Country Diagnostic Costa Rica



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Abbreviations

AC	Air Conditioning
AFD	French Development Agency
ARESEP	Public Services Regulatory Authority
BAU	Business As Usual
CAGR	Compound Annual Growth Rate
CANABUS	National Chamber of Bus Operators
CANATRANS	National Chamber of Transportation of Costa Rica
CAPEX	Capital Expenditure
CIF	Cost Insurance Freight
CNC	National Concessions Council
CNG	Compressed Natural Gas
CONAVI	National Road Council
CONSEVI	Road Safety Council
CTP	Public Transport Council
DSM	Demand Side Management
EV	Electric Vehicle
GAM	Metropolitan Area of San Jose
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GIZ	German International Cooperation
ICE	Costa Rican Institute of Electricity
IEA	International Energy Agency
INS	National Insurance Institute
LCV	Light Commercial Vehicle
LPG	Liquefied Petroleum Gas
MINAE	Ministry of Environment and Energy
MOF	Ministry of Finance
MOPT	Ministry of Public Works and Transport
NDC	Nationally Determined Contributions
PNTE	National Plan for Electric Transport
TTW	tank-to-wheel
UNEP	United Nations Environment Programme
WHO	World Health Organization
WTW	well-to-wheel

Summary

1. Costa Rica has an area of 51,100 km^2 and 5.1 million inhabitants. In 2019, the GDP per capita was 12,200 USD. The metropolitan area of San José concentrates half of the population. The vehicle fleet of Costa Rica has grown on average annually by 6% between 1980 and 2019 whilst the population has only grown by 2%. In 2019 more than 1.5 million vehicles were operating in the country including nearly 1 million passenger cars, 300,000 motorcyles, and around 200,000 light commercial vehicles.

2. Costa Rica has a long tradition in being on the forefront of combating climate change. In its Nationally Determined Contribution (NDC), Costa Rica reaffirmed its aspiration of becoming a Carbon Neutral economy and aims for a decarbonized economy with net-zero emissions in 2050. Total GHG emissions of the country are estimated at 10.9 million tCO_{2e} in 2019 with land transport being responsible for more than 50% of total GHG emissions. Emissions under a Business as Usual (BAU) scenario are expected to increase by 45% by 2050. The updated NDC of Costa Rica includes as targets net emissions of 9.1 $MtCO_{2e}$ by 2030 (commensurate with a 2 degree scenario) and holds on to the net zero target by 2050. Greening the transportation sector is key to achieving these targets. Electrifying mobility is considered as essential and a national priority.

3. The updated NDC has concrete 2030 electric mobility targets for public transport, passenger cars and fleets (8% of the vehicle stock). For other vehicle areas e.g. motorcycles targets and measures shall be developed to migrate towards EVs. Costa Rica has also developed a national plan for electric transport which includes concrete steps towards electrification of vehicles and has approved 2018 the law on incentives and promotion of electric transportation which includes targets for EV penetration, the establishment of a public charging infrastructure as well as important tax incentives for private EVs. Costa Rica has therefore already various not always consistent policies, regulations and development plans (e.g. in terms of targets of EVs) important for the promotion of EVs. End 2020 some 3,100 EVs are circulating of which 1,300 cars and 600 motorcycles with the rest being “others” such as golf carts. While an increase in EVs can be observed, the percentages compared to total vehicle imports are still very low.

4. Costa Rica has no vehicle manufacturing or assembly industry. A large number of people work currently in small garages for vehicle repair and maintenance. EVs require less maintenance and repairs due to having less moving parts thus less jobs will be available in this area. The major positive job impact of EVs is an induced impact: savings of consumers on petrol and maintenance result in increased spending on goods with a high income elasticity which tend to be labour intensive service-goods. The major macro-economic advantage of the country for deploying EVs will however be to spend less on the import of fossil fuels and to be less exposed to external fuel price shocks. Electricity is produced nationally with renewables, whilst 100% of fossil fuels need to be imported. In 2019 the fuel bill was equivalent to 10.2% of the goods imported. Transportation emission costs modelled in this report are close to 500 MUSD for 2019 and 2030 with the cost of pollutants decreasing due to the modernization of the vehicle fleet whilst the cost of global warming emissions increases due to increased energy usage. In 2019 around 30% of these costs are due to local pollutants whilst by 2030 the share halves due to the introduction of cleaner fossil vehicles. Vehicle emission costs represents for 2019 0.7% of the countries GDP.

5. The emission standard Euro 4 is compulsory since 2018 for passenger cars and light commercial vehicles up to 3.5t and it is discussed to establish Euro 6 from 2023 onwards. Heavy duty vehicles only need to comply with annual inspections but for buses at minimum Euro III is required. The fuel quality is maximum 50ppm sulphur contents. More than 60% of vehicles circulating in the country are more than 10 years old. It is estimated that more than 50% of all vehicles circulate in the metropolitan area of San José resulting in high levels of air pollution.

6. At the national level there are about 355 public transport operators with 5,000 buses whilst 70 operators with 2,000 buses operate in the metropolitan area of San José. There are some medium sized companies with fleets of more than 100 units whilst 45% of operators have less than 5 buses. By early 2020, 12 companies had publicly announced their intention to each acquire at least one electric bus. This plan was put on hold, given the impact on bus operators of the drop in demand due to the COVID 19 pandemic. Starting January 2021, 3 electric buses will operate within a pilot project of GIZ.

7. Bus operators do not receive direct operational subsidies i.e. the fare box must cover their expenditures. Indirectly subsidies are given as buses pay no import taxes and bus operators also do not pay for the infrastructure they use nor for external costs caused by their operations such as air pollution with the consequential health and environmental impacts. Buses can be used for 15 years - concessions are however only for 7 years.

8. In 2019, there were around 7,000 taxis registered in the country which are mostly operated in a double shift. 70% of units are gasoline powered and the rest diesel. Very few taxis are hybrids and two or three electric units circulate. The ride share market is composed of Uber and DiDi vehicles. Many Uber drivers run the vehicle based on daily or monthly renting agreements with individuals some of which own and rent out multiple vehicles.

9. The urban freight sector is atomized with many individuals owning a vehicle and renting services to 3rd parties. There are various companies interested in electrifying their fleet and the postal service has acquired various electric motorcycles and is testing 2 electric light commercial vehicles (LCVs). Currently there are about 143,000 LCVs in the country.

10. Electricity distributors are responsible for setting up the legally required minimum charging network. There are currently around 40 7.6kW chargers and 15 50kW fast chargers installed throughout the country with 28 100kW being added in this year. The law 9518 establishes that on national roads at least every 80km and on cantonal roads at least every 120km a public charging site must be established. Fast chargers are basically on inter-urban roads and targeted towards private car users. No fast charging urban network exists currently which would support deployment of taxis or LCVs which operate in urban surroundings and cannot re-charge sufficiently during the night.

11. Costa Rica has produced in the last 5 years consistently more than 99% of electricity based on renewables (around 70% hydropower and 15% each geothermal and wind). Projections estimate that the share of renewables will remain constant at this level also in the future, with an annual increase of production by 2%. Electricity generation is sufficient to cover 100% of national demand year-round. The average projected carbon grid factor to 2030 is 0.015 $kgCO_2/kWh$. Costa Rica has a considerable renewable energy production potential not yet tapped.

12. Transport GHG emissions of Costa Rica in 2019 are estimated at 6.35 million tCO_{2e}[1] based on a bottom-up transport model calibrated with top-down fuel consumption data[2]. Commercial vehicles including taxis, buses and LCVs are responsible for around 1/3rd of GHG emissions and 50% of pollutants ($PM_{2.5}$ and NO_x). GHG emission from the transport sector are expected to grow under a BAU scenario by around 30% reaching 8.1 million tCO_2 by 2030. Obviously the target of 9.1 $MtCO_{2e}$ by 2030 of the NDC cannot be reached with such emission levels i.e. significant changes to the transportation sector will be required.

[1] Tank-to-wheel approach; well-to-wheel approach including Black Carbon: 8.4 $MtCO_{2e}$

[2] This is 15% more than projected by the national inventory for the same year

13. Different EV penetration scenarios have been modelled for Costa Rica. The targets as declared in the updated NDC of Costa Rica result in a well-to-wheel GHG reduction of 0.5 $MtCO_{2e}$ by 2030 relative to the baseline. A high ambition scenario with 100% electric newly registered urban and small buses, LCVs and taxis by latest 2030 (not vehicle stock; new registrations) and for other vehicle sectors a target of 30% of new registered units (commensurate with the IEA EV30@30 initiative) results in well-to-wheel GHG reductions of 1.5 $MtCO_{2e}$ by 2030.

14. The 2030 projected electricity demand of EVs represents 3% of same year electricity generation for the EV scenario using national targets and 9% for the highest potential scenario. The renewable energy potential of the country is 400% higher than the current production level i.e. an increase of 9% would not face any technical difficulties to be met 100% by renewables. The electricity demand increase resulting from EVs is very gradual and thus leaves enough time to the country to plan a potential production expansion.

15. The power system has a peak at midday and early evening managed with differential pricing. Fast as well as overnight charged e-buses can avoid charging during these peaks. Taxi fast charging could be managed through differential prices for charging at peaks, as already done in Costa Rica. 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 in the evening 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. This can however be managed with appropriate regulations or incentives of the grid manager.

16. Costa Rica has established special electricity tariffs for e-buses and for public chargers. Basically the "special" tariff for buses is the same as the night tariff medium tension. The regulation also states that grid adjustments to allow for e-bus charging shall be prioritized by the power providers and costs are to be born by the power provider. For the charging infrastructure joint approaches between the operator and the power provider are possible.

17. The following table shows key results derived from the "potential EV scenario" in terms of number of electric vehicles, the GHG impact and the vehicle investment volume for the commercial vehicle sector targeted by the EV fund (taxis, buses and LCVs). As mentioned the "potential scenario" is based on achieving a 100% EV rate of newly registered commercial vehicles latest by 2030.

Key Figures Commercial Vehicles EV "Potential Scenario" (annual impacts except if indicated)

Parameter	Taxis	Small Buses	Urban Buses	LCVs	Total
EV stock 2025 (% of all vehicles)	1,320 (11%)	410 (4%)	410 (8%)	2,280 (1%)	4,400
EV Stock 2030 (% of all vehicles)	8,440 (59%)	3,070 (28%)	2,000 (40%)	57,880 (22%)	71,000
GHG impact in 2025[3]	13,000 tCO_2	9,000 tCO_2	39,000 tCO_2	13,000 tCO_2	75,000
GHG impact in 2030	86,000 tCO_2	71,000 tCO_2	190,000 tCO_2	324,000 tCO_2	670,000
$PM_{2.5}$ reduction in 2030	4 tons	13 tons	8 tons	159 tons	184 tons
NO_x reduction in 2030	77 tons	1,710 tons	976 tons	3,287 tons	6,050 tons
Savings emission costs in 2030	4 MUSD	6 MUSD	10 MUSD	36 MUSD	55 MUSD
Vehicle CAPEX by 2025 (cumulative)	31 MUSD	31 MUSD	90 MUSD	52 MUSD	203 MUSD
Vehicle CAPEX by 2030 (cumulative)	151 MUSD	196 MUSD	384 MUSD	1,193 MUSD	1,923 MUSD

Note: Constant real USD of 2020

[3] GHG reduction relative to the BAU scenario with a well-to-wheel including Black Carbon approach

18. By implementing this high-ambition strategy for commercial vehicles Costa Rica would have more than 70,000 commercial EVs by 2030 reducing in 2030 670,000 tCO_2. Around 50% of the impact by 2030 would be with LCVs followed by urban buses with 30%. The estimated cumulative vehicle investment required by 2025 is around 200 MUSD and 1,900 MUSD by 2030. This is not the incremental investment for EVs relative to the BAU investment for fossil vehicles but the total required vehicle investment. Economic emissions costs of annually 55 MUSD (for 2030) would be saved.

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

Enabling factors	• E-mobility is a topic since many years in Costa Rica. The Government has issued important laws and regulations as well as national development plans containing EV targets, incentives and support structures. This has also resulted in some 3,000 EVs operating by 2020 including also a pilot of e-buses (3 units) and some LCVs and taxis. • Public charging infrastructure (primarily for passenger cars) is being established and electricity prices for public charging as well as e-buses have been fixed. • Costa Rica produces close to 100% of electricity based on renewables and has sufficient additional production capacity. Commercial EV deployment would not affect peak demand times. Fossil fuel on the other hand is 100% imported and creates a considerable financial burden to the economy.
Barriers	• Lack of experience and know-how on creating for commercials EVs an enabling surrounding including regulations (e.g. concession contracts), business models and financial support policies which enable their massive uptake. • Commercial EVs are perceived to lack profitability and have much higher upfront costs. The financial system has limited appetite for entering this market as it is not deemed to be profitable. • For taxi and LCV deployment an urban public fast charging infrastructure is required. This is not yet available making operations of such vehicles problematic. • Lack of significant financial support for the purchase or operations of commercial EVs. Kick-starting EV deployment in this area without concessional finance and subsidies covering part of the incremental investment will not be possible.

20. Costa Rica has very good enabling conditions for the promotion of e-mobility and considers this as a national priority. Many important steps have already been taken. The focus and the incentives provided are however to the moment primarily targeted towards private vehicles. Whilst it is well understood that commercial EVs are very important, the barriers in terms of regulations (e.g., concession contracts), profitability, business models, lack of tangible incentives and implementation risks continue to exist thus hampering EV deployment.

21. Major potentials seen for Costa Rica and activities which would reduce the barriers and facilitate commercial EV deployment are related to (i) technical assistance to assist in the design and implementation of an EV support structure conducive for the deployment of commercial EVs (ii) financial assistance for deployment of commercial EVs. Concessional finance including grants would enable to eliminate the barrier of limited profitability and high upfront investment of EVs and thus kick-start commercial EV deployment. The successful deployment of commercial EVs will require next to regulatory incentives (e.g., taxi licenses, longer concession contracts), financial instruments (e.g., concessional loans or leasing schemes, upfront grants) and an urban public fast-charging infrastructure for taxis and LCVs.

1. Country Brief

Costa Rica is a country recognized for its ambitious environmental policies and its large forest coverage (more than 50% of the area). It concentrates in an area of 51,100 km^2 6% of the biodiversity of the planet. The country has a projected population in 2020 of 5.1 million inhabitants and in 2030 of 5.56 million (INEC, 2013).

Costa Rica is considered a medium-high income country with one of the most solid and longest lasting democracies in Latin America. It has experienced sustained economic growth over the last 25 years. The combination of political stability, social contract, and sustained growth has resulted in one of the lowest poverty rates in Latin America and the Caribbean. In 2019, the GDP per capita was 12,200 USD[4].

The larger urban zone of San Jose also called the Great Metropolitan Area concentrates half of the population, making it the largest urban area in the country. The city's unplanned growth, added to a lack of investment and organization in public transport improvements, has led to a disproportionate growth in the vehicle fleet and consequently to congestion and high levels of pollution.

The larger urban zone of San Jose called GAM ("Gran Area Metropolitana") has 3% of the national territory and 52% of the country's population - an estimated 2.7 million people live 2020 in this area (INEC, 2013). The mode share of motorized trips is 42% cars, 41% buses, 9% taxis, 7% motorcycles and less than 1% by a very old and partially rehabilitated diesel train (MINAE, 2017). The public transport share has decreased dramatically from 64% in 2007 to 41% in 2017 whilst private car usage increased in the same period from 31% to 42% (L.C.R. Logistica S.A., 2007). Congestion in the city has increased significantly and vehicle operating speeds have dropped to 14-15 km/h. Congestion costs for the GAM in the year 2018 were estimated at 3.8% of the GDP (PEN-CONARE, 2018, p. 229). Public transport is dominated by a large number of privately operated bus operators. A bus trip has on average a 70% longer duration than a car trip (Government of Costa Rica, 2019), also due to route structuring which requires for over 40% of bus users at least one transfer (PEN-CONARE, 2018, p. 238).

2. Policy Framework Relevant for E-Mobility

2.1. Overview

Costa Rica has a long tradition in being on the forefront of combating climate change. In its Nationally Determined Contribution, Costa Rica reaffirmed its aspiration of becoming a Carbon Neutral economy and aims for a decarbonized economy with net-zero emissions in 2050 (Government of Costa Rica, 2019). Costa Rica has received from UNEP the 2019 Champions of the Earth award for its commitment to ambitious policies to combat climate change[5]. The same is reflected in different policies and actions in different sectors. It is not only in the environment and energy sector that the ambitions towards a decarbonized economy are reflected. The National Plan for Decarbonization is positioned as a policy agreed upon by all productive sectors (such as transport, agriculture and housing). The economic planning consequently follows the guidelines and goals proposed in this ambitious plan.

[4] https://datos.bancomundial.org/indicador/NY.GDP.PCAP.CD?end=2019&locations=CR&start=1960&view=chart

[5] https://www.unenvironment.org/news-and-stories/press-release/costa-rica-named-un-champion-earth-pioneering-role-fighting-climate

2.2. Climate Change and Environmental Policies

According to “National Inventory of GHG emissions by sources and removals by sinks in Costa Rica". (National Meteorological Institute, 2019), land transport was responsible for 5.5 million tons of CO_{2e} in 2015. This is equivalent to 76% of the entire energy sector or 50% of total GHG emissions (see following table). Updated calculations of vehicle emissions are found in chapter 3.

Table 1: GHG Emissions per Source in 2015

Emission source	CO_{2e} emissions in millions of tons
Energy	7.3
Industrial processes and product use	1.3
Agriculture, Forestry and other land uses	0.2
Waste	2.1
Total	**10.9**

Source: (National Meteorological Institute, 2019)

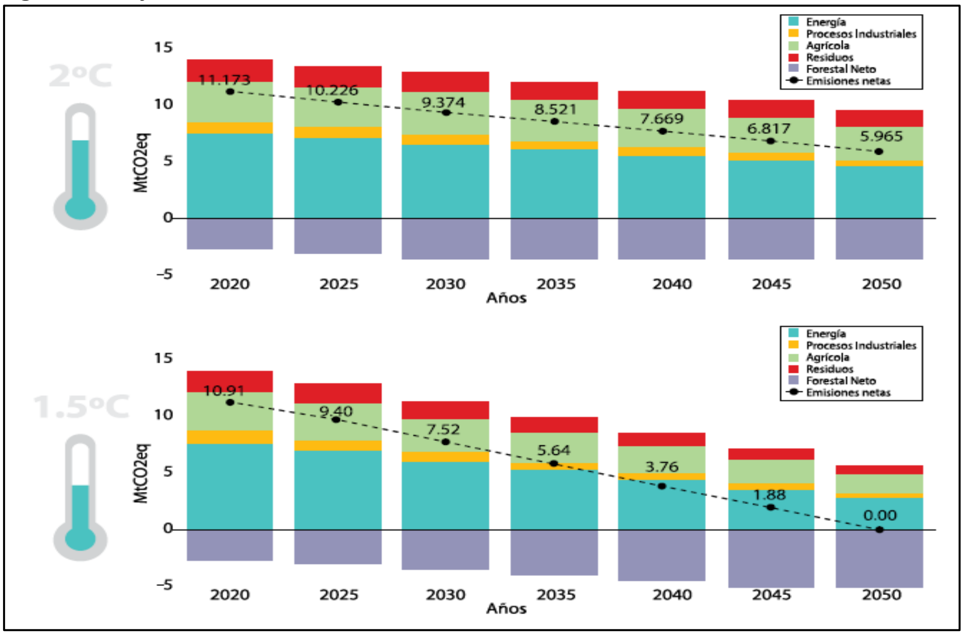
According to data from Sepse-Minae (2020), between 2005 and 2019, and with the exception of the agricultural and industrial sectors, secondary energy consumption increased in all areas. Transport is the one that records the highest proportion of consumption in the two years analysed: 57% in 2005 and 64% in 2019.

The most important documents guiding climate change policies are the National Decarbonization Plan and the Nationally Determined Contributions (NDC). In 2020 the NDC was being updated with the current version under public consultation.

National Decarbonization Plan

The Decarbonisation Plan, launched 2016, states that total emissions could increase by 45% by 2050 (reaching 29.6 $MtCO_{2e}$) in a Business As Usual (BAU) scenario, based on 2012 emissions. Emissions are projected with a 2°C and 1.5°C scenario, with 9.4 million net tons by 2030 in the first case and 7.5 million net tons for the second case (Government of Costa Rica, 2019). The plan emphasizes that to reach these goals, it is essential to electrify the transportation sector.

Figure 1: Projected Emissions for a 2° and a 1.5 °C Scenario



Source: (Government of Costa Rica, 2019)

The plan identifies the import of hydrocarbons for the transport sector as the greatest challenge. The plan has developed various goals concerning electric mobility in the areas of public transport, passenger vehicles and freight transport.

For public transport the electrification goals are:

- 30% of public transportation shall be zero emissions by 2035 and a new 100% Light Rail Transit shall be operating.
- By 2050, 85% of the public transport fleet shall be zero emissions.

In the short term, following activities are planned or under implementation to achieve the long-term targets:

- Implementation of the e-bus pilot project with 3 e-buses donated by Germany under a project run by GIZ with operational start of buses in January 2021.
- Design and approve a bus fare scheme suitable for e-buses.
- Establish a schedule for the implementation of fleet electrification.
- Align 2021 concession contracts with the objectives and goals of the Decarbonization Plan and Law 9518.
- Analyze the taxi fare scheme to facilitate adoption of electric taxis.
- Identify financing schemes to facilitate taxi fleet renewal.
- Design a pilot program for the electrification of taxis.

For passenger vehicles the goal is that 95% of the fleet by 2050 is 0-emissions. By 2030 40% of the passenger car vehicle stock shall be electric (and 60% plug-in hybrid) (MINAE, 2019, p. 87).

For freight transport the plan has no concrete electrification targets.

NDC

In November of this year, the "Nationally Determined Contribution 2020" was submitted for public consultation. This update responds to the commitments made in the Paris Agreement and is aligned with the National Decarbonization Plan. In the updated NDC Costa Rica commits to an absolute maximum of net emissions in 2030 of 9.1 million tons of CO_{2e} including all emissions and all sectors covered by the corresponding National Emissions Inventory. This goal is consistent with the 2-degree trajectory of the National Decarbonization Plan, the Long Term Strategy presented by Costa Rica in 2019 but retains the goal of net zero emissions by 2050 consistent with the 1.5^{0}C trajectory (MINAE, 2020).

In terms of e-mobility, the updated NDC mentions:

- By 2030, at least 8% of the country's public transport fleet shall be zero emissions;
- The adoption of standards to migrate to a zero emission motorcycle fleet and the stabilization of motorcycle fleet growth by 2025;
- By 2030, at least 8% of the light vehicle fleet -private and institutional- shall be electric. This target is considerably lower than the 2019 announced target of 40% in the National Plan for Electric Transport 2018-2030.

2.3. Energy Policies

The Costa Rican electricity system is one of the few decarbonized systems in the world: Since 2015, Costa Rica has always had >98% of renewable energy production . Planned energy expansions will diversify renewable energy sources even more (ICE, 2019). Electrification of the transport sector is a strategy to reduce drastically the carbon footprint of the country.

The **National Energy Plan 2015-2030** includes e-mobility as a mean to reduce fossil fuel dependency and to reduce GHGs. The general orientation of the national plan is to cover the national energy demand with renewable energy sources. For more details concerning the power sector see chapter 6.

The **National Plan for Electric Transport (PNTE)** was developed jointly by the energy and the transport ministries. Its objective is to promote the electrification of transport in all of its modes, thus contributing to the country's decarbonization policies (MINAE, 2019). It has a planning horizon of twelve years and describes the actions to strengthen and promote electric transportation in Costa Rica, as established by Law No. 9518, "Law on incentives and promotion for electric transportation".

It is the strategic framework for meeting the targets for the replacement of internal combustion vehicles with EVs as set out in the NDC or the Decarbonisation Plan. It is understood that the Law of Incentives and Promotion of Electric Transportation and its regulations, mark a clear line of government to decarbonize transportation through electrification. The PNTE is considered an energy policy because its ultimate goal is to reduce dependence on hydrocarbons and increase the demand for electricity, taking advantage of the fact that the matrix is 98% renewable. As mentioned the PNTE had as target 40% of passenger cars being electric by 2030 – a target revised to 8% by the updated NDC. At the organizational level, there is an Electrical Mobility Technical Committee and a Political Committee. Various sub-committees work on technical issues such as battery disposal policies. The following table compares expected and actual results 2.5 years after endorsement of the PNTE. The National Plan for Electric Transport 2018-2030 has as target that 10% of new taxi concessions are for electric vehicles (Art. 3.1.3.4 page 108). The law 9518 on "Incentives and Promotion for Electric Transportation" states that each company should have at least 5% electric buses within each new concession with an increase of 5% every two years – the National Plan for Electric Transport 2018-2030 (MINAE, 2019) includes this in its Action Plan from latest 2021. Although this target is stated in the law that was published three years ago, not one electric bus has been acquired by an operator so far. This has had no repercussions on their operations. The article of the law is currently being modified.

Table 2: Targets of the PNTE and Results as of 12/2020

Targets PNTE	Results as of 12/2020
Public charging network	36 semi-fast chargers (7.6 kW) and 13 fast chargers (50 kW)[6,7] installed by ICE and CNFL plus one fast charger by JASEC in Cartago. Regulations for charging stations have been realized[8] incl. the fixation of a fast-charging electricity tariff[9]. Art. 31 of the law 9518 establishes that energy distribution companies must install every 80km on national roads and every 120km on cantonal roads public chargers. The regulation establishes a total of 47 chargers.

[6] https://energia.minae.go.cr/?p=4100

[7] https://www.larepublica.net/noticia/el-guarco-tiene-primer-centro-de-carga-rapida-del-pais-instalado-por-empresa-electrica-privada

[8] Regulation 41642-MINAE

[9] See chapter 5 for details

Economic incentives to facilitate the acquisition of electric vehicles.	Regulations to law 9518 published (see for details of the incentives section 2.5.); financing lines with banks have been established: A special credit line for electric vehicles including specifically commercial units (buses, fleets) started operations October 2020 with disbursements through the Banco Nacional, the Banco Popular and the Banco de Costa Rica. Conditions vary between banks and are fixed also per project and credit subject[10] (see report "Assessment of Commercial EV demand in Costa Rica").
Non-economic incentives for the use of electric vehicles	The regulations are published, but most municipalities have not implemented the parking meter exemption. [11]
Regulations to encourage the acquisition of EVs by government	Guideline issued
Consumer information on EVs	Information campaign in different networks
Electricity rate defined for public transport	Has been defined as of November 2020
Pilot e-bus project	3 e-bus will start services as pilot in January 2021

In total some 330 EVs have been purchased to the date by public institutions including 230 cars and 90 motorcycles plus some special vehicles. Notable are the 100 Hyundai Ioniq purchased 2 years ago by the electric utility ICE (financed by an IDB loan) or the Costa Rican Post Office, which has acquired 49 electric motorcycles and is currently testing two Renault Kangoo Z.E. for parcel services[12].

See chapter 6 for more details on the power sector as well as the grid factor of the sector.

2.4. Transport Policies

The Ministry of Public Works and Transport (MOPT), as the governing body of the transport sector, supports the transition to electric mobility, however, in terms of specific policies that correspond to it, it has been lagging behind. The Public Transport Council (CTP) can demand a quota of buses to be electrified in the GAM but has not yet issued any criteria in this regard.

The governing body has so far been unable to regulate ride-hailing apps like Uber and DiDi. Both operate in the country, but pay less fees than regular taxis. In the meantime, an application has also emerged, to request regulated cabs with the smartphone at lower rates than the meter would show. The Omni company raffled off an electric cab among its drivers to show its commitment to the Decarbonization Plan[13].

See chapter 4 for more details on transport policies, regulations and organization of the sector.

[10] The offer of Banco Popular (comparable for Banco Nacional) for commercial EVs is currently:

- Loans in national currency or USD;
- USD interest rate is prime rate USA plus 2.5% - this equals to around 7%;
- Commission of maximum 1.5%;
- Tenor up to 10 years (in practice however loans will be in accordance with each business and income streams e.g. as concession contracts for buses are for 7 years loan tenors are for maximum 7 years; for taxis BCR finances only for up to 5 years);
- Maximum 80% of vehicle investment.

[11] https://www.nacion.com/economia/negocios/exoneraciones-en-repuestos-y-parquimetros-siguen/47TJAHPGRVH5BMP34ED5A7GBDQ/story/

[12] https://correos.go.cr/46-motocicletas-y-2-vehiculos-electricos-se-suman-a-la-flotilla-cero-emisiones-de-correos-de-costa-rica-2/

[13] https://www.larepublica.net/noticia/omni-ya-entrego-primero-de-los-12-taxis-electricos-que-regala

2.5. Other Policies and Regulations

Law No. 9518 of 01/2018 on Incentives and Promotion for Electric Transportation and its regulation 41092-MINAE-H-MOPT, aims to create the regulatory framework for promotion of electric transportation in the country[14]. It defines institutional competencies and EV incentives. For public transport buses it has included as target 5% of buses to be electric when renewing concessions. It is unclear if this target increases by 5 percentage points every 2 years or not. For taxis the target is set that minimum 10% of the fleet shall be electric when giving new concessions. The law establishes that on national roads at least every 80km and on cantonal roads at least every 120km a public charging site must be established. At new commercial sites and at public institutions chargers must be installed at parking lots.

Incentives included are:

- Tax incentives for EVs are defined relative to the value of the vehicle and include the sales tax, the selective consumption tax and the customs value. For vehicles with a CIF value minor to 30,000 USD no tax is due. For vehicles with a price tag over 60,000 USD no tax incentives are given. Vehicles with values in-between have partial tax exemptions. These exemptions are valid for 5 years. Other imported vehicles pay 13% sales taxes, 1% customs duties and an excise tax of 30% for new vehicles and 48% for vehicles older than seven years. Buses used for public transportation only pay 1% of customs duties[15] and official taxis are exempted by 60% of taxes of fossil vehicles i.e. the tax difference with EVs is not so large for taxis as for private vehicles or ride-sharing vehicles.
- Spare parts for electric vehicles, spare parts related to the operation of the electric motor and batteries of EVs are exempted from sales and selective consumption tax for 10 years.
- EVs pay a reduced vehicle ownership tax for 5 years with the reduction starting in year 1 with 100% and declining 20 percentage points per year. The annual ownership tax is calculated based on the fiscal value of the vehicle. The tax rate is between 1.2 and 3.5% of the fiscal value of the vehicle depending on the vehicle value.[16] Buses, taxis and trucks > 8t only pay a fixed amount of 13 USD per year.
- No driving restrictions for EVs (in the urban centre driving restrictions depending on the ending of the licence plate are applied to conventional vehicles).
- Charge centres are exempt from the full payment of the selective consumption tax.
- Incentives are given for purchase of EVs by public institutions. In the case of tenders offers with EVs shall receive a 10% advantage in the evaluation relative to such without EVs. The Decree 41427-MOPT of 11/2018 indicates that public institutions shall preferably purchase 0-emission vehicles and shall establish, if feasible, charging stations at their premises.
- The government and public institutions shall realize the required investments to establish public charging sites, special parking sites for EVs or special lanes for EVs.
- National development banks shall create facilities for the financing of EVs.
- Private companies which purchase EVs can depreciate these within 3 years i.e. faster than conventional vehicles.

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[14] Sistema Costarricense de Información Jurídica (pgrweb.go.cr)

[15] http://www.pgrweb.go.cr/SCIJ/Busqueda/Normativa/Normas/nrm_texto_completo.aspx?nValor1=1&nValor2=55102

[16] https://www.hacienda.go.cr/contenido/14426-tarifas-impuesto-a-la-propiedad-de-vehiculos-automotores-aeronaves-y-embarcaciones

The Decree 41426-H-MINAE-MOPT of 11/2018 established also incentives for used EVs. Incentives are given to used EV with a maximal age of 5 years. Vehicles can be of all types including buses, trucks, cars, motorcycles etc. with a maximum CIF value of 30,000 USD (except for public transport and cargo vehicles). The incentive is that such vehicles need not pay the selective consumption tax. Used EVs also profit from not having driving restrictions.

Incentives, except for used vehicles, are basically for private passenger cars. Public transport buses, taxis or freight vehicles are above the threshold values for new vehicles and anyway pay low or no import taxes and duties and a fixed and very low annual ownership tax. Also parking incentives or public chargers are not for these vehicle categories. The public charging infrastructure constructed along national or cantonal roads relates basically to long-haul trips made by private car users whilst taxis or commercial vehicles which primarily operate in urban settings would require an urban fast-charging network.

Fossil fuel taxes are revised periodically and are currently 0.4 USD per litre for petrol 0.23 USD per litre for diesel[17]. This results in a petrol price of 0.92 USD per litre as of end 2020 which is around 10% below the world average of 1.04 USD/l[18] and of 0.75 USD/l for diesel which is 20% below the world average of 0.94 USD/l[19].

2.6. Summary

Costa Rica has established various not always consistent policies, regulations and development plans (especially in terms of targets) for the promotion of electric vehicles. Based on the DCC the internationally binding target, is the one established in the updated NDC submitted to the UNFCCC in December 2020[20]. These targets are also used for e-mobility projection scenarios. The following table summarizes the main policies.

Table 3: EV Relevant Policies of Costa Rica as of 12/2020

Policy	Major components
Law 9518 of 2018	Establishes targets for taxis and buses; creates fiscal and non-financial incentives for EVs (basically passenger cars), chargers and EV spare parts; promotes purchase of EVs by public institutions; demands the establishment of a public charging network on national and cantonal roads
National Plan for Electric Transport 2018-2030	The national plan operationalizes the Law 9518 and establishes strategic and operational actions. This includes the establishment of tariffs for public fast chargers as well as for electricity consumed by e-buses.
NDC updated 2020	The updated NDC has 2030 EV targets for public transport buses as well as private vehicles and institutional fleets.
National Decarbonization Plan of 2016	The plan has targets for EVs for 2035 and 2050. By 2050 the vehicle fleet shall be largely electrified.
National Energy Plan 2015-2030	The national energy plan includes e-mobility as a mean to reduce fossil fuel dependency and to reduce GHGs. Its general orientation is to cover the national energy demand with renewable energy sources.

[17] https://www.hacienda.go.cr/contenido/14437-tarifas-impuesto-unico-por-tipo-de-combustible
[18] Gasoline prices around the world, 28-Dec-2020 | GlobalPetrolPrices.com
[19] Diesel prices around the world, 28-Dec-2020 | GlobalPetrolPrices.com
[20] https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Costa%20Rica%20First/Contribucio%CC%81n%20Nacionalmente%20Determinada%20de%20Costa%20Rica%202020%20-%20Versio%CC%81n%20Completa.pdf

3. Macro-Economic Impact of EVs

Costa Rica has no vehicle manufacturing or assembly industry. A large number of people work currently in small garages for vehicle repair and maintenance. EVs require less maintenance and repairs due to having less moving parts thus less jobs will be available in this area. Jobs for establishing and maintaining the charging infrastructure is assume to be comparable for a fossil fuel distribution network. The major positive job impact of EVs is an induced impact: savings of consumers on petrol and maintenance result in increased spending on goods with a high income elasticity which tend to be labour intensive service-goods (NREL, 2016) (ILO, 2020).

The major macro-economic advantage of the country for deploying EVs will be to spend less on the import of fossil fuels and to be less exposed to external fuel price shocks. Electricity is produced nationally with renewables, whilst 100% of fossil fuels need to be imported. In 2019 the fuel bill was equivalent to 10.2% of the goods imported[21].

No scrapping projects have been established in the country. This is not surprising as scrapping programs are basically subsidies to the car industry and promoted strongly by vehicle manufacturers using as justification environmental and economic impacts.

The economic cost of emissions is calculated by assigning a monetary cost to emissions of $PM_{2.5}$ and NO_x based on values for Costa Rica derived from an IMF (International Monetary Fund) database (IMF, 2014). The cost of pollutants calculated by the IMF are based on local levels of pollution at the ground level and the impact on health and costs caused by this type of pollution based on the exposure of the population to contamination and how increased pollution increases mortality risks using the WHO's dose response functions to concentration. The greater risk of mortality or, more precisely, the value of premature death is valued economically on the basis of stated preference studies performed by the OECD. All values are updated to USD of 2019 using a GDP deflator and by updating the GDP/capita of each country (PPP approach) based on latest available data from the World Bank (2018 data).

Table 4: Estimated Pollution Costs Costa Rica (USD of 2019)

Year	Cost per ton of $PM_{2.5}$	Cost per ton of NO_x
2019	99,000	750
2030	123,094	933

Source: calculation by Grutter Consulting based on IMF database updating values for 2019

The global warming externality cost is expressed through the social cost of carbon (SCC). A value of 40 USD per ton CO_{2e} (based on USD of 2019) is taken in line with main IPCC assumptions (see Grutter Consulting, 2020, "Methodological Note").

Based on the emission model used (see chapter 7) the economic cost of transport emissions for 2019 and for 2030 are close to 500 MUSD or 0.7% of 2019 GDP[22].

Table 5: Emission Costs Caused by Transportation (constant USD of 2019)

Area	2019	2030
Pollutants	125 MUSD	72 MUSD
GHG	334 MUSD	404 MUSD
Total	**459 MUSD**	**476 MUSD**

Source: Grutter Consulting based on transport model (see chapter 7) and data cited above per pollutant

[21] Costa Rica | CR: Imports: % of Goods Imports: Fuel | Economic Indicators (ceicdata.com)
[22] 61.8 billion USD; Costa Rica | Data (worldbank.org)

4. Transport Sector

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

Ministry of Public Works and Transport (MOPT)

The MOPT is the state's governing body in charge of regulating and controlling transportation in Costa Rica, as well as executing infrastructure works. This makes it the most influential actor in the country with regard to urban mobility. The MOPT also supervises councils that operate as semi-autonomous institutions including:

- National Road Council (CONAVI);
- National Concessions Council (CNC);
- Road Safety Council (COSEVI);
- Public Transportation Council (CTP).

One of the most important bodies within the MOPT is the Directorate of Sectoral Planning, with which several studies have been coordinated for the optimization of public transport routes. The Directorate plans public transport routes that are then concessioned to private companies. The concession, however, is not in the hands of this directorate, but rather in the hands of the CTP. Although the MOPT appears as a Co-Author in the PNTE, it does not have specific policies or guidelines for the electrification of transport.

Public Transportation Council (CTP)

This council grants public transport concessions to entrepreneurs and oversees the service. Every seven years the council must consider the bidding of each route and decide whether to renew the licence with the current concessionaire (under the same or updated conditions) or to make a new bidding. During the concession period, the Council supervises service delivery. In addition to granting concessions for public transportation, the CTP also grants operating permits to buses for special services (student transportation, tourism, etc.), and taxis. The CTP defines the location of bus and taxi stops and also the change of public transportation routes.

The CTP has been actively involved in electric mobility. Whilst discussions have been on-going concerning longer concession periods for e-buses, this has not yet resulted in an official pronunciation or decision on behalf of the CTP. 2021 new concessions shall be awarded – as the sector has been affected greatly by COVID19 it is improbable that e-buses will be demanded at this time.

Public Services Regulatory Authority (ARESEP) - Intendencia de Transporte

This autonomous entity defines the prices, rates and fees for public services. It also ensures compliance with quality, quantity, reliability, timeliness, environmental standards and optimal provision of public services under its jurisdiction.

ARESEP establishes the public transport fare model. With support from the World Bank a consultancy for a new fare model structure which includes e-buses was realized without however being implemented. Currently, the actual demand per route is not known to ARESEP. For new concessions however electronic payment shall be implemented which will allow to determine better the demand and consequently the profitability of routes[23].

November 2020, ARESEP defined the electricity price for e-buses (ARESEP, 2020) and in 2019 the fee to be charged at public chargers (ARESEP, 2019).

[23] https://www.larepublica.net/noticia/pago-electronico-en-buses-sera-obligatorio-para-concesionarios

Ministry of Environment and Energy (MINAE)

Apart from being represented on the CTP Board of Directors, this ministry has taken on an important role in mobility related projects. The country's carbon-neutral goal and the National Energy Plan promote lower consumption of fossil fuels in transportation. Thus, through various cooperation projects, studies have been financed to guide the country towards sustainable mobility. These projects are executed in close coordination with the MOPT.

MINAE is the governing body for the regulation of vehicle emissions. In addition, it has promoted initiatives for the promotion of EVs. Law 9825, officially grants the leadership in electric mobility to this entity.

Ministry of Finance (MOF)

The Ministry of Finance is a key entity for the implementation of Law 9518, since it is responsible for exempting vehicles that enter the country from taxes. Buses that are operated for public transportation are exempted from taxes. However, if a third party that is not an operator, for example, a leasing company, would import the buses, it would have to pay all applicable taxes. It is up to the MOF to adjust such regulations to enable alternative business models e.g. for e-buses.

Bus Operators and Associations

Public transport services are formal. No informal passenger transport with buses exists. All passenger transport companies are private companies. At the national level there are about 355 private transport operators realizing public transport services, and for the GAM around 70. There are 11 medium sized companies with fleets of more than 90 units whilst 45% of operators have less than 5 units[24]. There is a trend towards less companies: the number of authorized public transport service providers has decreased from 424 in 2008 to 355 in 2018 – however, this goes in line with decreasing demand for public transport services i.e. it is not (only) a trend towards larger enterprises.

By early 2020, 12 companies had publicly announced their intention to each acquire at least one electric bus. [25] This plan was put on hold, given the impact on bus operators of the drop in demand due to the COVID 19 pandemic.

The two largest bus transport associations are the National Chamber of Transportation of Costa Rica (CANATRANS) and the National Chamber of Bus Operators (CANABUS).

All companies are private and operate under a concession contract that lasts for seven years. Companies have access to loans. However, the duration of the concession, which serves as a guarantee for the banks, is the main barrier for closing larger credits. Some operators also represent bus brands and pay in cash or through a manufacturer loan.

[24] https://ARESEP.go.cr/images/Discusiones_regulatorias/Enrique_Munoz.pdf; the largest companies are: Auto Transportes Lumaca S.A., Auto Transportes Pavas S.A., Autotransportes Cesmag S.A., Autotransportes Desamparados S.A., Compañía de Inversiones La Tapachula S.A., Cooperativa de Autobuseros Nacionales Asociados R.L., Empresa Guadalupe Limitada, Lared Limitada, Transportes del Atlántico Caribeño Sociedad Anónima (long distance routes), Transportes Unidos Alajuelenses Sociedad Anónima, and Transportes Unidos La Cuatrocientos Sociedad Anónima

[25] https://www.presidencia.go.cr/comunicados/2020/03/costa-rica-amplia-plan-piloto-de-buses-electricos-como-parte-de-la-modernizacion-del-transporte-publico/

Taxi and Ride-Hailing Services

Ride hailing services such as UBER and DiDi operate in a legal grey zone. It is unknown how many drivers and at what frequency and professional level provide these services. However, it is clear that the service has become very popular due to being significantly cheaper than regular taxi services.

Taxi licenses are granted by ARESEP. The permit is renewed every ten years. Taxis also need to pay a fee to ARESEP, and their tariff is regulated. This puts them in a disadvantage compared to ride-hailing services.

Municipalities

The GAM is composed of 31 municipalities. These have a diminished role in public transportation. However, they have a direct influence on bus and taxis stops, municipal routes, bicycle routes, sidewalks and pedestrian boulevards. Additionally, they are the ones that grant construction permits e.g. for installing a public charger in accordance with their regulatory plans.

4.2. Public Transport Operators

About 5,000 public transport buses operated by 355 companies circulate throughout the country, moving about 1.6 million passengers per day. This generates around 385 USD per year. There are more than 2,000 buses in the GAM. There is a disintegrated network, made up of a group of lines that operate individually, except in certain cases. Routes are of a radial nature generating a high number of transfers in a system that has not been designed with this criterion as there is neither proximity between lines nor comfortable facilities for transfer. This results in the average travel time by bus, covering similar distances, being 70% longer than the travel time by car (Ministry of Environment and Energy, 2018).

Bus operators receive a concession that allows them to provide the service on established routes. The CTP grants theses concessions for a period of seven years. The next concession period starts in 2021. There is no actual bidding process, normally concessions get renewed for the same operators. CTP and ARESEP however do check on the gradual implementation of different requirements, such as ramps for disabled people (100% of the buses in Costa Rica have installed this ramp), or the acquisition of buses compliant with the emission standard Euro III. In some cases, a bus operator declares bankruptcy. In such cases, the route is assigned to other operators, without any bidding process, to prevent the service being affected.

There are frequencies and time tables to be held on the contract, however, in the urban area, the required level of service is hardly reached.

Bus operators do not receive direct subsidies for operating the routes. Fares are fixed per route by ARESEP based on the declared passenger demand, route characteristics and a tariff formulae.. The fare box must cover their expenditures. Indirectly subsidies are given as buses pay no import taxes and bus operators also do not pay for the infrastructure they use nor for external costs caused by their operations such as air pollution with the consequential health and environmental impacts. According to the Public Services Regulatory Authority the average fare for bus routes in the GAM varies from 0.35 to 0.90 USD per trip in 2020.

ARESEP, made a national pre-selection of potential candidates for electric buses based on the regulation that 5% of the bus fleet needs to be electric. Only buses of operators with at least 20 buses and only buses operated on short and medium haul routes of less than 80km per round-trip are included, resulting in 3,100 standard 10.5-12m buses which could be initially electrified. The following table shows the companies and the number of buses as identified by ARESEP. Not all of them operate within the GAM.

Table 6: Bus Operators with Buses with Potential to be Electrified as identified by ARESEP

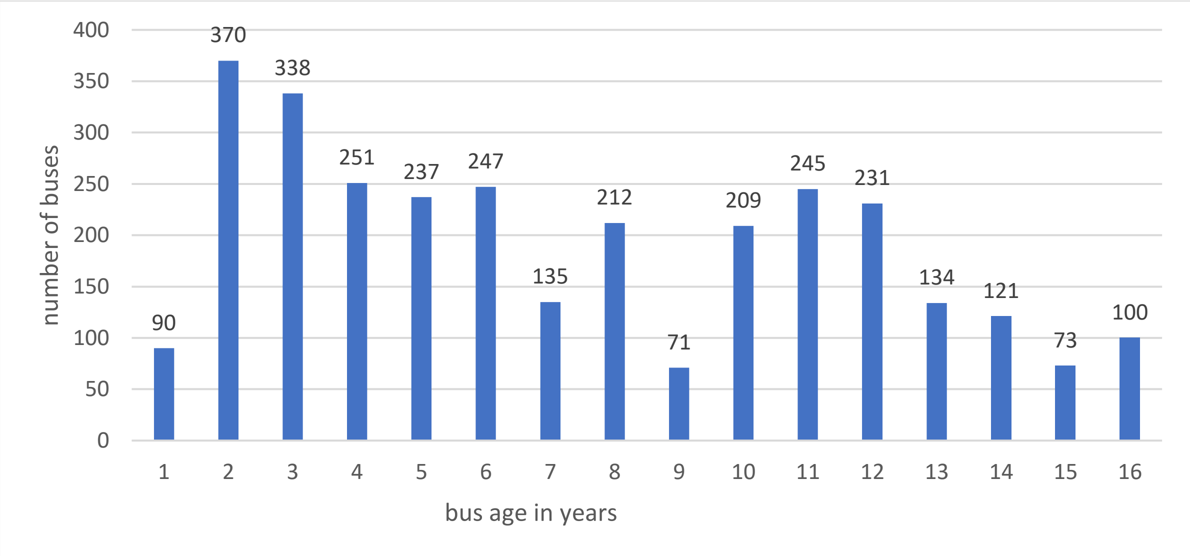
Operator	Number of Buses
Transportes Naranjo San José Sociedad Anónima	20
Ruta Ochenta y Tres AB SA	21
Transportes La Fortaleza Limitada	22
Transportes Unidos Poaseños Tupsa Sociedad Anonima	23
Cenebus S.A.	23
Autotransportes Palmares J A V Sociedad Anónima	23
Transportes del Este Montoya Sociedad Anónima	23
Corporación Autotransportes del Este Sociedad Anónima	24
Autotransportes Caribeños Sociedad Anónima	24
Cooperativa de Transportes de Sabanilla y San Isidro de Alajuela, R.L. Coopetransasi R.L.	24
Autobuses Barrantes Araya Sociedad Anónima	24
Transnorte de Upala Sociedad Anónima	25
Cooperativa de Autogestión de Transporte Colectivo R.L.	26
Magasoso de las Lomas Sur Sociedad Anónima	26
Autotransportes Raro Sociedad Anónima	27
Transportes Paracito Sociedad Anónima	27
Trancesa, Sociedad Anónima	28
Servicios De Transporte Heba De Guapiles Sociedad Anonima	29
Discar Sociedad Anónima	29
Empresa de Autotransportes Santa Gertrudis Limitada	29
Empresa Alfaro Limitada	29
Auto Transportes Mopvalhe Sociedad Anónima	30
Cooperativa de Usuarios y Gestores de Transporte y Servicios Múltiples de Cariari, RL.	30
Cooperativa De Transporte De Usuarios Y De Servicios Multiples De Atenas R L	31
Transportes San José A Venecia De San Carlos Sociedad Anónima	31
Rutas Cincuenta y Uno y Cincuenta y Tres, Sociedad Anónima	32
Empresa Villa Bonita Sociedad Anónima	33
Autotransportes Cuatro Por Tres Sociedad Anónima	33
Compañia Carbachez E Hijos E I R L	34
Corporación Nacional de Transportes Conatra Sociedad Anónima	34
Corporación Nacional de Transportes Conatra, Sociedad Anónima	34
Trasportes La Pampa Limitada	34
Autotransportes Zapote Sociedad Anónima	34
Buses San Miguel Higuito Sociedad Anónima	35
Pulmitán de Liberia, Sociedad Anónima	36
Transportes San Gabriel de Aserrí Sociedad Anónima	38
Alpízar S.A.	38
Autotransportes Los Guido S.A.	39
Transtusa Sociedad Anónima	39
Ticabus Sociedad Anónima	40
Autobuses Unidos de Coronado, Sociedad Anónima	43
Transportes Doscientos Cinco S.A.	44
Transportes Publicos La Unión Sociedad Anónima	44
Autotransportes Mepe Sociedad Anónima	46
Microbuses Rápidos Heredianos Sociedad Anónima	47
Busetas Heredianas S.A.	48
Empresarios Unidos de Puntarenas S.A.	49
Empresarios Unidos de Puntarenas S.A.	49
Transportes Unidos de Alajuela, Grecia y Naranjo Limitada	51
Consorcio de Transportes Cooperativos Metrocoop de Responsabilidad Limitada – Metrocoop	62
Buses Ina Uruca Sociedad Anónima	62

Empresarios Guapileños Sociedad Anónima	67
Autotransportes Moravia Sociedad Anónima	67
Cooperativa De Transportistas De Paraíso R.L.	67
Transportes Arnoldo Ocampo S.A.	69
Transportes Costarricenses Panameños, Sociedad De Responsabilidad Limitada	71
Compañia Transportista Del Suroeste Sociedad Anonima	78
Autotransportes San Antonio Sociedad Anónima	79
Transportes Del Atlántico Caribeño Sociedad Anónima	90
Autotransportes Cesmag Sociedad Anónima	93
Cooperativa De Autobuseros Nacionales Asociados R.L.	93
Lared Limitada	94
Auto Transportes Pavas Sociedad Anónima	95
Transportes Unidos La Cuatrocientos Sociedad Anónima	96
Auto Transportes Lumaca S.A.	118
Empresa Guadalupe Limitada	118
Autotransportes Desamparados S.A.	127
Transportes Unidos Alajuelenses Sociedad Anónima	149
Compañía de Inversiones La Tapachula Sociedad Anónima	184

Source: ARESEP

Buses can be used for 15 years (concessions are however only for 7 years) but some operators opt to replace them earlier and sell them off either to smaller operators, such operating in rural areas or companies which operate them as school or private charter buses. The following figure shows the bus age structure of the 68 companies which operate 20 buses or more and which have routes shorter than 80 km.

Figure 2: Age Structure Urban Public Transport Buses 2019



Notes:
a). includes only buses from operators with minimum 20 units and routes <80km
b). projected for 2019 based on age structure of 2018
Source: Compiled by Grutter Consulting based on data of ARESEP

Urban buses used in Costa Rica are relatively basic 12m (and some 14m) high floor buses without AC. Buses are required to have at grade entry for disabled passengers which is resolved through an elevator located at the mid door. A characteristic of urban buses in Costa Rica is a large number of seats (45+) and limited standing space.

Photo 1: Typical Urban Buses in Costa Rica

The majority of units are diesel powered with one company also running LPG buses. Multiple brands and models are used. Recently Chinese brands including Foton, Yutong, Kinglong and others have entered massively the market. Vehicle emission regulations of Costa Rica request that buses comply with the emission standard Euro I. In practice however, the majority of new buses purchased are Euro III or IV. The diesel sold has 50ppm sulfur [26]which allows for operations of Euro IV units. It is assumed that bus companies would purchase Euro IV diesel units as alternative to electric buses. The following table summarizes the main characteristics of urban buses procured currently in Costa Rica.

Table 7: Characteristics of Standard Conventional Urban Bus Procured as of 2020 in Costa Rica

Parameter	Value
Bus size; passenger capacity	12 meter; 45-50 passengers seated; 80 total
Bus features	No AC; textile seats; partially internet; GPS
Vehicle emission standard / fuel	Euro IV (not compulsory); diesel
Specific fuel consumption	47 liters / 100km [27]
Annual mileage	60,000 km[28]
Commercial lifetime	15 years as urban bus with another 5 years for other services (school or company bus)
CAPEX	110,000 USD [29]
Financing ratio and interest rate	50% loan financed; 8 years maturity; 8.5% interest rate flexible resulting in monthly payments of 800 USD excl. insurance
Residual value bus year 8	33,000 USD or 30% of initial CAPEX
Maintenance cost per km (only diesel engine excl. other maintenance or repairs and spare parts)	0.044 USD/km [30]

The company with the largest bus fleet (184 units) is Tapachula, which provides service in Escazú and Santa Ana. It owns around 200 buses. Next are Autotransportes Desamparados (127 buses) operating in Deamparados, TUASA (149 buses) operating in Alajuela and COESA, a consortium of three companies providing services on the Eastside of San José (the three companies have together around 140 buses), all of them will participate in the pilot e-bus project in 2021.

The COVID 19 pandemic has significantly affected the sector. The restrictions imposed on mobility, the recession in the economy, high levels of unemployment, closed schools and universities all

[26] Decree 36372-MINAET of 2011
[27] Based on ARESEP; data confirmed by operators and also in line with values from many cities worldwide
[28] Based on ARESEP; data confirmed by operators and also in line with values from many cities worldwide
[29] Data source bus importers as well as bus operators
[30] ARESEP

affected passenger demand. According to the CTP, many companies only operate currently 50% of the fleet. On the other hand various large operators seem keen to acquire electric buses and give them in leasing to smaller companies as this model already exists with diesel buses. However, they require more favourable loan conditions and clarity on concession renewals.

4.3. Taxi and Ride-Hailing Services

In 2019, there were around 7,000 taxis registered in the country which are mostly operated in a double shift. Standard taxis are composed basically of Hyundai Accents (>50%), Toyota Corollas and Toyota Yaris. Airport taxis also use frequently minibuses. More than 90% of standard taxis are older than 4 years. 70% of units are gasoline powered and the rest diesel. Very few taxis are hybrids and two or three electric units are used.

Taxi license plates are issued by the public transport council CTP to individuals and cooperatives. There is no data on the share of the license plates issued to individuals or cooperatives. According to CTP, the number of cooperatives has been declining since the entering of Uber Unlike Uber drivers, taxi drivers need to pay a fee to the regulatory entity ARESEP in order to operate.

The ride share market is composed of Uber and DiDi vehicles. Many Uber drivers run the vehicle based on daily or monthly renting agreements with some individuals owning and renting out multiple vehicles. A large variety of cars are used for Uber services with the majority being small units e.g. BYD F0.

There is interest to electrify the fleet, specially for airport taxis[31]. Costa Rica sells its green image well, so environmentally conscious tourists might willing to pay a higher fare. Another advantage is, that these taxis are kept during the night at the airport and could thus be re-charged during the night.

Table 8: Characteristics of Standard Taxis in Costa Rica

Parameter	Value
Vehicle emission standard / fuel	Euro 4 gasoline
Specific fuel consumption	7.5 liters / 100km (urban consumption level)[32]
Annual mileage	50,000 km [33]
Commercial lifetime	10 years
CAPEX	15,000 USD
Interest rate	9.5% [34]
Incremental maintenance cost compared to EV [35]	100 USD/ month

According to MINAE, a GEF/ONU pilot project on e-taxis might start in May 2021. This sector too, has been affected by the pandemic. According to the CTP, around 15 Taxi license plates are being returned every week.

[31] from the government as included in the law 9518 and from private operators, expressed in various interviews maintained with taxi operators
[32] (EEA, 2020) for small cars; see also Hyundai Accent technische Daten - Abmessungen, Verbrauch & Motorisierung – AutoScout24
[33] ARESEP
[34] ARESEP; 8 years maturity
[35] Based on oil and filter costs; only differential costs to EVs

4.4. Light Commercial Vehicles for Urban Freight

The sector is atomized with many individuals owning a vehicle and renting services to 3rd parties. However, there are many companies with interest in electrifying their fleet, such as Automercado and also Correos de Costa Rica which is currently testing 2 vehicles. Currently there are about 143,000 LCVs in the country.

5. E-Mobility System

The promotion of electric mobility plays an important role for the country. The opportunity to use the country's renewable energy matrix to decarbonize this sector through a technological transition has been recognized. The technical roundtable on electric mobility is in charge of planning and regulating issues that are still pending such as the proper disposal of batteries, concession contracts, public charging network and incentives for taxis and LCVs, the modification of Law 9518 etc.

Public Charging Network

ICE and other electricity distributors are responsible for setting up the legally required minimum charging network. Carthage. Art. 31 of the law 9518 establishes that energy distribution companies must install every 80km on national roads and every 120km on cantonal roads public chargers. Art IX of the Regulation 41642-MINAE regulating the construction and operation of a charging network by power distribution companies, states that it is the obligation of public service companies to establish the charging infrastructure even if this is not profitable.

The regulation 41642-MINAE of 04/2019 obliges the power companies to establish at minimum the following quantity of public chargers[36]:

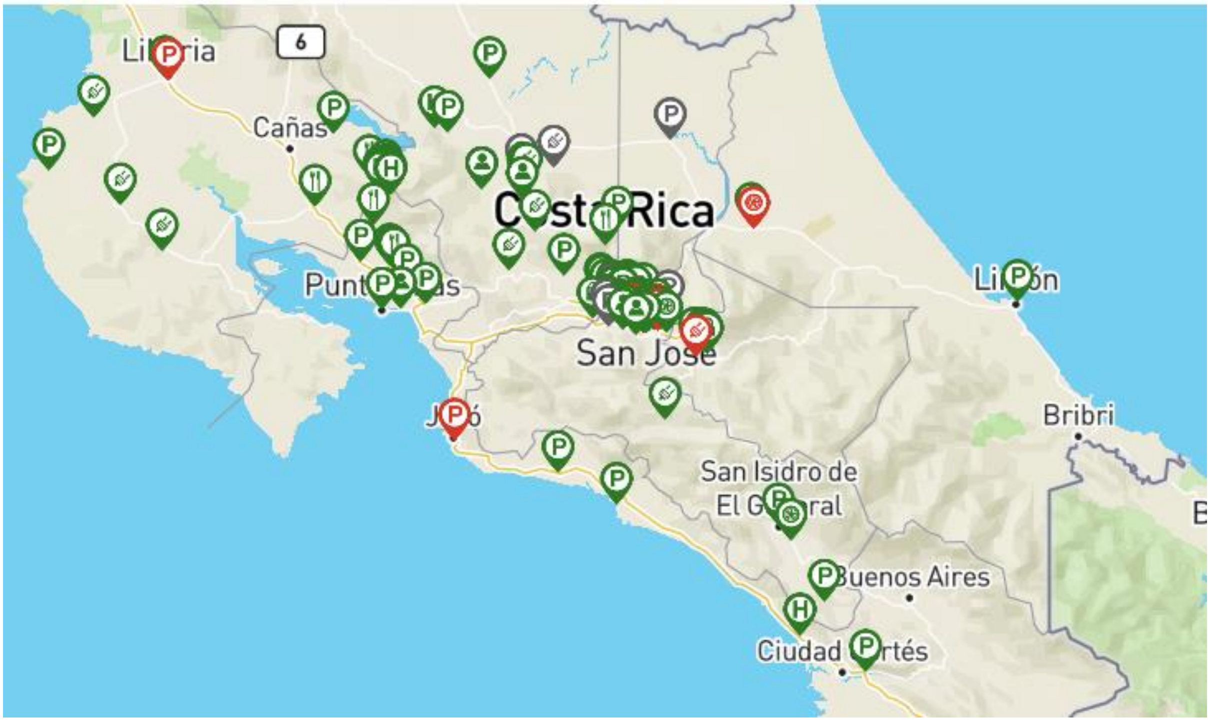
- 9 in the urban area of San Jose (responsible: CNFL)
- 38 outside the urban area of San Jose (by ICE, COOPEGUANCASTE, COOPEALFARORUIZ, COOPELESCA, COOPESANTOS, JASEC, ESPH

There are currently around 36 Type 1 7.6 kW chargers and 15 50 kW fast chargers (50 kW) installed throughout the country (target 34 units). 28 new 100 kW chargers are currently being installed by ICE which allow for connection to CCS1, CHAdeMO or GB/T[37]. ICE chargers have been financed through a loan from the IDB. In total some 180 publicly accessible chargers exist including also slow chargers (see map below), various of which have been established by private parties e.g. at shopping malls, at restaurants or at hotels. However outside the network established by the power companies no private network of chargers exists in Costa Rica..

[36] Art. 24 and 25

[37] ICE inicia instalación de 28 cargadores rápidos en el territorio nacional (larepublica.net)

Figure 3: Public Fast Chargers Costa Rica 12/2020



Source: [Listado de puntos de recarga en Costa Rica (electromaps.com)]

In the urban area currently there are predominantly public slow chargers (SAEJ1772; up to 7.4kW) installed. Very few fast-chargers are available. Such slow chargers are fine for private passenger cars realizing a topping-up whilst shopping or eating. To charge an additional 100km of driving range with this power output will take 2-3 hours. This is not feasible for taxis or LCVs which would require at minimum 50, better 100 or 150 kW chargers[38]. A study financed by the BCIE found that for 17,500 electric LCVs around 65 charging points with 2 fast-chargers of 50kW or more would be required (Utgard, 2017) i.e. for the 2030 target of nearly 60,000 LCVs around 400 urban chargers would be required. The target in the "potential scenario" for 2025 is only around 2,300 LCVs. However, the number of charge points would not reduce proportionally as still a certain density of the charging network is required to prevent driving long detours for re-charging. This makes the establishment of a fast charging network costly as long as the density of EVs is low and is the prime justification for kick-starting EV deployment by subsidizing the establishment of an urban fast-charging network indispensable for taxis and for LCVs.

EVs in Costa Rica

The Directorate of Energy updates the data periodically and publishes them on its website[39]. The category of "others" includes golf carts, quads, freight elevators, etc. In total some 3,100 EVs are circulating as of October 2020 of which 1,300 cars and 600 motorcycles with the rest being "others". While a slight increase in registered electric vehicles can already be seen in 2020 compared to 2019, the percentages compared to total imports are still very low.

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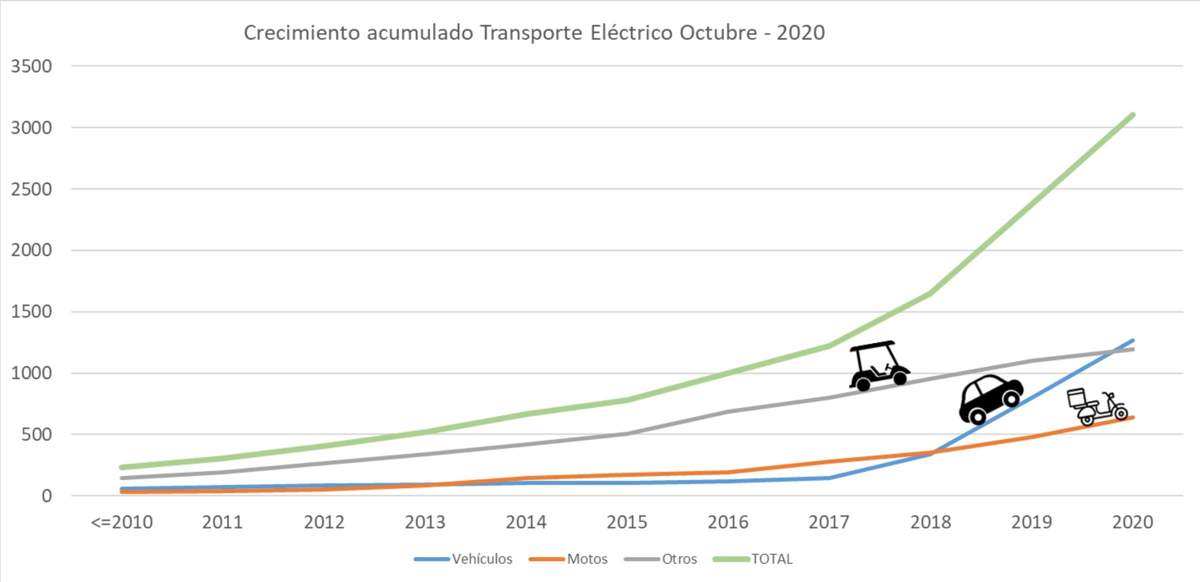
[38] A 50 kW charger would require 20 minutes of charging for 100km, a 100 kW charger less than 10 minutes (however, not all vehicles and batteries currently accept charges beyond 50kW).
[39] https://energia.minae.go.cr/?p=5634

Figure 4: EVs in Costa Rica 2010 to 2020



Source: https://energia.minae.go.cr/?p=5634

In December of this year, the German Government donated to the Costa Rican government 3 new electric buses of the brand BYD. They are 12m units overnight charged buses, with a capacity for 80 passengers and a range of up to 250 km per load. The main purpose of this pilot is to test the buses on different routes, showcase electric buses to the public and get operators acquainted with electric buses. The pilot also serves to identify all regulatory barriers and problems associated currently with the import and operations of e-buses. Additionally capacity building and training sessions are made around the e-buses e.g. for bus drivers or for maintenance staff.

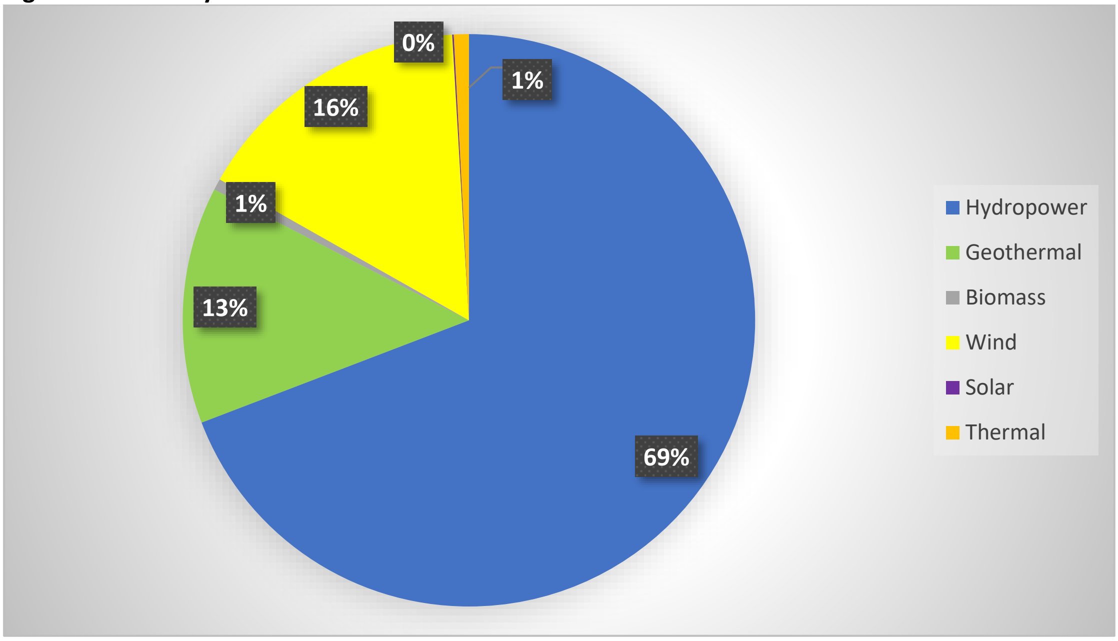
Photo 2: Delivery of E-Buses to the Costa Rican Government

6. Power Sector

6.1. Electricity Generation

2019 Costa Rica produced 99.2% of electricity based on renewables (see following figure).

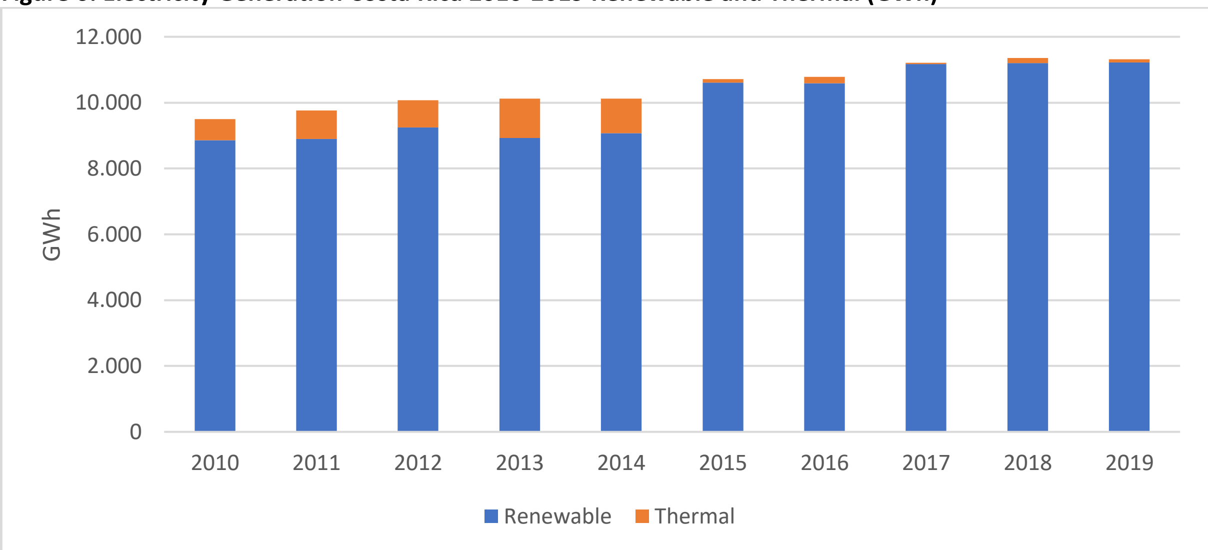
Figure 5: Electricity Generation Costa Rica 2019



Source: (ICE, 2020)

The average share of renewables in the last 5 years has been 99%. The following figure shows thermal and renewable electricity generation since 2010.

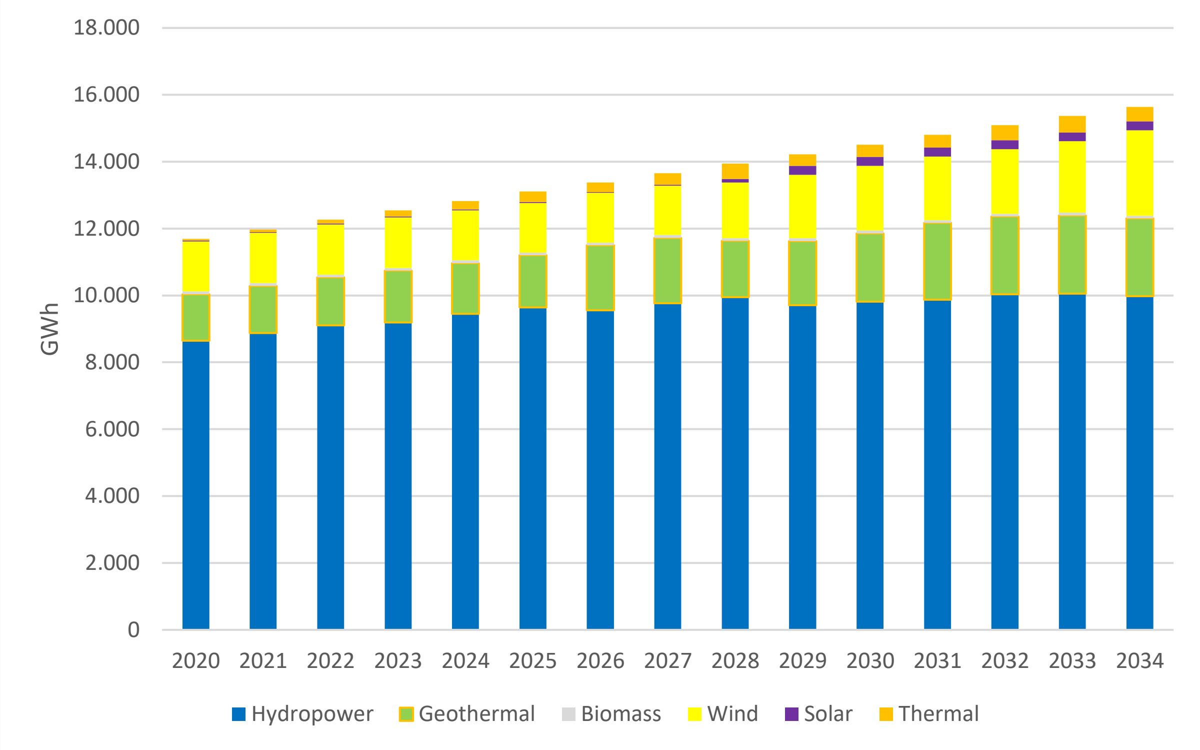
Figure 6: Electricity Generation Costa Rica 2010-2019 Renewable and Thermal (GWh)



Source: (ICE, 2020)

Projections estimate that the share of renewables will remain constant at 98% also for the future (see following figure).

Figure 7: Projected Electricity Generation per Source 2020 to 2034 Costa Rica (GWh)



Source: (ICE, 2019)

Production as well as consumption are expected to grow on average annually around 2% (ICE, 2019). Energy interchange (exports/imports) haver averaged in the last decade only 1% with on average more exports of electricity than imports (ICE, 2020). Electricity generation is projected to be sufficient to cover 100% of national demand by 2034 (ICE, 2019).

Costa Rica still has a considerable non-exploited renewable energy capacity as can be seen from the following table. Only 25% of the potential are currently being exploited.

Table 9: Renewable Energy Potential as of 12/2017

Source	Installed capacity MW	Potential capacity MW	installed as % of potential
Hydropower	2,328	7,651	30%
Geothermal	207	875	24%
Biomass	47	452	10%
Wind	378	2,400	16%
Solar	30	576	5%
Total	**2,990**	**11,954**	**25%**

Source: (ICE, 2019)

Summarized Costa Rica covers 100% of its national electricity demand, produces consistently electricity by 98-99% on a renewable base (historically as well as based on projections) and still has a significant potential to produce additional renewable electricity.

6.2. Grid Factor

The carbon emission factor of the grid is calculated based on national data. The emissions factor for 2019 and a projected grid factor is calculated. The grid factor has been calculated by determining the

GHG emissions of the thermal power plants. The following table shows the average carbon emission factor of the thermal power plants operating in Costa Rica.

Table 10: GHG Emissions Thermal Power Plants Costa Rica 2019

Plant (year)	average generation in GWh	specific fuel usage kWh/l	fuel type	fuel consumed liters	NCV per fuel type MJ/kg	EF_{CO2} per fuel type gCO_2/MJ	density kg/l	CO_2 emissions in tons
Garabito (2011)	225	4.48	bunker	50,223,214	40.4	77.4	0.96	150,764
Guapiles (2008)	9	4.07	bunker	2,211,302	40.4	77.4	0.96	6,638
Moin 2 (1991)	22	2.88	diesel	7,638,889	43	74.1	0.84	20,445
Moin 3 (2003)	28	2.95	diesel	9,491,525	43	74.1	0.84	25,404
Orotina (2008)	7	4.18	bunker	1,674,641	40.4	77.4	0.96	5,027
Total	**291**							**208,279**

Source: Average GWh, specific fuel consumed and fuel type: (ICE, 2019, p. 78); NCV and EF_{CO2} from (IPCC, 2006); density from (IEA, 2005)

This results in an average carbon factor of thermal production in Costa Rica of 0.761 $kgCO_2/kWh$. For projections to 2034 the plants older than 2005 are excluded resulting in a thermal power plant carbon factor of 0.674 $kgCO_2/kWh$. The following table shows past and projected total generation, past and projected thermal generation and the resultant past and projected carbon grid factor of the electricity grid in Costa Rica.

Table 11: Carbon Grid Factor Electricity Grid Costa Rica Past and Future

Parameter	2015-2019 (last 5 years)	2020-2034 (next 15 years)
Average total production	11,075 GWh	13,668 GWh
Average thermal production	119 GWh	304 GWh
Average grid factor	0.008 tCO_2/MWh	0.015 tCO_2/MWh

Source: calculations by Grutter Consulting based on (ICE, 2020) and (ICE, 2019)

For calculation purposes the higher of the two values[40] is taken for the carbon factor of the electricity grid of Cost Rica namely: **0.015 $kgCO_2/kWh$**.

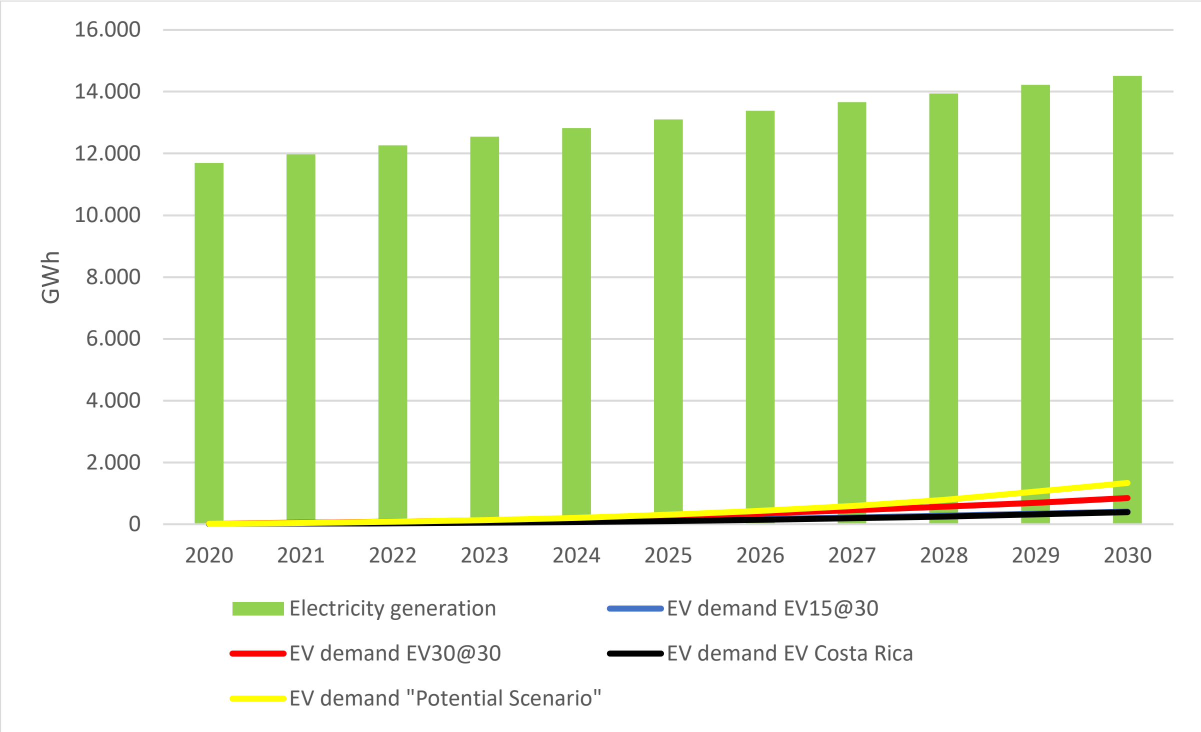
6.3. Electricity Demand from EVs

6.3.1. Supply versus Demand

The following figure shows the projected electricity demand from EVs based on the four scenarios and the projected electricity generation of Costa Rica.

[40] Conservative approach as the project uses electricity and not the baseline

Figure 8: EV Electricity Demand vs Generation Costa Rica 2020-2030



Source: Grutter Consulting based on EV scenarios and generation based on (ICE, 2019)

The 2030 electricity demand of EVs represents 3% of projected electricity generation for the EV15@30 and the EV Costa Rica scenario, 6% for the EV30@30, and 9% for the highest potential scenario. The renewable energy potential of the country is however 400% higher than the current production level (ICE, 2019) i.e. an increase of 9% would not face any technical difficulties to be met 100% by renewables. Also the demand increase is very gradual and thus leaves enough time to the country to plan a production expansion required however only in a decade from now.

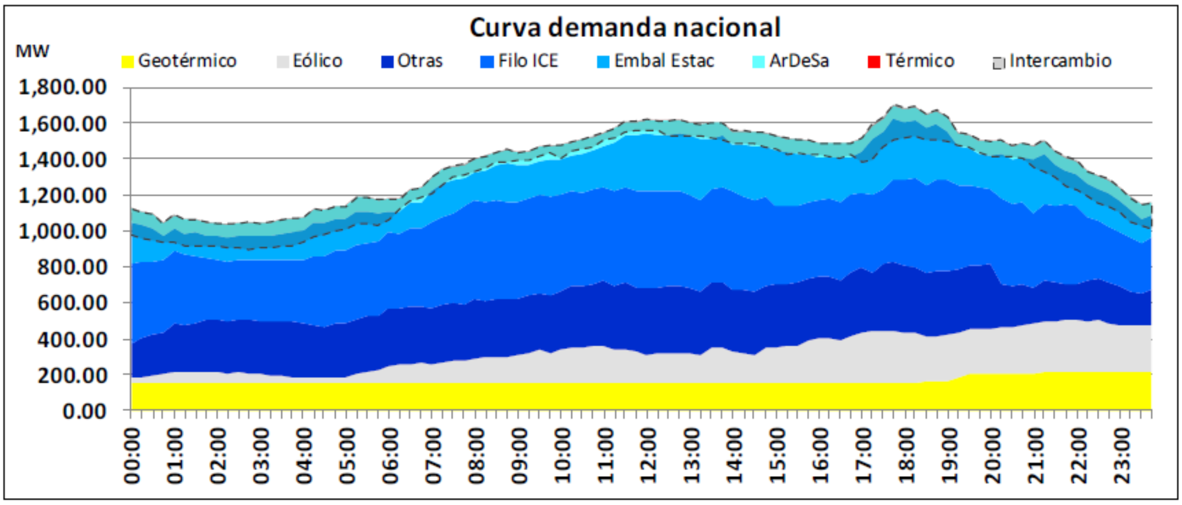
6.3.2. Peak Demand

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[41]. 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 the typical demand curve during the day in Costa Rica as well as for one specific day. Even peak demand can be covered in general 100% through renewables.

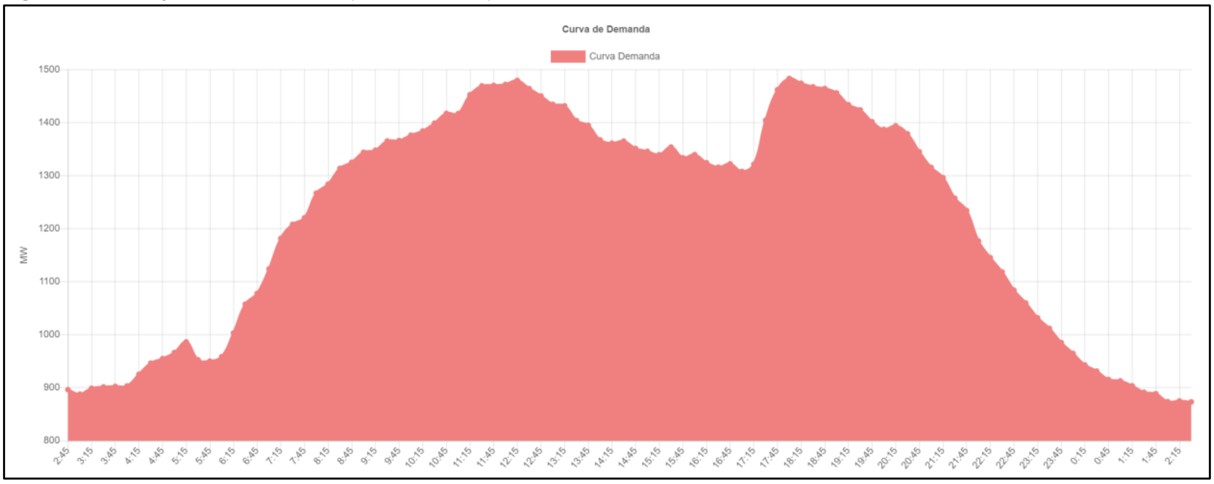
[41] Peak demand from a single EV using a top-of-the-range fast charger can be 80 times higher than the expected peak demand of a single typical household. See (McKinsey, 2018)

Figure 9: Demand Curve Costa Rica



Source: ICE, El Estado del SEN 04/12/2020

Figure 10: Daily Demand Curve (05/12/2020)



Source: ICE; [Curva de Demanda (grupoice.com)]

The system has a peak at midday and early evening (peak power prices are from 10-12.30 and from 17.30-20.00). Peak demand is managed also with differential pricing. The system has limited monthly variations. In all months of 2019 renewable energy production was able to cover >97% of the national demand. February/March are the months with the highest peak demands – however variations to annual average peak demands are not more than 5-10% (ICE, 2020). Thermal power basically enters in such situations of very high peak demands. Avoiding charging EVs at such peaks therefore results in using 100% renewable electricity and reduces stress on the grid.

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 (charging slots are typically 8-10 and 13-16) and opportunity charged buses can easily be equipped with large-enough battery sets to run 2-3 hours without charging. The grid system of Costa Rica therefore does not imply a preference for a certain e-bus technology.

Taxi fast charging could partially occur during the midday peak albeit the peak finishes at 12.30 i.e. if taxi drivers take lunch and meanwhile charge their vehicles they could be partially in the peak hour (during the evening peak this is not expected as this also coincides with peak demand for taxi services). This could be managed through differential prices for charging at peaks, as already done in Costa Rica.

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 in the evening 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. Solutions being proposed for these problems involve controlled charging and smart charging using Demand Side Management (DSM).

6.4. Potential Grid Issues with Commercial EV Connections

This section relates to the connection of charging sites for commercial electric vehicles[42] (EV) to the public electricity grid in urban areas of Costa Rica, with the main focus on the San Jose metropolitan area. In contrast to private EVs, commercial EVs will be usually charged at sites with many chargers (e.g. depots) and/or by fast chargers with large power ratings. Consequently, the charging sites will require power connections in the range of typically 500 kW to 5 MW. This power range is usually connected directly or indirectly - via a dedicated transformer - to medium voltage (MV) networks. For that reason, this section’s focus is on connecting charging sites to MV networks.

Electricity Network in Costa Rica

Medium voltage (MV) networks in the metropolitan area of San José are mainly operated at a relatively high voltage level for distribution networks: 34.5 kV. An exception is the MV network in the city centre of San José which is operated at 13.8 kV[43]. MV networks in other urban areas in Costa Rica are typically operated at 24.9 kV. The MV networks mainly consist of overhead lines although there are also underground cables installed such as in the city centre of San José.

Because of the relatively high voltage level of the MV networks on 34.5 kV, the capacity of the feeders is relatively high. The MV feeders could typically accommodate a total load of 15 to 20 MW[44]. Consequently, charging sites of 500 kW – 5 MW would normally not require dedicated MV feeders, but will likely share the MV feeders with other customers. This may be different for the MV feeders on 13.8 kV in the city centre of San José. If not already completely loaded, these feeders may be able to facilitate charging sites at the lower end of the 500 kV – 5 MW range. However, larger charging sites will require a dedicated feeder. The network operator reports that the loading of the MV feeders is hugely different throughout the network. Consequently it is not possible to provide generic statements on the available feeder capacity for connecting the charging sites.

The medium voltage networks are usually powered from a substation in which High Voltage (HV, 138 kV or 230 kV) is transformed to MV (34.5 kV, 24.9 kV or 13.8 kV). The MV side of these substations typically connects several MV feeders. In San José, these feeders are constructed in a so called meshed topology and operated radially. This means that feeders starting from one HV substations may be connected via switching actions to other feeders powered from the same or other HV substations.

[42] Commercial vehicles include urban buses, minibuses, taxis, light and medium trucks and public fleet etc.
[43] Another exception is a MV subsystem bordering the city centre of San José which is also operated at 13.8kV. That subsystem is using overhead lines.
[44] The MV feeders have a capacity of 20 MVA to more than 30MVA and are operated up to 80%. Considering an assumed power factor 0.9, the load per feeder should be in the range of 15- 20MW.

This has the advantage that in case of a power outage due to a fault in a feeder line or cable or a substation, the power supply can be restored via another route. Consequently, after a fault in a MV feeder or an HV/MV substation, the supply to all customers could be restored within typically a few hours. On average, a customer in Costa Rica is without power 8.3 times per year (=SAIFI) and the average duration of an outage is 1 hour and 7 minutes (=CAIDI)[45]. The figures are similar for network operator CNFL that operates a network in the metropolitan area and are rather constant since 2013. The technical standard on electricity network quality of Costa Rica[46] aims for an improvement to not more than 7 interruptions per year (=SAIFI) with a total duration of not more than 6 hours/year (=SAIDI). For the charging sites this means that it should be taken into account that they can be on average without power every second month for a duration of up to several hours (on average about 1 hour).

In addition to these reliability targets, the technical standard on electricity network quality also defines a target voltage quality, including limits for voltage level, harmonic distortion, and voltage dips in MV networks[47]. The limits are in line with internationally applied standards (e.g. IEEE 519-2014) and should be sufficient to connect charging equipment without problems. The technical standard adds requirements on monitoring and reporting on these aspects of voltage quality, which are also in line with international standards (e.g. IEC-61000-4-30). The regulator already started reporting on voltage quality in low voltage networks and commercial quality, including the response to voltage quality complaints[48]. However, there is no generic report on the voltage quality in MV networks in Costa Rica.

Connecting to the Electricity Network

After a request for a connection, the distribution company's engineers visit the site, evaluate the local network and start an engineering study. This study results in the specific design for the connection, including the need for protection, new support structures, changes in the circuit routes, line extensions, transformers etc.

In addition to this, requested connections of more than 4 MW require a planning study that validates the impact of the new load on the redundancy of the network, (voltage) quality and other operational issues.

In case of a simple extension to the feeder, the network operator considers that a connection can be realised within 15 days. However, if there is a need for a network extension, the implementation time of an overhead or underground network extension are highly variable and depend on many factors.

Although the distribution feeders usually have backup possibilities for feeder faults, the network connection itself is not redundant, a fault in the connection line/cable will directly result in an interruption of the supply to the charging site.

Summary and Conclusion Concerning Connection of Commercial EVs

In summary, the MV network in San José is considered in good shape for accommodating the connection and the load of chargers for commercial vehicles. Especially at the lower end of the 500 kW to 5 MW range, a connection should in general not be of much concern and could be realised pretty

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[45] Chapter 1 of 'Informe de evaluación de la calidad del suministro eléctrico Sector Distribución 2019' by Aresep. CAIDI is calculated by dividing SAIDI (or DPIR in Spanish, 9:24 hours/year) by SAIFI (FPI, 8,3 times/year)
[46] Article 62 of "Supervisión de la calidad del suministro eléctrico en baja y media tensión" (AR-NT-SUCAL)
[47] Chapter III of "Supervisión de la calidad del suministro eléctrico en baja y media tensión" (AR-NT-SUCAL)
[48] Chapter 3 and 4 of 'Informe de evaluación de la calidad del suministro eléctrico Sector Distribución 2019' by Aresep.

quickly. An exception may be the networks in the city centre of San José which are operated at a lower voltage level (13.8 kV) and may more likely require of new underground feeders for charging stations in the 500 kW to 5 MW range, which may take more time to install.

There are no major concerns about the quality of the network, although it has to be taken into account that on average there is a power outage every second month that may have a duration of up to several hours. Similarly, there are no major concerns about the connection process.

6.5. Electricity Pricing for EVs

Costa Rica has established specific electricity prices for EVs. The special prices fixed are for buses with chargers at their bus depot and for public chargers which can be used by any vehicle type (e.g. passenger cars, motorcycles, LCVs). Public chargers are not intended for usage by buses. The following table shows electricity prices valid for EV and compares them to standard prices.

Table 12: Electricity Prices Costa Rica 2020

Tariff	Cost
For buses charged at bus depots[49]	0.09 USD/kWh
Standard tariff medium tension (T-MT) based on ICE for buses, LCVs[50]	Power charge differentiated between night, day off-peak and day peak with: 7.50 / 11.70 / 16.7 USD/kW Consumption charge differentiated between night, day off-peak and day peak with: 0.024 / 0.038 / 0.103 USD/kWh Calculated cost standard tariff with night charge: 0.10 USD/kWh Calculated tariff with 50% day charge off-peak: 0.15 USD/kWh
Fixed price at public fast chargers	0.30 USD/kWh plus VAT
Residential for consumption >200kWh/month[51]	0.22 USD/kWh

Source: (ARESEP, 2020), (ICE, 2020), (ARESEP, 2019)

Basically the “special” tariff for buses is the same as the night tariff medium tension. The regulation also states that grid adjustments to allow for e-bus charging shall be prioritized by the power providers and costs are born by the power provider. For the charging infrastructure joint approaches between the operator and the power provider are possible.

7. Transport Emissions

7.1. Introduction

The vehicle fleet of Costa Rica has grown on average annually by 6% between 1980 and 2019 whilst the population has only grown by 2% (CONARE, 2020). 2019 more than 1.5 million vehicles were operating in the country.

For new and used vehicles imported to the country under 3.5t Euro 4 is compulsory since 2018 (MOPT-MINAE, 2016) and it is discussed to establish Euro 6 from 2023 onwards[52]. Prior to 2018 vehicles did

[49] Valid for 2 years and then to be revised; the tariff is based on the night tariff for medium tension
[50] As required by e-buses; tariffs can vary between providers; medium tension tariffs are those used by commercial vehicles such as buses, trucks or LCVs charged at specific premises.
[51] This tariff would also apply for home-charging e.g. of taxis or LCVs
[52] 2021 originally but changed to 2023 and not yet decided;

not need to comply with any standard but an inspection maintenance program was in place (which effectively any vehicle Euro 1 onwards could pass). For heavy duty vehicles including buses no emission standard is compulsory but new buses comply in general with Euro III or Euro IV. The fuel quality is maximum 50ppm sulphur contents i.e. is "Euro 4 fuel"[53]. More than 60% of vehicles circulating in the country are more than 10 years old (CONARE, 2020).

7.2. Transport Emissions 2019

The following table shows registered vehicles of Costa Rica in 2019.

Table 13: Vehicles Registered Costa Rica 2019

Vehicle category	gasoline	Diesel	total
Passenger car	867,842	105,552	973,394
Taxi	6,764	3,731	10,495
Motorcycle	291,580	0	291,580
small bus	0	10,927	10,927
standard urban bus	0	5,000	5,000
coach	0	2,732	2,732
LCV	62,648	143,021	205,669
Truck < 7.5t	0	3,233	3,233
Truck 7.5-16t	0	16,167	16,167
Truck 16-32t	0	6,467	6,467
Truck >32t	0	6,467	6,467

Source: (CONARE, 2020) Table 4.1. based on information from Riteve, INS and SEPSE-MINAE compiled by Fernandez; Urban bus number from ARESEP; Buses have been split in urban and coach buses based on ARESEP data for urban buses; The split between coach and small buses is based on an estimate by the Consultant (small buses include minibuses and coaster buses for up to 35 passengers used frequently by hotels and tourism agencies); truck data split up based on sizes based on relative distribution of other countries

Compressed Natural Gas (CNG) is not used as transportation fuel in Costa Rica. A very small number of urban buses run with Liquefied Petroleum Gas (LPG). No significant number of 3-wheelers operate in the country. The number of taxis only includes official units, not however ride-hailing vehicles, especially Uber, which is very popular in the country. Urban buses are basically standard 12m units. Light Commercial Vehicles (LCVs) also include private and not only commercial vehicles as pick-ups, also due to tax reasons, are very popular as private cars.

It is estimated that more than 50% of all vehicles circulate in the larger urban zone of San Jose (GAM) with around 50% of emissions resulting in this area[54].

The National University of Costa Rica, engaged in air quality monitoring since more than 2 decades, estimates that vehicles are responsible for 65% of air pollution. $PM_{2.5}$ levels monitored in the GAM surpass widely the air quality guideline value of the WHO (PEN-CONARE, 2018, p. 243). $PM_{2.5}$ and NO_x are today the air pollutants which cause the most health problems.

For 2019 emissions the average emission factor used for modelling purposes is Euro 2/II and for 2030 Euro 4/IV. The average age of circulating vehicles is currently more than 10 years and the Euro 4 standard is only compulsory since 2018. Vehicles could be imported as new or used units prior to 2018 which basically comply with Euro 1. Therefore the Euro 2 standard is considered to be a good

[53] CCAC Mexico & Costa Rica HDV Nov3 Leticia Pineda ICCT.pdf

[54] The share of vehicles is larger than the share of emissions due to higher mileage outside the urban area; vehicle distribution based on estimates by FUDEU cited in (Grutter Consulting, 2016)

approximation. In 2030, assuming again an average age of 10 years of vehicles the median vehicle should be Euro 4. Euro 6 shall only be introduced 2023 (no final decision has yet been taken – the Euro 5 standard is overjumped, as is done by many countries). The following table summarizes core assumptions on milage and fuel consumption used for calculations[55].

Table 14: Main Parameters Used for Emission Calculations 2019

Vehicle Category	Fuel Used	Specific fuel consumption (l/100km)	Annual mileage (km)
Passenger car	Gasoline	7.6	16,500
	Diesel	8.6	18,000
Taxi	Gasoline	7.6	50,000
	Diesel	6.5	55,000
Motorcycles	Gasoline	2.7	14,000
small bus	Diesel	18	43,000
standard urban bus	Diesel	47	60,000
Coach	Diesel	29	60,000
LCV	Gasoline	9.4	22,000
	Diesel	9.5	26,000
Truck < 7.5t	Diesel	12	28,000
Truck 7.5-16t	Diesel	18.4	43,000
Truck 16-32t	Diesel	24.9	71,000
Truck >32t	Diesel	29.7	85,000

Source: Passenger car size: small gasoline and large/SUV diesel; Fuel consumption values from (EEA, 2020) Tier 2 approach for vehicles > Euro 1/I; Passenger car mileage based on daily 49km and 365 days per year based on RTV measurements as published as published (CONARE, 2020) graph 4.6 and adjusted by factor 0.925 for gasoline cars by calibrating modelled and actual gasoline consumption 2019 with car mileage; Taxi mileage based on daily 136km gasoline and 150km diesel and 365 days per year based on RTV measurements as published (CONARE, 2020) graph 4.6; Motorcycle mileage based on daily 37km and 365 days per year based on RTV measurements as published (CONARE, 2020) graph 4.6; Small buses mileage based on daily 120 km and 365 days per year based on RTV measurements as published (CONARE, 2020) graph 4.6; urban bus mileage based on ARESEP (same data assumed for coach buses); LCV mileage based on daily 60km and 365 days per year based on RTV measurements as LCV mileage based on daily 60km and 365 days per year based on RTV measurements as published graph 4.6, CONARE, 2020: LCV mileage diesel adjusted upwards by 20% calibrating with actual diesel consumed 2019 with LCV mileage diesel adjusted upwards by 20% calibrating with actual diesel consumed 2019; Truck mileage based on daily 78km and 365 days per year based on RTV measurements as published (CONARE, 2020) graph 4.6: adjusted for larger units upwards to calibrate with actual diesel fuel consumed 2019 in Costa Rica

The following table shows estimated 2019 transport emissions for Costa Rica. The model has been calibrated with actual transport fuel consumed by Costa Rica in 2019 based on RECOPE[56] with a difference between top-down actual gasoline and diesel consumption and the modelled bottom-up consumption of 0.1%.

[55] 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.

[56] RECOPE - Refinadora Costarricense de Petróleo

Table 15: Estimated 2019 Transport Emissions

Vehicle category	NO_x	$PM_{2.5}$	CO_2 TTW	CO_2 WTW	Energy in TJ
Passenger car	4,639	135	2,907,392	3,558,953	41,543
Taxi	223	12	93,523	120,950	1,316
Motorcycles	1,752	55	241,864	300,222	3,490
small bus	422	76	225,886	322,337	3,048
standard urban bus	3,210	66	379,182	505,004	5,117
Coach	1,467	27	128,998	174,489	1,741
LCV	876	443	1,252,920	1,846,632	17,184
Truck < 7.5t	321	6	29,624	39,722	400
Truck 7.5-16t	3,797	72	340,968	461,393	4,601
Truck 16-32t	3,641	71	307,971	420,538	4,156
Truck >32t	5,170	107	441,718	605,995	5,961
Total	**25,518**	**1,070**	**6,350,046**	**8,356,236**	**88,558**

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

Transport GHG emissions of Costa Rica TTW in 2019 were 6.35 million tCO_{2e}[57]. Based on fuel sales the emissions are 6.36 million tCO_{2e} i.e. the modelled values reflect well the monitored top-down calculation. WTW GHG emissions of 8.36 million tCO_{2e} reflect the GHG emissions caused directly and indirectly by the transportation sector of Costa Rica. WTW also includes partially emissions caused outside the territory of the country as transport fuels are not refined in Costa Rica.

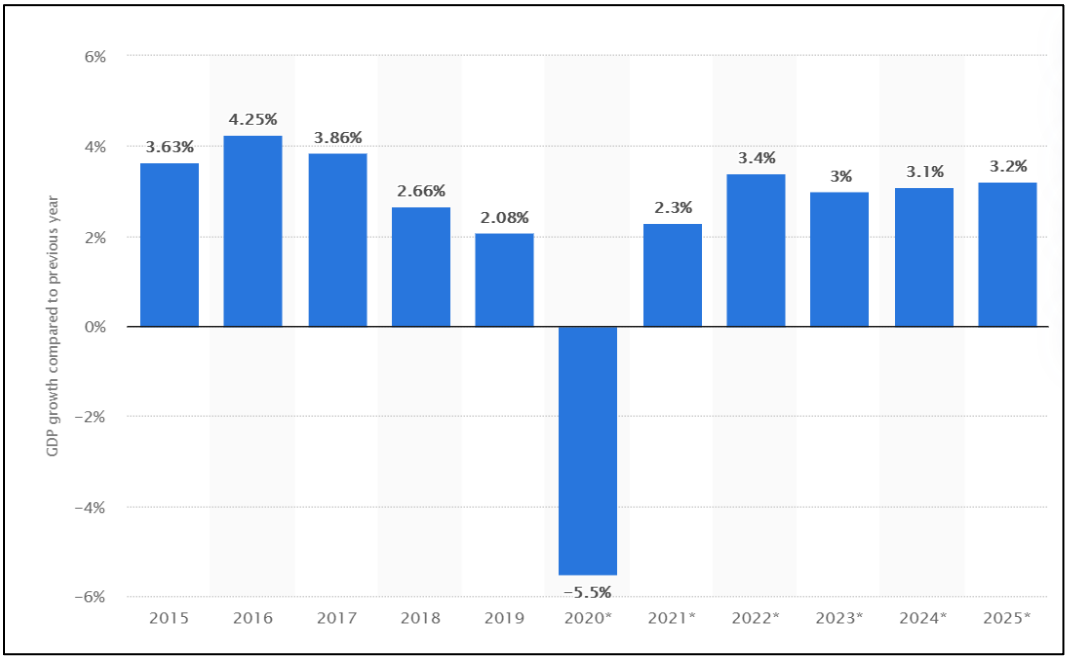
Taxis represent in 2019 around 1% of GHG emissions, buses 12% and LCVs 20%. However, the actual share of taxi emissions is estimated to be significantly larger as ride-hailing services are very popular in the country and not included under taxis but passenger cars. On the other hand LCVs emissions are not only commercial units as many such vehicles are also used by private persons. Noteworthy is that commercial vehicles represent around 50% of pollutants (NO_x and $PM_{2.5}$), due to being primarily diesel vehicles whilst passenger cars and motorcycles used by private persons are predominantly gasoline powered.

7.3. 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 Costa Rica including the recent COVID-19 impact followed by a table showing data relevant for calculation of the projected vehicle numbers in the country.

[57] (CONARE, 2020) reports emissions of 6.8 $MtCO_{2e}$ based on different assumptions concerning fuel consumption and mileage of vehicles; However the value reported by CONARE does not match fuel sales

Figure 11: Medium Term Real GDP Growth Rate



Source: Statista[58]

Table 16: Parameters for Projection of Vehicle Numbers and Emissions

Parameter	Value	Source/Explanation
CAGR population growth 2019-2030	0.9%[59]	INEC projections
CAGR GDP real growth 2019-2030	2.5%	Statista CAGR 2020 to 2025 with assumed constant values 2025 to 2030
CAGR GDP per capita growth 2019-2030	1.6%	Calculated from GDP and population growth rate
CAGR freight transport growth rate	2.5%	Freight intensity of 0.98[60] based on income per capita 2030 (PPP) of 15,300 USD using 2019 data from the World Bank and the real GDP growth rate
CAGR private passenger transport and taxi growth rate	2.9%	Based on Gomperz function with α of -4.32 and β of -0.000138 with a saturation level of 590 vehicles per 1,000 population[61]
CAGR bus growth rate	0%	The 2017 mode share of motorized trips is 42% cars, 41% buses, 9% taxis, 7% motorcycles and less than 1% by train (MINAE, 2017). The public transport share has decreased dramatically from 64% in 2007 to 41% in 2017 whilst private car usage increased in the same period from 31% to 42% (L.C.R. Logistica S.A., 2007). Therefore even with increased population demand for bus services is considered to be at best constant.

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 introduced compulsory by 2018. The mileage of vehicles is kept constant. The following table shows projected 2030 transport emissions of Costa Rica.

[58] • Costa Rica - gross domestic product (GDP) growth rate 2025 | Statista

[59] Population 2019: 5,058 million; 2030 5.564 million

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

[61] Saturation level based on Japanese pattern (Tian, 2014); parameters calculated by Grutter Consulting based on data of Costa Rica

Table 17: Projected 2030 Transport Emissions

Vehicle category	NO_x	$PM_{2.5}$	CO_2 TTW	CO_2 WTW	Energy in TJ
Passenger car	2,589	102	3,816,949	4,626,413	54,657
Taxi	187	9	127,530	160,629	1,795
Motorcycles	1,702	19	329,812	396,704	4,759
small bus	2,376	19	225,886	290,439	3,048
standard urban bus	1,626	14	379,182	475,750	5,117
coach	741	6	128,998	162,584	1,741
LCV	4,191	203	1,635,140	2,153,184	22,426
Truck < 7.5t	197	1	38,661	48,413	522
Truck 7.5-16t	2,388	15	444,984	557,122	6,005
Truck 16-32t	2,301	14	401,921	504,053	5,424
Truck >32t	3,323	19	576,470	722,097	7,780
Total	**21,621**	**421**	**8,105,534**	**10,097,391**	**113,274**

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 30% reaching 8.1 million tCO_2 by 2030 (10.1 million tCO_{2e} with a WTW approach).

8. EV Scenarios

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

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

The 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 18: Average Lifespan and Replacement Rate per Vehicle Category Costa Rica

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

Source: Grutter Consulting based on median ages of INS per vehicle category

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 19: EV Rates of Newly registered Vehicles

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

Source: Grutter Consulting based on IEA scenarios

Scenario Costa Rica

The targets are derived from the updated NDC. The NDC has as target 8% of the passenger cars and public transport vehicle stock in 2030 to be electric. To achieve this target more than 100,000 passenger cars need to be electric by 2030 and around 1,500 buses (includes urban as well as small buses and coach units). The target has been reformulated to annual new vehicle registration targets to achieve the EV vehicle stock target of the NDC. Important in this aspect is that the median age of passenger cars is 12 years in Costa Rica (INS) i.e. on average cars will be kept for at least 20 years which results in an average 5% replacement rate per annum. End 2019 Costa Rica had around 1,000 electric passenger cars of a total of over 1 million cars i.e. 0.1% of stock[62]. In 2020 for the first 6 months a total of 1,500 EVs (used plus new) were sold.[63]

The MINAE 2019 plan has as target that 10% of new taxi concessions are for electric vehicles. This is equivalent to asking for 10% of replaced taxis to be electric (Art. 3.1.3.4 page 108).

For all other vehicle categories no explicit targets are formulated.

Table 20: EV Rates of Newly Registered Vehicles EV Scenario Costa Rica

Vehicle Category	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Cars	1%	2%	4%	6%	8%	10%	12%	14%	16%	19%	21%
Buses	0%	2%	4%	6%	8%	10%	12%	14%	16%	18%	20%
Taxis	0%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%

Source: Grutter Consulting based on above cited targets

Scenarios are made for illustrative purposes to assess their impact on the EV stock, the electricity sector and the environmental impact. The table below shows an illustrative calculation of the electric passenger cars under the EV scenario Costa Rica reaching the target of 8% electric cars as percentage of car stock in 2030.

Table 21: EV Car Scenario Costa Rica

Passenger cars Scenario Costa Rica	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all cars	1,001,230	1,029,861	1,059,311	1,089,604	1,120,762	1,152,812	1,185,778	1,219,687	1,254,566	1,290,442	1,327,344
Replacement cars	48,670	50,061	51,493	52,966	54,480	56,038	57,641	59,289	60,984	62,728	64,522
Additional new cars	27,836	28,632	29,450	30,292	31,159	32,050	32,966	33,909	34,879	35,876	36,902
EV car fleet new	765	1,574	3,238	4,995	6,851	8,809	10,873	13,048	15,338	18,242	21,299
EV car fleet stock	1,765	3,339	6,577	11,572	18,423	27,232	38,105	51,153	66,491	84,732	106,031
EV fleet as % of stock	0%	0%	1%	1%	2%	2%	3%	4%	5%	7%	8%
GHG reduction WTW in tons	5,978	11,309	22,275	39,194	62,399	92,234	129,060	173,252	225,202	286,987	359,126
Electricity demand GWh	5.3	9.9	19.6	34.5	54.9	81.1	113.5	152.3	198.0	252.3	315.7

Source: Grutter Consulting

[62] plug-in hybrids 170 cars or 0.02%

[63] http://ev-sales.blogspot.com/2020/07/costa-rica-june-2020.html

EV Potential Scenario

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

Table 22: Share of EVs of Newly Registered Vehicles "Potential Scenario"

Vehicle Category	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Taxis	0%	7%	11%	15%	22%	33%	48%	69%	100%	100%	100%
Urban Buses	0%	0%	15%	23%	34%	51%	76%	100%	100%	100%	100%
Small buses	0%	0%	7%	10%	15%	23%	35%	52%	78%	100%	100%
LCVs	0%	0%	1%	2%	4%	7%	14%	27%	52%	100%	100%

Source: For urban buses, taxis and LCVs the target is that 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 until ending their lifespan. The growth builds upon initial experiences which remove barriers cost reductions of vehicles to achieve financial equivalence in the future. For taxis a kick-start with 100 taxis in 2021 is assumed. The growth rate is then assumed 50% for new registered taxis per annum reaching 100% in 2028. For buses a kick-start of 50 units in 2022 is assumed and then a growth of 50% of new registered per year reaching 100% of new registered in 2027/2029. For LCVs a kick-start of 50 units in 2022 is assumed and then a growth of 100% of new registered per year reaching 100% of new registered in 2029.

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 23: Scenario Results

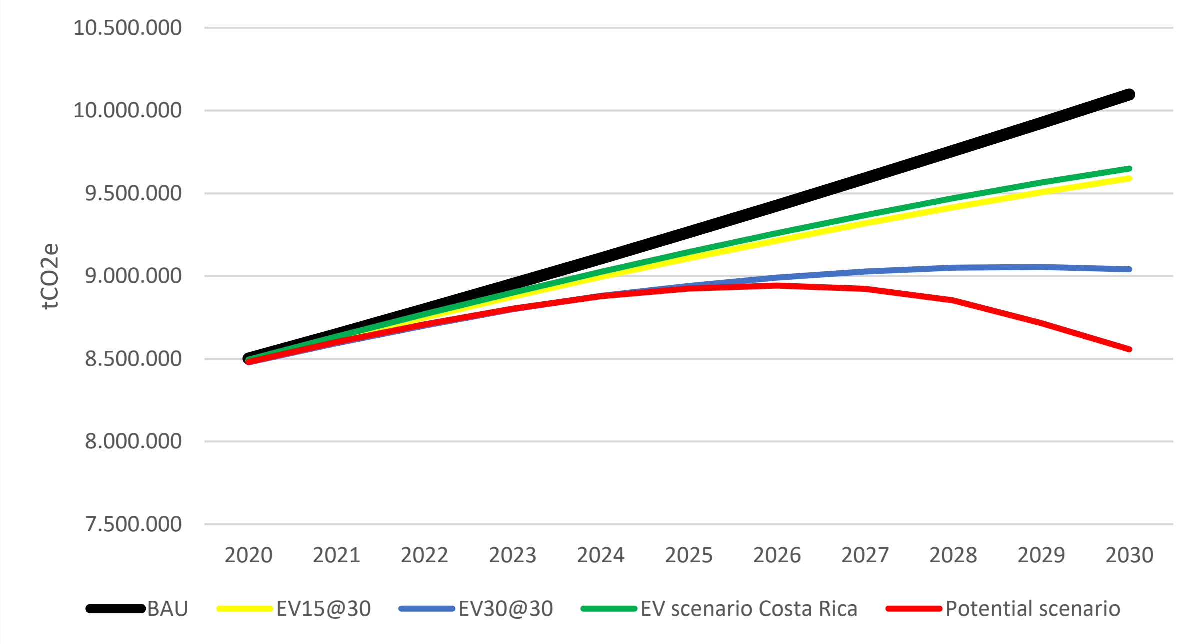
Impact	Scenario	By 2025	By 2030
GHG reduction WTW in tCO_{2e} per annum	IEA 15@30	157,000	507,000
	IEA30@30	325,000	1,057,000
	Costa Rica scenario	119,000	448,000
	"Potential" scenario	341,000	1,540,000
Electricity demand of EVs in GWh per annum	IEA 15@30	126	407
	IEA30@30	260	846
	Costa Rica scenario	104	390
	"Potential" scenario	305	1,335

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 18% reduction of GHGs relative to the baseline. Only the EV 30@30 and the "potential" scenario result in a trend change in this period and only latter result in GHG transportation emissions in 2030 not being higher than in 2019. The figure below shows the slow reaction of GHG emission reductions of the sector due to long permanence of vehicles once purchased. The introduction of EVs takes a long time to reduce in absolute terms GHG emissions of the transport sector as vehicle growth still occurs and as vehicle replacement rates are relatively low i.e. it takes time to achieve a large stock and therefore large impact of EVs. This highlights the importance of early actions. Waiting 5-10 years more until the market has evolved without support will result in a 5-10-year time lag of GHG reductions and thus non-attainment of climate targets.

Figure 12: Projected GHG Transport Emissions Costs Rica 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 24: Projected GHG Reductions for Taxis "Potential Scenario"

Taxis Scenario Potential	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all taxis	10,795	11,104	11,421	11,748	12,084	12,429	12,785	13,151	13,527	13,913	14,311
Replacement taxis	1,050	1,080	1,110	1,142	1,175	1,208	1,243	1,278	1,315	1,353	1,391
Additional new taxis	300	309	318	327	336	346	355	366	376	387	398
EV taxi fleet new	0	100	150	225	338	506	759	1,139	1,691	1,739	1,789
EV taxi fleet stock	0	100	250	475	813	1,319	2,078	3,217	4,908	6,648	8,437
EV taxi as % of stock	0%	1%	2%	4%	7%	11%	16%	24%	36%	48%	59%
GHG reduction WTW in tons	0	1,016	2,541	4,827	8,257	13,402	21,120	32,696	49,882	67,560	85,743
Electricity demand GWh	0.0	0.9	2.2	4.2	7.3	11.8	18.6	28.7	43.9	59.4	75.4

Source: Grutter Consulting

Table 25: Projected GHG Reductions for Small Buses "Potential Scenario"

Small Bus Scenario potential	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	10,927	10,927	10,927	10,927	10,927	10,927	10,927	10,927	10,927	10,927	10,927
Replacement vehicles	728	728	728	728	728	728	728	728	728	728	728
Additional new vehicles	0	0	0	0	0	0	0	0	0	0	0
EV vehicle fleet new	0	0	50	75	113	169	253	380	570	728	728
EV vehicle fleet stock	0	0	50	125	238	406	659	1,039	1,609	2,337	3,066
EV fleet as % of stock	0%	0%	0%	1%	2%	4%	6%	10%	15%	21%	28%
GHG reduction WTW in tons	0	0	1,156	2,890	5,491	9,393	15,245	24,024	37,192	54,035	70,878
Electricity demand GWh	0.0	0.0	1.2	3.0	5.7	9.7	15.8	24.8	38.5	55.9	73.3

Source: Grutter Consulting

Table 26: Projected GHG Reductions for Urban Buses "Potential Scenario"

Urban bus standard Scenario CR	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Replacement vehicles	333	333	333	333	333	333	333	333	333	333	333
Additional new vehicles	0	0	0	0	0	0	0	0	0	0	0
EV vehicle fleet new	0	7	13	20	27	33	40	47	53	60	67
EV vehicle fleet stock	5	12	25	45	72	105	145	192	245	305	372
EV fleet as % of stock	0%	0%	1%	1%	1%	2%	3%	4%	5%	6%	7%
GHG reduction WTW in tons	476	1,110	2,379	4,282	6,819	9,991	13,797	18,237	23,312	29,020	35,364
Electricity demand GWh	0.3	0.7	1.5	2.7	4.3	6.3	8.7	11.5	14.7	18.3	22.3

Source: Grutter Consulting

Table 27: Projected GHG Reductions for LCVs "Potential Scenario"

LCV Potential scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	210,708	215,870	221,159	226,577	232,129	237,816	243,642	249,611	255,727	261,992	268,411
Replacement vehicles	10,283	10,535	10,794	11,058	11,329	11,606	11,891	12,182	12,481	12,786	13,100
Additional new vehicles	5,039	5,162	5,289	5,418	5,551	5,687	5,826	5,969	6,115	6,265	6,419
EV vehicle fleet new	0	0	152	304	608	1,216	2,433	4,865	9,731	19,052	19,518
EV vehicle fleet stock	0	0	152	456	1,064	2,281	4,713	9,579	19,309	38,361	57,879
EV fleet as % of stock	0%	0%	0%	0%	0%	1%	2%	4%	8%	15%	22%
GHG reduction WTW in tons	0	0	852	2,556	5,964	12,780	26,412	53,675	108,202	214,962	324,337
Electricity demand GWh	0.0	0.0	0.7	2.0	4.7	10.0	20.6	42.0	84.6	168.0	253.5

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 28: Key Figures Commercial Vehicles EV "Potential Scenario"

Parameter	Taxis	Small Buses	Urban Buses	LCVs	Total
EV stock 2025 (% of all vehicles)	1,320 (11%)	410 (4%)	410 (8%)	2,280 (1%)	4,400
EV Stock 2030 (% of all vehicles)	8,440 (59%)	3,070 (28%)	2,000 (40%)	57,880 (22%)	71,000
GHG impact 2025	13,000 tCO_2	9,000 tCO_2	39,000 tCO_2	13,000 tCO_2	75,000
GHG impact 2030	86,000 tCO_2	71,000 tCO_2	190,000 tCO_2	324,000 tCO_2	670,000
$PM_{2.5}$ reduction 2030 (tons)	4	13	8	159	184
NO_x reduction 2030 (tons)	77	1,710	976	3,287	6,050
Savings emission costs in 2030 (MUSD)	4	6	10	36	55
Savings in pollutants costs in 2030 (MUSD)	1	3	2	23	28
Vehicle CAPEX 2025 (cumulative)	31 MUSD	31 MUSD	90 MUSD	52 MUSD	203 MUSD
Vehicle CAPEX 2030 (cumulative)	151 MUSD	196 MUSD	384 MUSD	1,193 MUSD	1,923 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 Costa Rica would have more than 70,000 commercial EVs by 2030 reducing 670,000 tCO_2. Around 50% of the impact by 2030 would be with LCVs followed by urban buses with 30%. The estimated cumulative vehicle investment required by 2025 is around 200 MUSD and 1,900 MUSD by 2030. This excludes the investment required for chargers, grid upgrades or other investments e.g. in depot facilities. More than 60% of the investment would be in LCVs. 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 55 MUSD (annual figure) of which around 50% is due to savings on less local pollutants and the other 50% due to reduced GHG emissions.

9. Enablers and Barriers

Costa Rica has made important steps towards electrification of the transportation sector, which is considered a national priority as well as an opportunity for the country to reduce dependency on fossil fuel imports and to green the economy. Enablers and barriers listed below have been identified and discussed with national stakeholders.

Enabling Factors

- **EV policies and deployment targets:** E-mobility is a topic since many years in Costa Rica. It is well recognized by stakeholders that shifting to EVs is positive for the country and a necessity. Ambitious targets and policies have sent a strong signal to commercial as well as private vehicle owners. The promotion of EVs is deeply embedded in the country policies at various levels and is a clear national priority. The country has not only set forth ambitious goals but has provided essentially for private car owners also important tax incentives and is keen on expanding EV application in the commercial sector.
- **Charging infrastructure policies:** Costa Rica already installed public fast-chargers and is installing more units. Whilst this is basically for private car owners, the know-how associated with the establishment of charges can be transferred to other applications. Also, regulations have been implemented fixing the price for electricity for e-buses and for usage of public fast-chargers. This creates more certainty on the cost of operating EVs and enables their uptake.
- **Renewable energy generation:** Costa Rica produces no fossil fuels. It produces electricity to >98% based on renewables resulting in a very low grid factor. Various renewable sources form the base and thus the country can provide all-year full coverage without requiring energy imports or fossil fuel production. Electricity is available with reserves not only during the night but also during vast periods of the day. Options for day charging of EVs are thus also valid in Costa Rica and will not stress the grid (avoidance of day peak hours is recommended and also easily achievable, especially with commercial vehicles). EV usage has thus significant environmental and financial positive parts for the country and reduces external dependency.
- **Taxation on fossil fuel:** Fossil fuel prices are below world average but compared to other Latin American countries still relatively high creating an incentive to switch to EVs.

Barriers

- **Lack of experience and know-how in creating enabling surroundings and project design**: In the field of passenger cars various steps have been taken. However know-how on optimal technical solutions as well as business models and policy structures which could enable and foster application of e-mobility in commercial fields is lacking. This includes the design of optimal e-bus systems as well as business models for e-buses and how to create conditions (concession contracts, payment guarantees) etc. which could foster e-buses without massive financial transfers from the government. In terms of taxis targets have been set but more knowledge on the interaction of charging network and technology for taxis is required. This is particularly relevant as most taxis are operated in two shifts (day and night shift) thus not being able to re-charge daily the vehicle at home for 8-10 hours. For urban freight only very limited experience is available. Interest of companies is there but it is unclear for the government what incentives and enabling conditions could be provided to foster the application of e-mobility in this area. At project level only very limited know-how is available for rapid assessments (as demanded e.g. by companies for their initial assessment for investing or not in EVs) as well as for full project design, specifically in assessing the optimal technical and financial e-system approach. This is reflected in bus operators (as well as many other actors) only being aware of the option of overnight charged e-buses which are being strongly promoted especially by BYD and which in many cases are not an optimal technical, operational and financial solution. The lack of know-how and experience in this area results in a barrier to commercial EV application as the policies and regulations do not promote sufficiently EV usage and systems are sub-optimally designed. Limited know-how on appropriate regulations and options how to manage EV battery re-usage, recycling and disposal also forms a barrier (it is one of the main environmental arguments brought forward against EV promotion) as well as a potential environmental threat.

- **Lack of know-how in project implementation areas:** The know-how and skills required to maintain and operate well EV systems are not yet developed. This includes driver skills, maintenance of EVs and their charging infrastructure, or skills required by safety and rescue personnel. The non-availability of such skills poses a barrier for investors to purchase EVs as they see a risk of the asset not being available for operations at a similar reliability level as fossil units.
- **Lack of Urban public fast-charging infrastructure**: For taxi and LCV deployment an urban public fast charging infrastructure is required. Overnight charging for a driving range of 250-300km will require 8-10 hours of charging with standard home chargers. This is not feasible for most operators given also the fact that most taxis operate with double shifts. An urban public fast-charging system is not yet available making the deployment of such vehicles operationally problematic. Current initiatives are geared towards private passenger cars which require such infrastructure on inter-urban trips. Urban chargers are too spread out and of to low power capacity i.e. serve as top-ups for private but not for commercial users such as taxis which require at least 50kW but better 100-150kW chargers to enable a top-up of additional 100km in 15-20 minutes.
- **Existing operational system for buses favours diesel units:** the current public bus operations are managed by a large number of small and some medium sized enterprises with limited financial power. Bus operations are not directly subsidized and the operators directly receive the fare revenues. The technical fare does not include e-bus system costs. Concession contracts are for 7 years. All these elements form effective barriers as e-buses require high upfront investments which are used for long periods. Leasing as well as separation of ownership and operation are business models which have proven to be effective to foster e-buses but require enabling conditions like secured payments, long concession periods, transferability of concessions and assets etc. Bus operators as well as various government stakeholders are aware of these problems but are not clear on concrete steps how to resolve them.
- **Lack of profitability:** Commercial EVs are being perceived to be not profitable. It is clear for actors that operational costs are lower. However, the magnitude of savings depends on the actual performance of such vehicles (especially in terms of energy efficiency and actual maintenance costs also influenced by spare parts costs) and energy prices (fossil fuel prices to determine savings as well as electricity costs). Operational savings are also not easily to determine: if e.g. a LCV e.g. charges at public fast chargers the electricity tariff is for example 50% higher than if the vehicle is charged at home and triple than if charged overnight at an industrial facility. TCO calculations include many assumptions and the long payback period and the profitability of EVs versus fossil vehicles is not perceived to be sufficient against the risks of the new technology.
- **High upfront costs and lack of long-term financing options:** Many bus operators do not have the capital to purchase e-buses or to finance the normally required 30% with own capital. 30% of an e-bus reflects double or more of the investment for a diesel unit. Financial institutions are reluctant to finance even 70% of e-buses as concession contracts are only for 7 years and the investment cannot be recovered potentially in this time. Also re-sale values are unclear creating a barrier for a leasing system. Since public transport is not directly subsidized by the government, the margin for any public institution to aid with the financing of e-bus

deployment is very limited. The government explicitly is not willing to make cash-transfers or direct subsidies for the purchase of e-buses or other electric vehicles[64].

Summarized Costa Rica has very good enabling conditions for the promotion of e-mobility and considers this as a national priority. Many important steps have already been taken. The focus and the incentives provided are however to the moment primarily targeted towards private vehicles. Tax incentives in this area can be equivalent to a financial subsidy of 10-30,000 USD per vehicle considering the high taxes for importing vehicles. Similar incentives are not in place for commercial vehicles which is also related to tax incentives not being classified as subsidies[65]. Whilst it is well understood that commercial EVs are very important, the barriers in terms of regulations (e.g., concession contracts), profitability, business models and implementation risks continue to exist thus hampering commercial EV deployment. Concession contracts are e.g. limited to 7 years. Banks are therefore not willing to finance buses beyond the concession period. The differential investment in e-buses can however not be recovered in this time frame and the lifespan of e-buses is also considerably longer. The short length of concession contracts as well as the non-guaranteed transfer of assets in case an operator discontinues services are a barrier towards long-term financing of e-buses.

Major potentials seen for Costa Rica and activities which would reduce the barriers and facilitate commercial EV deployment are:

- Technical assistance to provide for concrete steps to reduce barriers for EV deployment including adjustments of concession contracts, design and establishment with financial partners of new business models and regulatory mechanisms for buses which provide financial guarantees for investors. This could be e.g. in the form of specific detailed and action-oriented roadmaps for e-buses, for e-taxis and for commercial LCVs.
- Concessional finance for deployment of commercial EVs. Based on the atomized structure in the taxi and LCV market a promising step could be to have special loan facilities for purchase of commercial EVs. Similar facilities which also include incentive payments exist in various countries and have been used successfully not only for EV deployment but also for fleet renovation or for technology change e.g., to CNG vehicles. Concessional finance including grants would enable to eliminate the barrier of limited profitability and high upfront investment of EVs and thus kick-start commercial EV deployment.
- Successful EV deployment for taxis and commercial vehicles will not only require regulatory incentives (e.g., taxi licenses), but also financial instruments (e.g., concessional loans or leasing schemes, upfront grants) and an urban public fast-charging infrastructure.

The next reports for Costa Rica will detail more the cost-benefit of commercial electric vehicles and identify possible intervention and investment areas (EV demand report previewed for early January) and the related intervention strategy of the EV fund (EV intervention strategy previewed for end of January).

[64] Tax incentives or contract incentives are not considered by the government as subsidies.
[65] Tax incentives do not work for commercial vehicles as also fossil buses or trucks only pay very limited taxes.

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Annex: Detailed Data

Vehicle Data

Vehicle category	gasoline	diesel	CNG	total
Passenger car	867,842	105,552	0	973,394
Taxi	6,764	3,731	0	10,495
3-wheeler	0	0	0	0
Motorcycle	291,580	0	0	291,580
small bus	0	10,927	0	10,927
standard urban bus	0	5,000	0	5,000
coach	0	2,732	0	2,732
LCV	62,648	143,021	0	205,669
Truck < 7.5t	0	3,233	0	3,233
Truck 7.5-16t	0	16,167	0	16,167
Truck 16-32t	0	6,467	0	6,467
Truck >32t	0	6,467	0	6,467

CONARE, 2020, Table 4.1. based on information from Riteve, INS and SEPSE-MINAE compilated by Fernendez; Urban bus number from Aresep; assumption remaining buses 80% small units and 20% large coach buses

10% <7.5t; 50% 7.5-16t; 20% 16-32t and 20% >32t (Switzerland as base i.e. small country)

Year of data	2019
Country	Costa Rica
Growth rate freight transport	2.5%

See below

Bus, coach growth	0%

decreasing mode share and population increase result in 0% growth

Passenger car, MC, taxi growth	2.9%
Carbon grid factor	0.015

Default Emissions

vehicle distances have been adjusted i.e. Model was calibrated with actual fuel usage 2019 in the country

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	56	0.229	0.002	172	0	205	2.5	16,544
Passenger Car	diesel	73	0.716	0.055	233	39	326	3.1	17,885
Passenger Car	CNG	63	0.056	0.001	189	0	264	3.0	15,000
Taxi	gasoline	56	0.229	0.002	172	0	205	2.5	49,640
Taxi	diesel	55	0.716	0.055	175	39	255	2.4	54,750
Taxi	CNG	63	0.056	0.001	189	0	264	3.0	51,465
3-wheeler	gasoline	24	0	0.000	75	0	89	1.1	20,000
3-wheeler	diesel	19	0.500	0.050	61	11	86	0.8	20,000
3-wheeler	CNG	32	0.5	0.000	96	0	134	1.5	20,000
Motorcycle	gasoline	20	0.445	0.014	61	3	76	0.9	13,505
Small bus	gasoline	148	0.000	0.000	455	0	541	6.6	42,705
Small bus	diesel	152	0.904	0.163	484	95	691	6.5	42,705
Urban standard bus	diesel	397	10.700	0.220	1264	129	1,683	17.1	60,000
Urban standard bus	CNG	515	10.000	0.010	1,545	0	2,155	24.7	60,000
Coach bus	diesel	247	8.950	0.165	787	97	1,065	10.6	60,000
LCV	gasoline	70	0.230	0.002	215	1	256	3.1	21,900
LCV	diesel	80	0.149	0.117	255	84	398	3.4	26,280
Truck < 7.5t	diesel	101	3.490	0.061	322	36	432	4.3	28,470
Truck 7.5-16t	diesel	155	5.500	0.104	494	61	668	6.7	42,705
Truck 16-32t	diesel	210	7.910	0.155	669	91	914	9.0	71,175
Truck >32t	diesel	251	9.360	0.194	800	113	1,097	10.8	85,410

urban standard bus fuel consumption taken from ARESEP

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	56	0.056	0.001	172	0	205	2.5	16,544
Passenger Car	diesel	55	0.580	0.031	175	25	240	2.4	17,885
Passenger Car	CNG	63	0.056	0.001	189	0	264	3.0	15,000
Taxi	gasoline	56	0.056	0.001	172	0	205	2.5	49,640
Taxi	diesel	55	0.580	0.031	175	25	240	2.4	54,750
Taxi	CNG	63	0.056	0.001	189	0	264	3.0	51,465
3-wheeler	gasoline	24	0.000	0.000	75	0	89	1.1	20,000
3-wheeler	diesel	19	0.500	0.050	61	11	86	0.8	20,000
3-wheeler	CNG	32	0.500	0.000	96	0	134	1.5	20,000
Motorcycle	gasoline	20	0.317	0.004	61	1	74	0.9	13,505
Small bus	gasoline	148	0.000	0.000	455	0	541	6.6	42,705
Small bus	diesel	152	5.092	0.040	484	27	622	6.5	42,705
Urban standard bus	diesel	397	5.420	0.046	1264	31	1,586	17.1	60,000
Urban standard bus	CNG	455	2.500	0.005	1,365	0	1,904	21.8	60,000
Coach bus	diesel	247	4.520	0.035	787	24	992	10.6	60,000
LCV	gasoline	70	0.064	0.001	215	0	256	3.1	21,900
LCV	diesel	80	0.831	0.041	255	32	346	3.4	26,280
Truck < 7.5t	diesel	101	1.640	0.011	322	7	403	4.3	28,470
Truck 7.5-16t	diesel	155	2.650	0.016	494	11	618	6.7	42,705
Truck 16-32t	diesel	210	3.830	0.024	669	16	839	9.0	71,175
Truck >32t	diesel	251	4.610	0.027	800	18	1,002	10.8	85,410

Source and Assumptions

Emission factors and fuel consumption EEA, (2020), COPERT Tier 2 except for small buses and 3-wheelers

car/taxi: small size gasoline and large/SUV size diesel

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

all units g/km

Urban bus mileage based on ARESEP

Taxi mileage based on daily 136km gasoline and 150km diesel and 365 days per year based on RTV measurements as published graph 4.6, CONARE, 2020

Motorcycle mileage based on daily 37km and 365 days per year based on RTV measurements as published graph 4.6, CONARE, 2020

Small buses mileage based on daily 120 km and 365 days per year based on RTV measurements as published on graph 4.6, CONARE, 2020

Passenger car mileage based on daily 49km and 365 days per year based on RTV measurements as published cuadro 4.1, CONARE, 2020; adjusted by factor 0.925 for gasoline cars by calibrating modelled and actual gasoline consumption 2019 with car mileage.

LCV mileage based on daily 60km and 365 days per year based on RTV measurements as published graph 4.6, CONARE, 2020: LCV mileage diesel adjusted upwards by 20% calibrating with actual diesel consumed 2019

Truck mileage based on daily 78km and 365 days per year based on RTV measurements as published graph 4.6, CONARE, 2020: adjusted for larger units upwards to calibrate with actual diesel fuel consumed 2019 in Costa Rica

Fuel consumption motorcycle: Average between values monitored in Delhi (scooters, 70cc, 4-stroke; realized by Grutter Consulting, 2011) and data for Hanoi based on World Bank, 2014; engine capacity 110-125cc; 4-stroke; the fuel efficiency standard for 100-125cc motorcycles in PR China is 2.5l/100km (https://www.transportpolicy.net/standard/china-motorcycles-fuel-consumption/)

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

Vehicle average age	lifespan	% replaced per annum
Passenger car	20	5%
Taxi	10	10%
3-wheeler	5	20%
Motorcycles	8	13%
small bus	15	7%
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%

Emissions

All data in tons per annum

2019

Vehicle category	NO_x	$PM_{2.5}$	CO_2 TTW	CO_2 WTW	Energy in TJ		Share GHG WTW
Passenger car	4,639	135	2,907,392	3,558,953	41,543		43%
Taxi	223	12	93,523	120,950	1,316		1%
Motorcycles	1,752	55	241,864	300,222	3,490		4%
small bus	422	76	225,886	322,337	3,048		4%
standard urban bus	3,210	66	379,182	505,004	5,117		6%
coach	1,467	27	128,998	174,489	1,741		2%
LCV	876	443	1,252,920	1,846,632	17,184		22%
Truck < 7.5t	321	6	29,624	39,722	400		0%
Truck 7.5-16t	3,797	72	340,968	461,393	4,601		6%
Truck 16-32t	3,641	71	307,971	420,538	4,156		5%
Truck >32t	5,170	107	441,718	605,995	5,961		7%
Total	**25,518**	**1,070**	**6,350,046**	**8,356,236**	**88,558**		100%

2030

Vehicle category	NO_x	$PM_{2.5}$	CO_2 TTW	CO_2 WTW	Energy in MJ		Share GHG WTW
Passenger car	2,589	102	3,816,949	4,626,413	54,657		46%
Taxi	187	9	127,530	160,629	1,795		2%
Motorcycles	1,702	19	329,812	396,704	4,759		4%
small bus	2,376	19	225,886	290,439	3,048		3%
standard urban bus	1,626	14	379,182	475,750	5,117		5%
coach	741	6	128,998	162,584	1,741		2%
LCV	4,191	203	1,635,140	2,153,184	22,426		21%
Truck < 7.5t	197	1	38,661	48,413	522		0%
Truck 7.5-16t	2,388	15	444,984	557,122	6,005		6%
Truck 16-32t	2,301	14	401,921	504,053	5,424		5%
Truck >32t	3,323	19	576,470	722,097	7,780		7%
Total	**21,621**	**421**	**8,105,534**	**10,097,391**	**113,274**		100%

Emission costs	2019	2030
Pollutants	125	72
GHG	334	404
Total	**459**	**476**

in MUSD of 2019

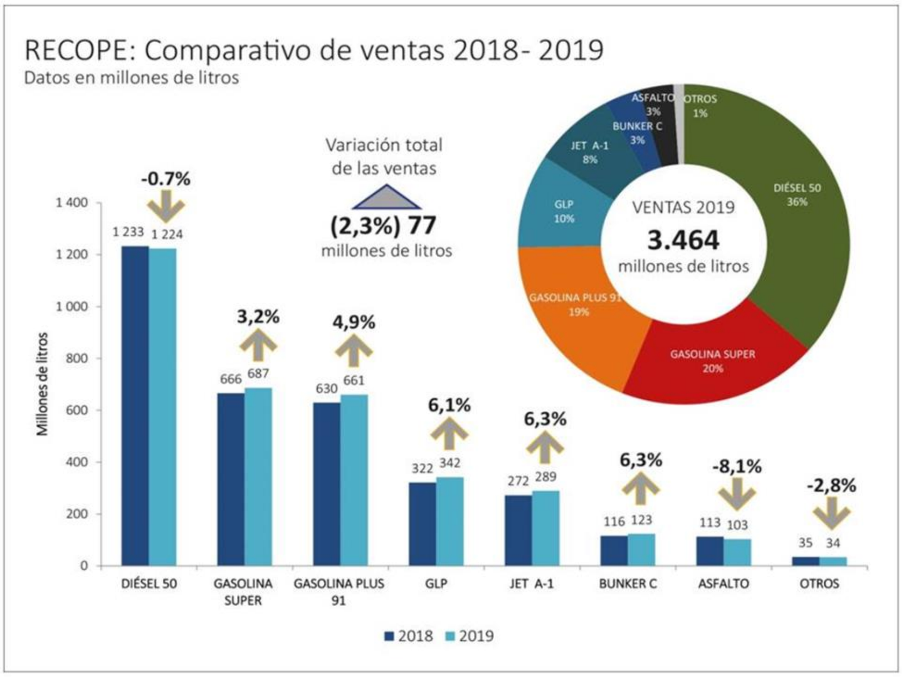
Modelled

Fuel Usage	2019	2030
Gasoline	1,346	1,828
Diesel	1,222	1,467
CNG	0	0

in million liters for diesel and gasoline and tons for CNG

Actual

Fuel Usage	2019	variation model to actual
Gasoline	1,348	99.9%
Diesel	1,224	99.9%



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%

Scenario Costa Rica	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Scenario Costa Rica cars	1%	2%	4%	6%	8%	10%	12%	14%	16%	19%	21%
Scenario Costa Rica buses	0%	2%	4%	6%	8%	10%	12%	14%	16%	18%	20%
Scenario Costa Rica taxis	0%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%

The NDC has as target 8% of the passenger cars and public transport vehicle stock in 2030 to be electric; The public transport target has been applied to all 3 bus categories

Reality 2019: 1004 electric passenger cars of a total of over 1 million cars i.e. 0.1% of stock and plug-in hybrids 170 cars or 0.02%; In 2020 for the first 6 months a total of 1,500 Evs (used plus new) were sold http://ev-sales.blogspot.com/2020/07/costa-rica-june-2020.html

The MINAE 2019 plan has as target that 10% of new taxi concessions are for electric vehicles. This is equivalent to asking for 10% of replaced taxis to be electric (Art. 3.1.3.4 page 108)

High Potential Scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Taxis	0%	7%	11%	15%	22%	33%	48%	69%	100%	100%	100%
Urban Buses	0%	0%	15%	23%	34%	51%	76%	100%	100%	100%	100%
Small buses	0%	0%	7%	10%	15%	23%	35%	52%	78%	100%	100%
LCVs	0%	0%	1%	2%	4%	7%	14%	27%	52%	100%	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)

For taxis a kick-start with 100 taxis in 2021 is assumed. The growth rate is then assumed 50% for new registered taxis per annum reaching 100% in 2029

For urban buses a kick-start of 50 units in 2022 is assumed and then a growth of 50% of new registered per year reaching 100% of new registered in 2027

For small buses a kick-start of 50 units in 2022 is assumed and then a growth of 50% of new registered per year reaching 100% of new registered in 2029

For LCVs a kick-start of 50 units in 2022 is assumed and then a growth of 100% of new registered per year reaching 100% of new registered in 2030

Passenger cars S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all cars	1,001,230	1,029,861	1,059,311	1,089,604	1,120,762	1,152,812	1,185,778	1,219,687	1,254,566	1,290,442	1,327,344
Replacement cars	48,670	50,061	51,493	52,966	54,480	56,038	57,641	59,289	60,984	62,728	64,522
Additional new cars	27,836	28,632	29,450	30,292	31,159	32,050	32,966	33,909	34,879	35,876	36,902
EV car fleet new	1,929	2,555	3,383	4,479	5,930	7,852	8,963	10,230	11,677	13,329	15,214
EV car fleet stock	1,929	4,484	7,866	12,345	18,276	26,128	35,091	45,322	56,999	70,327	85,541
EV fleet as % of stock	0%	0%	1%	1%	2%	2%	3%	4%	5%	5%	6%
GHG reduction WTW in tons	6,535	15,187	26,643	41,813	61,899	88,495	118,853	153,503	193,053	238,197	289,725
Electricity demand GWh	5.7	13.4	23.4	36.8	54.4	77.8	104.5	135.0	169.7	209.4	254.7

Passenger cars S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all cars	1,001,230	1,029,861	1,059,311	1,089,604	1,120,762	1,152,812	1,185,778	1,219,687	1,254,566	1,290,442	1,327,344
Replacement cars	48,670	50,061	51,493	52,966	54,480	56,038	57,641	59,289	60,984	62,728	64,522
Additional new cars	27,836	28,632	29,450	30,292	31,159	32,050	32,966	33,909	34,879	35,876	36,902
EV car fleet new	3,859	5,109	6,765	8,958	11,861	15,705	17,926	20,461	23,355	26,657	30,427
EV car fleet stock	3,859	8,968	15,733	24,691	36,551	52,256	70,182	90,643	113,998	140,655	171,082
EV fleet as % of stock	0%	1%	1%	2%	3%	5%	6%	7%	9%	11%	13%
GHG reduction WTW in tons	13,069	30,374	53,287	83,626	123,798	176,991	237,705	307,006	386,107	476,395	579,451
Electricity demand GWh	11.5	26.7	46.9	73.5	108.8	155.6	209.0	269.9	339.5	418.8	509.5

Passenger cars Scenario Costa Rica	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all cars	1,001,230	1,029,861	1,059,311	1,089,604	1,120,762	1,152,812	1,185,778	1,219,687	1,254,566	1,290,442	1,327,344
Replacement cars	48,670	50,061	51,493	52,966	54,480	56,038	57,641	59,289	60,984	62,728	64,522
Additional new cars	27,836	28,632	29,450	30,292	31,159	32,050	32,966	33,909	34,879	35,876	36,902
EV car fleet new	765	1,574	3,238	4,995	6,851	8,809	10,873	13,048	15,338	18,242	21,299
EV car fleet stock	1,765	3,339	6,577	11,572	18,423	27,232	38,105	51,153	66,491	84,732	106,031
EV fleet as % of stock	0%	0%	1%	1%	2%	2%	3%	4%	5%	7%	8%
GHG reduction WTW in tons	5,978	11,309	22,275	39,194	62,399	92,234	129,060	173,252	225,202	286,987	359,126
Electricity demand GWh	5.3	9.9	19.6	34.5	54.9	81.1	113.5	152.3	198.0	252.3	315.7

Taxis S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all taxis	10,795	11,104	11,421	11,748	12,084	12,429	12,785	13,151	13,527	13,913	14,311
Replacement taxis	1,050	1,080	1,110	1,142	1,175	1,208	1,243	1,278	1,315	1,353	1,391
Additional new taxis	300	309	318	327	336	346	355	366	376	387	398
EV taxi fleet new	34	45	60	79	105	139	158	180	206	235	268
EV taxi fleet stock	34	79	139	218	322	461	619	800	1,006	1,241	1,509
EV taxi as % of stock	0%	1%	1%	2%	3%	4%	5%	6%	7%	9%	11%
GHG reduction WTW in tons	346	804	1,410	2,213	3,276	4,684	6,291	8,125	10,219	12,608	15,336
Electricity demand GWh	0.3	0.7	1.2	1.9	2.9	4.1	5.5	7.1	9.0	11.1	13.5

Taxis S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all taxis	10,795	11,104	11,421	11,748	12,084	12,429	12,785	13,151	13,527	13,913	14,311
Replacement taxis	1,050	1,080	1,110	1,142	1,175	1,208	1,243	1,278	1,315	1,353	1,391
Additional new taxis	300	309	318	327	336	346	355	366	376	387	398
EV taxi fleet new	68	90	119	158	209	277	316	361	412	470	537
EV taxi fleet stock	68	158	278	436	645	922	1,238	1,599	2,011	2,481	3,018
EV taxi as % of stock	1%	1%	2%	4%	5%	7%	10%	12%	15%	18%	21%
GHG reduction WTW in tons	692	1,608	2,821	4,427	6,553	9,369	12,582	16,251	20,438	25,217	30,672
Electricity demand GWh	0.6	1.4	2.5	3.9	5.8	8.2	11.1	14.3	18.0	22.2	27.0

Taxis Scenario Costa Rica	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all taxis	10,795	11,104	11,421	11,748	12,084	12,429	12,785	13,151	13,527	13,913	14,311
Replacement taxis	1,050	1,080	1,110	1,142	1,175	1,208	1,243	1,278	1,315	1,353	1,391
Additional new taxis	300	309	318	327	336	346	355	366	376	387	398
EV taxi fleet new	0	139	143	147	151	155	160	164	169	174	179
EV taxi fleet stock	0	139	282	428	580	735	895	1,059	1,228	1,402	1,581
EV taxi as % of stock	0%	1%	2%	4%	5%	6%	7%	8%	9%	10%	11%
GHG reduction WTW in tons	0	1,411	2,862	4,355	5,890	7,469	9,094	10,764	12,483	14,251	16,069
Electricity demand GWh	0.0	1.2	2.5	3.8	5.2	6.6	8.0	9.5	11.0	12.5	14.1

Taxis Scenario Potential	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all taxis	10,795	11,104	11,421	11,748	12,084	12,429	12,785	13,151	13,527	13,913	14,311
Replacement taxis	1,050	1,080	1,110	1,142	1,175	1,208	1,243	1,278	1,315	1,353	1,391
Additional new taxis	300	309	318	327	336	346	355	366	376	387	398
EV taxi fleet new	0	100	150	225	338	506	759	1,139	1,691	1,739	1,789
EV taxi fleet stock	0	100	250	475	813	1,319	2,078	3,217	4,908	6,648	8,437
EV taxi as % of stock	0%	1%	2%	4%	7%	11%	16%	24%	36%	48%	59%
GHG reduction WTW in tons	0	1,016	2,541	4,827	8,257	13,402	21,120	32,696	49,882	67,560	85,743
Electricity demand GWh	0.0	0.9	2.2	4.2	7.3	11.8	18.6	28.7	43.9	59.4	75.4

Motorcycle S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all MC	299,918	308,495	317,317	326,391	335,724	345,325	355,200	365,357	375,805	386,552	397,606
Replacement MC	36,448	37,490	38,562	39,665	40,799	41,966	43,166	44,400	45,670	46,976	48,319
Additional new MC	8,338	8,577	8,822	9,074	9,334	9,600	9,875	10,157	10,448	10,747	11,054
EV MC fleet new	1,129	1,495	1,980	2,622	3,472	4,597	5,247	5,989	6,836	7,803	8,906
EV MC fleet stock	1,129	2,625	4,605	7,227	10,698	15,295	20,542	26,531	33,367	41,169	50,075
EV fleet as % of stock	0%	1%	1%	2%	3%	4%	6%	7%	9%	11%	13%
GHG reduction WTW in tons	1,127	2,619	4,595	7,210	10,674	15,260	20,495	26,471	33,291	41,076	49,961
Electricity demand GWh	0.4	0.9	1.6	2.4	3.6	5.2	6.9	9.0	11.3	13.9	16.9

Motorcycle S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all MC	299,918	307,266	314,794	322,507	330,408	338,503	346,796	355,293	363,998	372,915	382,052
Replacement MC	36,448	37,490	38,562	39,665	40,799	41,966	43,166	44,400	45,670	46,976	48,319
Additional new MC	8,338	8,577	8,822	9,074	9,334	9,600	9,875	10,157	10,448	10,747	11,054
EV MC fleet new	2,259	2,991	3,960	5,244	6,943	9,194	10,494	11,978	13,672	15,605	17,812
EV MC fleet stock	2,259	5,250	9,210	14,454	21,397	30,590	41,084	53,062	66,733	82,338	100,150
EV fleet as % of stock	1%	2%	3%	4%	6%	9%	12%	15%	18%	22%	26%
GHG reduction WTW in tons	2,254	5,238	9,189	14,421	21,348	30,521	40,991	52,941	66,582	82,151	99,923
Electricity demand GWh	0.8	1.8	3.1	4.9	7.2	10.3	13.9	17.9	22.5	27.8	33.8

Small Bus S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	10,927	10,927	10,927	10,927	10,927	10,927	10,927	10,927	10,927	10,927	10,927
Replacement vehicles	728	728	728	728	728	728	728	728	728	728	728
Additional new vehicles	0	0	0	0	0	0	0	0	0	0	0
EV vehicle fleet new	18	24	30	39	50	65	72	80	89	98	109
EV vehicle fleet stock	18	42	72	112	162	227	299	379	468	566	676
EV fleet as % of stock	0%	0%	1%	1%	1%	2%	3%	3%	4%	5%	6%
GHG reduction WTW in tons	425	972	1,675	2,581	3,748	5,249	6,915	8,764	10,816	13,093	15,619
Electricity demand GWh	0.4	1.0	1.7	2.7	3.9	5.4	7.2	9.1	11.2	13.5	16.2

Small Bus S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	10,927	10,927	10,927	10,927	10,927	10,927	10,927	10,927	10,927	10,927	10,927
Replacement vehicles	728	728	728	728	728	728	728	728	728	728	728
Additional new vehicles	0	0	0	0	0	0	0	0	0	0	0
EV vehicle fleet new	37	47	61	78	101	130	144	160	177	197	219
EV vehicle fleet stock	37	84	145	223	324	454	598	758	936	1,133	1,351
EV fleet as % of stock	0%	1%	1%	2%	3%	4%	5%	7%	9%	10%	12%
GHG reduction WTW in tons	849	1,943	3,351	5,163	7,496	10,499	13,831	17,529	21,632	26,185	31,238
Electricity demand GWh	0.9	2.0	3.5	5.3	7.8	10.9	14.3	18.1	22.4	27.1	32.3

Small Bus Scenario Costa Rica	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	10,927	10,927	10,927	10,927	10,927	10,927	10,927	10,927	10,927	10,927	10,927
Replacement vehicles	728	728	728	728	728	728	728	728	728	728	728
Additional new vehicles	0	0	0	0	0	0	0	0	0	0	0
EV vehicle fleet new	0	15	29	44	58	73	87	102	117	131	146
EV vehicle fleet stock	0	15	44	87	146	219	306	408	525	656	801
EV fleet as % of stock	0%	0%	0%	1%	1%	2%	3%	4%	5%	6%	7%
GHG reduction WTW in tons	0	337	1,011	2,021	3,369	5,053	7,074	9,432	12,127	15,159	18,527
Electricity demand GWh	0.0	0.3	1.0	2.1	3.5	5.2	7.3	9.8	12.5	15.7	19.2

Small Bus Scenario potential	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	10,927	10,927	10,927	10,927	10,927	10,927	10,927	10,927	10,927	10,927	10,927
Replacement vehicles	728	728	728	728	728	728	728	728	728	728	728
Additional new vehicles	0	0	0	0	0	0	0	0	0	0	0
EV vehicle fleet new	0	0	50	75	113	169	253	380	570	728	728
EV vehicle fleet stock	0	0	50	125	238	406	659	1,039	1,609	2,337	3,066
EV fleet as % of stock	0%	0%	0%	1%	2%	4%	6%	10%	15%	21%	28%
GHG reduction WTW in tons	0	0	1,156	2,890	5,491	9,393	15,245	24,024	37,192	54,035	70,878
Electricity demand GWh	0.0	0.0	1.2	3.0	5.7	9.7	15.8	24.8	38.5	55.9	73.3

Urban bus standard S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Replacement vehicles	333	333	333	333	333	333	333	333	333	333	333
Additional new vehicles	0	0	0	0	0	0	0	0	0	0	0
EV vehicle fleet new	8	11	14	18	23	30	33	37	41	45	50
EV vehicle fleet stock	8	19	33	51	74	104	137	173	214	259	309
EV fleet as % of stock	0%	0%	1%	1%	1%	2%	3%	3%	4%	5%	6%
GHG reduction WTW in tons	800	1,829	3,155	4,861	7,057	9,885	13,022	16,504	20,367	24,654	29,412
Electricity demand GWh	0.5	1.2	2.0	3.1	4.5	6.2	8.2	10.4	12.8	15.5	18.5

Urban bus standard S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	5,000	5,123	5,248	5,377	5,508	5,643	5,782	5,923	6,068	6,217	6,369
Replacement vehicles	333	333	342	350	358	367	376	385	395	405	414
Additional new vehicles	0	123	126	129	132	135	138	142	145	149	152
EV vehicle fleet new	17	30	39	51	68	90	102	116	132	150	170
EV vehicle fleet stock	17	46	85	137	205	294	396	512	643	793	963
EV fleet as % of stock	0%	1%	2%	3%	4%	5%	7%	9%	11%	13%	15%
GHG reduction WTW in tons	1,600	4,416	8,129	13,027	19,487	28,005	37,690	48,701	61,218	75,449	91,627
Electricity demand GWh	1.0	2.8	5.1	8.2	12.3	17.7	23.8	30.7	38.6	47.6	57.8

Urban bus standard Scenario CR	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Replacement vehicles	333	333	333	333	333	333	333	333	333	333	333
Additional new vehicles	0	0	0	0	0	0	0	0	0	0	0
EV vehicle fleet new	0	7	13	20	27	33	40	47	53	60	67
EV vehicle fleet stock	5	12	25	45	72	105	145	192	245	305	372
EV fleet as % of stock	0%	0%	1%	1%	1%	2%	3%	4%	5%	6%	7%
GHG reduction WTW in tons	476	1,110	2,379	4,282	6,819	9,991	13,797	18,237	23,312	29,020	35,364
Electricity demand GWh	0.3	0.7	1.5	2.7	4.3	6.3	8.7	11.5	14.7	18.3	22.3

Urban bus standard Scenario potential	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Replacement vehicles	333	333	333	333	333	333	333	333	333	333	333
Additional new vehicles	0	0	0	0	0	0	0	0	0	0	0
EV vehicle fleet new	0	0	50	75	113	169	253	333	333	333	333
EV vehicle fleet stock	5	5	55	130	243	411	664	998	1,331	1,664	1,998
EV fleet as % of stock	0%	0%	1%	3%	5%	8%	13%	20%	27%	33%	40%
GHG reduction WTW in tons	476	476	5,233	12,369	23,074	39,130	63,215	94,931	126,647	158,364	190,080
Electricity demand GWh	0.3	0.3	3.3	7.8	14.6	24.7	39.9	59.9	79.9	99.9	119.9

Coach S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	2,732	2,732	2,732	2,732	2,732	2,732	2,732	2,732	2,732	2,732	2,732
Replacement vehicles	182	182	182	182	182	182	182	182	182	182	182
Additional new vehicles	0	0	0	0	0	0	0	0	0	0	0
EV vehicle fleet new	5	6	8	10	13	16	18	20	22	25	27
EV vehicle fleet stock	5	11	18	28	41	57	75	95	117	142	169
EV fleet as % of stock	0%	0%	1%	1%	1%	2%	3%	3%	4%	5%	6%
GHG reduction WTW in tons	273	625	1,078	1,661	2,412	3,378	4,450	5,640	6,960	8,425	10,051
Electricity demand GWh	0.3	0.6	1.1	1.7	2.4	3.4	4.5	5.7	7.0	8.5	10.1

Coach S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	2,732	2,799	2,867	2,938	3,010	3,083	3,159	3,236	3,315	3,397	3,480
Replacement vehicles	182	182	187	191	196	201	206	211	216	221	226
Additional new vehicles	0	67	69	70	72	74	76	77	79	81	83
EV vehicle fleet new	9	16	21	28	37	49	56	63	72	82	93
EV vehicle fleet stock	9	25	47	75	112	161	216	280	352	433	526
EV fleet as % of stock	0%	1%	2%	3%	4%	5%	7%	9%	11%	13%	15%
GHG reduction WTW in tons	547	1,509	2,778	4,452	6,659	9,571	12,880	16,643	20,921	25,784	31,313
Electricity demand GWh	0.6	1.5	2.8	4.5	6.7	9.6	13.0	16.8	21.1	26.0	31.6

Coach Scenario Costa Rica	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	2,732	2,799	2,867	2,938	3,010	3,083	3,159	3,236	3,315	3,397	3,480
Replacement vehicles	182	182	187	191	196	201	206	211	216	221	226
Additional new vehicles	0	67	69	70	72	74	76	77	79	81	83
EV vehicle fleet new	0	5	10	16	21	27	34	40	47	54	62
EV vehicle fleet stock	0	5	15	31	52	80	113	154	201	255	317
EV fleet as % of stock	0%	0%	1%	1%	2%	3%	4%	5%	6%	8%	9%
GHG reduction WTW in tons	0	296	904	1,837	3,112	4,745	6,753	9,152	11,962	15,200	18,885
Electricity demand GWh	0.0	0.3	0.9	1.9	3.1	4.8	6.8	9.2	12.1	15.3	19.0

LCV S1	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Stock all vehicles	210,708	215,870	221,159	226,577	232,129	237,816	243,642	249,611	255,727	261,992	268,411
Replacement vehicles	10,283	10,535	10,794	11,058	11,329	11,606	11,891	12,182	12,481	12,786	13,100
Additional new vehicles	5,039	5,162	5,289	5,418	5,551	5,687	5,826	5,969	6,115	6,265	6,419
EV vehicle fleet new	386	510	672	886	1,169	1,542	1,753	1,993	2,265	2,575	2,928
EV vehicle fleet stock	386	896	1,568	2,454	3,623	5,165	6,918	8,910	11,175	13,751	16,678
EV fleet as % of stock	0%	0%	1%	1%	2%	2%	3%	4%	4%	5%	6%
GHG reduction WTW in tons	2,165	5,021	8,787	13,754	20,304	28,943	38,764	49,929	62,623	77,054	93,460
Electricity demand GWh	1.7	3.9	6.9	10.8	15.9	22.6	30.3	39.0	48.9	60.2	73.1

LCV S2	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Stock all vehicles	210,708	215,870	221,159	226,577	232,129	237,816	243,642	249,611	255,727	261,992	268,411
Replacement vehicles	10,283	10,535	10,794	11,058	11,329	11,606	11,891	12,182	12,481	12,786	13,100
Additional new vehicles	5,039	5,162	5,289	5,418	5,551	5,687	5,826	5,969	6,115	6,265	6,419
EV vehicle fleet new	773	1,019	1,344	1,773	2,338	3,083	3,505	3,985	4,530	5,151	5,856
EV vehicle fleet stock	773	1,792	3,136	4,909	7,247	10,330	13,835	17,820	22,351	27,501	33,357
EV fleet as % of stock	0%	1%	1%	2%	3%	4%	6%	7%	9%	10%	12%
GHG reduction WTW in tons	4,331	10,042	17,574	27,507	40,608	57,885	77,527	99,858	125,245	154,107	186,920
Electricity demand GWh	3.4	7.8	13.7	21.5	31.7	45.2	60.6	78.1	97.9	120.5	146.1

LCV Potential scenario	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Stock all vehicles	210,708	215,870	221,159	226,577	232,129	237,816	243,642	249,611	255,727	261,992	268,411
Replacement vehicles	10,283	10,535	10,794	11,058	11,329	11,606	11,891	12,182	12,481	12,786	13,100
Additional new vehicles	5,039	5,162	5,289	5,418	5,551	5,687	5,826	5,969	6,115	6,265	6,419
EV vehicle fleet new	0	0	152	304	608	1,216	2,433	4,865	9,731	19,052	19,518
EV vehicle fleet stock	0	0	152	456	1,064	2,281	4,713	9,579	19,309	38,361	57,879
EV fleet as % of stock	0%	0%	0%	0%	0%	1%	2%	4%	8%	15%	22%
GHG reduction WTW in tons	0	0	852	2,556	5,964	12,780	26,412	53,675	108,202	214,962	324,337
Electricity demand GWh	0.0	0.0	0.7	2.0	4.7	10.0	20.6	42.0	84.6	168.0	253.5

Truck <7.5t S1	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Stock all vehicles	3,313	3,394	3,477	3,562	3,649	3,739	3,830	3,924	4,020	4,119	4,220
Replacement vehicles	162	166	170	174	178	182	187	192	196	201	206
Additional new vehicles	79	81	83	85	87	89	92	94	96	98	101
EV vehicle fleet new	6	8	11	14	18	24	28	31	36	40	46
EV vehicle fleet stock	6	14	25	39	57	81	109	140	176	216	262
EV fleet as % of stock	0%	0%	1%	1%	2%	2%	3%	4%	4%	5%	6%
GHG reduction WTW in tons	70	162	283	443	654	932	1,248	1,607	2,016	2,480	3,008
Electricity demand GWh	0.1	0.2	0.4	0.6	0.9	1.3	1.7	2.2	2.8	3.4	4.2

Truck <7.5t S2	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Stock all vehicles	3,313	3,394	3,477	3,562	3,649	3,739	3,830	3,924	4,020	4,119	4,220
Replacement vehicles	162	166	170	174	178	182	187	192	196	201	206
Additional new vehicles	79	81	83	85	87	89	92	94	96	98	101
EV vehicle fleet new	12	16	21	28	37	48	55	63	71	81	92
EV vehicle fleet stock	12	28	49	77	114	162	217	280	351	432	524
EV fleet as % of stock	0%	1%	1%	2%	3%	4%	6%	7%	9%	10%	12%
GHG reduction WTW in tons	139	323	566	885	1,307	1,863	2,495	3,214	4,031	4,960	6,016
Electricity demand GWh	0.2	0.4	0.8	1.2	1.8	2.6	3.5	4.5	5.6	6.9	8.4

Truck 16-32t S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	6,625	6,787	6,954	7,124	7,299	7,477	7,661	7,848	8,041	8,238	8,439
Replacement vehicles	323	331	339	348	356	365	374	383	392	402	412
Additional new vehicles	158	162	166	170	175	179	183	188	192	197	202
EV vehicle fleet new	12	16	21	28	37	48	55	63	71	81	92
EV vehicle fleet stock	12	28	49	77	114	162	217	280	351	432	524
EV fleet as % of stock	0%	0%	1%	1%	2%	2%	3%	4%	4%	5%	6%
GHG reduction WTW in tons	726	1,683	2,945	4,609	6,804	9,699	12,990	16,732	20,986	25,822	31,320
Electricity demand GWh	1.0	2.4	4.2	6.6	9.7	13.9	18.6	23.9	30.0	36.9	44.8

Truck 16-32t S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	6,625	6,787	6,954	7,124	7,299	7,477	7,661	7,848	8,041	8,238	8,439
Replacement vehicles	323	331	339	348	356	365	374	383	392	402	412
Additional new vehicles	158	162	166	170	175	179	183	188	192	197	202
EV vehicle fleet new	24	32	42	56	74	97	110	125	142	162	184
EV vehicle fleet stock	24	56	99	154	228	325	435	560	703	865	1,049
EV fleet as % of stock	0%	1%	1%	2%	3%	4%	6%	7%	9%	10%	12%
GHG reduction WTW in tons	1,451	3,365	5,889	9,218	13,608	19,398	25,981	33,464	41,972	51,644	62,640
Electricity demand GWh	2.1	4.8	8.4	13.2	19.5	27.7	37.2	47.9	60.0	73.9	89.6

Truck >32t S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	6,625	6,787	6,954	7,124	7,299	7,477	7,661	7,848	8,041	8,238	8,439
Replacement vehicles	323	331	339	348	356	365	374	383	392	402	412
Additional new vehicles	158	162	166	170	175	179	183	188	192	197	202
EV vehicle fleet new	12	16	21	28	37	48	55	63	71	81	92
EV vehicle fleet stock	12	28	49	77	114	162	217	280	351	432	524
EV fleet as % of stock	0%	0%	1%	1%	2%	2%	3%	4%	4%	5%	6%
GHG reduction WTW in tons	1,039	2,410	4,218	6,603	9,747	13,895	18,610	23,970	30,064	36,992	44,868
Electricity demand GWh	1.6	3.8	6.6	10.3	15.2	21.6	29.0	37.3	46.8	57.6	69.9

Truck >32t S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	6,625	6,787	6,954	7,124	7,299	7,477	7,661	7,848	8,041	8,238	8,439
Replacement vehicles	323	331	339	348	356	365	374	383	392	402	412
Additional new vehicles	158	162	166	170	175	179	183	188	192	197	202
EV vehicle fleet new	24	32	42	56	74	97	110	125	142	162	184
EV vehicle fleet stock	24	56	99	154	228	325	435	560	703	865	1,049
EV fleet as % of stock	0%	1%	1%	2%	3%	4%	6%	7%	9%	10%	12%
GHG reduction WTW in tons	2,079	4,821	8,437	13,206	19,495	27,789	37,219	47,940	60,127	73,984	89,736
Electricity demand GWh	3.2	7.5	13.1	20.6	30.4	43.3	58.0	74.7	93.6	115.2	139.7

Total excl. trucks >7.5t S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
GHG reduction WTW in tons	11,740	27,218	47,626	74,537	110,024	156,826	210,038	270,543	339,345	417,587	506,573
Electricity demand GWh	9	22	38	60	88	126	169	217	273	336	407

Total excl. trucks >7.5t S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
GHG reduction WTW in tons	23,480	55,452	97,694	153,508	227,256	324,703	435,702	562,142	706,173	870,248	1,057,160
Electricity demand GWh	19	45	78	123	182	260	349	450	566	697	846

Total excl. trucks >7.5t Scenario CR	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
GHG reduction WTW in tons	6,454	14,463	29,430	51,689	81,589	119,492	165,777	220,838	285,085	360,616	447,972
Electricity demand GWh	6	13	26	45	71	104	144	192	248	314	390

Scenario Costa Rica includes for non-targeted vehicles S2

GHG Transport Projections WTW

Scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
BAU	8,501,259	8,648,800	8,798,901	8,951,607	9,106,964	9,265,017	9,425,813	9,589,399	9,755,824	9,925,138	10,097,391
EV15@30	8,489,519	8,621,582	8,751,275	8,877,071	8,996,940	9,108,191	9,215,775	9,318,856	9,416,480	9,507,551	9,590,818
GHG reduction EV15@30	11,740	27,218	47,626	74,537	110,024	156,826	210,038	270,543	339,345	417,587	506,573
EV30@30	8,477,779	8,593,348	8,701,207	8,798,099	8,879,708	8,940,314	8,990,111	9,027,257	9,049,651	9,054,890	9,040,231
GHG reduction EV30@30	23,480	55,452	97,694	153,508	227,256	324,703	435,702	562,142	706,173	870,248	1,057,160
EV scenario Costa Rica	8,494,805	8,634,337	8,769,471	8,899,918	9,025,375	9,145,525	9,260,035	9,368,561	9,470,739	9,564,522	9,649,419
GHG reduction EV scenario Costa Rica	6,454	14,463	29,430	51,689	81,589	119,492	165,777	220,838	285,085	360,616	447,972

Potential scenario impact only 4 vehicle sectors

Parameter	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
GHG reduction WTW in tons	476	1,492	9,782	22,643	42,786	74,705	125,991	205,326	321,924	494,921	671,038
Electricity demand GWh	0	1	7	17	32	56	95	155	247	383	522

Potential 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	20,015	47,122	89,928	148,451	229,002	340,838	483,262	666,534	901,664	1,209,838	1,540,117
Electricity demand GWh	19	44	83	135	207	305	429	587	789	1,052	1,335
GHG potential scenario	8,481,245	8,601,678	8,708,974	8,803,157	8,877,962	8,924,179	8,942,550	8,922,865	8,854,161	8,715,300	8,557,274

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	2,818,276	2,842,120	2,866,461	2,891,309	2,916,668	2,942,547	2,968,953	2,995,894	3,023,377	3,051,411	3,080,003
EV15@30	2,814,540	2,833,494	2,851,434	2,867,899	2,882,282	2,893,786	2,903,961	2,912,571	2,919,353	2,924,002	2,926,176
EV30@30	2,810,804	2,824,111	2,834,587	2,841,185	2,842,525	2,836,789	2,827,322	2,813,556	2,794,844	2,770,453	2,739,546
Costa Rica target	2,817,800	2,839,599	2,861,221	2,882,672	2,903,959	2,925,087	2,946,063	2,966,892	2,987,582	3,008,139	3,028,570
Potential scenario	2,817,800	2,840,628	2,856,680	2,868,666	2,873,882	2,867,842	2,842,962	2,790,568	2,701,453	2,556,490	2,408,964

Investment cost other vehicle categories

Taxi relative to Nissan Sentra

Category	Value	Source
2020	30,000	Nissan Leaf or BAIC taxi 28-32,000 USD
2025	19,000	see McKinsey
2030	15,000	Assumes cost parity
CAGR	-7%	

Expected price parity by 2030

Electric vehicle trends | Deloitte Insights

Coaster Bus 6-8m

2020	90,000	offer Chinese bus manufacturers

annual decrease same as for large buses

LCVs

2020	25,000	BYD T3 is 19,000 USD and Nissan EVN is 30,000 USD
2030	20,000	cost parity with Nissan diesel
CAGR	-2%	

Bus price trend in real USD (average slow and fast charged	
Cost 2020	263,000
Projected e-bus cost 2025	203,850
Projected e-bus cost 2030	170,120
CAGR decrease	-4.3%

Based on battery costs 2025 of 100 USD and 60 USD in 2030 based on BNEF (https://www.sustainable-bus.com/news/electric-vehicle-outlook-2020-bnef-electric-buses/#:~:text=With%20regards%20to%20electric%20bus,needed%20to%20keep%20prices%20falling%C2%BB.&text=But%20by%202030%20demand%20grows%20almost%2014%2Dfold%20to%201%2C755GWh.)

Additional 20% reduction in 2025 and 30% in 2030 due to larger manufacturing systems

Electricity Production

Electricity Production 2019

Source	GWh	%
Hydropower	7,827	69%
Geothermal	1,513	13%
Biomass	72	1%
Wind	1,796	16%
Solar	10	0%
Thermal	96	0.8%
Total	**11,313**	**100%**

Source: ICE SEN 2019

Time series electricity production

Source	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Average last 5
Renewable	8,863	8,897	9,246	8,928	9,075	10,606	10,589	11,173	11,197	11,217	**10,956**
Thermal	641	863	830	1,196	1,043	108	193	37	159	96	**119**
Total production	9,504	9,760	10,076	10,124	10,118	10,714	10,782	11,210	11,355	11,313	**11,075**
Share renewable	**93.3%**	**91.2%**	**91.8%**	**88.2%**	**89.7%**	**99.0%**	**98.2%**	**99.7%**	**98.6%**	**99.2%**	**98.9%**

Source: ICE SEN 2019

Interchange energy GWH (if negative imports more exports)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Average
Imports	29	-37	17	48	205	-106	150	-190	-241	21	-10.4
Total consumption	9,533	9,723	10,093	10,172	10,323	10,607	10,932	11,019	11,115	11,334	
As % of total consumption	0.3%	0.4%	0.2%	0.5%	2.0%	1.0%	1.4%	1.7%	2.2%	0.2%	1.0%

Source: ICE SEN 2019

Production/ consumption in GWH

Parameter	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	CAGR
Production	9,504	9,760	10,076	10,124	10,118	10,714	10,782	11,210	11,355	11,313	1.8%
Consumption	9,533	9,723	10,093	10,172	10,323	10,607	10,932	11,019	11,115	11,334	1.7%

Installed power @ 31.12.2019

Source	MW	%
Hydropower	2,344	66%
Geothermal	262	7%
Wind	411	12%
Solar	5	0%
Biomass	71	2%
Thermal	474	13%
Total	3,567	100%

Source: ICE SEN 2019

Projections GWh

Parameter	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	average	CAGR
Demand	11,693	11,974	12,264	12,545	12,826	13,105	13,383	13,661	13,942	14,226	14,513	14,804	15,094	15,375	15,645		2.0%
Generation	11,692	11,973	12,264	12,546	12,825	13,105	13,381	13,659	13,939	14,222	14,511	14,802	15,089	15,373	15,642		2.0%
Hydropower	8,651	8,880	9,105	9,197	9,450	9,640	9,558	9,764	9,953	9,708	9,816	9,870	10,032	10,053	9,982		1%
Geothermal	1,387	1,406	1,437	1,546	1,515	1,559	1,939	1,961	1,681	1,921	2,038	2,302	2,329	2,343	2,324		4%
Biomass	80	82	81	81	82	82	81	80	81	81	84	80	80	80	80		0%
Wind	1,499	1,504	1,502	1,512	1,496	1,483	1,490	1,480	1,662	1,901	1,941	1,903	1,936	2,135	2,556		4%
Solar	26	26	26	26	26	26	26	26	105	261	264	263	265	265	263		17%
Thermal	49	75	113	184	256	315	287	348	457	350	368	384	447	497	437		16%
Share renewable	99.6%	99.4%	99.1%	98.5%	98.0%	97.6%	97.9%	97.5%	96.7%	97.5%	97.5%	97.4%	97.0%	96.8%	97.2%	98%	

Source: ICE, 2019, Planificacion y desarrollo electrico proceso expansion del sistema

Renewable potential MW as of 12/2017

Source	Installed capacity	Potential	installed as % of potential
Hydropower	2,328	7,651	30%
Geothermal	207	875	24%
Biomass	47	452	10%
Wind	378	2,400	16%
Solar	30	576	5%
Total	**2,990**	**11,954**	**25%**

Source: ICE, 2019, Planificacion y desarrollo electrico proceso expansion del sistema, Table 7.1

Plant	average generation in GWh	specific fuel usage kWh/l	fuel type	fuel consumed liters	NCV per fuel type MJ/kg	EFCO2 per fuel type gCO2/MJ	density kg/l	CO2 emissions in tons
Garabito (2011)	225	4.48	bunker	50,223,214	40.4	77.4	0.96	150,764
Guapiles (2008)	9	4.07	bunker	2,211,302	40.4	77.4	0.96	6,638
Moin 2 (1991)	22	2.88	diesel	7,638,889	43	74.1	0.84	20,445
Moin 3 (2003)	28	2.95	diesel	9,491,525	43	74.1	0.84	25,404
Orotina (2008)	7	4.18	bunker	1,674,641	40.4	77.4	0.96	5,027
Total	291							208,279

Source: average GWh, specific fuel consumed and fuel type: ICE, 2019, Planificacion y desarrollo electrico proceso expansion del sistema, p.78; NCV and EFCO2 from IPCCC, 2006; density from IEA, 2005

Resultant EF fossil	**0.716**	**tCO2/MWh**

Grid emission factor in kgCO2/kWh (or tCO2/MWh)

Average total production last 5 years	11,075	GWh
Average thermal production last 5 years	119	GWh
Average GHG emissions last 5 years	84,836	tCO2
Average EF last 5 years	**0.008**	**tCO2/MWh**
Projected average production next 15 years	13,668	GWh
Projected thermal production next 15 years	304	GWh
Projected EF thermal (excludes plants prior 2005)	0.674	tCO2/MWh
Average projected EF next 15 years	**0.015**	**tCO2/MWh**

The higher of both values is taken to be conservative

EV Electricity Demand and Supply in GWh

Parameter	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2030 share
Electricity generation	11,692	11,973	12,264	12,546	12,825	13,105	13,381	13,659	13,939	14,222	14,511	
EV demand EV15@30	9	22	38	60	88	126	169	217	273	336	407	3%
EV demand EV30@30	19	45	78	123	182	260	349	450	566	697	846	6%
EV demand EV Costa Rica	6	13	26	45	71	104	144	192	248	314	390	3%
EV demand "Potential Scenario"	19	44	83	135	207	305	429	587	789	1,052	1,335	9%