grütter consulting

Country Diagnostic Argentina

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Vehicle Data

Vehicle category	gasoline	diesel	CNG	total
Passenger car	9,359,195	1,300,837	1,545,734	11,453,615
Taxi	15,886	23,829	169,656	209,371
Motorcycle	5,405,596			5,405,596
standard urban bus		31,640		31,640
coach		16,371		16,371
LCV	303,410	1,069,159		1,372,570
Truck < 7.5t		15,149		15,149
Truck 7.5-16t		85,844		85,844
Truck 16-32t		109,645		109,645
Truck >32t		222,613		222,613
Source: WB, 2020, PMR, passenger car incl. private "utilitarios"				
Year of data	2019			18,922,414
Country	Argentina			
GDP growth rate	0.9%			
take from country values				
Carbon grid factor	0.382			
take from country values				
Growth rate freight transport	0.9%			
See below				
Bus, coach growth	0.8%			
based on growth population				
Passenger car, MC, taxi growth	1.0%			

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	-3		
β	-0.00013		
vehicl pop 2030	12,803,130		
CAGR	1.0%		
Based on OECD pattern, see source above			
GDP per capita 2019	9912		
GDP per capital 2030	9972		
GDP per capita (current US$) - Ecuador | Data (worldbank.org)			
Projected population 2(	49.3		Eurominitor
Population 2019	44.94		
CAGR	0.8%		
WB			

Abbreviations

ADEFA: Automobile Manufacturers Association

AMBA: Buenos Aires Metropolitan Area

C3T: Technological Center for Transport, Traffic and Road Safety of the National Technological University.

INDEC: Instituto de Estadísticas y Censos (Institute of Statistics and Census)

CABA: Autonomous City of Buenos Aires

CNRT: National Commission for Transportation Regulation.

GHGs: Greenhouse Gases

IEA: International Energy Agency

MAyDS: Ministry of Environment and Sustainable Development.

MERCOSUR: Common Market of the South

MT: Ministry of Transportation

MINCYT: Ministry of Science, Technology and Productive Innovation.

ONDaT: National Transportation Data Observatory

SSPT: Undersecretary of Cargo Transportation and Logistics Planning of the National Ministry of Transportation.

TAC: Motor Transport of Loads

TCN: Third National Communication

SAyDS: Secretary of Environment and Sustainable Development

USCUSS: Land Use, Land Use Change and Forestry

PANTyCC: National Action Plan for Transportation and Climate Change

AAVEA: Argentine Association of Electric and Alternative Vehicles

AFAC: Argentine Association of Component Factories

GVA: gross value added

NDC: Nationally Determined Contribution

EU: European Union

ULEV: Ultra low emission vehicles

UTN: National Technological University

UBA: University of Buenos Aires

VEUB: Ultra Low Emission Vehicles

1. Country Brief

The Argentine Republic is a federal country made up of 23 provinces and an autonomous city that dictate their own constitutions, administer themselves through their respective executive, legislative and judicial powers and holds all the powers not explicitly delegated by the National Constitution to the national government. (Article 5 of the National Constitution)[1] The Argentine Republic is located in the south of the American continent and extends over the South Atlantic islands and part of Antarctica. Its continental surface is 2,737,000 km^2.

In 2010, the year of the last national census, the population was 40 million inhabitants; it is estimated that in 2020 we will have reached 45 million inhabitants. Due to increased industrial and agricultural activity, two thirds of the population is concentrated in Buenos Aires and nearby provinces. The low population density in the rest of the territory and long distances are factors that increase transportation costs (Instituto Nacional de Estadísticas y Censos, 2021).

It is important to note that Argentina is one of the most urbanized countries in the world; the high levels of urbanization are a long-standing phenomenon. Already in the 1914 census, the urban population reached 52.7% of the total. Today, it is estimated to be 92%, 39% of which live in the Buenos Aires Metropolitan Region. The rate of urbanization is uneven among the different regions of the country. The population density is 13 inhabitants per km² (Plan Estrategico Territorial Argentina, 2018)

The structure of the national urban system is made up of 1,044 urban agglomerations. The Metropolitan Region of Buenos Aires and 4 large cities with more than 1,000,000 inhabitants (Córdoba, Rosario, Mendoza and Tucumán) stand out, accounting for almost 50% of the country's population. On the other hand, there are 34 intermediate cities, between 1,000,000 and 100,000 inhabitants; 330 small cities, between 100,000 and 10,000 inhabitants and 675 small agglomerations between 10,000 and 2,000 inhabitants. Finally, rural population, less than 2,000 inhabitants representing 9% of the population. (Plan Estrategico Territorial Argentina, 2018)

[1] http://servicios.infoleg.gob.ar/infolegInternet/anexos/0-4999/804/norma.htm

Table 1: Main cities of the Argentine Republic

	Ciudad	Provincia	Población (INDEC, 2010)
1	Buenos Aires	Ciudad de Buenos Aires	2 890 151
2	Córdoba	Provincia de Córdoba	1 317 298
3	Rosario	Santa Fe	948 312
4	Mar del Plata	Buenos Aires	593 337
5	San Miguel de Tucumán	Tucumán	548 866
6	Salta	Salta	520 683
7	Santa Fe	Santa Fe	391 164
8	Corrientes	Corrientes	346 334
9	Bahía Blanca	Buenos Aires	291 327
10	Resistencia	Chaco	290 723
11	Posadas	Misiones	275 028
12	San Salvador de Jujuy	Jujuy	257 970
13	Guaymallén	Mendoza	252 618
14	Santiago del Estero	Santiago del Estero	252 192
15	Paraná	Entre Ríos	247 139
16	Neuquén	Neuquén	231 198

Source: INDEC

Due to its geographic and climatic characteristics, Argentina has a high potential for the generation of renewable energies, since it has good levels of radiation in the northwest region and appropriate winds in the Patagonian region, in addition to a significant potential for hydrogen production.A study from the University of Córdoba states, that Argentina could produce almost 1 billion tons of hydrogen per year from solar, wind and biomass. The idea is to mix H2 with CNG to reduce dependance on fossil fuels. (Sigal, Leiva, & Rodriguez, 2014)

Argentina is one of the largest economies in Latin America, with a Gross Domestic Product (GDP) of approximately USD 450 billion. It is also, along with Brazil, Mexico and Colombia, one of the main producers of automobiles and auto parts in Latin America. Gross Domestic Product (GDP) per capita was USD 8,317 in 2020. Transportation contributes 5% of GDP. Lithium reserves represent a unique opportunity for the transition towards electric mobility. In northern Argentina there is a hidden treasure that could mean billions of dollars for the country and turn it into one of the world's largest producers of the mineral of the future: lithium. Usable in batteries, medicines, glass and clay, as well as in different alloys, this "white gold" has already attracted investments of US$ 1.5 billion, with which it aims to more than triple its current production of 40,000 tons per year[2]. Currently, there are two ventures in the extraction and production of the mineral, which produce around 40,000 tons/year between the two of them. Olaroz, from Sales de Jujuy, situated in Jujuy, produces 17,500 tons, and Salar del Hombre Muerto, of FMC, in Catamarca, that produces 22,500 tons. This represents 16% of the world's lithium". [3]
To reduce the negative social and environmental impact of the mining industry, technologies that run on solar power and use less water for the extraction are being developed. Although there are no known concrete policies that ensure a sustainable extraction, this issue has been addressed by other institutions such as the University of Buenos Aires. [4]

[2] https://www.lanacion.com.ar/economia/litio-el-oro-blanco-de-la-argentina-nid2058909/
[3] https://movelatam.org/litio-el-oro-blanco-de-la-argentina/
[4] https://www.unsam.edu.ar/tss/por-un-litio-sustentable/

2. Policy Framework Relevant for E-Mobility

2.1 Climate Change and Environmental Policies

According to the NDC 2020, total emissions in Argentina in 2016 were 364 million tons of CO_{2eq} (Segunda Contrición Determinada a Nivel Nacional de la Reública Argentina, 2020). In this it commits to an absolute net emission of 359 million tCO_{2eq}. The transportation sector was responsible for the emission of 56 MCO_{2eq} in 2016, representing 15% of the country's total GHG emissions of that year (Inventario Nacional de Gases de Efecto Invernadero, 2017, p. 13). Road transport, mainly trucks and automobiles, accounts for more than 90% of GHG emissions in the transport sector.

In order to establish a state policy on climate change, in 2016 the National Climate Change Cabinet was created. It was made up of the most relevant ministries and secretaries in terms of their potential to achieve the mitigation of greenhouse gas emissions as well as the necessary adaptation to the impacts and other consequences that climate change is already causing in Argentina. This cabinet proposed the preparation of the National Plan for Mitigation and Adaptation to Climate Change, which will detail the policies and measures that each agency will carry out in coordination with the others. To this end, during the last few years, the different ministries and secretaries have been preparing the so-called Sectoral Plans, which detail strategies and measures to reduce GHG emissions and measures for the adaptation of each sector. In this context, the National Action Plan for Transport and Climate Change (PANTyCC) represents the set of initiatives that Argentina has planned to do to reduce GHG emissions in this sector, and adapt to the effects of climate change in the transport sector, in accordance with the commitments assumed before the United Nations Framework Convention on Climate Change. The PANTyCC is based on strategic intervention axes and mitigation and adaptation measures. In other words, they are corrective actions that mitigate or reduce the undesired effects of transportation activities. The PNATyCC aims to meet current and future needs in terms of people mobility and freight logistics, under the premise of prioritizing environmental sustainability (Plan de acción nacional de transporte y cambio climático, 2017).

Air Quality Network

Air quality stations in the country continuously monitor typical pollutants (CO, NO_x, SO_2, O_3 and PM10). The city of Buenos Aires has three continuous air quality monitoring stations; located in the Zárate Campana area, the petrochemical pole has three continuous monitoring stations; the city of Bahía Blanca has an air quality monitoring station located in the petrochemical pole of the city. Finally, in the province of Santa Fe, there is a continuous air quality monitoring program in the industrial area of the San Lorenzo zone.

Buenos Aires is a major emitter of atmospheric pollutants that mainly come from mobile sources (automotive transportation). The contribution to atmospheric pollution from stationary sources is lower since the industrial sector has decreased. In addition, being in a flat area, it has the privilege of enjoying wind circulation that facilitates the dispersion of pollutants. For this reason, air quality monitoring is an indispensable policy to obtain information related to pollutants and to detect eventual anomalies.

The National Traffic and Road Safety Law No. 24.449, through its regulatory Decree No. 779/95, establishes the regulatory basis for controlling pollutant emissions from all new and used mobile sources, sold or transiting within the national territory. The Laboratory of Vehicular Gaseous Emissions Control, under the Ministry of Environment and Sustainable Development, has been operating since 1998, and has achieved results in terms of emissions control through the implementation of emission

certification tests for new models, control of automotive production and Research and Development. The Laboratory's field of action also allows certifying Greenhouse Gas emissions and fuel consumption, both parameters linked to the rational use of energy and global climate warming.

2.2 Energy Policies

Argentina has many natural energy resources, including hydrocarbons, hydraulic, wind and solar energy, as well as uranium deposits. In 2019, the total domestic supply of primary energy reached 81 thousand ktoe. 87% of locally produced energy comes from fossil fuels, 54% from natural gas, 31% from oil and oil derivatives, and 1% from coal. Hydraulic and nuclear energy contribute 4% and 3%, respectively, and non-conventional renewable energies (biomass, small hydroelectric, wind and solar) 6% (Segunda Contrición Determinada a Nivel Nacional de la Reública Argentina, 2020, pág. 14). In the NDC, the country commits to increase the share of non-conventional renewable energies by 2030 in order to achieve a reduction of 6 $MtCO_{2e}$ in the next 10 years (Segunda Contrición Determinada a Nivel Nacional de la Reública Argentina, 2020, pág. 29).

2.3 Transport Policies

Argentina launched the development of its National Electric Mobility Strategy in May 2018 with the support of UN Environment. Compared to other Latin American countries, the country was lagging behind in terms of incentives and infrastructure for electric mobility. However, efforts have recently increased to make electric mobility and achievable goal in this area. Argentina is currently formulating specific legislation on electric vehicles, establishing the conditions for the installation or operation of charging centers, and at the same time, exploring possible options for the local development of the electric mobility industry. Because the country has large lithium reserves and a recognized industrial history in the region, the commitment to transport electrification extends beyond the environmental aspect of sustainable mobility: lithium batteries are already being assembled with imported cells and investments are being explored to enter the lithium value chain, including the possibility of manufacturing battery cells[5].

In 2016, the Interministerial Roundtable on Sustainable Transportation was formed, convened by the Ministry of Transportation of the Nation and integrated by the then Ministry of Environment and Sustainable Development (today, Secretary), the Ministry of Production, the Ministry of Energy and the Secretary of Transportation of the City Government. This Round Table led to the formulation of two Decrees. The first one, Executive Decree 331/17 establishes, among other things, benefits for automotive companies through the reduction of tariffs for the importation of hybrid, electric and fuel cell vehicles for a maximum of six thousand units in a period of 36 months, depending on whether the vehicle is assembled in the country or not. This decree expired in May 2020 but was re-established by the decree 846/20 in November 2020 for 6 more months till May 2021 for a total of one thousand units. The second, Executive Decree 51/18, which was valid for 36 months till 17/01/2021, applied to imports of electric buses and established a tariff decrease on the importation of up to 350 units, as well as up to 2,500 chargers with power greater than or equal to 50kW. Various legislative initiatives are currently being discussed through bills such as the presentation at the end of 2017, aiming to establish a new Electric Vehicle Mobility Law. The Argentine Association of Electric and Alternative Vehicles (AAVEA) also presented a citizen's initiative bill in August 2017 in order to encourage the

[5] https://movelatam.org/argentina-avanza-en-la-elaboracion-de-su-estrategia-nacional-de-movilidad-electrica-a-traves-de-la-capacitacion-del-sector-tecnico-sobre-los-avances-y-proyecciones-de-la-industria/

development and use of electric vehicles and sustainable mobility systems in Argentina. For its part, the Argentine Automobile Manufacturers Association (ADEFA), made up of the country's automotive companies, submitted a formal request to the Ministry of Production in 2018 for a luxury tax exemption for electric vehicles. At the provincial level, a congresswoman presented a project for the promotion of the industrialization of electric and alternative vehicles in the province of Buenos Aires.

As part of the Clean Mobility Plan 2035 of the City of Buenos Aires, a pilot test of battery electric buses was carried out[6]. In a period of time that will extend for one year, it will incorporate eight units of different technologies in bus lines 12, 34, 39 and 59. This test seeks to evaluate the technical-economic and environmental feasibility of these buses in order to establish regulatory and economic frameworks that promote the inclusion of these vehicles in the public transportation system. The evaluation of these vehicles is supported by the Development Bank of Latin America (CAF). The results will be key to decide on a greater incorporation in the Buenos Aires Metropolitan Area with more than 18,000 buses in operation, which represents one of the largest fleets in Latin America.

As part of the Clean Mobility Plan 2035 by the City of Buenos Aires to improve public transportation in the city, a pilot test with alternative bus propulsion technologies has been carried out, in order to analyze their environmental, technical, operational and financial feasibility.[7] For this test, two Electric, two biodiesel and two CNG buses were incorporated into normal commercial operations and monitored for one year between 2019 and 2020. The evaluation of these vehicles has been supported by the Development Bank of Latin America (CAF). The results regarding the electric buses[8], reveal key points that must be considered for a wider adoption in Buenos Aires.

3. Transport Sector

3.1. Actors in the Transport Sector Relevant for E-Mobility

Transportation plays a fundamental role in Argentina's social and economic development prospects. Its capacity to provide mobility to people and goods, the transportation system has a direct impact on competitiveness, social cohesion, the environment and territorial integration of the country. On one hand, logistics costs, of which transportation is the main component, have a significant impact on business competitiveness. On the other hand, transportation directly conditions people's accessibility, due to its weight in the consumption basket, particularly for lower-income households. Finally, transportation integrates national and international markets and makes it possible to exploit local comparative advantages and sectoral economies of scale. In this sense, a modern and efficient transportation system translates into a more competitive economy, a more cohesive and equitable society, and a more integrated national and international territorial space.

Its contribution in terms of value added (4.4% of the national total) and employment (almost half a million jobs) reinforces its importance. Transportation activity demands infrastructure and equipment and fuels, with a particular capacity to dynamize the economy. In the same sense, it constitutes a tool for economic development. Regarding urban passenger mobility, Argentina has a high concentration of urban population where the Buenos Aires Metropolitan Area (AMBA) stands out notably, concentrating more than a third of the country's population. The number of trips per year has reached almost 9 billion in 2012, with a strong participation of bus (38%), followed by car (37%), rail (4.5%) and

[6] https://www.itba.edu.ar/intranet/ols/wp-content/uploads/sites/4/2018/09/PML-CABA-NACION_300518.pdf
[7] https://www.buenosaires.gob.ar/carbononeutral/plan-de-movilidad-limpia
[8] https://scioteca.caf.com/handle/123456789/1687

subways (4%). The number of passengers in intercity automotive transport services in 2015 amounted to 37.2 million, with a total distance traveled of 708.5 million kilometers, while the air mode carried 11.4 million passengers, according to the latest available data for 2016. In relation to intercity cargoes, the preponderance of road mode stands out (92.7%); followed by rail (3.7% of the total) and river-sea mode (3.6%) in ships and barges. Air cargoes have a minimal share. The diversity of transport modes corresponds to a wide spectrum of actors and modes of regulation along with multiple public agencies with the power to define these regulatory frameworks and their oversight (Plan de acción nacional de transporte y cambio climático, 2017, págs. 20-25).

According to the system of national accounts, the gross value added of the transportation sector contributed 271 billion pesos to the national total in 2016, which represented 4.4% of that total. In relation to employment, it generated 482,103 registered jobs in 2016, which explained 7.4% of the total generated in the private sector in that year. Companies registered in the sector reached 53,447 units in 2015 and explained 8.9% of the total number of companies registered in the private sector in the country; most of which are micro-enterprises (72%) and small companies (22%); with a minority participation formed by large (2%) and medium-sized (4%) (Plan Nacional de Mitigación del sector Transporte, 2017, pág. 6).

The Argentine automotive industry is characterized by the production of two types of goods: automobiles in their different categories (cars, utility vehicles, trucks, buses and vans) and auto parts. Auto parts comprise a large number of products ranging from bolts and nuts to engines, transmission systems and gearboxes. Overall, the sector's gross value added (GVA) represents, as of 2017, just over 4.1% of the manufacturing industry's GVA and less than 1% of the economy's total GVA. Employment totaled 76.5 thousand registered jobs as of 2017, including workers in the terminals and in the auto parts factories. Such value meant a drop of almost 2% from the previous year and sustains a trend of labor dismantling that started in 2013. Of the total employment in the sector in 2017, 37.5% are employees of the automotive terminals sector, while the remaining 62.5% are employees of auto parts manufacturers (52.8%) and body manufacturers (9.7%). This structure has remained relatively unchanged over a decade, but with a total employment level 10% higher than in 2007. It should be recalled that the level of production (measured by sector GVA) remained unchanged over the same period, while the number of vehicles produced decreased by 10%. Approximately 60% of the registered jobs are devoted to the manufacture of parts and auto parts, while the remaining is dedicated to the manufacture of vehicles. As of 2017, registered jobs in the sector accounted for 6.2% of manufacturing employment and 1.2% of total employment. If employment in services directly linked to the sector (sale of new and used vehicles, maintenance and repair, and sale of auto parts) is considered, the proportion within total employment amounts to 3%. The companies in the sector differ in number and size depending on whether they are automotive terminals or auto parts manufacturers. While among the latter there are more than a thousand, among the former, by the end of 2018, there are only 12 of considerable relevance, namely: Ford, General Motors, Fiat, Mercedes Benz, Nissan6, PSA Peugeot-Citroën, Renault, Toyota, Volkswagen, Honda and Iveco (Fiat Group). The industrial centers of these companies are located in Buenos Aires, Córdoba and Santa Fe, while the commercial centers are mostly located in the Autonomous City of Buenos Aires (CABA).

The auto parts sector is made up of around 650 core companies, of which more than 50% are direct suppliers of automotive vehicle manufacturers. The production of automobiles has a greater weight than that of auto parts in terms of exports. Measured in dollars, vehicle exports represent close to 80% of the sector's total, versus the 20% corresponding to auto parts exports.

Towards 2017, exports of the sector as a whole registered close to 6.3 billion dollars, which represents 8.5% of the total exported by the country in that year. For its part, 44% of the 473 thousand vehicles

produced in 2017 were destined for the foreign market. Imports of the sector accounted for US$ 15 billion in 2017, becoming one of the determining items for the total trade balance. They represent 22% of total imports. The specific external balance of the sector, structurally in deficit, recorded a record close to -8.5 billion dollars (similar to the result of the total trade balance for the same year).

3.2. Public Transport Operators

Regarding urban passenger mobility, Argentina has a high concentration of urban population, where the Buenos Aires Metropolitan Area (AMBA) stands out, followed by the urban agglomerations in the provinces of Córdoba, Santa Fe, Mendoza and Tucumán. The information on trips corresponding to the AMBA indicates that more than 16 million inhabitants demanded 8.7 billion trips in 2012, including public and private transportation (Plan Nacional de Mitigación del sector Transporte, 2017, pág. 7).

According to CNRT data, the 138 passenger lines with urban services in the AMBA, had 9,892 vehicles, transported 1,620 million passengers and totaled a route of 672.4 million km in 2016. Free offer services registered 1,095 additional vehicles. Paid passengers carried on the metropolitan rail network in 2016 practically totaled 358 million, for which they ran 657 thousand formations covering a distance of 21.2 million km. As for the subway network, 303 million passengers were registered during 2016 (Plan Nacional de Mitigación del sector Transporte, 2017, pág. 8).

Although there is no systematic data for urban trips in the rest of the country, different surveys compiled by C3T indicate that, while in the AMBA inhabitants make about 2 trips per day, the average for the cities of Córdoba, Rosario and Mendoza, barely reaches 1.5 trips per day per inhabitant and motor transport is preponderant. The number of passenger motor vehicles registered in the different provinces -excluding the AMBA- reached 7,294 units in municipal jurisdiction and 3,738 units in provincial jurisdiction in June 2016.

The transportation actors are mainly the governmental body in its three jurisdictions: national, provincial and municipal. This jurisdictional differentiation corresponds to the route of the line and the jurisdictions in which it operates, and therefore is the permit held by each transport line. That is to say, if the route of a transport line does not leave the municipal jurisdiction its permit is municipal, when the line crosses such jurisdiction without entering another province its jurisdiction is provincial and if it passes between two provinces its jurisdiction corresponds to the national jurisdiction. In this regard, the Ministry of Transportation of the Nation and more specifically the Secretary of Transportation Management are the ones managing the sector at the national level. Another intervening body is the National Commission for Transport Regulation (CNRT). Each of these organizations has bodies and agencies in charge of the control and supervision of transport. Another important actor is the transport unions, mainly the UTA, which is the one with the greatest preponderance among the drivers of the bus lines. Finally, there are the private businessmen and women who are in charge of providing transportation services. Their main purpose is to obtain profit from the exploitation of a public service. There are different levels of organization, from the independent provider, owner of a vehicle (bus, micro), to large companies that monopolize several lines and modalities. In this space, there are small companies that generally operate at the municipal level, up to the large ones that are concession holders at the national level. As noted, the transformations of the RMBA in the 1990s, particularly the expansion of upper-middle and high-income sectors to the periphery of the region and the increase of low-income sectors, have had an impact on the dynamics of transportation, generating alternative modes to the public passenger service provided by public passenger transport companies and the FFCC. This is reflected in the increase of APP, charter, and remise services that have expanded both in their formal and informal modalities.

Companies are grouped in sectorial chambers, according to their interests and affinities. Among the most important are: the Argentine Association of Automotive Transportation Entrepreneurs (AAETA), the Chamber of Passenger Transportation Entrepreneurs (CEAP), the Chamber of Long Distance Transportation Entrepreneurs (CELADI), the Chamber of Passenger Automotive Transportation Entrepreneurs (CETAP), the Chamber of Transportation of the Province of Buenos Aires (CTPBA), the Argentine Federation of Passenger Automotive Transportation Entrepreneurs (FATAP).

The companies operate a diverse number of lines ranging from 1 to 15. 40% of the companies have a "traditional" structure (i.e., they serve only one line), but own only 13% of the total number of routes served by the intermodal companies. Together with the companies owning up to four lines, they account for 84% of the companies and own 50% of the lines. The other 50% belong to only 11 companies. On the other hand, the companies that own the largest number of lines provide service on routes in different jurisdictions under the same company name, i.e., they serve national, provincial and communal lines. In some cases, they also have non-metropolitan urban or interurban lines. Only in two cases (Grupo DOTA and Grupo PLAZA) do they adopt the strategy of presenting themselves as business groups to users, identifying themselves by the color of their units. But they are not the only ones, and they also own other companies that do not share their corporate name.

Until 2019, the National Ministry of Transportation subsidized, through different mechanisms, all short, medium and long distance public services, with a mechanism instituted in 2002.

In this way, it was possible to reliably know the operating parameters of services in jurisdictions other than the national jurisdiction, a fact that until 2002 was known (and not always) only by the authorities responsible for each jurisdiction: number and type of units, mileage traveled by each vehicle, fuel consumption and passengers transported, mainly.

In December 2018 this mechanism ceased its operations in this form. Although the 2020 pandemic and quarantine that was implemented, led to an almost total reduction in urban traffic and the suspension of long-distance services. The particular circumstances again forced the incomplete implementation in the way of subsidies to companies which served to complete the information. In this way, the key variables for the estimation of fuel consumption (diesel) of regular services are known since they are captured by the records, fully up to 2018 and in a more partial way for 2020.

In this segment there are two registries that help estimate its operating parameters, both administered by the CNRT. On the one hand, the Registry of Free Offer Operators, which includes companies and vehicles operating in non-regular urban services in the RMBA. On the other hand, the Registry of Operators of Transportation Services for Tourism, which includes companies and vehicles that carry out non-regular inter-jurisdictional trips between provinces. These are the typical transportation services for contingents of students on their graduation trips, contingents of retirees or contingents of pilgrims to religious festivals, among others.

It is important to note that the passenger buses are 12 m long, have a diesel engine and that the RMBA regulation allows buses that are up to 10 years old to circulate.

Table 2: Passenger Transportation Sector

Provincias	Servicios urbanos regulares					
	Servicios urbanos regulares Jurisdicciones Provinciales		Servicios urbanos regulares Jurisdicciones municipales		Servicios urbanos regulares Jurisdicción Nacional	
	Cantidades vehículos	Consumo (Gasoil en miles de litros)	Cantidad de vehículos	Consumo (Gasoil en miles de litros)	Cantidad de vehículos	Consumo (Gasoil en miles de litros)
RMBA	5,195	150,452	3,498	87,392	9,647	289,686
Resto de Buenos Aires	132	3,873	1,069	22,389	33	1,029
Catamarca	198	5,809	0	0	0	0
Chaco	37	1,086	156	3,267	13	412
Chubut	0	0	209	4,377	0	0
Córdoba	613	17,984	1,136	23,792	0	0
Corrientes	2	59	312	6,534	15	475
Entre Ríos	0	0	366	7,665	14	443
Formosa	0	0	97	2,032	0	0
Jujuy	50	1,467	398	8,336	0	0
La Pampa	0	0	37	775	0	0
La Rioja	0	0	101	2,115	0	0
Mendoza	1,004	29,455	0	0	0	0
Misiones	104	3,051	404	8,461	2	63
Neuquén	29	851	173	3,623	37	1,172
Río Negro	12	352	200	4,189	40	1,267
Salta	0	0	582	12,189	0	0
San Juan	391	11,471	0	0	0	0
San Luis	38	1,115	125	2,618	0	0
Santa Cruz	1	29	33	691	0	0
Santa Fe	421	12,351	1,024	21,446	44	1,378
Santiago del Estero	80	2,347	275	5,760	0	0
Tierra del Fuego	0	0	46	963	0	0
Tucumán	698	20,478	421	8,817	0	0
Total	**9,005**	**262,229**	**10,662**	**237,433**	**9,844**	**295,925**

Source: World Bank, 2020, Partnership for Market Readiness

3.3 Cab and Ride-Hailing Services

In Buenos Aires there are about 38,000 cab licenses. Generally, drivers rent the cab from the owner[9]. Uber is not legal in Argentina and the app is blocked. However, there is a similar application to order regular cabs through an app called BA Taxi.

3.4. Light Commercial Vehicles for Urban Freight and Municipal vehicles

The Undersecretary of Cargo Transportation and Logistics Planning has surveyed 443 million tons transported in 2014 within the national territory. It is estimated that this volume represents about 85% of interurban loads, suggesting that the total load would amount to about 521.7 million tons (Plan Nacional de Mitigación del sector Transporte, 2017, p. 9). The estimated modal split for this total can be seen below.

Particularly significant is the preponderance of road mode in intercity cargo transport (92.7%); 19.3 million tons were transported in 2014 by rail (3.7% of the total) 18.8 million tons by water (3.6%) on

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https://web.archive.org/web/20070818135156/http://www.buenosaires.gov.ar/areas/obr_publicas/taxis/index.php

ships and barges, while air cargo barely exceeded 9 thousand tons. The structure alters very slightly in favor of the railroads if it is calculated taking into account ton-km. In relation to transport units, the fleet of freight vehicles formally registered with interjurisdictional circulation, according to data from the Ministry of Transportation, currently amounts to 180 thousand trucks with a maximum weight of more than 12 metric tons. The distance traveled by this fleet, without considering the unregistered fleet, would exceed 17.4 billion km, with an estimated consumption of 6.3 billion liters of fuel. There is very little information on the vehicles that serve the movement of urban freight.

However, it should be noted that the number of units formally registered with interjurisdictional circulation under the N2 category (with load capacity between 3.5 ton and 12 ton) reaches 91 thousand units, for which a distance traveled of 3.6 billion km/year and a consumption of 448 million liters of fuel per year is estimated. In relation to light utility vehicles, according to data from the Association of Automotive Manufacturers (ADEFA), the total number of vehicles in the country amounted to 2.5 million in December 2015.

In terms of urban transportation, there is little information. There has been a significant growth of last mile delivery firms in urban areas , especially during the pandemic.[10] These firms are private and have modernized and made their service more attractive with the implementation of smart phone applications. Some of these firms have seen converting their fleet to electric vehicles as an opportunity. But not only logistic firms have shown interest. The utility firm from the Corrientes Province (public) for instance, and the Municipality of Cordoba have shown interest in acquiring 20-25 e-LCVs for their operations. And the Cordoba Energy Company (also public) intends to buy 100 commercial e-LCVs. Their daily mileage is less than 100 km. The Municipality of Córdoba also has the plan of electrifying the vehicles for waste collection. They intend to gradually replace their 30 garbage trucks with electric ones until 2026 (5 truck per year). These trucks also have a mileage of 100 km/day.

To gain more knowledge the urban logistics sector itself, it is recommended to conduct some specific studies to gain more detailed information.

4. E-Mobility System

Electric vehicles and charging infrastructure

Currently, two brands of electric vehicles are offered in the Argentine market: Renault Kangoo ZE, and Nissan Leaf. Andreani, a local logistics company, is conducting a pilot test using two Renault Kangoo ZE electric vehicles. This project is being monitored in collaboration with the Government of the City of Buenos Aires. In turn, as part of the Clean Mobility Plan 2035 of the City of Buenos Aires, which seeks to promote the penetration of alternative technologies in the transportation sector, Renault delivered two Kangoo ZE on loan to the Government of the City of Buenos Aires for evaluation - the vehicles were incorporated into the city's transit fleet. For this test, the electric company Enel provided two charging centers. On the other hand, the oil refining company YPF, with a private consortium, plans to install a network of 220 fast charging points. Also, in November 2018, the province of San Luis inaugurated the first electric route in the country, with four public charging centers over a distance of 212 km[11].

[10] https://www.forbesargentina.com/negocios/a-menos-mes-cierre-verano-estos-fueron-numeros-temporada-n5208

[11] https://parabrisas.perfil.com/noticias/noticias/2018-11-21-inauguraron-la-primera-ruta-electrica-de-la-argentina.phtml

In May 2019, a pilot test was conducted to assess the feasibility of implementing electric buses in the Autonomous City of Buenos Aires (CABA)[12]. The test lasted one year and was part of the Clean Mobility Plan 2035, promoted by the city of Buenos Aires in 2018. The buses, however, do not belong to the company that operates the line, but were managed by local companies associated with manufacturers of these vehicles of Chinese origin to be loaned for a trial period of one year. Enel, the multinational controlling company of Edesur, provided the infrastructure for the charging stations at the head of line 59, the work being financed by the city government, which also promoted incentives for the adoption of this technology. Originally, a total of 8 vehicles were planned to be incorporated, including also fast charging units (one on line 12, two on line 34 and one on line 39), which could circulate around 70 kilometers, depending on usage, and take up to 20 minutes to refuel up to 80 percent of the energy during the day and around 40 minutes to reach one hundred percent. A working hypothesis is that, out of an approximate fleet of 9,982 buses under national jurisdiction in the AMBA, the activity could aim for electric units to represent at least 30% of the total by 2030. Negotiations are currently at an advanced stage for the establishment of electric bus manufacturing companies.

In 2019, the Government of the province of Mendoza implemented 18 electric buses, 12 manufactured by BYD and distributed by Andesmar, and 6 by Zhongtong, represented by Corven[13]. These units provide service in the trunk network of the urban public transportation system of the city of Mendoza, forming the main fleet of electric buses in Argentina that provides regular services. They are managed by Sociedad de Transporte Mendoza, which operates the trunk lines of the Intermodal Transport System called MendoTRAN. The financing for their acquisition was provincial, at a cost of US$ 400,000 per unit and US$ 15,000 per charger. The units are labeled as city low-floor buses. Each of them is 12 meters long, with AC and three side access doors. They have a capacity of 26 seated passengers and 57 standing passengers, together with space reserved for wheelchairs.

Public policy and legal framework

Argentina has worked on public policies and specific regulations on electric mobility at the national and provincial levels. Currently, seven different projects are pending discussion in order to move forward. At the national level, Argentina is working on the development of its National Electric Mobility Strategy:

- The Traffic Law was modified by Decree 32/2018, where the incorporation of definitions and categories of vehicles with electric and hybrid motorization according to their capacity (in kW), with emphasis on the requirements for their homologation, stands out.
- Decree 26/2019, modified the classifications of driver's licenses to include vehicles with electric motorization.
- Decree 331/20171 was repealed by Decree 230/2019, extending the reduction of the import tariff that was previously only granted for companies of the automotive sector based in the country, to also include importers of vehicles manufactured abroad, directly affecting 6,000 vehicles for 3 years.
- Decree 51/2018 establishes a tariff reduction for the import of electric buses of a maximum of 350 units for a term of 36 months, as well as up to 2,500 charging centers of power greater than or equal to 50kW.
- At the provincial level, Santa Fe has Law N. 13781 for the promotion of the industrialization of electric vehicles and technologies linked to alternative energies.

[12] https://www.buenosaires.gob.ar/movilidad/noticias/circulan-los-primeros-colectivos-electricos-en-la-ciudad
[13] https://revistavial.com/la-incorporacion-de-buses-electricos-en-la-ciudad-de-mendoza/

There are also bills in the province of Buenos Aires, the Autonomous City of Buenos Aires and the province of Neuquén, among others. The Autonomous City of Buenos Aires passed legislation regulating the use of electric scooters through a modification of the Traffic and Transport Code. Said law establishes a series of safety requirements, a maximum power of 500W and a speed limit of 25km/h. It also prohibits the circulation on sidewalks and defines 16 years as the minimum age for their use. The Argentine Institute for Standardization and Certification established the IRAM 60020 standard that defines the safety requirements for bicycles with electric pedal assistance.

Regarding electric vehicle recharging infrastructure, provision 283/2019 regulates the provision of electric recharging services at fuel dispensing stations and defines safety specifications on the installation and registration of charging centers. In turn, AEA regulation 90364-7-722, developed by the Argentine Electronic Association, defines the basis for the standardization of electrical installations for electric vehicle recharging.

Charging Infrastructure

The country has a public and private network of more than 250 charging centers. It should be noted that there is an electric corridor in the province of San Luis of more than 200 km. Currently, 15 different brands are commercialized in the market, which has facilitated the deployment of the recharging infrastructure. In the province of Cordoba, the Public Services Regulatory Body (ERSeP) approved a special tariff for charging electric vehicles through time bands - the tariff is limited to those who can prove ownership of an electric vehicle. The province of Neuquén also has a recharging center.

Electricity costs

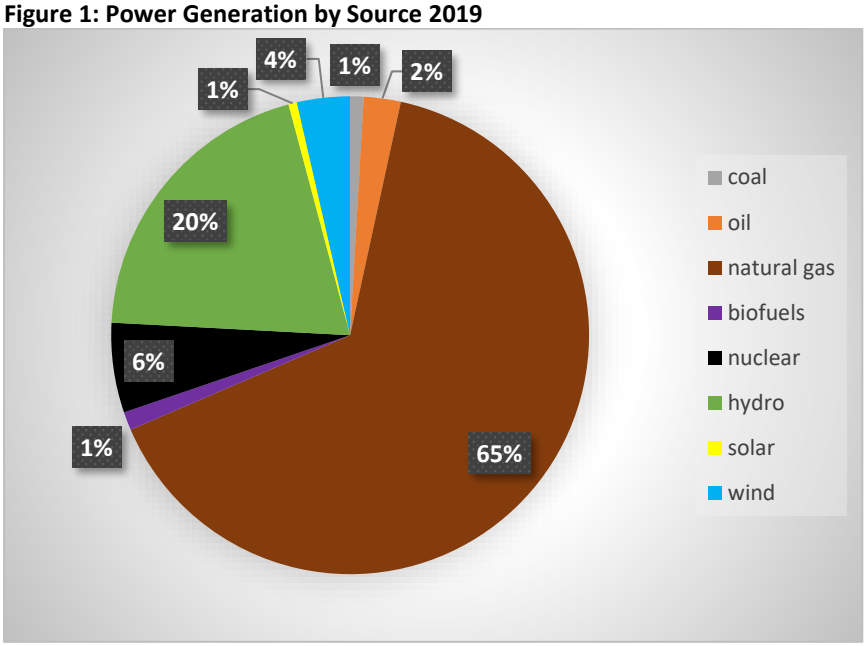
In Argentina, billing is composed of a fixed charge and a variable charge, both based on the monthly energy consumed. The value added tax is 21% and, depending on the jurisdiction, provincial and municipal taxes may be added, which increase the tax burden to approximately 32%. In addition to the residential use tariff, there is a residential use tariff with a social tariff and a residential use tariff for public welfare entities. The Social Tariff aims to take care of the most vulnerable sectors by granting them a discount on the cost of the service. Since 2019, each jurisdiction defines the Social Tariff according to the socioeconomic conditions of residential users. Tariff schemes vary among jurisdictions and while, in some of them, tariffs follow increasing blocks that benefit small consumers, in others, the blocks introduce distortions as smaller consumers face higher tariffs.

5. Power Sector

5.1. Electricity Generation

In 2019 25% of electricity was generated by renewables including hydropower (see figure below).

Figure 1: Power Generation by Source 2019

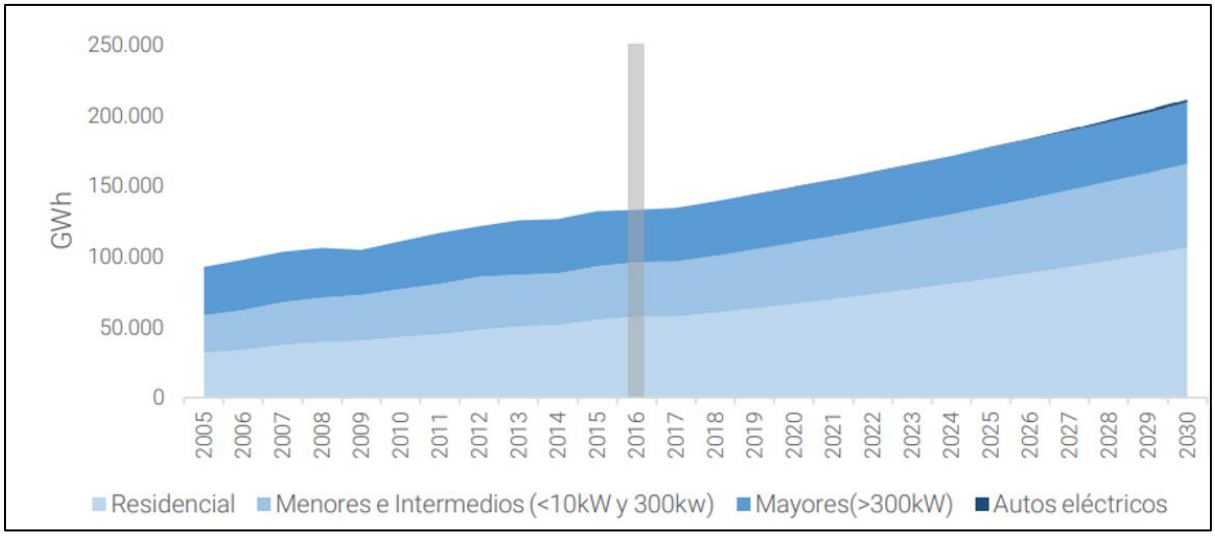


Source: IEA database

For 2030 a comparable the share of renewables including hydropower is expected to increase to 49%, nuclear from 6 to 13% and thermal to decrease from nearly 70% to 38% (MINEM, 2017 based on tendential scenario). This would green the grid factor considerably.

The following figure shows the projected demand increase in electricity usage for Argentina.

Figure 2: Projected Electricity Consumption Argentina (GWh)



Source: MINEM, 2017, Escenarios Energeticos 2030

5.2. 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[14]. 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) resources defined as power plants with low marginal generation costs or dispatched independently of the daily or seasonal load of the grid including primarily hydro, geothermal, wind, low-cost biomass, nuclear and solar generation and (ii) the non-inclusion of CDM projects in the CM. Especially the non-inclusion of LCMR resources result in misleading results.

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

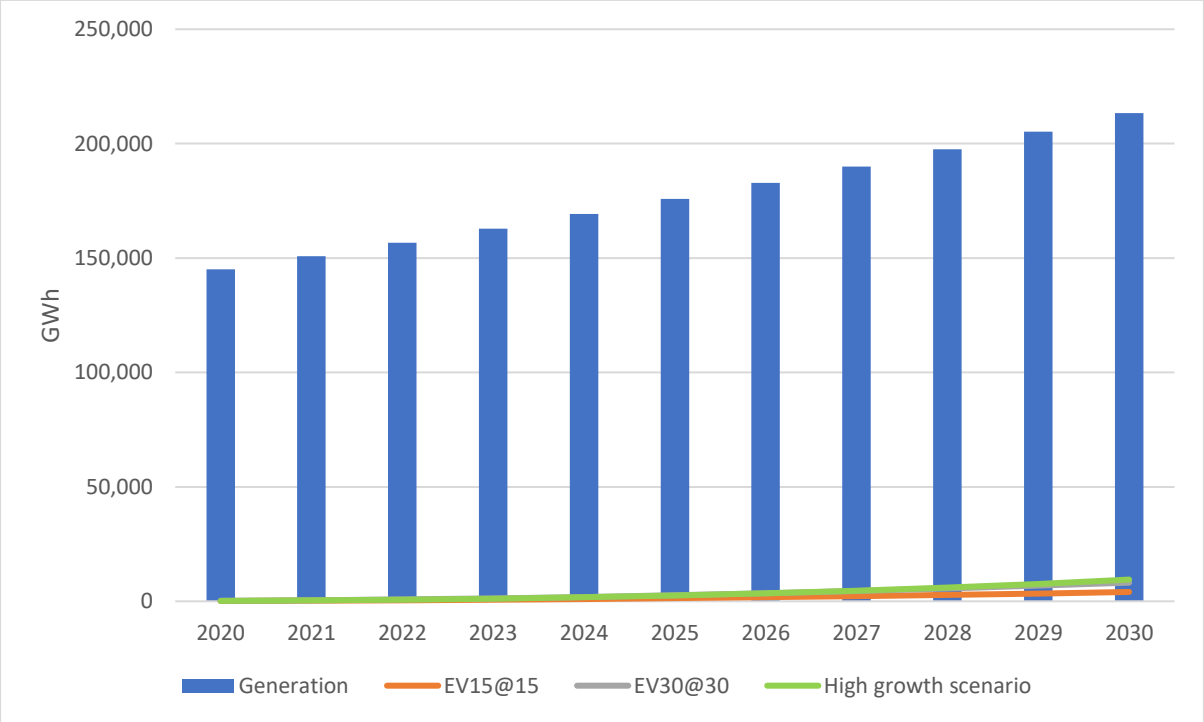
- Total electricity generation: 146,800 GWh
- Electricity losses: 23,676 GWh
- GHG emissions from electricity generation: 47,062,300 tCO_{2e}

The carbon factor of the electricity grid of Argentina is therefore: **0.382 $kgCO_2/kWh$**[15].

5.3. Electricity Sector and EVs

The following figure shows the projected electricity demand from EVs based on the three scenarios and the projected electricity generation of Argentina.

Figure 3: EV Electricity Demand versus Projected Electricity Consumption Argentina 2020-2030



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

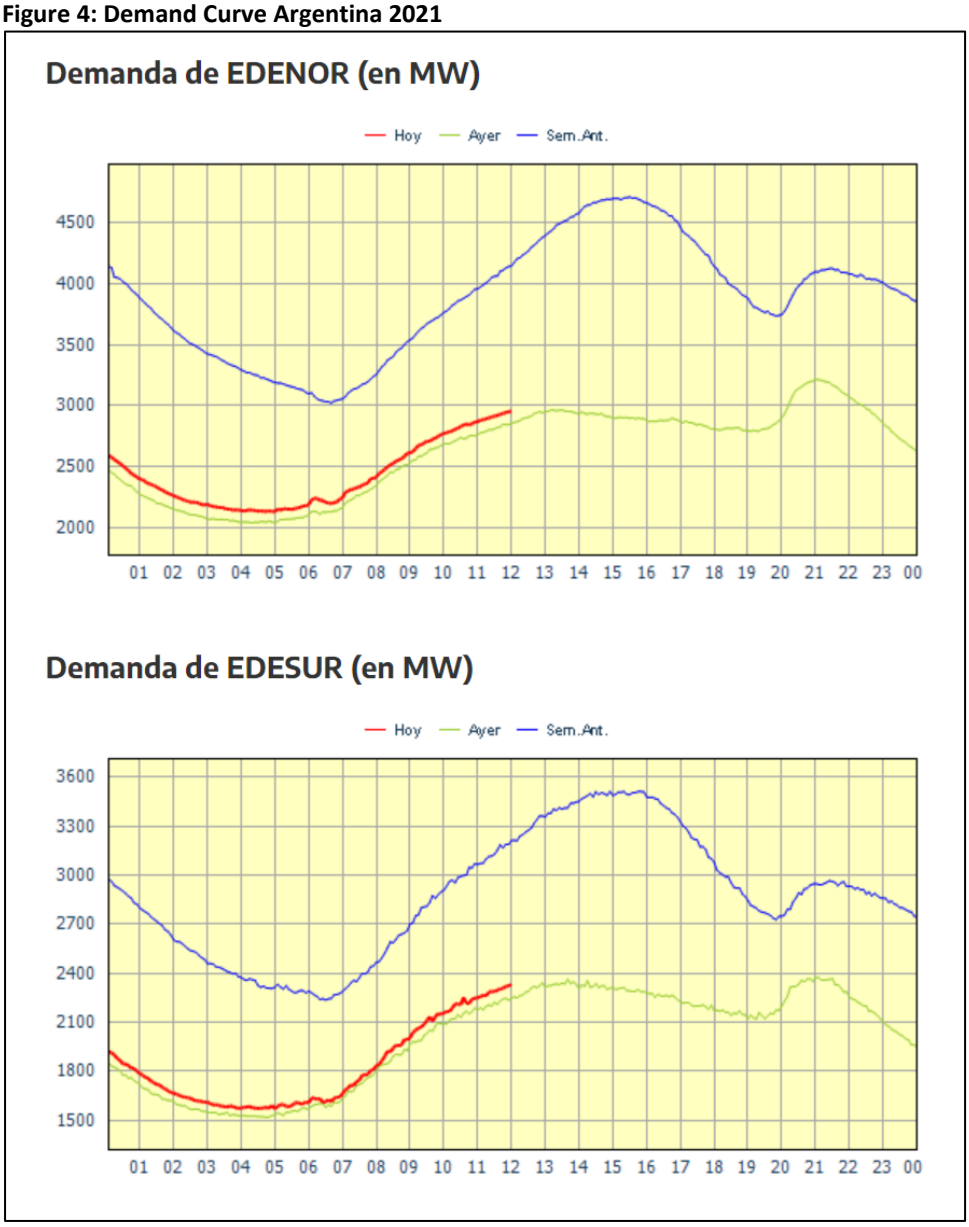
The 2030 electricity demand of EVs represents for the EV15@30 2%, and for the EV30@30 and the high growth scenario 4% of total expected generation. The demand increase is very gradual and thus leaves enough time to the country to plan a small production expansion required.

[14] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v6.pdf
[15] 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[16]. 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 Argentina.

Figure 4: Demand Curve Argentina 2021



Source: Curva de demanda eléctrica | Argentina.gob.ar

[16] 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 **Invalid source specified.**

The system has a pronounced peak between 1and 5PM and a smaller evening peak at 9-10PM.

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-charged buses are charged 1-2x per day during off-peak transport hours which also coincide with low demand times of the power sector and opportunity charged buses can easily be equipped with large-enough battery sets to run 2-3 hours without charging.

Taxi fast charging could basically be done outside the peak as well and fast chargers could apply significant differential pricing to avoid peak charging. Passenger cars and LCVs are basically charged overnight which minimises the need for incremental electricity generation capacity and investment in distribution infrastructure upgrades. 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 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.

6. Road Transport Emissions

6.1. Introduction

2019 nearly 19 million vehicles were operating in Argentina. As of January 1, 2018, all new heavy-duty vehicles and engines (light vehicles partially 1 year earlier) were required to comply with the Euro V standard. The Euro IV standard was adopted in 2011 but never implemented, so Argentina jumped directly from Euro III (implemented 2006 for HDVs and 2004 for light vehicles) to Euro V implementation. The Euro II standard was in force since the year 2000[17]. However sulfur levels sold in conventional fuel until recently matches more Euro I and II than Euro III (which requires 350ppm diesel fuel).

Since 04/2018 the emission standard Euro 4/IV is in force. Diesel fuel sold has various levels of sulphur ranging from 50ppm to over 2,000ppm. Currently the average is estimated to be between 500 and 2,000ppm (ICCT, 2019).

6.2. Road Transport Emissions

The following table shows operating vehicles of Argentina in 2019.

[17] Argentina: Heavy-duty: Emissions | Transport Policy

Table 3: Vehicles Operating in Argentina 2019

Vehicle category	gasoline	diesel	CNG	total
Passenger car	9,359,195	1,300,837	1,545,734	11,453,615
Taxi	15,886	23,829	169,656	209,371
Motorcycle	5,405,596			5,405,596
standard urban bus		31,640		31,640
coach		16,371		16,371
LCV	303,410	1,069,159		1,372,570
Truck < 7.5t		15,149		15,149
Truck 7.5-16t		85,844		85,844
Truck 16-32t		109,645		109,645
Truck >32t		222,613		222,613

Source: World Bank, 2020, PMR report

For 2019 emissions the average emission factor used for modelling purposes is Euro 2/II and for 2030 Euro 4/IV. Although Euro 3/III had been introduced vehicles could continue using Euro 1 and 2 fuels. The following table summarizes core assumptions on mileage and fuel consumption used for calculations[18].

Table 4: Main Parameters Used for Emission Calculations 2019

Vehicle category	Fuel	Fuel consumption in l/100km	Annual distance driven in km
Passenger Car	gasoline	7,0	8,500
	diesel	6,3	8,500
	CNG	6,3	8,500
Taxi	gasoline	8,2	50,000
	diesel	5,5	43,000
	CNG	6,3	43,000
Motorcycle	gasoline	1,6	6,000
Urban standard bus	diesel	40,5	65,000
Coach bus	diesel	24,7	90,000
LCV	Gasoline	7,0	20,000
	Diesel	8,0	20,000
Truck < 7.5t	Diesel	10,1	30,000
Truck 7.5-16t	Diesel	15,5	40,000
Truck 16-32t	Diesel	21,0	60,000
Truck >32t	Diesel	25,1	75,000

Source: World Bank, 2020, PMR report

The following table shows estimated 2019 road transport emissions for Argentina.

[18] 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 5: Estimated 2019 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	28,939	795	21,725,441	26,926,355	315,303
Taxi	1,345	66	1,757,032	2,421,044	27,346
Motorcycles	10,281	114	1,623,202	1,957,152	23,423
standard urban bus	22,006	452	2,654,729	3,530,001	35,826
coach	13,187	243	1,159,582	1,568,504	15,649
LCV	4,582	2,516	6,754,713	10,060,594	92,376
Truck < 7.5t	1,586	28	146,256	196,112	1,974
Truck 7.5-16t	18,886	357	1,695,853	2,294,810	22,886
Truck 16-32t	52,038	1,020	4,401,959	6,010,934	59,406
Truck >32t	156,274	3,239	13,352,795	18,318,764	180,200
Total	**309,123**	**8,830**	**55,271,562**	**73,284,271**	**774,388**

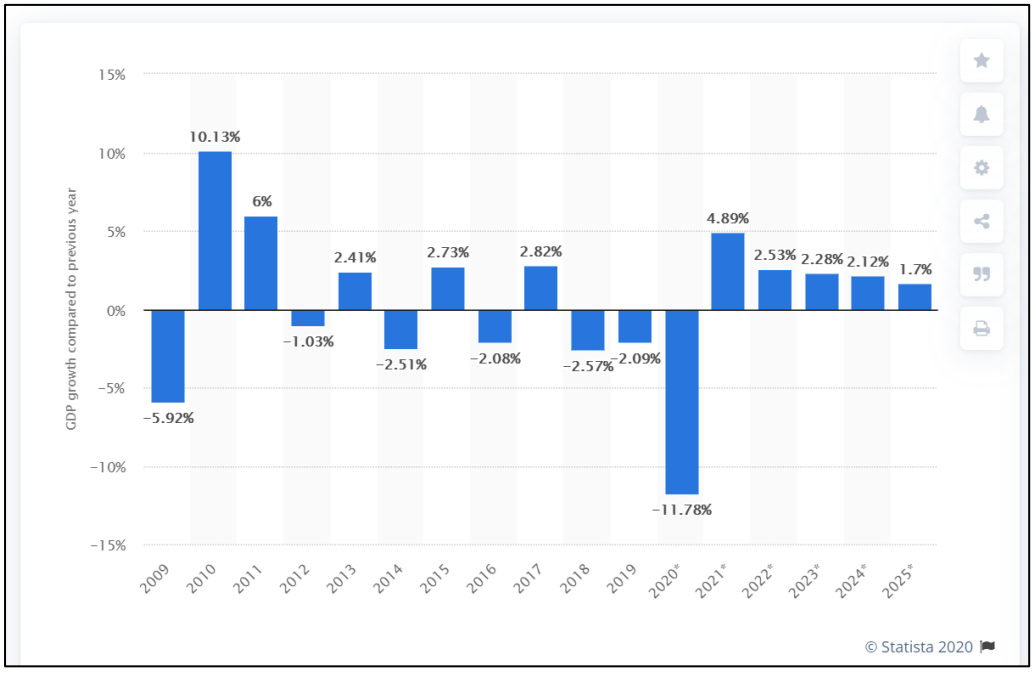
Source: Grutter Consulting; for details of modelling data see Annex 1

Road transport GHG emissions of Argentina TTW in 2019 were 55 million tCO_{2e}. WTW GHG emissions of 73 million tCO_{2e} reflect the GHG emissions caused directly and indirectly by the road transportation sector of Argentina. Taking into account the 12% bio-ethanol share (based on resolution 37/2016 of MINEM) and the 10% biodiesel share (based on Resolution 1125/2013 of SEA) and assuming 0 TTW emissions of these biofuels the TTW GHG emissions are 50 $MtCO_{2e}$ in 2019. Commercial vehicles (buses, LCVs and taxis) represent 24% of emissions.

6.3. Projected 2030 Transport Emissions

For 2030 projections an elasticity or growth factor per vehicle category was determined. The following graph shows the projected medium-term GDP growth rate in real terms of Argentina including the recent COVID-19 impact followed by a table showing data relevant for calculation of the projected vehicle numbers in the country.

Figure 5: Medium Term Real GDP Growth Rate



Source: Statista

Table 6: Parameters for Projection of Vehicle Numbers and Emissions

Parameter	Value	Source/Explanation
CAGR population growth 2020-2030	0.8%	World Bank and Euromonitor
CAGR GDP real growth 2019-2030	0.9%	Statista CAGR 2020 to 2025 with assumed constant values 2025 to 2030
CAGR GDP per capita growth 2019-2030	0.1%	Calculated from GDP and population growth rate
CAGR freight transport growth rate	0.9%	Freight intensity of 0.98[19] based on income per capita 2030 (PPP) of 6,200 USD using 2019 data from the World Bank and the real GDP growth rate
CAGR public transport	0.8%	Based on population growth
CAGR passenger transport	1.0%	Based on Gomperz function with α of -3 and β of -0.00013 with a saturation level of 590 vehicles per 1,000 population[20]

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 Argentina.

Table 7: 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	13,416	502	24,285,228	29,884,334	352,453
Taxi	1,175	46	1,964,054	2,688,963	30,568
Motorcycles	7,033	127	1,814,455	2,187,753	26,183
standard urban bus	12,228	104	2,669,596	3,353,960	36,027
coach	7,306	57	1,272,082	1,603,283	17,167
LCV	19,999	971	7,439,734	9,848,650	101,744
Truck < 7.5t	821	5	161,088	201,720	2,174
Truck 7.5-16t	10,022	61	1,867,836	2,338,539	25,207
Truck 16-32t	27,752	173	4,848,379	6,080,400	65,430
Truck >32t	84,774	493	14,706,953	18,422,212	198,474
Total	**184,527**	**2,539**	**61,029,405**	**76,609,815**	**855,427**

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 10% reaching 61 million tCO_2 by 2030 (77 million tCO_{2e} with a WTW approach; 55 $MtCO_{2e}$ TTW assuming constant biofuel shares).

7. EV Scenarios

3 different EV scenarios have been constructed which are contrasted with the BAU scenario:

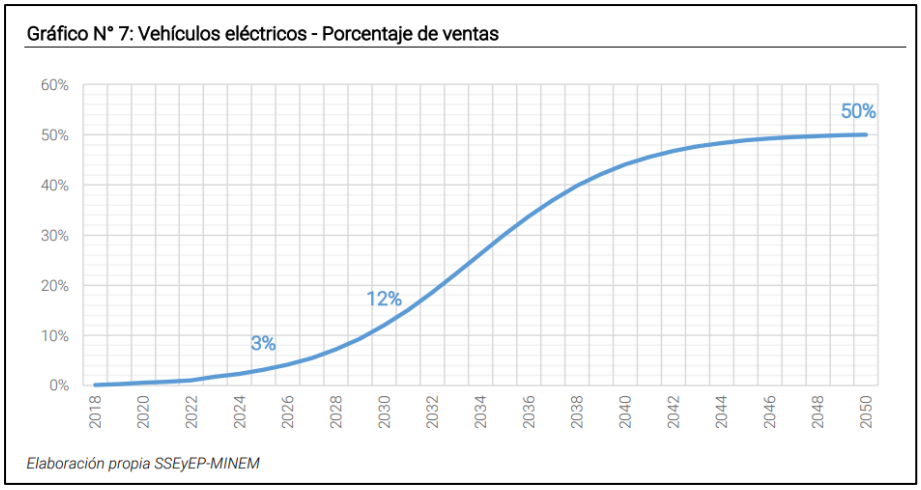
- EV30@30: The EV30@30 scenario of IEA has as target that 30% of all vehicles sold in 2030 are electric. The scenario is built on newly purchased vehicles (and not the stock of vehicles) in line with IEA scenarios (IEA, 2019). In addition to the IEA also motorcycles and trucks <7.5t are included with the same EV penetration rates.

[19] Freight intensity rates based on groupings; see Annex
[20] Saturation level based on Japanese pattern; parameters calculated by Grutter Consulting

- 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 “high growth” scenario focusing on the potential for commercial vehicles targeted by the e-mobility fund with an EV target of 100% of new registered vehicles for these categories by 2030. In all other vehicle categories the maximum of the 3 other scenarios has been chosen.

Argentina has a target which is a bit below the scenario EV15@30 as can be seen from the following graph.

Figure 6: EV Projections Argentina



Source: MINEM, 2017, Escenarios Energeticos 2030

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 8: Average Lifespan and Replacement Rate per Vehicle Category Argentina

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

Source: assumption of author

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 9: 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

EV High Growth Scenario

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

Table 10: 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 11: Scenario Results

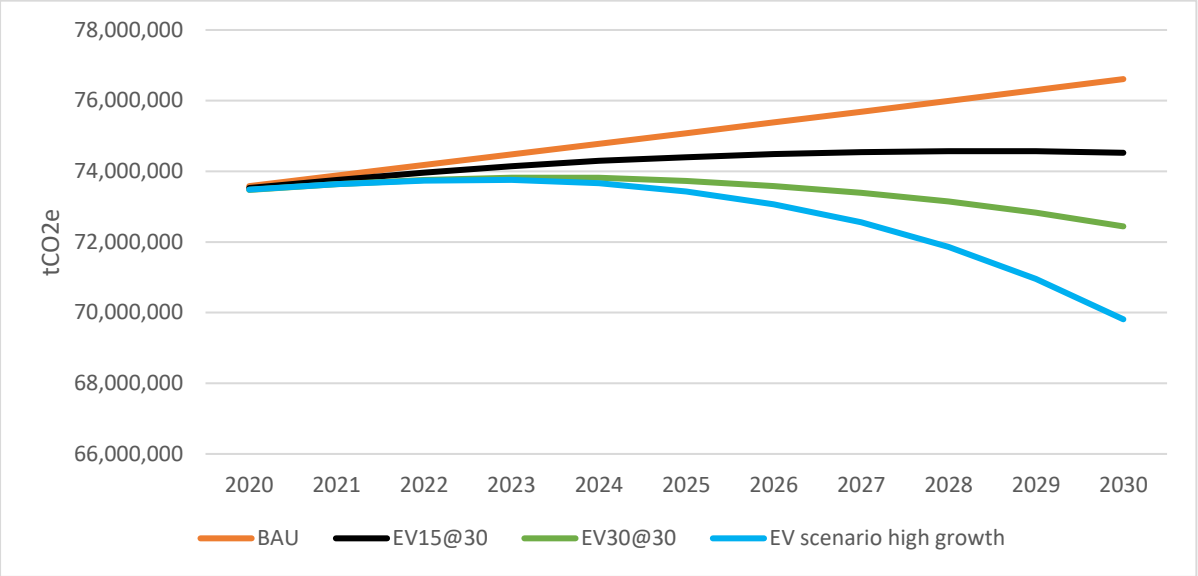
Impact	Scenario	By 2025	By 2030
GHG reduction WTW in tCO_{2e} per annum	IEA 15@30	680,000	2,080,000
	IEA30@30	1,360,000	4,170,000
	"High growth" scenario	1,650,000	6,800,000
Electricity demand of EVs in GWh per annum	IEA 15@30	1,330	4,070
	IEA30@30	2,650	8,140
	"High growth" scenario	2,560	9,500

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 9% reduction of GHGs relative to the baseline. The "high growth" and the EV30@30 scenario result in a trend change in this period and result in GHG transportation emissions in 2030 being lower 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 7: Projected GHG Transport Emissions Argentina BAU and with EV Scenarios (WTW)



Source: Grutter Consulting

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

Table 12: Projected GHG Reductions for Taxis "High Growth Scenario"

Taxis High Potential	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all taxis	211,502	213,654	215,829	218,025	220,244	222,486	224,750	227,037	229,348	231,682	234,040
Replacement taxis	20,937	21,150	21,365	21,583	21,803	22,024	22,249	22,475	22,704	22,935	23,168
Additional new taxis	2,131	2,153	2,174	2,197	2,219	2,241	2,264	2,287	2,311	2,334	2,358
EV taxi fleet new	0	152	900	1,878	3,328	5,323	7,930	11,215	15,244	20,082	25,526
EV taxi fleet stock	0	152	1,052	2,930	6,258	11,581	19,510	30,725	45,969	66,050	91,577
EV taxi as % of stock	0%	0%	0%	1%	3%	5%	9%	14%	20%	29%	39%
GHG reduction WTW in tons	0	1,738	12,052	33,562	71,691	132,672	223,516	351,996	526,632	756,693	1,049,127
Electricity demand GWh	0.0	1.4	9.5	26.4	56.3	104.2	175.6	276.5	413.7	594.5	824.2

Source: Grutter Consulting

Table 13: Projected GHG Reductions for Urban Buses "High Growth Scenario"

Urban bus high growth	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	31,907	32,177	32,449	32,723	33,000	33,279	33,560	33,844	34,130	34,419	34,710
Replacement vehicles	2,109	2,127	2,145	2,163	2,182	2,200	2,219	2,237	2,256	2,275	2,295
Additional new vehicles	267	270	272	274	277	279	281	284	286	289	291
EV vehicle fleet new	0	126	92	192	341	544	809	1,142	1,549	2,038	2,586
EV vehicle fleet stock	0	126	219	411	752	1,295	2,104	3,246	4,795	6,833	9,418
EV fleet as % of stock	0%	0%	1%	1%	2%	4%	6%	10%	14%	20%	27%
GHG reduction WTW in tons	0	9,059	15,695	29,511	53,960	92,995	151,046	233,007	344,223	490,485	676,084
Electricity demand GWh	0.0	8.2	14.2	26.7	48.9	84.2	136.8	211.0	311.7	444.1	612.2

Source: Grutter Consulting

Table 14: Projected GHG Reductions for LCVs "High Growth Scenario"

LCV high growth	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	1,384,676	1,396,888	1,409,209	1,421,638	1,434,177	1,446,826	1,459,587	1,472,461	1,485,448	1,498,550	1,511,767
Replacement vehicles	68,628	69,234	69,844	70,460	71,082	71,709	72,341	72,979	73,623	74,272	74,927
Additional new vehicles	12,106	12,213	12,321	12,429	12,539	12,649	12,761	12,874	12,987	13,102	13,217
EV vehicle fleet new	0	48	3,142	6,545	11,586	18,505	27,530	38,882	52,780	69,437	88,145
EV vehicle fleet stock	0	48	3,190	9,735	21,321	39,825	67,355	106,237	159,018	228,455	316,600
EV fleet as % of stock	0%	0%	0%	1%	1%	3%	5%	7%	11%	15%	21%
GHG reduction WTW in tons	0	171	11,448	34,935	76,513	142,919	241,712	381,247	570,656	819,842	1,136,161
Electricity demand GWh	0.0	0.2	12.8	38.9	85.3	159.3	269.4	424.9	636.1	913.8	1266.4

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 15: Key Figures Commercial Vehicles EV "Potential Scenario"

Parameter	Taxis	Urban Buses	LCVs	Total
EV stock 2025 (% of all vehicles)	11,600 (5%)	1,300 (4%)	40,000 (3%)	53,000
EV Stock 2030 (% of all vehicles)	92,000 (39%)	9,400 (27%)	316,000 (21%)	418,000
GHG impact 2025	133,000	93,000	143,000	369,000
GHG impact 2030	1,049,000	676,000	1,136,000	2,861,000
$PM_{2.5}$ reduction 2030 (tons)	18	28	203	250
NO_x reduction 2030 (tons)	460	3,318	4,188	7,966
Savings emission costs in 2030 (MUSD)	49	45	121	215
Savings in pollutants costs in 2030 (MUSD)	7 MUSD	17	76 MUSD	100 MUSD
Vehicle CAPEX 2025 (cumulative)	710 MUSD	310 MUSD	910 MUSD	1,900 MUSD
Vehicle CAPEX 2030 (cumulative)	2,040 MUSD	1,940 MUSD	6,600 MUSD	10,600 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 Argentina would have more than 400,000 commercial EVs by 2030 reducing 2.9 million tCO_2. The estimated cumulative vehicle investment required by 2025 is around 2 billion USD and 11 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 220 MUSD (annual figure) of which around 50% is due to savings on less local pollutants and the other 50% due to reduced GHG emissions.

8. Enablers and Barriers

Barriers:

- Two main barriers to the implementation of electric buses are identified: i) the cost of the initial investment in the bus and its financing conditions; ii) the cost of the associated infrastructure (charging station). Charging infrastructure is still scarce.
- By having a reliance of 87% on fossil fuel for the energy sector and big CNG reserves to exploit, Argentina faces challenges on adding renewable sources to their electricity matrix. Having these fossil resources, based on initial meetings, the Ministry of Transportation has a clear position in favor of CNG buses. Not having a common position amongst stakeholders, has hindered the process towards a consistent e-mobility policy.
- Even more recent official papers such as the NDC 2020, do not cite e-mobility as a way of lowering the GHG emissions in the country. The EV targets cited by MINEM are far below the international recommendations.

Enablers:

- In 2016 Argentina already implemented a tax reduction for electric and hybrid vehicles and charging stations. The Electric Vehicle Mobility Law will be put into practice, at the beginning of 2021. These legal and financial steps are the beginning of a wider implementation of EVs.
- Electric public transport pilot tests in Mendoza and Buenos Aires are taking place. They will familiarize the local governments and public of the capacity, benefits and risks regarding an all-electric bus fleet.

- Private businesses are approaching electric mobility. The oil refining company YPF will set up 220 points for fast chargers.
- From an industrial point of view, having their own lithium reserves and an established vehicle producing industry, Argentina is in position to create their own electric vehicles at a competitive price.
- There is a high potential to produce energy from renewable sources, Argentina is well positioned to adopt technologies that take advantage of this clean energy.
- With the “Plan de acción nacional de transporte y cambio climático” for the reduction of greenhouse gasses, Argentina promises to implement technologies of low or no emissions. This paves the way for the introduction of electric vehicles.
- There are pilots in Buenos Aires that are looking into the conversion of diesel buses into electric buses locally.

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Annex: Detailed Data

Vehicle Data

Vehicle category	gasoline	diesel	CNG	total
Passenger car	9,359,195	1,300,837	1,545,734	11,453,615
Taxi	15,886	23,829	169,656	209,371
Motorcycle	5,405,596			5,405,596
standard urban bus		31,640		31,640
coach		16,371		16,371
LCV	303,410	1,069,159		1,372,570
Truck < 7.5t		15,149		15,149
Truck 7.5-16t		85,844		85,844
Truck 16-32t		109,645		109,645
Truck >32t		222,613		222,613
Source: WB, 2020, PMR, passenger car incl. private "utilitarios"				
Year of data	2019			18,922,414
Country	Argentina			
GDP growth rate	0.9%			
take from country values				
Carbon grid factor	0.382			
take from country values				
Growth rate freight transport	0.9%			
See below				
Bus, coach growth	0.8%			
based on growth population				
Passenger car, MC, taxi growth	1.0%			

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	-3
β	-0.00013
vehicl pop 2030	12,803,130
CAGR	1.0%
Based on OECD pattern, see source above	
GDP per capita 2019	9912
GDP per capital 2030	9972
GDP per capita (current US$) - Ecuador | Data (worldbank.org)	
Projected population 2(	49.3
Population 2019	44.94
CAGR	0.8%
WB	

2019					
Vehicle category	**NO_x**	**$PM_{2.5}$**	**CO_2 TTW**	**CO_2 WTW**	**Energy in TJ**
Passenger car	28,939	795	21,725,441	26,926,355	315,303
Taxi	1,345	66	1,757,032	2,421,044	27,346
Motorcycles	10,281	114	1,623,202	1,957,152	23,423
standard urban bus	22,006	452	2,654,729	3,530,001	35,826
coach	13,187	243	1,159,582	1,568,504	15,649
LCV	4,582	2,516	6,754,713	10,060,594	92,376
Truck < 7.5t	1,586	28	146,256	196,112	1,974
Truck 7.5-16t	18,886	357	1,695,853	2,294,810	22,886
Truck 16-32t	52,038	1,020	4,401,959	6,010,934	59,406
Truck >32t	156,274	3,239	13,352,795	18,318,764	180,200
Total	**309,123**	**8,830**	**55,271,562**	**73,284,271**	**774,388**
with biofuels			**49,727,962**		

2030					
Vehicle category	**NO_x**	**$PM_{2.5}$**	**CO_2 TTW**	**CO_2 WTW**	**Energy in MJ**
Passenger car	13,416	502	24,285,228	29,884,334	352,453
Taxi	1,175	46	1,964,054	2,688,963	30,568
Motorcycles	7,033	127	1,814,455	2,187,753	26,183
standard urban bus	12,228	104	2,669,596	3,353,960	36,027
coach	7,306	57	1,272,082	1,603,283	17,167
LCV	19,999	971	7,439,734	9,848,650	101,744
Truck < 7.5t	821	5	161,088	201,720	2,174
Truck 7.5-16t	10,022	61	1,867,836	2,338,539	25,207
Truck 16-32t	27,752	173	4,848,379	6,080,400	65,430
Truck >32t	84,774	493	14,706,953	18,422,212	198,474
Total	**184,527**	**2,539**	**61,029,405**	**76,609,815**	**855,427**
with biofuels			**54,936,026**		

Emission costs	**2019**	**2030**
Pollutants	2,909	1,283
GHG	2,931	3,064
Total	**5,840**	**4,347**
in MUSD of 2019		

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%

High Potential 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	11,570,182	11,687,935	11,806,886	11,927,048	12,048,433	12,171,054	12,294,922	12,420,051	12,546,453	12,674,142	12,803,130
Replacement cars	572,681	578,509	584,397	590,344	596,352	602,422	608,553	614,746	621,003	627,323	633,707
Additional new cars	116,567	117,753	118,951	120,162	121,385	122,620	123,868	125,129	126,402	127,689	128,988
EV car fleet new	17,381	22,603	29,392	38,221	49,703	64,633	72,452	81,217	91,043	102,057	114,404
EV car fleet stock	17,381	39,984	69,376	107,598	157,300	221,933	294,385	375,602	466,645	568,702	683,107
EV fleet as % of stock	0%	0%	1%	1%	1%	2%	2%	3%	4%	4%	5%
GHG reduction WTW in tons	27,452	63,151	109,573	169,940	248,441	350,522	464,953	593,228	737,021	898,211	1,078,902
Electricity demand GWh	26.6	61.2	106.1	164.6	240.7	339.6	450.4	574.7	714.0	870.1	1045.2

Passenger cars S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all cars	11,570,182	11,687,935	11,806,886	11,927,048	12,048,433	12,171,054	12,294,922	12,420,051	12,546,453	12,674,142	12,803,130
Replacement cars	572,681	578,509	584,397	590,344	596,352	602,422	608,553	614,746	621,003	627,323	633,707
Additional new cars	116,567	117,753	118,951	120,162	121,385	122,620	123,868	125,129	126,402	127,689	128,988
EV car fleet new	34,763	45,205	58,784	76,443	99,405	129,265	144,904	162,434	182,086	204,115	228,809
EV car fleet stock	34,763	79,968	138,753	215,195	314,600	443,866	588,770	751,204	933,290	1,137,405	1,366,213
EV fleet as % of stock	0%	1%	1%	2%	3%	4%	5%	6%	7%	9%	11%
GHG reduction WTW in tons	54,905	126,302	219,147	339,880	496,881	701,044	929,906	1,186,455	1,474,043	1,796,423	2,157,804
Electricity demand GWh	53.2	122.4	212.3	329.2	481.3	679.1	900.8	1149.3	1427.9	1740.2	2090.3

Taxis S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all taxis	211,502	213,654	215,829	218,025	220,244	222,486	224,750	227,037	229,348	231,682	234,040
Replacement taxis	20,937	21,150	21,365	21,583	21,803	22,024	22,249	22,475	22,704	22,935	23,168
Additional new taxis	2,131	2,153	2,174	2,197	2,219	2,241	2,264	2,287	2,311	2,334	2,358
EV taxi fleet new	582	756	984	1,279	1,663	2,163	2,425	2,718	3,047	3,416	3,829
EV taxi fleet stock	582	1,338	2,322	3,601	5,265	7,428	9,853	12,571	15,618	19,033	22,862
EV taxi as % of stock	0%	1%	1%	2%	2%	3%	4%	6%	7%	8%	10%
GHG reduction WTW in tons	6,664	15,331	26,600	41,255	60,312	85,094	112,874	144,014	178,922	218,053	261,918
Electricity demand GWh	5.2	12.0	20.9	32.4	47.4	66.8	88.7	113.1	140.6	171.3	205.8

Taxis S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all taxis	211,502	213,654	215,829	218,025	220,244	222,486	224,750	227,037	229,348	231,682	234,040
Replacement taxis	20,937	21,150	21,365	21,583	21,803	22,024	22,249	22,475	22,704	22,935	23,168
Additional new taxis	2,131	2,153	2,174	2,197	2,219	2,241	2,264	2,287	2,311	2,334	2,358
EV taxi fleet new	1,163	1,513	1,967	2,558	3,327	4,326	4,850	5,436	6,094	6,831	7,658
EV taxi fleet stock	1,163	2,676	4,644	7,202	10,529	14,855	19,705	25,142	31,236	38,067	45,725
EV taxi as % of stock	1%	1%	2%	3%	5%	7%	9%	11%	14%	16%	20%
GHG reduction WTW in tons	13,329	30,662	53,201	82,511	120,625	170,188	225,747	288,028	357,844	436,106	523,837
Electricity demand GWh	10.5	24.1	41.8	64.8	94.8	133.7	177.3	226.3	281.1	342.6	411.5

Taxis High Potential	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all taxis	211,502	213,654	215,829	218,025	220,244	222,486	224,750	227,037	229,348	231,682	234,040
Replacement taxis	20,937	21,150	21,365	21,583	21,803	22,024	22,249	22,475	22,704	22,935	23,168
Additional new taxis	2,131	2,153	2,174	2,197	2,219	2,241	2,264	2,287	2,311	2,334	2,358
EV taxi fleet new	0	152	900	1,878	3,328	5,323	7,930	11,215	15,244	20,082	25,526
EV taxi fleet stock	0	152	1,052	2,930	6,258	11,581	19,510	30,725	45,969	66,050	91,577
EV taxi as % of stock	0%	0%	0%	1%	3%	5%	9%	14%	20%	29%	39%
GHG reduction WTW in tons	0	1,738	12,052	33,562	71,691	132,672	223,516	351,996	526,632	756,693	1,049,127

Motorcycle S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all MC	5,460,610	5,516,184	5,572,324	5,629,035	5,686,324	5,744,195	5,802,655	5,861,711	5,921,367	5,981,630	6,042,507
Replacement MC	675,700	682,576	689,523	696,541	703,629	710,790	718,024	725,332	732,714	740,171	747,704
Additional new MC	55,014	55,574	56,140	56,711	57,288	57,871	58,460	59,055	59,656	60,263	60,877
EV MC fleet new	18,427	23,962	31,161	40,521	52,693	68,521	76,811	86,103	96,520	108,197	121,287
EV MC fleet stock	18,427	42,390	73,550	114,071	166,764	235,285	312,096	398,199	494,719	602,917	724,204
EV fleet as % of stock	0%	1%	1%	2%	3%	4%	5%	7%	8%	10%	12%
GHG reduction WTW in tons	5,615	12,917	22,413	34,760	50,817	71,697	95,103	121,341	150,753	183,724	220,683
Electricity demand GWh	2.8	6.4	11.0	17.1	25.0	35.3	46.8	59.7	74.2	90.4	108.6

Motorcycle S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all MC	5,460,610	5,516,184	5,572,324	5,629,035	5,686,324	5,744,195	5,802,655	5,861,711	5,921,367	5,981,630	6,042,507
Replacement MC	675,700	682,576	689,523	696,541	703,629	710,790	718,024	725,332	732,714	740,171	747,704
Additional new MC	55,014	55,574	56,140	56,711	57,288	57,871	58,460	59,055	59,656	60,263	60,877
EV MC fleet new	36,854	47,925	62,321	81,042	105,386	137,042	153,622	172,207	193,040	216,395	242,574
EV MC fleet stock	36,854	84,779	147,100	228,142	333,527	470,569	624,191	796,398	989,438	1,205,833	1,448,407
EV fleet as % of stock	1%	2%	3%	4%	6%	8%	11%	14%	17%	20%	24%
GHG reduction WTW in tons	11,230	25,834	44,825	69,521	101,634	143,394	190,207	242,682	301,507	367,448	441,366
Electricity demand GWh	5.5	12.7	22.1	34.2	50.0	70.6	93.6	119.5	148.4	180.9	217.3

Urban bus standard S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	31,907	32,177	32,449	32,723	33,000	33,279	33,560	33,844	34,130	34,419	34,710
Replacement vehicles	2,109	2,127	2,145	2,163	2,182	2,200	2,219	2,237	2,256	2,275	2,295
Additional new vehicles	267	270	272	274	277	279	281	284	286	289	291
EV vehicle fleet new	60	78	101	131	170	221	247	277	310	347	388
EV vehicle fleet stock	60	138	239	370	540	761	1,008	1,285	1,595	1,941	2,329
EV fleet as % of stock	0%	0%	1%	1%	2%	2%	3%	4%	5%	6%	7%
GHG reduction WTW in tons	4,303	9,888	17,139	26,552	38,771	54,634	72,386	92,252	114,482	139,360	167,200
Electricity demand GWh	3.9	9.0	15.5	24.0	35.1	49.5	65.5	83.5	103.7	126.2	151.4

Urban bus standard S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	31,907	32,177	32,449	32,723	33,000	33,279	33,560	33,844	34,130	34,419	34,710
Replacement vehicles	2,109	2,127	2,145	2,163	2,182	2,200	2,219	2,237	2,256	2,275	2,295
Additional new vehicles	267	270	272	274	277	279	281	284	286	289	291
EV vehicle fleet new	120	156	202	262	340	442	495	553	619	693	776
EV vehicle fleet stock	120	275	478	740	1,080	1,522	2,017	2,570	3,190	3,883	4,658
EV fleet as % of stock	0%	1%	1%	2%	3%	5%	6%	8%	9%	11%	13%
GHG reduction WTW in tons	8,605	19,776	34,278	53,104	77,543	109,269	144,772	184,503	228,965	278,720	334,400
Electricity demand GWh	7.8	17.9	31.0	48.1	70.2	98.9	131.1	167.1	207.3	252.4	302.8

Urban bus high growth	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	31,907	32,177	32,449	32,723	33,000	33,279	33,560	33,844	34,130	34,419	34,710
Replacement vehicles	2,109	2,127	2,145	2,163	2,182	2,200	2,219	2,237	2,256	2,275	2,295
Additional new vehicles	267	270	272	274	277	279	281	284	286	289	291
EV vehicle fleet new	0	126	92	192	341	544	809	1,142	1,549	2,038	2,586
EV vehicle fleet stock	0	126	219	411	752	1,295	2,104	3,246	4,795	6,833	9,418
EV fleet as % of stock	0%	0%	1%	1%	2%	4%	6%	10%	14%	20%	27%
GHG reduction WTW in tons	0	9,059	15,695	29,511	53,960	92,995	151,046	233,007	344,223	490,485	676,084
Electricity demand GWh	0.0	8.2	14.2	26.7	48.9	84.2	136.8	211.0	311.7	444.1	612.2

Coach S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	16,509	16,649	16,790	16,932	17,075	17,219	17,365	17,511	17,659	17,809	17,959
Replacement vehicles	1,091	1,101	1,110	1,119	1,129	1,138	1,148	1,158	1,167	1,177	1,187
Additional new vehicles	138	140	141	142	143	144	146	147	148	149	151
EV vehicle fleet new	31	40	52	68	88	114	128	143	160	179	201
EV vehicle fleet stock	31	71	124	191	279	394	522	665	825	1,005	1,205
EV fleet as % of stock	0%	0%	1%	1%	2%	2%	3%	4%	5%	6%	7%
GHG reduction WTW in tons	1,702	3,911	6,779	10,502	15,335	21,609	28,630	36,487	45,280	55,119	66,130
Electricity demand GWh	2.8	6.4	11.1	17.2	25.2	35.4	47.0	59.8	74.3	90.4	108.5

Coach S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	16,509	16,649	16,790	16,932	17,075	17,219	17,365	17,511	17,659	17,809	17,959
Replacement vehicles	1,091	1,101	1,110	1,119	1,129	1,138	1,148	1,158	1,167	1,177	1,187
Additional new vehicles	138	140	141	142	143	144	146	147	148	149	151
EV vehicle fleet new	62	81	105	136	176	229	256	286	320	359	401
EV vehicle fleet stock	62	143	247	383	559	788	1,044	1,330	1,650	2,009	2,410
EV fleet as % of stock	0%	1%	1%	2%	3%	5%	6%	8%	9%	11%	13%
GHG reduction WTW in tons	3,403	7,822	13,557	21,003	30,669	43,218	57,260	72,974	90,559	110,238	132,261
Electricity demand GWh	5.6	12.8	22.2	34.4	50.3	70.9	93.9	119.7	148.5	180.8	216.9

LCV S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	1,384,676	1,396,888	1,409,209	1,421,638	1,434,177	1,446,826	1,459,587	1,472,461	1,485,448	1,498,550	1,511,767
Replacement vehicles	68,628	69,234	69,844	70,460	71,082	71,709	72,341	72,979	73,623	74,272	74,927
Additional new vehicles	12,106	12,213	12,321	12,429	12,539	12,649	12,761	12,874	12,987	13,102	13,217
EV vehicle fleet new	2,036	2,644	3,434	4,459	5,791	7,520	8,418	9,424	10,550	11,811	13,222
EV vehicle fleet stock	2,036	4,680	8,114	12,573	18,363	25,883	34,302	43,726	54,276	66,087	79,308
EV fleet as % of stock	0%	0%	1%	1%	1%	2%	2%	3%	4%	4%	5%
GHG reduction WTW in tons	7,306	16,795	29,117	45,118	65,899	92,885	123,096	156,916	194,777	237,161	284,608
Electricity demand GWh	8.1	18.7	32.5	50.3	73.5	103.5	137.2	174.9	217.1	264.3	317.2

LCV S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	1,384,676	1,396,888	1,409,209	1,421,638	1,434,177	1,446,826	1,459,587	1,472,461	1,485,448	1,498,550	1,511,767
Replacement vehicles	68,628	69,234	69,844	70,460	71,082	71,709	72,341	72,979	73,623	74,272	74,927
Additional new vehicles	12,106	12,213	12,321	12,429	12,539	12,649	12,761	12,874	12,987	13,102	13,217
EV vehicle fleet new	4,072	5,288	6,867	8,918	11,581	15,040	16,837	18,848	21,100	23,621	26,443
EV vehicle fleet stock	4,072	9,360	16,227	25,145	36,726	51,766	68,603	87,452	108,552	132,173	158,617
EV fleet as % of stock	0%	1%	1%	2%	3%	4%	5%	6%	7%	9%	10%
GHG reduction WTW in tons	14,613	33,589	58,233	90,237	131,798	185,770	246,192	313,832	389,553	474,321	569,217
Electricity demand GWh	16.3	37.4	64.9	100.6	146.9	207.1	274.4	349.8	434.2	528.7	634.5

LCV high growth	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	1,384,676	1,396,888	1,409,209	1,421,638	1,434,177	1,446,826	1,459,587	1,472,461	1,485,448	1,498,550	1,511,767
Replacement vehicles	68,628	69,234	69,844	70,460	71,082	71,709	72,341	72,979	73,623	74,272	74,927
Additional new vehicles	12,106	12,213	12,321	12,429	12,539	12,649	12,761	12,874	12,987	13,102	13,217
EV vehicle fleet new	0	48	3,142	6,545	11,586	18,505	27,530	38,882	52,780	69,437	88,145
EV vehicle fleet stock	0	48	3,190	9,735	21,321	39,825	67,355	106,237	159,018	228,455	316,600
EV fleet as % of stock	0%	0%	0%	1%	1%	3%	5%	7%	11%	15%	21%
GHG reduction WTW in tons	0	171	11,448	34,935	76,513	142,919	241,712	381,247	570,656	819,842	1,136,161
Electricity demand GWh	0.0	0.2	12.8	38.9	85.3	159.3	269.4	424.9	636.1	913.8	1266.4

Truck <7.5t S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	15,283	15,417	15,553	15,691	15,829	15,969	16,109	16,251	16,395	16,539	16,685
Replacement vehicles	757	764	771	778	785	791	798	805	813	820	827
Additional new vehicles	134	135	136	137	138	140	141	142	143	145	146
EV vehicle fleet new	22	29	38	49	64	83	93	104	116	130	146
EV vehicle fleet stock	22	52	90	139	203	286	379	483	599	729	875
EV fleet as % of stock	0%	0%	1%	1%	1%	2%	2%	3%	4%	4%	5%
GHG reduction WTW in tons	127	293	508	787	1,149	1,619	2,146	2,735	3,395	4,134	4,961
Electricity demand GWh	0.4	0.9	1.5	2.3	3.4	4.8	6.4	8.1	10.1	12.3	14.7

Truck <7.5t S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	15,283	15,417	15,553	15,691	15,829	15,969	16,109	16,251	16,395	16,539	16,685
Replacement vehicles	757	764	771	778	785	791	798	805	813	820	827
Additional new vehicles	134	135	136	137	138	140	141	142	143	145	146
EV vehicle fleet new	45	58	76	98	128	166	186	208	233	261	292
EV vehicle fleet stock	45	103	179	278	405	571	757	965	1,198	1,459	1,751
EV fleet as % of stock	0%	1%	1%	2%	3%	4%	5%	6%	7%	9%	10%
GHG reduction WTW in tons	255	586	1,015	1,573	2,298	3,238	4,292	5,471	6,791	8,269	9,923
Electricity demand GWh	0.8	1.7	3.0	4.7	6.8	9.6	12.7	16.2	20.1	24.5	29.4

Truck 7.5-16t S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	86,601	87,365	88,136	88,913	89,697	90,488	91,286	92,091	92,904	93,723	94,550
Replacement vehicles	4,292	4,330	4,368	4,407	4,446	4,485	4,524	4,564	4,605	4,645	4,686
Additional new vehicles	757	764	771	777	784	791	798	805	812	819	827
EV vehicle fleet new	127	165	215	279	362	470	527	589	660	739	827
EV vehicle fleet stock	127	293	507	786	1,148	1,619	2,145	2,735	3,395	4,133	4,960
EV fleet as % of stock	0%	0%	1%	1%	1%	2%	2%	3%	4%	4%	5%
GHG reduction WTW in tons	1,592	3,659	6,344	9,830	14,358	20,238	26,820	34,189	42,438	51,673	62,011
Electricity demand GWh	4.1	9.4	16.2	25.2	36.8	51.8	68.6	87.5	108.6	132.3	158.7

Truck 7.5-16t S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	86,601	87,365	88,136	88,913	89,697	90,488	91,286	92,091	92,904	93,723	94,550
Replacement vehicles	4,292	4,330	4,368	4,407	4,446	4,485	4,524	4,564	4,605	4,645	4,686
Additional new vehicles	757	764	771	777	784	791	798	805	812	819	827
EV vehicle fleet new	255	331	429	558	724	941	1,053	1,179	1,320	1,477	1,654
EV vehicle fleet stock	255	585	1,015	1,573	2,297	3,238	4,291	5,469	6,789	8,266	9,920
EV fleet as % of stock	0%	1%	1%	2%	3%	4%	5%	6%	7%	9%	10%
GHG reduction WTW in tons	3,184	7,319	12,688	19,661	28,716	40,476	53,641	68,379	84,877	103,346	124,023
Electricity demand GWh	8.1	18.7	32.5	50.3	73.5	103.6	137.3	175.0	217.3	264.5	317.4

Truck 16-32t S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	110,612	111,588	112,572	113,565	114,566	115,577	116,596	117,625	118,662	119,709	120,765
Replacement vehicles	5,482	5,531	5,579	5,629	5,678	5,728	5,779	5,830	5,881	5,933	5,985
Additional new vehicles	967	976	984	993	1,002	1,010	1,019	1,028	1,037	1,047	1,056
EV vehicle fleet new	163	211	274	356	463	601	672	753	843	943	1,056
EV vehicle fleet stock	163	374	648	1,004	1,467	2,068	2,740	3,493	4,336	5,279	6,335
EV fleet as % of stock	0%	0%	1%	1%	1%	2%	2%	3%	4%	4%	5%
GHG reduction WTW in tons	3,713	8,534	14,796	22,927	33,487	47,200	62,552	79,738	98,977	120,515	144,626
Electricity demand GWh	11.7	26.9	46.7	72.3	105.6	148.9	197.3	251.5	312.2	380.1	456.1

Truck 16-32t S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	110,612	111,588	112,572	113,565	114,566	115,577	116,596	117,625	118,662	119,709	120,765
Replacement vehicles	5,482	5,531	5,579	5,629	5,678	5,728	5,779	5,830	5,881	5,933	5,985
Additional new vehicles	967	976	984	993	1,002	1,010	1,019	1,028	1,037	1,047	1,056
EV vehicle fleet new	325	422	549	712	925	1,201	1,345	1,506	1,686	1,887	2,112
EV vehicle fleet stock	325	748	1,296	2,009	2,934	4,135	5,480	6,986	8,671	10,558	12,671
EV fleet as % of stock	0%	1%	1%	2%	3%	4%	5%	6%	7%	9%	10%
GHG reduction WTW in tons	7,426	17,069	29,592	45,854	66,974	94,401	125,104	159,476	197,955	241,030	289,252
Electricity demand GWh	23.4	53.8	93.3	144.6	211.2	297.7	394.6	503.0	624.3	760.2	912.3

Truck >32t S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	224,576	226,557	228,555	230,571	232,605	234,657	236,726	238,814	240,920	243,045	245,189
Replacement vehicles	11,131	11,229	11,328	11,428	11,529	11,630	11,733	11,836	11,941	12,046	12,152
Additional new vehicles	1,963	1,981	1,998	2,016	2,034	2,052	2,070	2,088	2,106	2,125	2,144
EV vehicle fleet new	330	429	557	723	939	1,220	1,365	1,528	1,711	1,916	2,144
EV vehicle fleet stock	330	759	1,316	2,039	2,978	4,198	5,563	7,092	8,803	10,718	12,863
EV fleet as % of stock	0%	0%	1%	1%	1%	2%	2%	3%	4%	4%	5%
GHG reduction WTW in tons	10,043	23,084	40,021	62,016	90,579	127,672	169,197	215,683	267,724	325,981	391,199
Electricity demand GWh	38.6	88.8	154.0	238.6	348.5	491.2	650.9	829.7	1029.9	1254.1	1504.9

Truck >32t S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	224,576	226,557	228,555	230,571	232,605	234,657	236,726	238,814	240,920	243,045	245,189
Replacement vehicles	11,131	11,229	11,328	11,428	11,529	11,630	11,733	11,836	11,941	12,046	12,152
Additional new vehicles	1,963	1,981	1,998	2,016	2,034	2,052	2,070	2,088	2,106	2,125	2,144
EV vehicle fleet new	660	858	1,114	1,446	1,878	2,439	2,731	3,057	3,422	3,831	4,289
EV vehicle fleet stock	660	1,518	2,632	4,078	5,957	8,396	11,127	14,184	17,606	21,437	25,726
EV fleet as % of stock	0%	1%	1%	2%	3%	4%	5%	6%	7%	9%	10%
GHG reduction WTW in tons	20,085	46,169	80,042	124,032	181,158	255,344	338,394	431,367	535,447	651,962	782,398
Electricity demand GWh	77.3	177.6	307.9	477.2	696.9	982.3	1301.8	1659.5	2059.9	2508.1	3009.9

Total excl. trucks >7.5t S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
GHG reduction WTW in tons	53,170	122,285	212,128	328,914	480,724	678,061	899,188	1,146,973	1,424,631	1,735,763	2,084,404
Electricity demand GWh	50	115	199	308	450	635	842	1,074	1,334	1,625	1,951

Total excl. trucks >7.5t S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
GHG reduction WTW in tons	106,340	244,571	424,256	657,828	961,448	1,356,121	1,798,375	2,293,946	2,849,262	3,471,525	4,168,807
Electricity demand GWh	100	229	397	616	900	1,270	1,684	2,148	2,668	3,250	3,903

GHG Transport Projections WTW

Scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
BAU	73,580,531	73,877,990	74,176,650	74,476,519	74,777,599	75,079,897	75,383,416	75,688,163	75,994,142	76,301,357	76,609,815
EV15@30	73,527,361	73,755,704	73,964,522	74,147,605	74,296,875	74,401,836	74,484,229	74,541,190	74,569,511	74,565,595	74,525,411
GHG reduction EV15@30	53,170	122,285	212,128	328,914	480,724	678,061	899,188	1,146,973	1,424,631	1,735,763	2,084,404
Electricity usage	104	240	416	644	941	1,327	1,759	2,243	2,785	3,391	4,071
EV30@30	73,474,191	73,633,419	73,752,394	73,818,690	73,816,152	73,723,775	73,585,041	73,394,217	73,144,880	72,829,832	72,441,008
GHG reduction EV30@30	106,340	244,571	424,256	657,828	961,448	1,356,121	1,798,375	2,293,946	2,849,262	3,471,525	4,168,807
Electricity usage	208	479	831	1,288	1,882	2,654	3,518	4,485	5,569	6,783	8,142
EV scenario high growth	73,480,043	73,635,920	73,736,589	73,756,986	73,667,104	73,430,195	73,068,338	72,555,109	71,861,452	70,955,622	69,811,417
GHG reduction high growth	100,488	242,069	440,061	719,533	1,110,495	1,649,701	2,315,078	3,133,054	4,132,690	5,345,735	6,798,398
Electricity usage	174	410	730	1,167	1,761	2,562	3,517	4,655	6,008	7,612	9,496

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	10,969	39,195	98,009	202,164	368,586	616,275	966,250	1,441,511	2,067,019	2,861,372
Electricity demand GWh	0	10	36	92	190	348	582	912	1,361	1,952	2,703

High groiwth 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	100,488	242,069	440,061	719,533	1,110,495	1,649,701	2,315,078	3,133,054	4,132,690	5,345,735	6,798,398
Electricity demand GWh	174	410	730	1,167	1,761	2,562	3,517	4,655	6,008	7,612	9,496

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	16,154,854	16,299,354	16,445,151	16,592,257	16,740,684	16,890,444	17,041,548	17,194,009	17,347,839	17,503,050	17,659,655
EV15@30	16,136,580	16,257,340	16,372,295	16,479,332	16,575,701	16,657,830	16,733,192	16,800,827	16,859,658	16,908,476	16,945,928
EV30@30	16,118,307	16,215,327	16,299,439	16,366,406	16,410,719	16,425,216	16,424,836	16,407,645	16,371,477	16,313,902	16,232,201
High growth scenario	16,154,854	16,288,384	16,405,956	16,494,249	16,538,520	16,521,858	16,425,273	16,227,759	15,906,328	15,436,031	14,798,283

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	70	0.255	0.002	214	0	255	3.1	8,500
Passenger Car	diesel	63	0.716	0.055	202	39	288	2.7	8,500
Passenger Car	CNG	63	0.056	0.001	189	0	264	3.0	8,500
Taxi	gasoline	82	0.255	0.002	250	0	298	3.6	50,000
Taxi	diesel	55	0.716	0.055	175	39	254	2.4	43,000
Taxi	CNG	63	0.056	0.001	189	0	264	3.0	43,000
Motorcycle	gasoline	16	0.317	0.004	50	1	60	0.7	6,000
Urban standard bus	diesel	405	10.700	0.220	1291	129	1,716	17.4	65,000
Coach bus	diesel	247	8.950	0.165	787	97	1,065	10.6	90,000
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	30,000
Truck 7.5-16t	diesel	155	5.500	0.104	494	61	668	6.7	40,000
Truck 16-32t	diesel	210	7.910	0.155	669	91	914	9.0	60,000
Truck >32t	diesel	251	9.360	0.194	800	113	1,097	10.8	75,000

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	70	0.061	0.001	214	0	255	3.1	8,500
Passenger Car	diesel	63	0.580	0.031	202	25	273	2.7	8,500
Passenger Car	CNG	63	0.056	0.001	189	0	264	3.0	8,500
Taxi	gasoline	82	0.061	0.001	250	0	298	3.6	50,000
Taxi	diesel	55	0.580	0.031	175	25	240	2.4	43,000
Taxi	CNG	63	0.056	0.001	189	0	264	3.0	43,000
Motorcycle	gasoline	16	0.194	0.004	50	1	60	0.7	6,000
Urban standard bus	diesel	371	5.420	0.046	1183	31	1,487	16.0	65,000
Coach bus	diesel	247	4.520	0.035	787	24	992	10.6	90,000
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	30,000
Truck 7.5-16t	diesel	155	2.650	0.016	494	11	618	6.7	40,000
Truck 16-32t	diesel	210	3.830	0.024	669	16	839	9.0	60,000
Truck >32t	diesel	251	4.610	0.027	800	18	1,002	10.8	75,000

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)

world bank, 2020, pmr

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