tons)	469	19,911	1,091	474	**22,000**
Savings emission costs in 2030 (MUSD)	64	98	13	8	**182**
Savings in pollutants costs in 2030 (MUSD)	1	33	2	3	**39**
Vehicle CAPEX 2025 (cumulative)	1,050 MUSD	840 MUSD	115 MUSD	76	**2,090 MUSD**
Vehicle CAPEX 2030 (cumulative)	3,340 MUSD	5,630 MUSD	720 MUSD	600 MUSD	**10,300 MUSD**

Note: Constant real USD of 2020; vehicle values based on 2020 average values and annual reduction rate for each vehicle category based on market trends; see Annex for further details
Source: Grutter Consulting

By implementing this strategy Peru would have more than 270,000 commercial EVs by 2030 reducing 3.6 million tCO_2. Around 50% of the impact by 2030 would be with buses. The estimated cumulative vehicle investment required by 2025 is around 2 billion USD and 10 billion USD by 2030. This excludes the investment required for chargers, grid upgrades or other investments e.g. in depot facilities. More than 50% of the investment would be in buses. This is not the incremental investment for EVs relative to the BAU investment for fossil vehicles but the total required vehicle investment. Economic savings due to reduced emissions would reach by 2030 180 MUSD (annual figure) of which around 20% is due to savings on less local pollutants and the other 80% due to reduced GHG emissions.

9. Facilitators and Barriers

Facilitators

- **Lithium and uranium 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. A boom of unconventional metals is surely coming, which favors the demand for new technologies such as electromobility as it is the main component of batteries used in electric vehicles.
  In addition, there is a lithium outcrop 6 km west of the Falchani project (6th largest lithium-in-rock resource in the world), located in the Puno region. Mapping to 2019 had identified potential for this zone of lithium mineralization extending at least 1.5 km from north to south. (Osinergmin, 2019)
- **Manufacturers' interest in the market:** Through several pilot projects of companies such as Enel x, QEV Tech, Engie and BYD, where they have put electric buses and cabs into circulation, the interest of foreign companies in developing alliances and projects that promote the development of vehicles that meet social needs in Peru has been demonstrated.

Barriers

- **Political situation:** There is not currently a national policy on electric mobility.
- **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 incentives:** 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.
- **Regulatory framework to exploit lithium:** Peru does not have a regulatory framework for the exploitation and export of lithium and uranium (Osinergmin, 2019).
- **The low price of gas in relation to diesel:** and the existence of significant reserves, which can be available for more than 35 years at the current level of consumption, provides a short-term option for Peru. An exception to the impact of NGV is the cities of Arequipa, Cusco, Ayacucho, among others, which are not served by this fuel.
- **Atomized transport sector** which 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. This system of vehicle ownership makes it difficult for transporters to access credit under adequate financial conditions.

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Annex

Vehicle Data

Vehicle category	gasoline	diesel	CNG	total
Passenger car	1,354,816	348,987	230,000	1,933,803
Taxi	134,000		66,000	200,000
3-wheeler	1,082,741			1,082,741
Motorcycle	2,577,477			2,577,477
small bus		463,876		463,876
standard urban bus		12,800	3,200	16,000
coach		78,617		78,617
LCV		63,497		63,497
Truck < 7.5t		38,720		38,720
Truck 7.5-16t		38,720		38,720
Truck 16-32t		119,091		119,091
Truck >32t		62,315		62,315

Passenger cars incl. station wagons and camionetas; CNG car numbers based on conversion numbers; no official taxi numbers as very large number of informal taxis: estimate of taxi number from : https://larepublica.pe/economia/2019/06/22/hay-mas-de-68-mil-taxis-informales-solo-en-lima/ (includes informal taxis); assumed that the share of taxis converted is 50% higher than average as lower operating cost; small bus incl. camioneta rural which is classified in public transport: total buses are know. Urban buses based on 2x bus number of Lima: fuel distribution based on Lima for 50% and rest of countrz for other 50%; coach buses basd on rest of countrz fuel distribution; motorcycles and 3-wheelers based on Superintendencia Nacional de los Registros Públicos (SUNARP) for 2011 to 2018 and AAP sales 2019 based on registry cumulative since 2011

Year of data	2019
Country	Peru
GDP growth rate	2.8%
take from country values	
Carbon grid factor	0.223
take from country values	

Growth rate freight transport	2.7%		
See below			
Bus, coach, growth	1%		
based on population growth (decreasing mode share)			
Passenger car, MC, taxi growth	4.7%		
see below			

Income Group USD/Capita	**Freight Intensity**
< 5,000	1.18
5,000-25,000	**0.98**
25,000-50,000	0.87
> 50,000	0.82

Parameters Gompertz for medium income country			
α	-5.3		
β	-0.00012		
vehicl pop 2030	3195380		cars
CAGR	4.7%		
Based on OECD pattern, see source above			
GDP per capita 2019	6978		
GDP per capital 2030	8599		
[GDP per capita (current US$) - Ecuador | Data (worldbank.org)]			
Projected population 2030	35.8		
Population 2019	32.5		
CAGR	0.9%		

Emissions

All data in tons per annum

2019

Vehicle category	NO_x	$PM_{2.5}$	CO_2 TTW	CO_2 WTW	Energy in TJ
Passenger car	7,040	258	4,512,437	5,697,447	65,478
Taxi	1,904	19	2,018,848	2,541,053	30,167
3-wheeler	0	0	1,219,228	1,450,881	17,593
Motorcycles	4,085	45	1,424,309	1,705,077	20,553
small bus	18,451	3,327	9,879,983	14,098,626	133,333
standard urban bus	10,234	171	1,302,915	1,752,713	18,362
coach	35,181	649	3,093,642	4,184,605	41,750
LCV	189	149	323,713	505,146	4,369
Truck < 7.5t	2,703	47	249,211	334,164	3,363
Truck 7.5-16t	6,389	121	573,680	776,297	7,742
Truck 16-32t	28,260	554	2,390,596	3,264,390	32,262
Truck >32t	17,498	363	1,495,114	2,051,154	20,177
Total	**131,934**	**5,701**	**28,483,676**	**38,361,554**	**395,149**
With biofuel share			**26,940,322**		

2030

Vehicle category	NO_x	$PM_{2.5}$	CO_2 TTW	CO_2 WTW	Energy in MJ
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
standard 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**
With constant biofuel share			**35,471,029**		

Emission costs	2019	2030
Pollutants	570	333
GHG	1,534	1,890
Total	**2,105**	**2,223**

in MUSD of 2019

Fuel Usage	2019	2030		official	difference
				2019	
Gasoline	3,147	4,263		3,144	0.1%
Diesel	7,326	9,884		7,298	0.4%
CNG	541,548	726,943		540,296	0.2%
in million liters for diesel and gasoline and tons for CNG				Infogas for CNG	

GHG BAU	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
GHG	39,095,784	39,844,067	40,606,673	41,383,874	42,175,951	42,983,188	43,805,875	44,644,308	45,498,789	46,369,624	47,257,127

CAGR	0.019

92.2% Gasolina + 7.8% alcohol carburante, 95% Diésel + 5% biodiesel, (DS 013-2005-EM).

Biofuel share petrol	8%
biofeul share diesel	5%

EV Scenarios

Rate of EVs of newly registered vehicles

Scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
S1 EV 15@30	3%	3%	4%	5%	7%	9%	10%	11%	12%	14%	15%
S2 EV30@30	5%	6%	8%	11%	14%	18%	20%	22%	24%	27%	30%

Peru scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Passenger cars	0%	0%	0%	0%	0%	1%	2%	4%	8%	14%	28%
Passenger cars absolute	0	196	606	1,249	2,147	3,557	7,246	17,545	39,103	78,593	159,786
Urban buses plus coach bus	0%	1%	1%	2%	4%	6%	8%	10%	13%	17%	25%

Passenger cars and buses target 5% of vehicle stock in 2030 of MINEM based on 4.43 million vehicles (in 2019 only passenger cars are included but not station cars, vagonetas); modelled to achieve stock target

High Growth Scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Taxis	0%	1%	4%	8%	14%	22%	32%	45%	61%	79%	100%
Urban Buses	0%	5%	4%	8%	14%	22%	32%	45%	61%	79%	100%
Small buses	0%	0%	4%	8%	14%	22%	32%	45%	61%	79%	100%
LCVs	0%	0%	4%	8%	14%	22%	32%	45%	61%	79%	100%

This scenario is only made for the vehicle categories of the program i.e. urban buses, small buses, taxis and LCVs

For urban buses, taxis and LCVs the target is 100% of new registered buses/taxis/LCVs in 2030 are electric; This takes into consideration that Evs in this segment should be cost-competitive by 2030. No early replacement of vehicles is made i.e. conventional vehicles could still be used till ending their lifespan.

The growth curve towards 2030 is based on a power curve with the function y=0.0024*n^2.52 based on the curve of Norway for the last 10 years). Initial experiences are built and cost structures go down. Barriers are removed and financial equivalence will be achieved. The vehicle penetration rates increases then (for new vehicles)

Passenger cars S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all cars	2,024,139	2,118,696	2,217,670	2,321,267	2,429,703	2,543,206	2,662,010	2,786,364	2,916,528	3,052,772	3,195,380
Replacement cars	96,690	101,207	105,935	110,883	116,063	121,485	127,160	133,101	139,318	145,826	152,639
Additional new cars	90,336	94,557	98,974	103,597	108,437	113,502	118,804	124,354	130,163	136,244	142,608
EV car fleet new	4,716	6,355	8,563	11,538	15,546	20,948	24,331	28,261	32,826	38,128	44,287
EV car fleet stock	4,716	11,071	19,634	31,172	46,719	67,666	91,997	120,259	153,085	191,213	235,500
EV fleet as % of stock	0%	1%	1%	1%	2%	3%	3%	4%	5%	6%	7%
GHG reduction WTW in tons	10,907	25,603	45,404	72,086	108,036	156,477	212,743	278,097	354,007	442,178	544,591
Electricity demand GWh	9.8	22.9	40.6	64.5	96.7	140.1	190.4	248.9	316.9	395.8	487.5

Passenger cars S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all cars	2,024,139	2,118,696	2,217,670	2,321,267	2,429,703	2,543,206	2,662,010	2,786,364	2,916,528	3,052,772	3,195,380
Replacement cars	96,690	101,207	105,935	110,883	116,063	121,485	127,160	133,101	139,318	145,826	152,639
Additional new cars	90,336	94,557	98,974	103,597	108,437	113,502	118,804	124,354	130,163	136,244	142,608
EV car fleet new	9,433	12,710	17,126	23,076	31,093	41,895	48,662	56,522	65,652	76,257	88,574
EV car fleet stock	9,433	22,143	39,269	62,345	93,437	135,332	183,995	240,517	306,169	382,426	471,000
EV fleet as % of stock	0%	1%	2%	3%	4%	5%	7%	9%	10%	13%	15%
GHG reduction WTW in tons	21,813	51,205	90,809	144,171	216,073	312,955	425,486	556,193	708,013	884,356	1,089,183
Electricity demand GWh	19.5	45.8	81.3	129.1	193.4	280.1	380.9	497.9	633.8	791.6	975.0

Passenger cars Peru scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all cars	2,024,139	2,118,696	2,217,670	2,321,267	2,429,703	2,543,206	2,662,010	2,786,364	2,916,528	3,052,772	3,195,380
Replacement cars	96,690	101,207	105,935	110,883	116,063	121,485	127,160	133,101	139,318	145,826	152,639
Additional new cars	90,336	94,557	98,974	103,597	108,437	113,502	118,804	124,354	130,163	136,244	142,608
EV car fleet new	0	196	410	643	898	1,410	3,689	10,298	21,559	39,490	81,193
EV car fleet stock	0	196	606	1,249	2,147	3,557	7,246	17,545	39,103	78,593	159,786
EV fleet as % of stock	0%	0%	0%	0%	0%	0%	0%	1%	1%	3%	5%
GHG reduction WTW in tons	0	453	1,400	2,888	4,965	8,225	16,757	40,572	90,426	181,745	369,503
Electricity demand GWh	0.0	0.4	1.3	2.6	4.4	7.4	15.0	36.3	80.9	162.7	330.8

Taxis S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all taxis	209,343	219,122	229,358	240,073	251,288	263,026	275,313	288,175	301,636	315,727	330,476
Replacement taxis	20,000	20,934	21,912	22,936	24,007	25,129	26,303	27,531	28,817	30,164	31,573
Additional new taxis	9,343	9,779	10,236	10,714	11,215	11,739	12,287	12,861	13,462	14,091	14,749
EV taxi fleet new	740	997	1,343	1,810	2,439	3,286	3,817	4,434	5,150	5,982	6,948
EV taxi fleet stock	740	1,737	3,080	4,891	7,330	10,616	14,434	18,868	24,018	30,000	36,948
EV taxi as % of stock	0%	1%	1%	2%	3%	4%	5%	7%	8%	10%	11%
GHG reduction WTW in tons	7,440	17,465	30,972	49,172	73,696	106,739	145,120	189,700	241,481	301,626	371,486
Electricity demand GWh	6.7	15.6	27.7	44.0	66.0	95.5	129.9	169.8	216.2	270.0	332.5

Taxis S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all taxis	209,343	219,122	229,358	240,073	251,288	263,026	275,313	288,175	301,636	315,727	330,476
Replacement taxis	20,000	20,934	21,912	22,936	24,007	25,129	26,303	27,531	28,817	30,164	31,573
Additional new taxis	9,343	9,779	10,236	10,714	11,215	11,739	12,287	12,861	13,462	14,091	14,749
EV taxi fleet new	1,480	1,994	2,687	3,620	4,878	6,573	7,635	8,868	10,300	11,964	13,897
EV taxi fleet stock	1,480	3,474	6,161	9,781	14,660	21,233	28,867	37,735	48,035	59,999	73,896
EV taxi as % of stock	1%	2%	3%	4%	6%	8%	10%	13%	16%	19%	22%
GHG reduction WTW in tons	14,880	34,929	61,944	98,344	147,391	213,478	290,239	379,400	482,962	603,252	742,972
Electricity demand GWh	13.3	31.3	55.4	88.0	131.9	191.1	259.8	339.6	432.3	540.0	665.1

Taxis High Potential	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all taxis	209,343	219,122	229,358	240,073	251,288	263,026	275,313	288,175	301,636	315,727	330,476
Replacement taxis	20,000	20,934	21,912	22,936	24,007	25,129	26,303	27,531	28,817	30,164	31,573
Additional new taxis	9,343	9,779	10,236	10,714	11,215	11,739	12,287	12,861	13,462	14,091	14,749
EV taxi fleet new	0	200	1,229	2,657	4,880	8,087	12,483	18,294	25,765	35,170	46,322
EV taxi fleet stock	0	200	1,429	4,086	8,967	17,054	29,537	47,831	73,596	108,765	155,087
EV taxi as % of stock	0%	0%	1%	2%	4%	6%	11%	17%	24%	34%	47%
GHG reduction WTW in tons	0	2,011	14,372	41,086	90,153	171,463	296,975	480,904	739,953	1,093,559	1,559,292
Electricity demand GWh	0.0	1.8	12.9	36.8	80.7	153.5	265.8	430.5	662.4	978.9	1395.8

3-wheelers S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all cars	1,133,321	1,186,263	1,241,679	1,299,683	1,360,397	1,423,947	1,490,466	1,560,092	1,632,971	1,709,254	1,789,101
Replacement cars	135,343	141,665	148,283	155,210	162,460	170,050	177,993	186,308	195,012	204,121	213,657
Additional new cars	50,580	52,942	55,416	58,004	60,714	63,550	66,519	69,626	72,879	76,283	79,847
EV car fleet new	4,689	6,318	8,512	11,470	15,455	20,824	24,187	28,094	32,632	37,903	44,026
EV car fleet stock	4,689	11,006	19,518	30,988	46,443	67,267	91,454	119,548	152,181	190,084	234,109
EV fleet as % of stock	0%	1%	2%	2%	3%	5%	6%	8%	9%	11%	13%
GHG reduction WTW in tons	5,027	11,800	20,927	33,224	49,793	72,120	98,052	128,173	163,160	203,797	250,999
Electricity demand GWh	5.6	13.2	23.4	37.2	55.7	80.7	109.7	143.5	182.6	228.1	280.9

3-wheelers S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all cars	1,133,321	1,186,263	1,241,679	1,299,683	1,360,397	1,423,947	1,490,466	1,560,092	1,632,971	1,709,254	1,789,101
Replacement cars	135,343	141,665	148,283	155,210	162,460	170,050	177,993	186,308	195,012	204,121	213,657
Additional new cars	50,580	52,942	55,416	58,004	60,714	63,550	66,519	69,626	72,879	76,283	79,847
EV car fleet new	9,377	12,635	17,025	22,939	30,909	41,648	48,375	56,189	65,265	75,806	88,051
EV car fleet stock	9,377	22,012	39,037	61,976	92,886	134,533	182,908	239,097	304,361	380,168	468,219
EV fleet as % of stock	1%	2%	3%	5%	7%	9%	12%	15%	19%	22%	26%
GHG reduction WTW in tons	10,054	23,600	41,853	66,448	99,587	144,239	196,104	256,346	326,319	407,595	501,998
Electricity demand GWh	11.3	26.4	46.8	74.4	111.5	161.4	219.5	286.9	365.2	456.2	561.9

Motorcycle S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all MC	2,697,882	2,823,912	2,955,830	3,093,910	3,238,440	3,389,722	3,548,071	3,713,817	3,887,306	4,068,899	4,258,975
Replacement MC	322,185	337,235	352,989	369,479	386,739	404,805	423,715	443,509	464,227	485,913	508,612
Additional new MC	120,405	126,030	131,917	138,080	144,530	151,282	158,349	165,746	173,489	181,593	190,076
EV MC fleet new	11,161	15,039	20,264	27,304	36,790	49,571	57,578	66,879	77,681	90,229	104,803
EV MC fleet stock	11,161	26,200	46,464	73,768	110,558	160,129	217,707	284,586	362,268	452,497	557,300
EV fleet as % of stock	0%	1%	2%	2%	3%	5%	6%	8%	9%	11%	13%
GHG reduction WTW in tons	7,072	16,601	29,441	46,741	70,052	101,462	137,945	180,322	229,543	286,714	353,120
Electricity demand GWh	1.4	3.3	5.8	9.2	13.8	20.0	27.2	35.6	45.3	56.6	69.7

Motorcycle S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all MC	2,697,882	2,823,912	2,955,830	3,093,910	3,238,440	3,389,722	3,548,071	3,713,817	3,887,306	4,068,899	4,258,975
Replacement MC	322,185	337,235	352,989	369,479	386,739	404,805	423,715	443,509	464,227	485,913	508,612
Additional new MC	120,405	126,030	131,917	138,080	144,530	151,282	158,349	165,746	173,489	181,593	190,076
EV MC fleet new	22,322	30,078	40,528	54,608	73,580	99,143	115,157	133,758	155,363	180,458	209,607
EV MC fleet stock	22,322	52,400	92,928	147,535	221,115	320,258	435,415	569,173	724,536	904,994	1,114,600
EV fleet as % of stock	1%	2%	3%	5%	7%	9%	12%	15%	19%	22%	26%
GHG reduction WTW in tons	14,144	33,202	58,882	93,482	140,104	202,924	275,891	360,643	459,085	573,428	706,241
Electricity demand GWh	2.8	6.6	11.6	18.4	27.6	40.0	54.4	71.1	90.6	113.1	139.3

Small Bus S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	467,972	472,105	476,273	480,479	484,722	489,002	493,320	497,676	502,071	506,505	510,977
Replacement vehicles	18,555	18,719	18,884	19,051	19,219	19,389	19,560	19,733	19,907	20,083	20,260
Additional new vehicles	4,096	4,132	4,169	4,206	4,243	4,280	4,318	4,356	4,395	4,433	4,473
EV vehicle fleet new	571	742	963	1,251	1,625	2,110	2,362	2,644	2,960	3,314	3,710
EV vehicle fleet stock	571	1,313	2,276	3,527	5,152	7,262	9,624	12,268	15,229	18,543	22,253
EV fleet as % of stock	0%	0%	0%	1%	1%	1%	2%	2%	3%	4%	4%
GHG reduction WTW in tons	10,466	24,058	41,709	64,631	94,400	133,059	176,337	224,786	279,024	339,743	407,717
Electricity demand GWh	14.1	32.4	56.1	86.9	127.0	178.9	237.1	302.3	375.2	456.9	548.3

Small Bus S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	467,972	472,105	476,273	480,479	484,722	489,002	493,320	497,676	502,071	506,505	510,977
Replacement vehicles	18,555	18,719	18,884	19,051	19,219	19,389	19,560	19,733	19,907	20,083	20,260
Additional new vehicles	4,096	4,132	4,169	4,206	4,243	4,280	4,318	4,356	4,395	4,433	4,473
EV vehicle fleet new	1,142	1,484	1,927	2,502	3,249	4,220	4,724	5,289	5,920	6,628	7,420
EV vehicle fleet stock	1,142	2,626	4,553	7,055	10,304	14,524	19,248	24,537	30,457	37,085	44,505
EV fleet as % of stock	0%	1%	1%	1%	2%	3%	4%	5%	6%	7%	9%
GHG reduction WTW in tons	20,932	48,115	83,417	129,262	188,799	266,117	352,674	449,572	558,049	679,487	815,435
Electricity demand GWh	28.1	64.7	112.2	173.8	253.9	357.9	474.3	604.6	750.5	913.8	1096.6

Small Bus High growth scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	467,972	472,105	476,273	480,479	484,722	489,002	493,320	497,676	502,071	506,505	510,977
Replacement vehicles	18,555	18,719	18,884	19,051	19,219	19,389	19,560	19,733	19,907	20,083	20,260
Additional new vehicles	4,096	4,132	4,169	4,206	4,243	4,280	4,318	4,356	4,395	4,433	4,473
EV vehicle fleet new	0	50	882	1,836	3,251	5,192	7,724	10,910	14,809	19,483	24,733
EV vehicle fleet stock	0	50	932	2,768	6,019	11,211	18,935	29,845	44,654	64,138	88,871
EV fleet as % of stock	0%	0%	0%	1%	1%	2%	4%	6%	9%	13%	17%
GHG reduction WTW in tons	0	916	17,069	50,715	110,276	205,405	346,931	546,823	818,166	1,175,147	1,628,307
Electricity demand GWh	0.0	1.2	23.0	68.2	148.3	276.2	466.6	735.4	1100.3	1580.4	2189.8

Urban bus standard S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	16,141	16,284	16,428	16,573	16,719	16,867	17,016	17,166	17,317	17,470	17,625
Replacement vehicles	800	807	814	821	829	836	843	851	858	866	874
Additional new vehicles	141	143	144	145	146	148	149	150	152	153	154
EV vehicle fleet new	24	31	40	52	68	88	98	110	123	138	154
EV vehicle fleet stock	24	55	95	147	214	302	400	510	633	771	925
EV fleet as % of stock	0%	0%	1%	1%	1%	2%	2%	3%	4%	4%	5%
GHG reduction WTW in tons	1,799	4,136	7,171	11,112	16,230	22,876	30,317	38,646	47,971	58,410	70,096
Electricity demand GWh	1.4	3.3	5.7	8.8	12.8	18.1	24.0	30.6	38.0	46.2	55.5

Urban bus standard S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	16,141	16,284	16,428	16,573	16,719	16,867	17,016	17,166	17,317	17,470	17,625
Replacement vehicles	800	807	814	821	829	836	843	851	858	866	874
Additional new vehicles	141	143	144	145	146	148	149	150	152	153	154
EV vehicle fleet new	47	62	80	104	135	175	196	220	246	275	308
EV vehicle fleet stock	47	109	189	293	428	604	800	1,020	1,266	1,541	1,849
EV fleet as % of stock	0%	1%	1%	2%	3%	4%	5%	6%	7%	9%	10%
GHG reduction WTW in tons	3,599	8,272	14,341	22,223	32,459	45,752	60,633	77,292	95,942	116,820	140,193
Electricity demand GWh	2.8	6.5	11.4	17.6	25.7	36.2	48.0	61.2	75.9	92.5	111.0

Urban bus standard Peru scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	16,141	16,284	16,428	16,573	16,719	16,867	17,016	17,166	17,317	17,470	17,625
Replacement vehicles	800	807	814	821	829	836	843	851	858	866	874
Additional new vehicles	141	143	144	145	146	148	149	150	152	153	154
EV vehicle fleet new	0	5	10	19	39	59	79	100	131	173	257
EV vehicle fleet stock	0	5	14	34	73	132	211	311	442	616	873
EV fleet as % of stock	0%	0%	0%	0%	0%	1%	1%	2%	3%	4%	5%
GHG reduction WTW in tons	0	360	1,086	2,551	5,508	9,981	15,998	23,587	33,538	46,667	66,144
Electricity demand GWh	0.0	0.3	0.9	2.0	4.4	7.9	12.7	18.7	26.5	36.9	52.4

Urban bus high growth	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	16,141	16,284	16,428	16,573	16,719	16,867	17,016	17,166	17,317	17,470	17,625
Replacement vehicles	800	807	814	821	829	836	843	851	858	866	874
Additional new vehicles	141	143	144	145	146	148	149	150	152	153	154
EV vehicle fleet new	0	50	37	76	135	216	321	453	615	810	1,028
EV vehicle fleet stock	0	50	87	163	298	514	835	1,288	1,904	2,713	3,741
EV fleet as % of stock	0%	0%	1%	1%	2%	3%	5%	8%	11%	16%	21%
GHG reduction WTW in tons	0	3,790	6,567	12,352	22,592	38,947	63,278	97,645	144,295	205,669	283,578
Electricity demand GWh	0.0	3.0	5.2	9.8	17.9	30.8	50.1	77.3	114.2	162.8	224.5

Coach S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	79,311	80,012	80,718	81,431	82,150	82,875	83,607	84,345	85,090	85,842	86,600
Replacement vehicles	5,241	5,287	5,334	5,381	5,429	5,477	5,525	5,574	5,623	5,673	5,723
Additional new vehicles	694	700	707	713	719	725	732	738	745	751	758
EV vehicle fleet new	150	194	252	328	426	553	619	693	776	868	972
EV vehicle fleet stock	150	344	596	924	1,350	1,903	2,522	3,215	3,990	4,859	5,831
EV fleet as % of stock	0%	0%	1%	1%	2%	2%	3%	4%	5%	6%	7%
GHG reduction WTW in tons	5,753	13,224	22,926	35,526	51,889	73,139	96,928	123,559	153,373	186,748	224,112
Electricity demand GWh	7.5	17.2	29.8	46.2	67.5	95.1	126.1	160.7	199.5	242.9	291.5

Coach S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	79,311	80,012	80,718	81,431	82,150	82,875	83,607	84,345	85,090	85,842	86,600
Replacement vehicles	5,241	5,287	5,334	5,381	5,429	5,477	5,525	5,574	5,623	5,673	5,723
Additional new vehicles	694	700	707	713	719	725	732	738	745	751	758
EV vehicle fleet new	299	389	505	656	851	1,106	1,238	1,386	1,551	1,737	1,944
EV vehicle fleet stock	299	688	1,193	1,849	2,700	3,806	5,044	6,429	7,981	9,718	11,662
EV fleet as % of stock	0%	1%	1%	2%	3%	5%	6%	8%	9%	11%	13%
GHG reduction WTW in tons	11,506	26,448	45,852	71,052	103,778	146,278	193,856	247,119	306,745	373,497	448,224
Electricity demand GWh	15.0	34.4	59.6	92.4	135.0	190.3	252.2	321.5	399.0	485.9	583.1

Coach Peru	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	79,311	80,012	80,718	81,431	82,150	82,875	83,607	84,345	85,090	85,842	86,600
Replacement vehicles	5,241	5,287	5,334	5,381	5,429	5,477	5,525	5,574	5,623	5,673	5,723
Additional new vehicles	694	700	707	713	719	725	732	738	745	751	758
EV vehicle fleet new	0	30	60	122	246	372	501	631	828	1,092	1,620
EV vehicle fleet stock	0	30	90	212	458	830	1,331	1,962	2,790	3,882	5,502
EV fleet as % of stock	0%	0%	0%	0%	1%	1%	2%	2%	3%	5%	6%
GHG reduction WTW in tons	0	1,151	3,472	8,157	17,609	31,911	51,150	75,411	107,228	149,203	211,476
Electricity demand GWh	0.0	1.5	4.5	10.6	22.9	41.5	66.5	98.1	139.5	194.1	275.1

LCV S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	65,239	67,030	68,869	70,759	72,700	74,695	76,745	78,851	81,014	83,237	85,521
Replacement vehicles	4,536	4,660	4,788	4,919	5,054	5,193	5,335	5,482	5,632	5,787	5,946
Additional new vehicles	1,742	1,790	1,839	1,890	1,942	1,995	2,050	2,106	2,164	2,223	2,284
EV vehicle fleet new	158	209	277	366	484	641	731	833	950	1,083	1,234
EV vehicle fleet stock	158	368	645	1,011	1,495	2,136	2,867	3,700	4,649	5,732	6,966
EV fleet as % of stock	0%	1%	1%	1%	2%	3%	4%	5%	6%	7%	8%
GHG reduction WTW in tons	669	1,553	2,723	4,271	6,318	9,024	12,111	15,630	19,641	24,216	29,431
Electricity demand GWh	0.6	1.5	2.6	4.0	6.0	8.5	11.5	14.8	18.6	22.9	27.9

LCV S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	65,239	67,030	68,869	70,759	72,700	74,695	76,745	78,851	81,014	83,237	85,521
Replacement vehicles	4,536	4,660	4,788	4,919	5,054	5,193	5,335	5,482	5,632	5,787	5,946
Additional new vehicles	1,742	1,790	1,839	1,890	1,942	1,995	2,050	2,106	2,164	2,223	2,284
EV vehicle fleet new	317	419	554	733	969	1,281	1,461	1,666	1,899	2,165	2,469
EV vehicle fleet stock	317	735	1,289	2,022	2,991	4,272	5,733	7,399	9,298	11,464	13,933
EV fleet as % of stock	0%	1%	2%	3%	4%	6%	7%	9%	11%	14%	16%
GHG reduction WTW in tons	1,338	3,107	5,447	8,542	12,635	18,049	24,221	31,259	39,283	48,431	58,861
Electricity demand GWh	1.3	2.9	5.2	8.1	12.0	17.1	22.9	29.6	37.2	45.9	55.7

LCV high growth scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	65,239	67,030	68,869	70,759	72,700	74,695	76,745	78,851	81,014	83,237	85,521
Replacement vehicles	4,536	4,660	4,788	4,919	5,054	5,193	5,335	5,482	5,632	5,787	5,946
Additional new vehicles	1,742	1,790	1,839	1,890	1,942	1,995	2,050	2,106	2,164	2,223	2,284
EV vehicle fleet new	0	4	253	538	969	1,577	2,389	3,436	4,751	6,365	8,230
EV vehicle fleet stock	0	4	257	795	1,764	3,341	5,730	9,166	13,917	20,282	28,512
EV fleet as % of stock	0%	0%	0%	1%	2%	4%	7%	12%	17%	24%	33%
GHG reduction WTW in tons	0	16	1,087	3,358	7,453	14,114	24,207	38,724	58,795	85,687	120,455
Electricity demand GWh	0.0	0.0	1.0	3.2	7.1	13.4	22.9	36.7	55.7	81.1	114.0

Truck <7.5t S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	39,782	40,874	41,995	43,147	44,331	45,548	46,798	48,082	49,401	50,757	52,150
Replacement vehicles	1,936	1,989	2,044	2,100	2,157	2,217	2,277	2,340	2,404	2,470	2,538
Additional new vehicles	1,062	1,092	1,122	1,152	1,184	1,216	1,250	1,284	1,319	1,356	1,393
EV vehicle fleet new	76	100	132	175	231	306	349	398	454	517	590
EV vehicle fleet stock	76	176	308	483	714	1,020	1,369	1,767	2,221	2,738	3,327
EV fleet as % of stock	0%	0%	1%	1%	2%	2%	3%	4%	4%	5%	6%
GHG reduction WTW in tons	420	976	1,712	2,684	3,971	5,672	7,612	9,824	12,346	15,221	18,499
Electricity demand GWh	0.8	2.0	3.4	5.4	8.0	11.4	15.3	19.8	24.9	30.7	37.3

Truck <7.5t S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	39,782	40,874	41,995	43,147	44,331	45,548	46,798	48,082	49,401	50,757	52,150
Replacement vehicles	1,936	1,989	2,044	2,100	2,157	2,217	2,277	2,340	2,404	2,470	2,538
Additional new vehicles	1,062	1,092	1,122	1,152	1,184	1,216	1,250	1,284	1,319	1,356	1,393
EV vehicle fleet new	151	200	265	350	463	612	698	796	907	1,034	1,179
EV vehicle fleet stock	151	351	616	966	1,428	2,041	2,738	3,534	4,441	5,475	6,655
EV fleet as % of stock	0%	1%	1%	2%	3%	4%	6%	7%	9%	11%	13%
GHG reduction WTW in tons	841	1,953	3,424	5,369	7,942	11,345	15,224	19,648	24,691	30,441	36,997
Electricity demand GWh	1.7	3.9	6.9	10.8	16.0	22.9	30.7	39.6	49.7	61.3	74.5

Truck 7.5-16t S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	39,782	40,874	41,995	43,147	44,331	45,548	46,798	48,082	49,401	50,757	52,150
Replacement vehicles	1,936	1,989	2,044	2,100	2,157	2,217	2,277	2,340	2,404	2,470	2,538
Additional new vehicles	1,062	1,092	1,122	1,152	1,184	1,216	1,250	1,284	1,319	1,356	1,393
EV vehicle fleet new	76	100	132	175	231	306	349	398	454	517	590
EV vehicle fleet stock	76	176	308	483	714	1,020	1,369	1,767	2,221	2,738	3,327
EV fleet as % of stock	0%	0%	1%	1%	2%	2%	3%	4%	4%	5%	6%
GHG reduction WTW in tons	998	2,317	4,062	6,370	9,423	13,460	18,063	23,312	29,295	36,118	43,896
Electricity demand GWh	1.8	4.2	7.4	11.6	17.1	24.5	32.9	42.4	53.3	65.7	79.9

Truck 7.5-16t S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	39,782	40,874	41,995	43,147	44,331	45,548	46,798	48,082	49,401	50,757	52,150
Replacement vehicles	1,936	1,989	2,044	2,100	2,157	2,217	2,277	2,340	2,404	2,470	2,538
Additional new vehicles	1,062	1,092	1,122	1,152	1,184	1,216	1,250	1,284	1,319	1,356	1,393
EV vehicle fleet new	151	200	265	350	463	612	698	796	907	1,034	1,179
EV vehicle fleet stock	151	351	616	966	1,428	2,041	2,738	3,534	4,441	5,475	6,655
EV fleet as % of stock	0%	1%	1%	2%	3%	4%	6%	7%	9%	11%	13%
GHG reduction WTW in tons	1,995	4,634	8,124	12,740	18,845	26,920	36,127	46,623	58,591	72,235	87,792
Electricity demand GWh	3.6	8.4	14.8	23.2	34.3	49.0	65.7	84.8	106.6	131.4	159.7

Truck 16-32t S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	122,359	125,716	129,166	132,710	136,352	140,093	143,938	147,887	151,945	156,115	160,398
Replacement vehicles	5,955	6,118	6,286	6,458	6,636	6,818	7,005	7,197	7,394	7,597	7,806
Additional new vehicles	3,268	3,358	3,450	3,544	3,642	3,741	3,844	3,950	4,058	4,169	4,284
EV vehicle fleet new	233	308	407	538	712	941	1,073	1,224	1,395	1,591	1,813
EV vehicle fleet stock	233	540	947	1,485	2,197	3,138	4,211	5,435	6,830	8,420	10,234
EV fleet as % of stock	0%	0%	1%	1%	2%	2%	3%	4%	4%	5%	6%
GHG reduction WTW in tons	3,986	9,258	16,230	25,453	37,650	53,782	72,175	93,145	117,055	144,314	175,394
Electricity demand GWh	8.4	19.4	34.1	53.5	79.1	113.0	151.6	195.7	245.9	303.1	368.4

Truck 16-32t S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	122,359	125,716	129,166	132,710	136,352	140,093	143,938	147,887	151,945	156,115	160,398
Replacement vehicles	5,955	6,118	6,286	6,458	6,636	6,818	7,005	7,197	7,394	7,597	7,806
Additional new vehicles	3,268	3,358	3,450	3,544	3,642	3,741	3,844	3,950	4,058	4,169	4,284
EV vehicle fleet new	465	615	814	1,076	1,423	1,883	2,146	2,447	2,790	3,181	3,627
EV vehicle fleet stock	465	1,080	1,894	2,970	4,394	6,276	8,422	10,870	13,660	16,841	20,468
EV fleet as % of stock	0%	1%	1%	2%	3%	4%	6%	7%	9%	11%	13%
GHG reduction WTW in tons	7,972	18,516	32,461	50,905	75,300	107,564	144,350	186,291	234,109	288,629	350,788
Electricity demand GWh	16.7	38.9	68.2	106.9	158.2	225.9	303.2	391.3	491.7	606.3	736.8

Truck >32t S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	64,025	65,782	67,587	69,441	71,347	73,305	75,316	77,383	79,506	81,688	83,929
Replacement vehicles	3,116	3,201	3,289	3,379	3,472	3,567	3,665	3,766	3,869	3,975	4,084
Additional new vehicles	1,710	1,757	1,805	1,855	1,905	1,958	2,011	2,067	2,123	2,182	2,242
EV vehicle fleet new	122	161	213	282	372	493	562	640	730	832	949
EV vehicle fleet stock	122	283	496	777	1,149	1,642	2,204	2,844	3,574	4,406	5,355
EV fleet as % of stock	0%	0%	1%	1%	2%	2%	3%	4%	4%	5%	6%
GHG reduction WTW in tons	2,386	5,542	9,716	15,236	22,538	32,195	43,205	55,759	70,071	86,389	104,994
Electricity demand GWh	5.7	13.2	23.2	36.4	53.8	76.8	103.1	133.1	167.3	206.2	250.6

Truck >32t S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	64,025	65,782	67,587	69,441	71,347	73,305	75,316	77,383	79,506	81,688	83,929
Replacement vehicles	3,116	3,201	3,289	3,379	3,472	3,567	3,665	3,766	3,869	3,975	4,084
Additional new vehicles	1,710	1,757	1,805	1,855	1,905	1,958	2,011	2,067	2,123	2,182	2,242
EV vehicle fleet new	243	322	426	563	745	985	1,123	1,280	1,460	1,665	1,898
EV vehicle fleet stock	243	565	991	1,554	2,299	3,284	4,407	5,688	7,147	8,812	10,710
EV fleet as % of stock	0%	1%	1%	2%	3%	4%	6%	7%	9%	11%	13%
GHG reduction WTW in tons	4,772	11,084	19,432	30,473	45,076	64,390	86,411	111,517	140,142	172,779	209,989
Electricity demand GWh	11.4	26.5	46.4	72.7	107.6	153.7	206.3	266.2	334.5	412.4	501.2

GHG Transport Projections WTW

Scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
BAU	39,095,784	39,844,067	40,606,673	41,383,874	42,175,951	42,983,188	43,805,875	44,644,308	45,498,789	46,369,624	47,257,127
EV15@30	39,046,231	39,728,651	40,403,688	41,064,427	41,701,566	42,302,619	42,888,711	43,455,572	43,998,244	44,510,970	44,987,075
GHG reduction EV15@30	49,553	115,416	202,985	319,447	474,384	680,568	917,164	1,188,736	1,500,545	1,858,654	2,270,052
Electricity usage	64	148	260	408	604	863	1,159	1,497	1,884	2,325	2,830
EV30@30	38,996,678	39,613,235	40,200,703	40,744,980	41,227,182	41,622,051	41,971,547	42,266,836	42,497,699	42,652,317	42,717,023
GHG reduction EV30@30	99,106	230,832	405,969	638,894	948,769	1,361,137	1,834,328	2,377,473	3,001,090	3,717,307	4,540,104
Electricity usage	128	296	520	815	1,207	1,726	2,318	2,994	3,767	4,650	5,660
EV scenario Peru	39,095,784	39,842,104	40,600,714	41,370,277	42,147,870	42,933,070	43,721,969	44,504,739	45,267,597	45,992,009	46,610,004
GHG reduction Peru	0	1,963	5,959	13,597	28,081	50,118	83,906	139,569	231,192	377,615	647,123
Electricity usage Peru	0	2	7	15	32	57	94	153	247	394	658
EV scenario high growth	39,022,687	39,666,692	40,266,741	40,801,722	41,238,773	41,536,644	41,701,036	41,695,832	41,479,883	41,006,602	40,234,283
GHG reduction high growth	73,097	177,375	339,932	582,152	937,178	1,446,544	2,104,839	2,948,476	4,018,906	5,363,022	7,022,844
Electricity usage	82	197	378	646	1,037	1,597	2,318	3,239	4,404	5,861	7,656

High growth scenario impact only 4 vehicle sectors

Parameter	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
GHG reduction WTW in tons	0	6,733	39,096	107,511	230,473	429,929	731,391	1,164,096	1,761,209	2,560,062	3,591,631
Electricity demand GWh	0	6	42	118	254	474	805	1,280	1,933	2,803	3,924

High growth scenario impact 4 vehicle sectors plus highest for other vehicle categories

Parameter	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
GHG reduction WTW in tons	73,097	177,375	339,932	582,152	937,178	1,446,544	2,104,839	2,948,476	4,018,906	5,363,022	7,022,844
Electricity demand GWh	82	197	378	646	1,037	1,597	2,318	3,239	4,404	5,861	7,656

GHG WTW emissions in tCO2e of selected 4 commercial vehicle sectors (LCVs, small and urban bus, taxis)

Scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
BAU	19,170,077	19,449,777	19,736,919	20,031,796	20,334,713	20,645,991	20,965,963	21,294,978	21,633,401	21,981,611	22,340,008
EV15@30	19,149,703	19,402,565	19,654,344	19,902,610	20,144,071	20,374,293	20,602,079	20,826,216	21,045,283	21,257,616	21,461,278
EV30@30	19,129,329	19,355,354	19,571,769	19,773,424	19,953,428	20,102,595	20,238,195	20,357,455	20,457,165	20,533,622	20,582,548
EV scenario Peru	19,170,077	19,449,417	19,735,833	20,029,244	20,329,206	20,636,010	20,949,965	21,271,391	21,599,862	21,934,945	22,273,864
High growth scenario	19,170,077	19,443,044	19,697,823	19,924,284	20,104,240	20,216,062	20,234,572	20,130,882	19,872,192	19,421,550	18,748,377

High growth scenario

Parameter	Taxis	Small Buses	Urban Buses	LCVs	Total
EV stock 2025	17,054	11,211	514	3,341	32,119
EV Stock 2030	155,087	88,871	3,741	28,512	276,211
GHG impact 2025 tCO2	171,463	205,405	38,947	14,114	429,929
GHG impact 2030 tCO2	1,559,292	1,628,307	283,578	120,455	3,591,631
PM2.5 reduction 2030 (tons)	9	156	9	23	197
NOx reduction 2030 (tons)	469	19,911	1,091	474	21,945
Savings emision costs 2030 (MUSD)	64	98	13	8	182
Emissions savings excl. GHG	1	33	2	3	39
Vehicle CAPEX 2025 cumulative MUSD	1053	841	115	76	2,085
Vehicle CAPEX 2030 cumulative MUSD	3342	5633	724	596	10,296

Investment based on real 2020 USD

Default Emissions

Euro 2/II

Vehicle category	Fuel	Fuel consumption	NO_x	$PM_{2.5}$	CO_2 TTW	BC	CO_2 WTW incl. BC	Energy Usage MJ	Annual distance
Passenger Car	gasoline	66	0.255	0.002	203	0	242	2.9	11,500
Passenger Car	diesel	55	0.716	0.055	175	39	255	2.4	11,500
Passenger Car	CNG	63	0.056	0.001	189	0	264	3.0	15,000
Taxi	gasoline	66	0.255	0.002	203	0	242	2.9	50,000
Taxi	diesel	55	0.716	0.055	175	39	255	2.4	50,000
Taxi	CNG	63	0.056	0.001	189	0	264	3.0	53,000
3-wheeler	gasoline	24	0	0.000	75	0	89	1.1	15,000
3-wheeler	diesel	19	0.500	0.050	61	11	86	0.8	15,000
3-wheeler	CNG	32	0.5	0.000	96	0	134	1.5	15,000
Motorcycle	gasoline	36	0.317	0.004	111	1	132	1.6	5,000
Small bus	gasoline	148	0.000	0.000	455	0	541	6.6	44,000
Small bus	diesel	152	0.904	0.163	484	95	691	6.5	44,000
Urban standard bus	diesel	405	10.700	0.220	1291	129	1,716	17.4	60,000
Urban standard bus	CNG	515	10.000	0.010	1,545	0	2,155	24.7	63,000
Coach bus	diesel	247	8.950	0.165	787	97	1,065	10.6	50,000
LCV	gasoline	70	0.230	0.002	215	1	256	3.1	20,000
LCV	diesel	80	0.149	0.117	255	84	398	3.4	20,000
Truck < 7.5t	diesel	101	3.490	0.061	322	36	432	4.3	20,000
Truck 7.5-16t	diesel	155	5.500	0.104	494	61	668	6.7	30,000
Truck 16-32t	diesel	210	7.910	0.155	669	91	914	9.0	30,000
Truck >32t	diesel	251	9.360	0.194	800	113	1,097	10.8	30,000

Euro 4/IV

Vehicle category	Fuel	Fuel consumption	NO_x	$PM_{2.5}$	CO_2 TTW	BC	CO_2 WTW incl. BC	Energy Usage MJ	Annual distance
Passenger Car	gasoline	66	0.061	0.001	203	0	241	2.9	11,500
Passenger Car	diesel	55	0.580	0.031	175	25	240	2.4	11,500
Passenger Car	CNG	63	0.056	0.001	189	0	264	3.0	15,000
Taxi	gasoline	66	0.061	0.001	203	0	241	2.9	50,000
Taxi	diesel	55	0.580	0.031	175	25	240	2.4	50,000
Taxi	CNG	63	0.056	0.001	189	0	264	3.0	53,000
3-wheeler	gasoline	24	0.000	0.000	75	0	89	1.1	15,000
3-wheeler	diesel	19	0.500	0.050	61	11	86	0.8	15,000
3-wheeler	CNG	32	0.500	0.000	96	0	134	1.5	15,000
Motorcycle	gasoline	36	0.194	0.004	111	1	132	1.6	5,000
Small bus	gasoline	148	0.000	0.000	455	0	541	6.6	44,000
Small bus	diesel	152	5.092	0.040	484	27	622	6.5	44,000
Urban standard bus	diesel	371	5.420	0.046	1183	31	1,487	16.0	60,000
Urban standard bus	CNG	490	2.500	0.005	1,470	0	2,051	23.5	63,000
Coach bus	diesel	247	4.520	0.035	787	24	992	10.6	50,000
LCV	gasoline	70	0.064	0.001	215	0	256	3.1	20,000
LCV	diesel	80	0.831	0.041	255	32	346	3.4	20,000
Truck < 7.5t	diesel	101	1.640	0.011	322	7	403	4.3	20,000
Truck 7.5-16t	diesel	155	2.650	0.016	494	11	618	6.7	30,000
Truck 16-32t	diesel	210	3.830	0.024	669	16	839	9.0	30,000
Truck >32t	diesel	251	4.610	0.027	800	18	1,002	10.8	30,000
since									

Source and Assumptions

Emission factors and fuel consumption EEA, (2020), COPERT Tier 2 except for small buses, 3-wheelers and standard urban buses (standard urban buses based on Tier 3 with 15km/h and 50% load)

car/taxi: medium size

Motorcycle 4-strooke<250cm3, Euro 1 respectively Euro 2

all units g/km

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