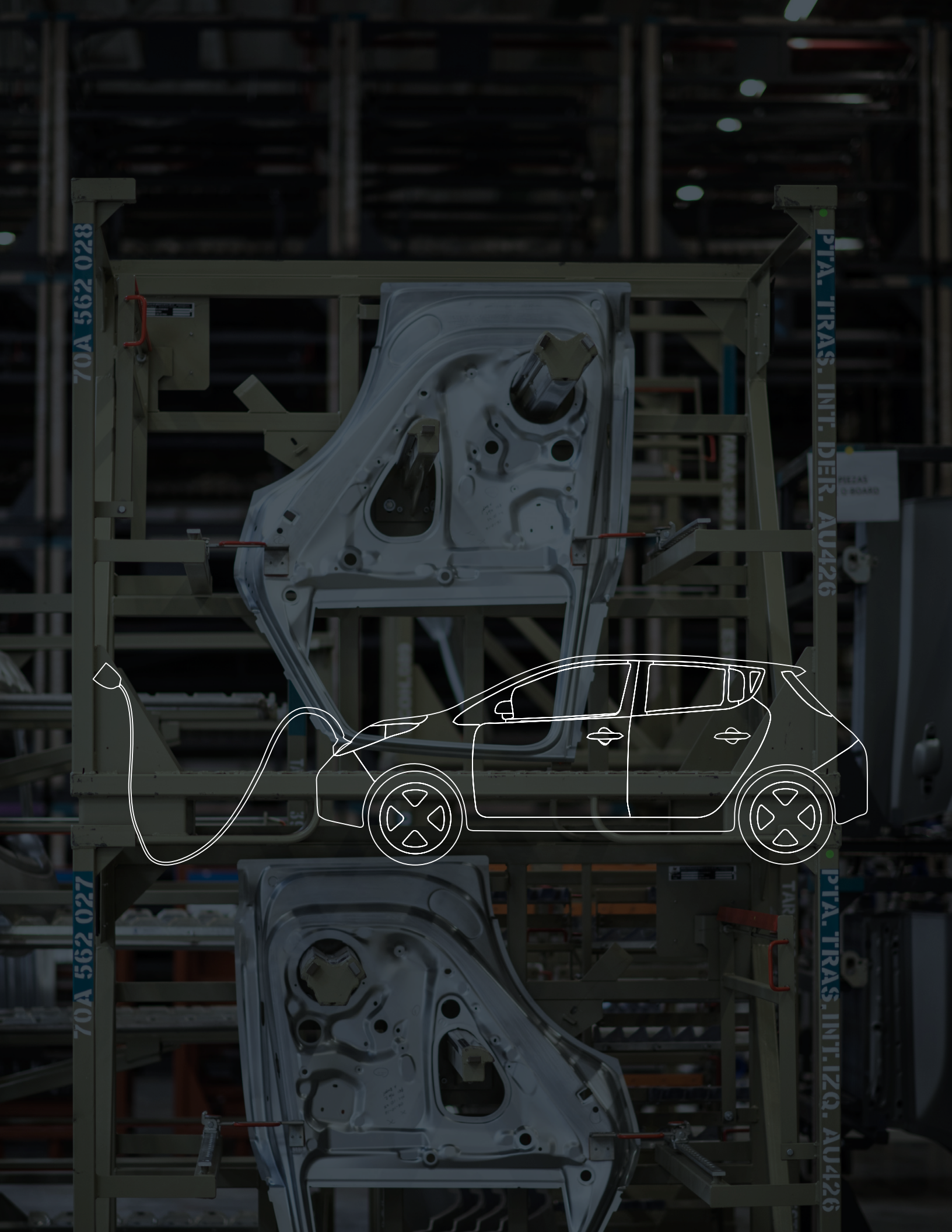
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Evolution of auto parts for electric vehicles in Mexico.

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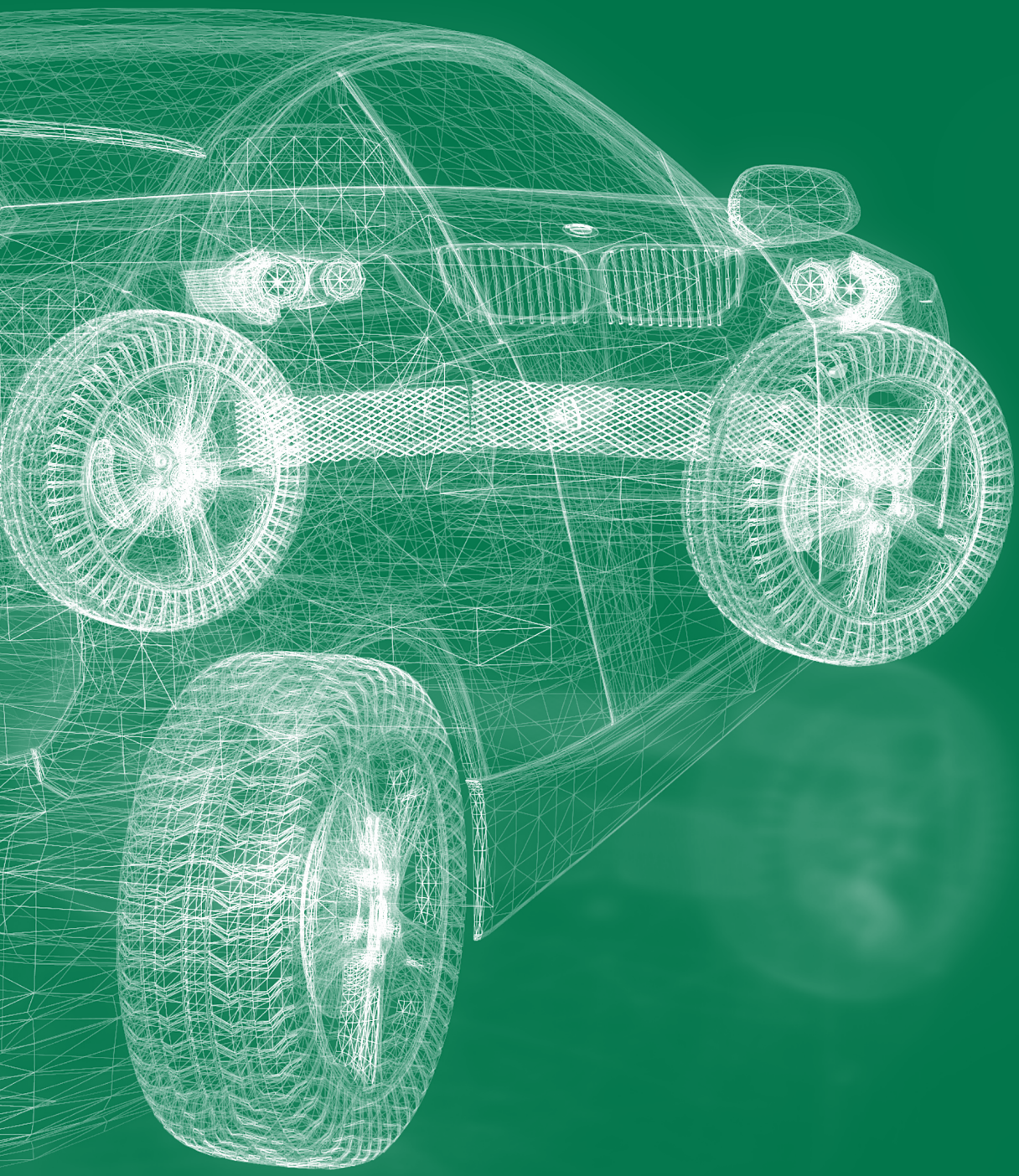
Evolution of auto parts for electric vehicles in Mexico

María Verónica Orendain de los Santos

Industria Nacional
de Autopartes, A.C.



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ACRONYM GLOSSARY

Prologue

The electric vehicle industry seems very new; however, it is as old as internal combustion vehicles. In fact, the first automobile owned by Thomas Edison in the late 19th century was a Baker Motor Vehicle Company model, which came equipped with a nickel-iron battery (designed by Edison himself).

While the 20th century was marked by vehicles with internal combustion engines, this century will see a greater diversity of technologies, from hybrids to battery electric vehicles (BEVs) and combustion cell electric vehicles (FCEVs). This technological transformation stems from the environmental situation we are living in.

At this juncture, electric vehicles have increased their production, export, and use exponentially around the world, opening new opportunities for Mexico. It is estimated that by 2050 more than half of the cars circulating globally will be powered by clean energy. This represents a milestone and an opportunity for Mexico, which is already a world power in the industry.

Currently, Latin America and the Caribbean is one of the regions with the lowest incorporation of this type of vehicles, but leading countries such as ours are making steady progress to achieve the transformation, since transportation is one of the activities that generates the highest levels of CO2 emissions per capita and per unit of gross domestic product.

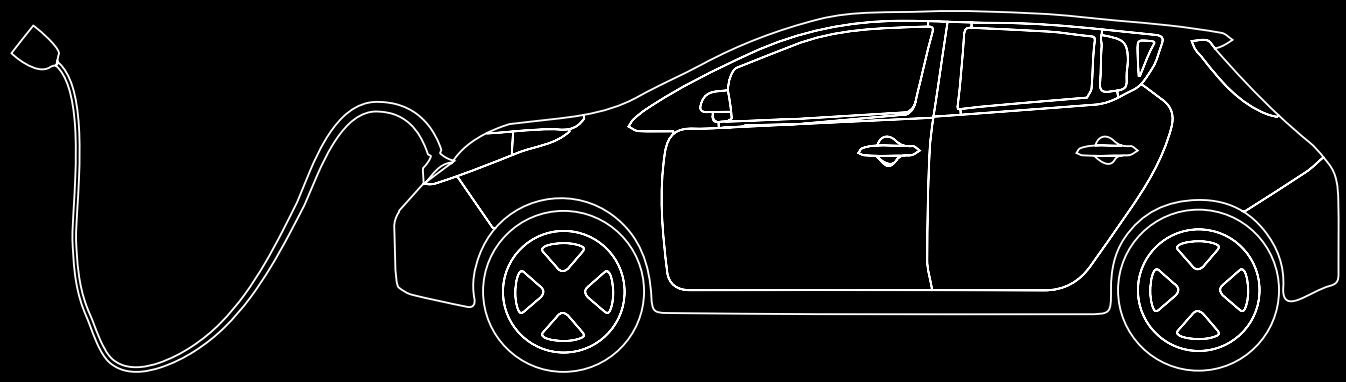
In the National Auto Parts Industry, we are convinced that we possess competitive advantages capable of bolstering Mexico's role in the industry, primarily through the strength of the supply chain. Underlining these strengths is the reason that prompted us to publish this book that you hold in your hands.

In the coming years, we will witness one of the most important transformations in the history of mobility, which will contribute to decarbonization while generating new jobs and developing cleaner technologies.

The following pages present information and reflections to prepare us for these challenges. With the support of everyone involved in the supply chain, we will position Mexico in its rightful place as a world leader in the auto parts manufacturing and electric vehicle automotive industry.

Sincerely,

Francisco N. González Díaz
Presidente Ejecutivo
Industria Nacional de Autopartes



CHAPTER 1.

Background

We are dangerously close to the 1.5 °C limit which, according to scientists, is the maximum level of warming to avoid the worst climatic effects.

International environmental agreements

Weather events such as snowfall, hurricanes, fires and extreme floods in recent years have caused disruptions in global economic activity and the global supply chain. For example, the snowfall in the state of Texas (January, 2021),[1] hich resulted in the closure of semiconductor plants and aggravated the shortages that the automotive industry was suffering due to the SARS-CoV-2 pandemic; the floods in central China (July, 2021) that forced companies such as Nissan and SAIC Motors to close plants and reduce vehicle production; and the heat wave and fires (June, 2022) in Europe with temperatures above 40 °C[2] that put pressure on the electricity system in several countries.

In light of this scenario, António Manuel de Oliveira Guterres, Secretary-General of the United Nations (UN), has been emphatic in declaring that "fossil fuels are the cause of the climate crisis" and that "we are dangerously close to the 1.5 °C limit which, according to scientists, is the maximum level of warming to avoid the worst climatic effects."[3] Coincidentally, 2022 marks the 50th anniversary of the first steps, at the international level, to analyze and take action on the effects of the impact of human activity on the environment. The first milestone was the United Nations Conference on the Human Environment, held in Stockholm in 1972, and the theme of the environment was central; participants adopted principles for the sound management of the environment, including the Stockholm Declaration and Action Plan for the Human Environment[4]. This was a priority not only for governments, but also for civil society, business and policy makers.[5] The conference established the United Nations Environment Programme (UNEP), the UN entity responsible for monitoring the state of the environment.

1 Jacques, L. (2022). How Climate Change Is Disrupting the Global Supply Chain. 27 de julio de 2022, de Yale Environment 360 Sitio web: https://e360.yale.edu/features/how-climate-change-is-disrupting-the-global-supply-chain#:~:text=Scientists%20say%20that%20such%20climate,and%20perhaps%20more%20%E2%80%94%20by%202100

2 Look on the NASA web page for the map showing the heat wave. https://earthobservatory.nasa.gov/images/150083/heatwaves-and-fires-scorch-europe-africa-and-asia

3 https://www.un.org/es/climatechange/articles/world-is-burning-renewables-revolution.

4 https://www.un.org/es/conferences/environment/stockholm1972.

5 https://mexico.un.org/es/167731-2022-en-modo-emergencia-por-el-medio-ambiente.

Climate action timeline

Source: INA with information from United Nations https://unfccc.int/es

The Copenhagen agreement and future climate change negotiations

Several decades had to pass since that first manifestation of political will to care for the environment, for governments to raise the need for stricter agreements. A first example was the Kyoto Protocol (2005-2012), which became partially binding. On the other hand, the COP15, held in Copenhagen in 2009, promulgated the international agreement against climate change. This document generated expectations that were not fulfilled because the agreement was not legally binding in terms of emission reductions. But one of the positive aspects of the Copenhagen Agreement was "the recognition of the need to limit the increase in global temperature to 2°C" and to reach a "global and country-specific emissions ceiling as soon as possible."[6] The countries that signed the Agreement accounted for 80% of global greenhouse gas emissions.

The Copenhagen Agreement was followed by a series of meetings which, with progress and setbacks, led to the negotiation of the Agreement reached in the French capital. This agreement was signed by 196 parties at the COP21 in Paris on December 12, 2015 and entered into force on November 4, 2016. The main goal "is to limit global warming to well below 2, preferably 1.5 degrees Celsius, compared to pre-industrial levels. To achieve this long-term temperature goal, countries aim to peak greenhouse gas emissions as soon as possible to achieve a climate-neutral planet by mid-century."[7]

In this global scenario, each country is obliged to provide technological and public policy solutions to ensure low carbon emissions and the creation of new markets. In recent years, it has been observed that more countries, regions, cities, and companies are setting carbon neutrality or net-zero emissions goals.[8] Carbon-neutral solutions are becoming competitive in all economic sectors and already account for 25% of emissions. This trend puts the energy and transportation sectors at the center of the action, and has created many new business opportunities for early movers. It is estimated that by 2030, carbon-neutral solutions could be competitive in sectors that account for more than 70% of global emissions.[9]

In this context, the automotive industry has been in the eye of the hurricane in the environmental public policy agenda, particularly with the issue of the strong contribution of the transportation and mobility industry to

6 https://www.energiaysociedad.es/manual-de-la-energia/3-1-el-cambio-climatico-y-los-acuerdos-internacionales/
7 https://unfccc.int/es/process-and-meetings/the-paris-agreement/el-acuerdo-de-paris
8 Carbon neutrality or net zero emissions means that any emissions will be balanced by schemes to offset an equivalent amount of greenhouse gases from the atmosphere, such as planting trees or using technology such as carbon capture and storage.
9 https://onuhabitat.org.mx/index.php/que-es-el-acuerdo-de-paris

Carbon neutral solutions are becoming competitive in all economic sectors and already account for 25% of emissions.

greenhouse gas (GHG) emissions. This contribution, in general terms, comes from two sources:

"First, there is the contribution of road transport - passengers and goods - which is related to economic activity, the end use of products from the automotive industry. The UN Intergovernmental Panel on Climate Change estimates that the transport sector as a whole accounts for approximately 23% of total energy-related CO_2 emissions."[10]

Also, according to David Leggett, it is estimated that cars, trucks, buses and other vehicles contribute nearly three-quarters of transportation CO_2 emissions.

Faced with this scenario, governments have pursued various strategies to enable the automotive industry to move towards emission mitigation and net-zero emission scenarios. A good example is the CARS 21 High Level Group led by the European Union authorities in 2005[11], in which a group of automotive industry experts drew up a roadmap for the future of the industry. The main goal was to define actions to achieve the medium-term goals of reducing greenhouse gases and improving air quality. Perhaps the most important conclusion was that internal combustion engine technology would face radical technological changes that would include improved efficiency in the use of fossil fuels; these actions were expected to reduce GHG emissions. In a complementary manner, recommendations were included to promote new technologies such as hybrid and electric vehicles, although these are not yet the focus of the analysis.

Some examples of environmental regulations aimed at reducing emissions are led by those implemented by the United States, Corporate Average Fuel Economy (CAFE)[12] rules that approach the problem through manufacturers from a fleet average fuel economy direction (and penalties for non-compliance). The European Union, on its part, has opted for manufacturer penalties and fines linked to fleet average CO2 levels. While China's approach has been driven by national economic and strategic priorities, which have put electric vehicles at the center of its long-term development plans.[13] Each of these regulations will be reviewed in more detail below.

Consumer behavior trends

What has been promoted for years by automakers and governments worldwide, the pandemic seems to have achieved within months: interest in more sustainable vehicles and especially electric vehicles (EVs). Among consumers, ecological awareness and environmental concerns are now considered the main factor for EV buyers in all age groups. Increases in EV sales are part of a broader resurgence in car buying, driven by changes in mobility patterns and the perceived risk of SARS-CoV-2.[14]

According to the World Economic Forum (WEF), it is expected that by 2050, around 70% of the world's po-

10 Leggett, D. (2021). COP26 – climate change and the automotive sector (1). COP26 – climate change and the automotive sector (1), de Just Auto website: https://www.just-auto.com/analysis/cop26-climate-change-and-the-automotive-sector-1/

11 European Commission. (2012). Cars 21 High Level Group. On the Competitiveness and Sustainable Growth of the Automotive Industry in the European Union . July 21st, 2022, of European Commission website: https://www.fiaregion1.com/wp-content/uploads/2018/06/Cars-21-High-Le- vel-Group-2012.pdf

12 The purpose of the CAFE standards is to reduce energy consumption by increasing the fuel economy of cars and trucks. These standards are fleet-wide averages that each automaker must achieve for its fleet of cars and trucks each year. For more details, see: https://www.transportation.gov/mission/sustainability/corporate-average-fuel-economy-cafe-standards

13 Leggett, D. (2021). COP26 – climate change and the automotive sector (1). COP26 – climate change and the automotive sector (1), de Just Auto Sitio web: https://www.just-auto.com/analysis/cop26-climate-change-and-the-automotive-sector-1/

14 Miller, R., Cardell, M. y Batra, G. (2021). How did a global crisis pave the way for EV sales? July 25th, 2022, of EY Website: https://www.ey.com/en_cz/automotive-transportation/how-did-a-global-crisis-pave-the-way-for-ev-sales

Faced with this scenario, governments have pursued various strategies to enable the automotive industry to move towards emission mitigation and net-zero emission scenarios.

pulation will live and work in urban areas. Cities and their surroundings require major transformations to create sustainable living conditions for their residents: mobility and energy are the two key variables in this challenge.[15] Undoubtedly, changes in transportation patterns are relevant in this process.

A global study by Deloitte on the automotive consumer[16] shows that personal vehicles continue to be the preferred means of transportation for the population. And while willingness to pay for advanced technologies remains limited, interest in electric vehicles is being driven by lower operating costs and a better experience.

Previously, many consumers expressed widespread concerns about sustainability, but those concerns did not translate into action when it came to buying their next car; however, today we do see an impact in the marketplace. The latest "EY Mobility Lens Consumer Index" shows one of the biggest shifts observed in both purchase intentions and motivations among consumers in major international markets. At least 41% of consumers who intend to buy a new car are considering an EV, 66% of them within the next 12 months. That represents an 11% increase from the initial wave of the pandemic and a turning point in consumer attitudes that could impact demand for EVs and alternative powertrain vehicles.[17]

What these trends show is an imperative for the industry to innovate, use new tools, and offer new experiences. Consumers are demanding more sustainable, affordable, and functional mobility options for personal use, public transport, and the industrial sector.

Conclusions

Current trends, such as zero-emission vehicles and carbon-neutral manufacturing, demonstrate the growing importance of sustainability in the automotive industry. These trends are not only driven by the introduction of stricter emission regulations, but also by an increased awareness of environmental and sustainability issues within society and a growing interest among consumers in sustainable vehicles.

Therefore, automotive manufacturers and suppliers must re-evaluate the sustainability of their products and

15 World Economic Forum. (2018). Electric vehicles for smarter cities: the future of energy and mobility. 20 de julio de 2022, de WEF Website: https://www3.weforum.org/docs/WEF_2018_%20Electric_For_Smarter_Cities.pdf

16 Nieblas, M. y Torrijos, A. (2022). Global Automotive Consumer Study 2022 Tracking key trends in the automotive industry. July 20, 2022, by Deloitte, website: https://www2.deloitte.com/mx/es/pages/manufacturing/articles/estudio-consumidor-automotriz-2022.html

17 Miller, R., Cardell, M. y Batra, G. (2021). How did a global crisis pave the way for EV sales? July 25th, 2022, of EY Website: https://www.ey.com/en_cz/automotive-transportation/how-did-a-global-crisis-pave-the-way-for-ev-sales

Cities and their surroundings require major transformations to create sustainable living conditions for their residents: mobility and energy are the two key variables in this challenge.

value chains. Their biggest challenge is to comply with legislative requirements and, at the same time, ensure cost-effective manufacturing and meet consumer demands.

Chapter 2.

Evolution of the Global Automotive Industry

It is possible that these last five years will be seen in the future as the inflection period for the development and adoption of BEV technology[18]. A number of elements can be identified that have coincided to make this happen. More restrictive public policies for the control of GHG emissions, especially focused on CO2, significant investments by vehicle manufacturing companies that will allow a greater variety of brands and models in the market, as well as a decrease in the cost of vehicles mainly due to the reduction in the price of batteries. Finally, and perhaps the greatest determinant, is the consumer's perception that the adoption of BEV technology contributes to the reduction of their carbon footprint.

Watch the following video if you want to know about BEV.

Beyond manufacturers' statements, the National Academies of Sciences, Engineering, and Medicine have noted that "the 2025-2035 period could bring the most fundamental transformation in the more than 100-year history of the automobile" as battery costs decline and electric vehicles reach price parity with internal combustion engine vehicles, leading them to become "the dominant type of new vehicles sold by 2035". [19] Around the world, countries have announced deadlines for allowing the sale of only zero-emission vehicles (ZEVs) to accelerate the transition to a cleaner, electrified transportation sector.

On their part, the governments of the EU[20] member countries and our main trading partner, the United States, have undertaken programs to restrict emissions and direct economic incentives for the conversion of automotive manufacturing plants for the production of electric vehicles and tax credits on the purchase of these vehicles, as can be seen in "Energy Security and Climate Change Investments in the Inflation Reduction Act of 2022."[21]

The electric vehicle market worldwide

According to the International Energy Agency (IEA)[22], in just one year, the size of the global fleet of both battery electric vehicles (BEVs) and fuel cell electric vehicles (PHEVs)[23] increased by just over six million units. It seems that no renewable energy sector has ever shown this performance in years as difficult as those of the Sars-Cov-2 pandemic. Thus, in 2021, the size of the global vehicle fleet reached 16.5 million units. This figure almost tripled in just three years. It is possible to observe in figures 1 and 2 that battery electric vehicles (BEVs) are the most widely adopted technology.

On its part, Bloomberg[24], in a recent report on the behavior of annual sales, states that the pace of growth is accelerating: it is China and Europe that maintain the commercial leadership. It also estimates a growth in sales of just over four million units by 2022. According to the IEA, there are a couple of data that may indicate the transformation of the market in just ten years; the first is the fact that 2012 sales amounted to 120 thousand vehicles. That figure represented sales in one week in

18 La Environmental Protection Agency (EPA) de Estados Unidos define vehículo eléctrico como aquel que tiene un motor eléctrico en lugar de un motor deThe U.S. Environmental Protection Agency (EPA) defines an electric vehicle as a vehicle that has an electric motor instead of an internal combustion engine and is powered exclusively by energy stored in batteries. See: https://www.epa.gov/greenvehicles/explaining-electric-plug-hybrid-electric-vehicles

19 Lowell, D. and Huntington, A. (2021). Electric Vehicle Market Status - Update. August 1, 2022, from MJB & A Website: https://www.mjbradley.com/sites/default/files/EDF_EV_Market_Report_April_2021_Update.pdf

20 Regulation (EU) 2019/631 setting CO2 emission performance standards for new passenger cars and new light commercial vehicles. See: http://publications.europa.eu/resource/cellar/2a607219-6757-11e9-9f05-01aa75ed71a1.0023.03/DOC_1

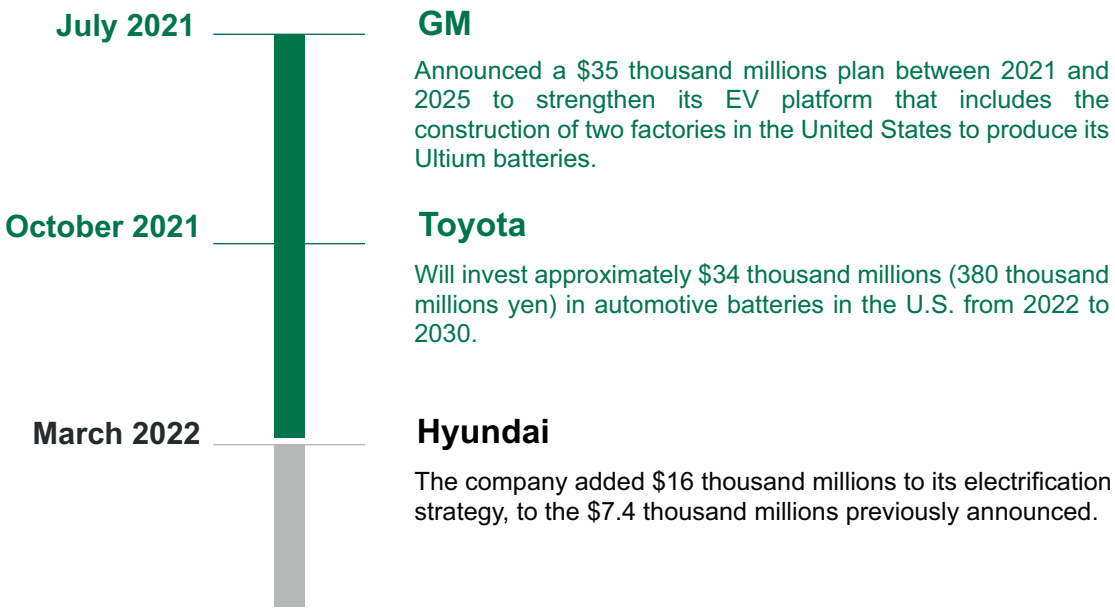
21 See: https://www.democrats.senate.gov/imo/media/doc/summary_of_the_energy_security_and_climate_change_investments_in_the_inflation_reduction_act_of_2022.pdf

22 International Energy Agency (2022). Global EV Outlook 2022 Accelerating ambitions despite the pandemic. July 15, 2022, from IEA Website: Global EV Outlook 2022

23 PHEVs (plug-in hybrid electric vehicles) are known as plug-in hybrids. They run on a combustion engine and additionally have one or more electric motors and higher-capacity batteries that are recharged by plugging the car into the electric grid. See: https://www.epa.gov/greenvehicles/explaining-electric-plug-hybrid-electric-vehicles

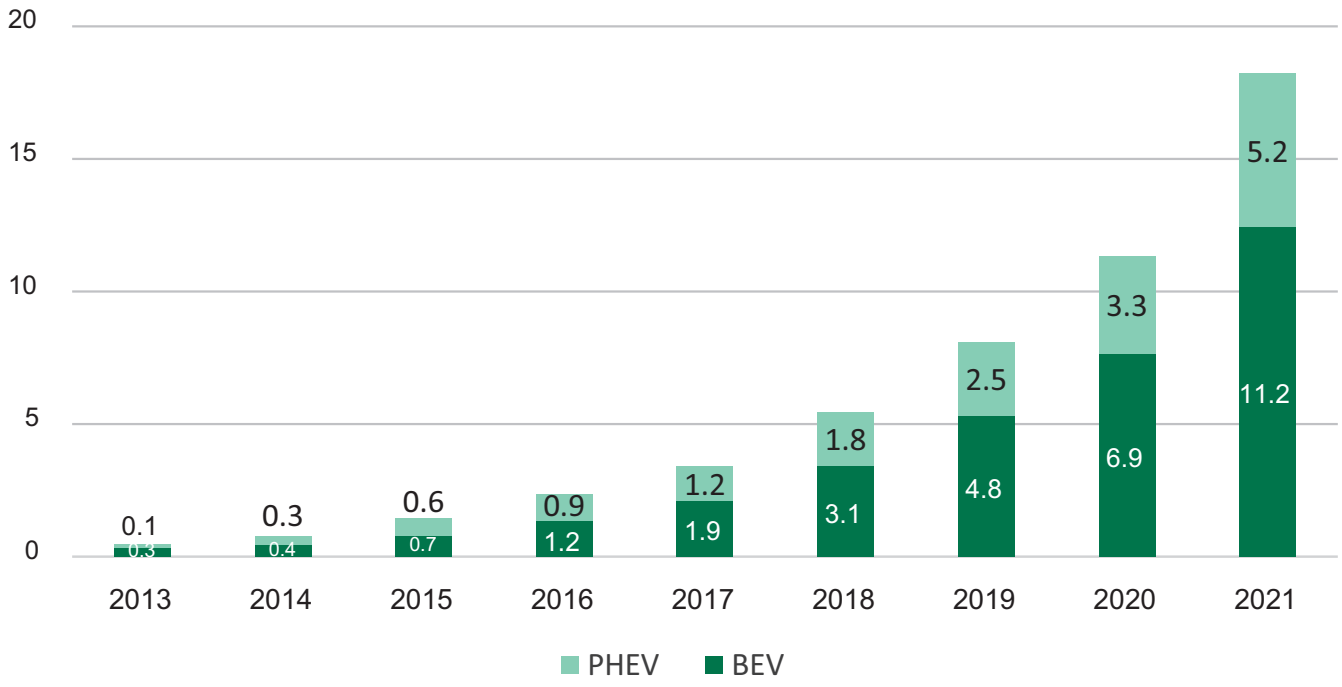
24 BNEF Electric Vehicle Outlook 2022 and Latin American electric vehicle market.

Diagram 1. Main investments in Evs



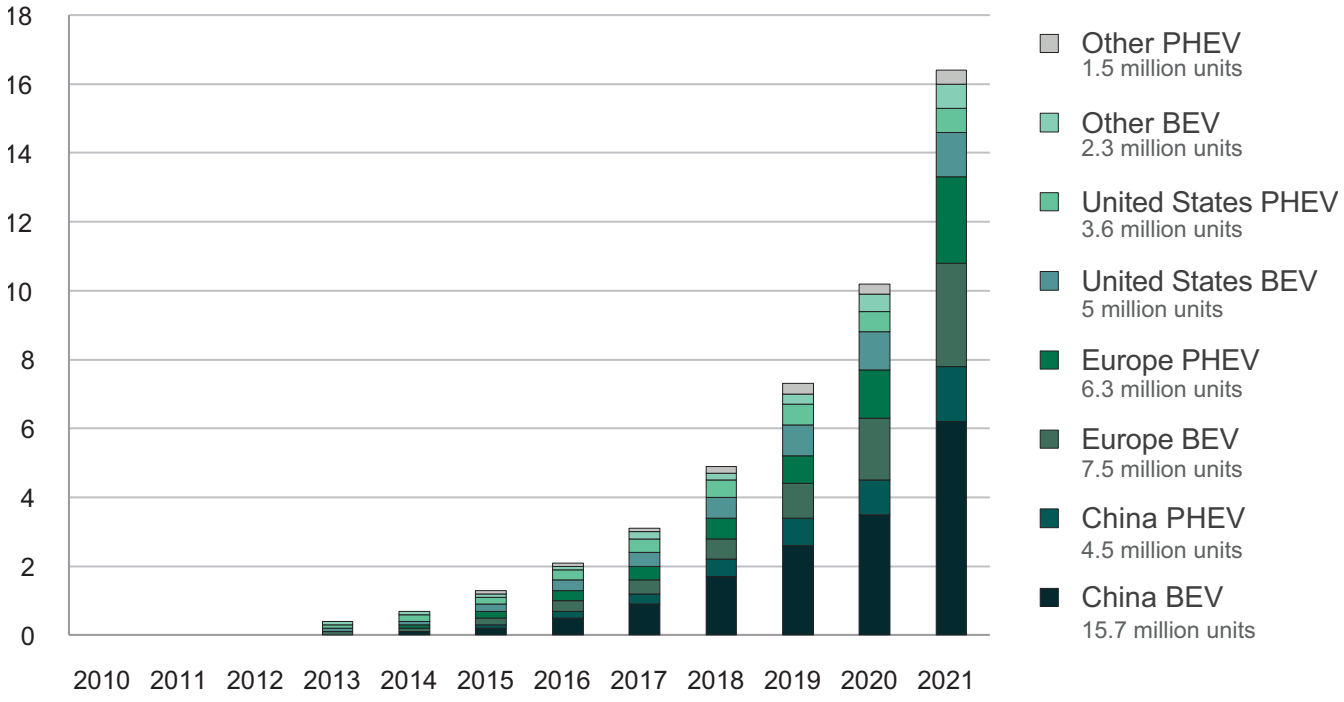
Source: INA with companies' own information. See press releases in references.

Figure 1. Electric Vehicle Fleet



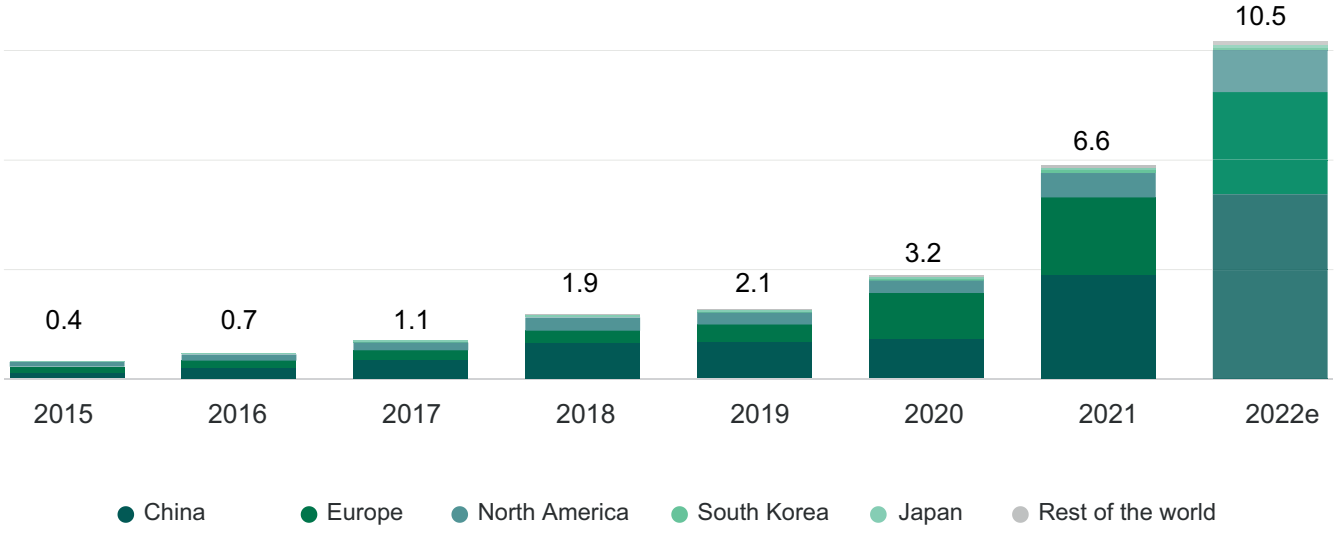
Source: INA, with information from the International Energy Agency.

FIgure 2. Electric Vehicle Fleet by Technology Type



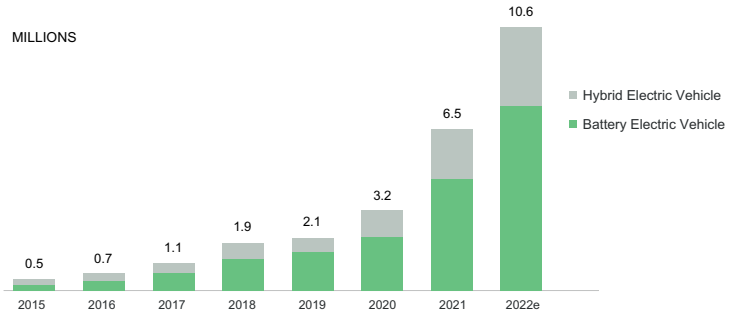
Source: INA with information from Bloomberg.

Figure 3. Annual Sales of Passenger Electric Vehicles



Source: INA with information from Bloomberg.

Figure 4. Annual Sales of Passenger Electric Vehicles by Region



Source: INA with information from BNEF Electric Vehicle Outlook 2022 and Latin American electric vehicle market.

Global sales of the top 5 electric vehicle companies (Plug-in: BEV+PHEVs)*

Company	2019	Company	2020	Company	2021	Company	2022 / 1st Quarter
Tesla	367,849	Tesla	499,535	Tesla	936,172	Tesla	310,411
BYD	225,757	VW Group	421,591	VW Group	757,994	BYD	285,849
Renault-Nissan-Mitsubishi	183,299	SAIC	272,210	SAIC	683,086	SAIC **	170,454
BAIC	163,838	Renault-Nissan-Mitsubishi	226,975	BYD	593,878	VW Group	154,824
BMW	145,815	BMW	195,979	Stellantis	360,953	Geely Volvo	110,253

* The top 5 groups of manufacturing companies account for 50% of total global sales.
** Includes SAIC-GM-Wuling

Source: INA with information from inside EV's.

2021, and in that same year, sales accounted for 9% of the global car market and quadrupled the market share in 2019.[25]

Regarding the historical sales of electric vehicles classified by transmission system, it is observed that BEVs maintain the dominant trend, as this technology has a 2-to-1 ratio compared to sales of PHEV vehicles.

Globally, it is possible to observe that since 2019, Tesla has maintained a strong leadership in global sales, reaching a figure of 936,172 vehicles sold worldwide in 2021. In the same year, VW achieved a sales figure of

25 International Energy Agency (2022). Global EV Outlook 2022 Accelerating ambitions despite the pandemic. July 15, 2022, from IEA Site. Website: Global EV Outlook 2022

759,994, and the third place was occupied by the Chinese company SAIC. For 2022, Bloomberg expects this market segment to surpass 10 million units sold.

While in the United States, the sales figure for electric vehicles reached 630,000 units[26]. Considering selected brands[27], in the table on the right it is possible to observe the distribution of sales between 2020 and 2021.

In the United States market, Tesla[28] has been the leading brand in this segment with its models X, Y, S and 3 for the last 3 years. In 2022, according to experts, there was a significant competition between brands born electric such as Tesla and Lucid[29], for example, and the "traditional" automotive brands with the launch of electric models, some new and others with electric versions, as is the case of Ford with the electric version of the iconic Mustang.

Electric vehicle sales
(selected brands in the United States)

BRAND	2020	2021
Tesla Model Y	39.200	172.700
Tesla Model 3	114.900	128.600
Ford Mustang Mach-E	3	27.140
Volvo XC4	23.778	26.844
Chevrolet Bolt	20.754	24.828
VW ID4	0	16.742
Nissan Leaf	9.564	14.239
Audi e-tron	7.202	10.921
Tesla Model S	14.700	9.100
Kia Niro	2.438	3.698
Tesla Model X	20.600	3.000
BMW i3	1.508	1.476
Mercedes Benz EQS	0	443

Source: INA with information from Automotive News Research & Data Center and KEEA.

What explains this growth?

It has already been mentioned that the phenomenon is multivariable and one of them is the commitment of the global automotive industry to create production platforms in various models and improve battery charging speed conditions and BEV autonomy.

According to the IEA, 450 electric vehicle models were available on the market in 2021 and the average annual growth rate for the period 2015-2021 was 34%.

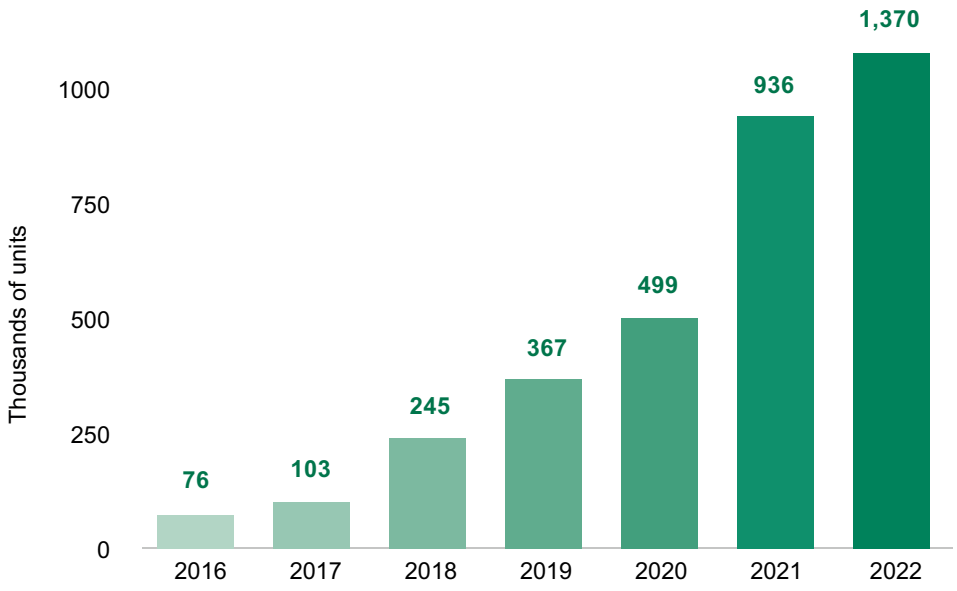
By market segment and vehicle type, it is possible to observe that China has 298 models, Europe has 184, and the United States has 63. The models that stand out in all three markets are SUVs and mid-sized vehicles, with the following market shares for SUVs: 44.3%, 44.6%, and 57.1%, while for mid-sized vehicles, the distribution is 23.5%, 22.3%, and 22.2%, respectively.[30]

In 2021, some OEMs announced plans to reconfigure their product lines to produce only electric vehicles. Thus, by 2030:

- Toyota plans to have 30 BEV models and achieve the annual target of 3.5 million units sold[31].
- Volvo will only sell electric cars.
- Ford aims to sell only electric cars in Europe.

26 In China, sales of electric cars nearly tripled in 2021 to 3.3 million, representing about half of the world total. Sales also grew strongly in Europe (rising 65% to 2.3 million) and the United States (more than doubling to 630 000). Source: IEA.
27 IEA and sales of selected brands account for 70% of total sales in 2021.
28 https://www.statista.com/statistics/502208/tesla-quarterly-vehicle-deliveries/
29 Lucid Group reported, at year-end 2021, orders for more than 25,000 units and claims to have installed capacity by 2022 of 34,000 units and sales potential of $2.4 thousands of millions of dollars. Source: Lucid Group (February 28, 2022). Fourth quarter and fiscal year 2021 earnings. Retrieved from: https://ir.lucidmotors.com/news-releases/news-release-details/lucid-announces-fourth-quarter-and-full-year-2021-financial
30 International Energy Agency (2022). Global EV Outlook 2022 Accelerating ambitions despite the pandemic. July 15, 2022, from IEA Website: Global EV Outlook 2022
31 Ibid.

Figure 5. Tesla Vehicle Production



Source: INA with information from Stastista.

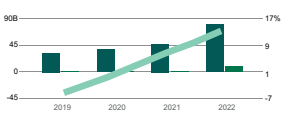
Tesla

www.tesla.com

Tesla Inc. operates as a multinational automotive and clean energy company. The company specializes in the design and manufacturing of electric vehicles, domestic and grid-scale energy storage solutions, solar panels, solar roof tiles, and related products and services. Tesla maintains ownership of its sales and service network, in addition to supplying electric powertrain components to other automakers.

Model Y

Income Statement

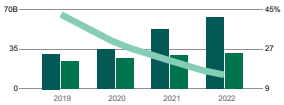


2022 (Millions of dollars)

Revenue	81, 462.00
Net income	12, 556.00
Profit margin	15.41%

Model 3

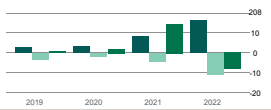
Balance Sheet



2022 (Millions of dollars)

Total assets	82, 338.00
Total liabilities	36,440.00
Debt to assets	6.98%

Cash flow



2022 (Millions of dollars)

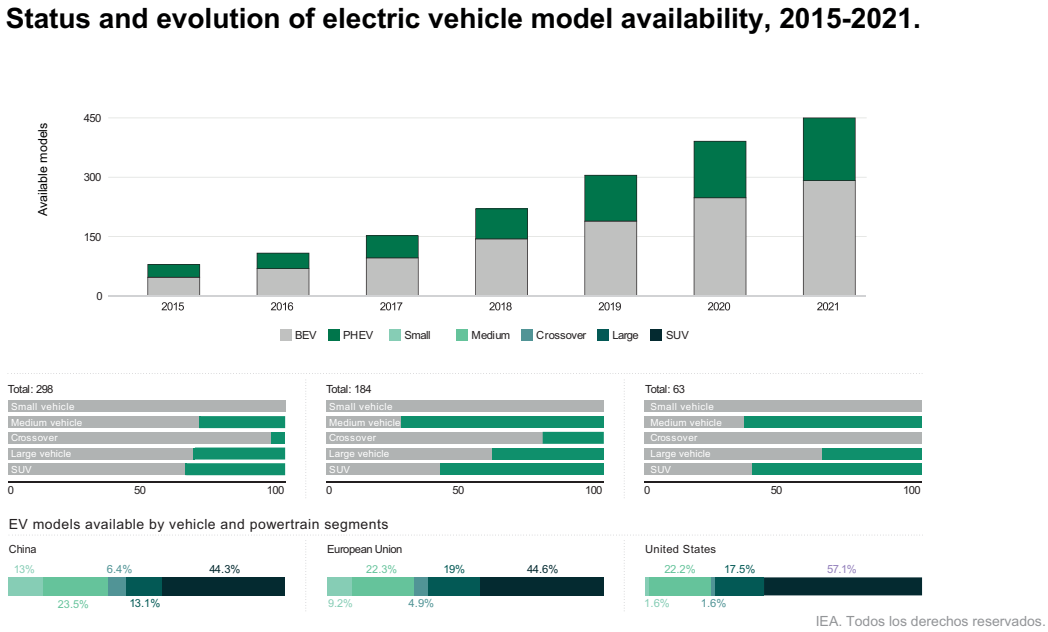
Operating	14, 724.00
Investing	- 11, 973.00
Financing	- 3, 971.00

The company was founded in 2003 by Marc Tarpenning and Martin Eberhard, and it is currently led by Elon Musk.

- **2008:** Launch of the Roadster model, the first premium all-electric sedan built from scratch.
- **2012:** First production from the Fremont factory in California. Tesla's first factory produces the Model S, Model 3, Model X, and Model Y.
- **2015:** Production of the Model X, a sport utility vehicle.
- **2016:** Unveiling of the Model 3, a mass-market electric vehicle. Production began in 2017.
- **2019:** Marks the internationalization of the company as the more affordable models start being assembled in China. The Tesla Gigafactory near Shanghai, China, is constructed with an estimated investment of $7 thousand million dolllars.
- **2022:** Inauguration of electric vehicle production plants in Grünheide near Berlin, Germany, and Texas. The investments amounted to $5 and $1.1 thousand million dolllars respectively, with a potential generation of 12,000 jobs and a maximum production capacity of 500,000 vehicles per year. Tesla reported fiscal year 2021 revenues of $17.719 millions of dollars, with a net profit margin of 27% and free cash flow of $2.775 millions of dollars. The Model 3 was the best-selling car in Europe.
- **2023**: Tesla announces a $5 thousand million dolllars investment to build an electric vehicle plant in Nuevo León, Mexico.

Source: INA with information from Tesla Inc, Bloomberg, ABC Motors, Deutsche Welle and Reuters.

Figure 6. Electric Vehicle models in 2021



Notes: BEV = battery electric vehicle; PHEV = plug-in hybrid electric vehicle. Small vehicles include A- and B-segments. Medium vehicles include segments C and D. Crossovers are a type of sport utility vehicle (SUV) built on a passenger car platform. Large cars include segments E and F and multipurpose vehicles. Vehicle models do not include the various equipment levels.

Source: INA with information from IEA Analysis based on EV Volumes and Marklines.

- Stellantis aims for 70% of its sales in Europe and 35% of its sales in the North American market to be electric cars.

- Volkswagen estimates that 70% of its sales will be electric cars in Europe and 50% in China and the United States.

- Meanwhile, General Motors (GM) plans to offer only electric light vehicles by 2035.[32]

It is estimated that OEM automotive companies will invest around $268 thousand million dollars[33] globally in the electrification of their light vehicle production platforms over the next seven years.

In summary, consulting firm Deloitte provides an overview of the positioning of automotive companies in the global electric vehicle segment in diagram 2 (page 26).

Charging points network infrastructure and investments

According to the IEA[34], the number of publicly available charging points for electric vehicles globally increased by nearly 40% in 2021. This growth occurred despite a slowdown in charging infrastructure development during the pandemic years. There is a clear relationship between the expansion of the EV fleet and the size and type of charging infrastructure required to support market growth.

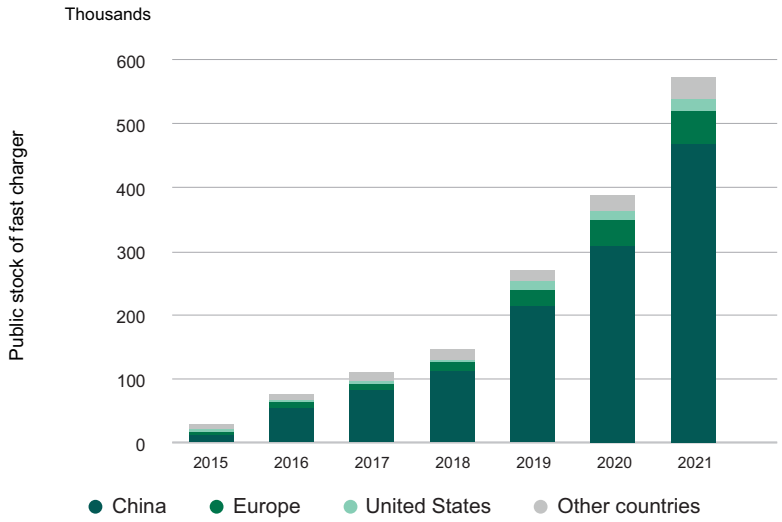
Currently, the majority of this charging infrastructure is privately owned, meaning that charging points are located at residential or workplace locations. Consumers expect electric charging services to provide similar quality, range, and simplicity as their experience with conventional vehicles. In the given year, the total number of public chargers worldwide reached 1.8 million, one-

32 Lowell, D. and Huntington, A. (2021). Electric Vehicle Market Status - Update. August 1, 2022, from MJB & A Website: https://www.mjbrad-ley.com/sites/default/files/EDF_EV_Market_Report_April_2021_Update.pdf

33 Lowell, D. and Huntington, A. (2021). Electric Vehicle Market Status - Update. August 1, 2022, from MJB & A Website: https://www.mjbrad-ley.com/sites/default/files/EDF_EV_Market_Report_April_2021_Update.pdf

34 IEA. See: https://www.iea.org/reports/global-ev-outlook-2022/trends-in-charging-infrastructure

Figure 7. Public fast chargers available in the world (2015-2021)



Source: INA with information from the International Energy Agency.

In 2021, some OEM manufacturers announced plans to reconfigure their product lines to produce only electric vehicles.

third of them being fast chargers and nearly 500,000 additional chargers were installed. This quantity exceeded the total number of public chargers available in 2017[35].

The number of publicly accessible chargers increased by 37% in 2021, which is lower than the growth rate in 2020 (45%) and the pre-pandemic deployment rates. The average annual growth rate was nearly 50% between 2015 and 2019. In 2021, the stock of fast chargers increased slightly more than in 2020 (48% compared to 43%), while slow charging decreased (33% compared to 46%). As in previous years, China remains the global leader in the number of available public chargers. It accounts for approximately 85% of the total fast chargers and 55% of the slow chargers. This reflects the leadership demonstrated by this country in the electric vehicle market.

On the other hand, the development of charging infrastructure requires significant investment. Bloomberg reports that in 2022, over $4.8 million dollars has been invested in the electric vehicle charging industry.[36] These investments include implementation announcements, debt financing, and acquisitions. It has been found that the appetite for infrastructure investment funds is on a growing trend, such that it is possible to see "electric vehicle charging as a kind of maturing asset".[37] Much more effort is needed to reach investment amounts of thousands of millions over the next two decades.

For its part, BloombergNEF estimates that more than 73% of the investment in public chargers installed worldwide in 2021 was for ultrafast charging.

35 IEA. See: https://www.iea.org/reports/global-ev-outlook-2022/trends-in-charging-infrastructure
36 Fisher, R. (2022). Car-Charging Investment Soars, Driven by EV Growth and Government Funds. August 16, 2022, from Bloomberg. Website: https://www.bloomberg.com/news/articles/2022-08-16/car-charging-investment-soars-driven-by-ev-growth-and-government-funds?cmpid=BBD081622_hyperdrive&utm_medium=email&utm_source=newsletter&utm_term=220816&utm_campaign=hyperdrive#xj4y7vzkg
37 Idem.

That consultancy expects cumulative charging investment to exceed $360 thousand million globally by 2030 and more than $1 billion by 2040 to meet the needs of the electric vehicle fleet. More than $1.4 billion is needed in a net zero scenario where the entire vehicle fleet would be on track to be electric by 2050. It is expected that about 60% of this investment will be used to put in direct current (DC) fast chargers between 50 kilowatts and 1,000 kW in the kilowatts to 1000 kW in the field.

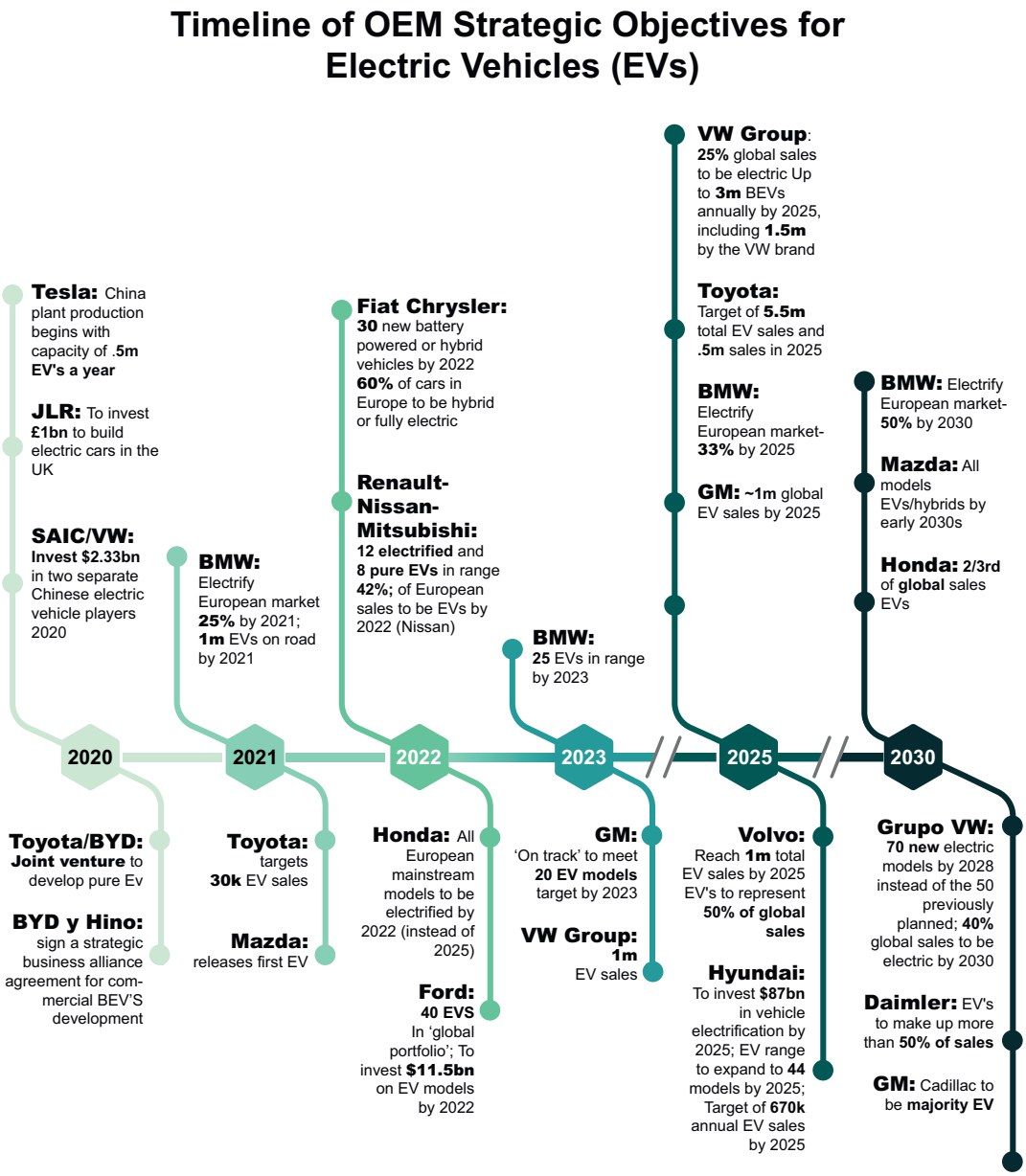
Understanding the electric vehicle paradigm.

An internal combustion engine (ICE) is ignited by a spark, and fuel is injected into the combustion chamber where it combines with air.[38]). This mixture is ignited by a spark from the spark plug. Additionally, this type of engine is thermal because combustion occurs within itself, inside the cylinder, through a process that converts the chemical energy of the fuel into mechanical energy.

While in a BEV there is an electric motor instead of an ICE. Because it runs on electricity, the vehicle does not emit gases from an exhaust pipe and does not contain the typical liquid fuel, nor does it contain a pump, line and fuel tank.[39]

38 US Department of Energy https://afdc.energy.gov/vehicles/how-do-gasoline-cars-work
39 US Department of Energy https://afdc.energy.gov/vehicles/electric_basics_ev.html

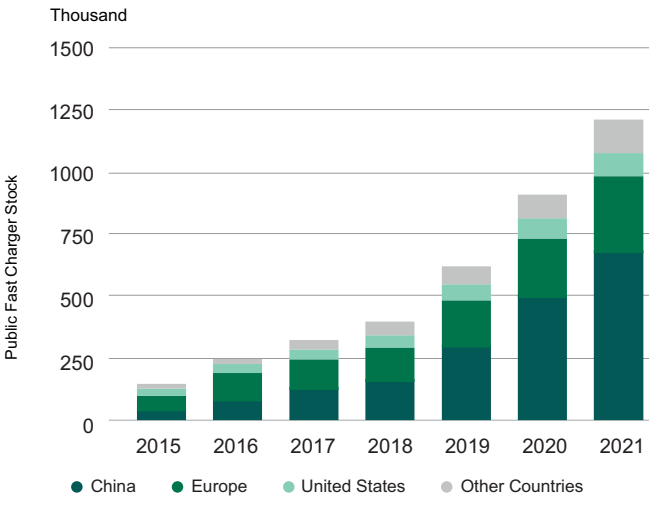
Diagram 2. Timeline of EV Production Targets



Source: INA with information from Deloitte.

The relationship between the growth of the electric vehicle (EV) fleet and the size and type of charging infrastructure required to support market expansion is evident.

Figure 8. Fast Charging Points Worldwide



Source: INA with information from the International Energy Agency.

Key production chains: Suppliers.

Batteries typically account for between 30% and 40% of the value of an electric vehicle (EV), and the race towards "net-zero" will focus on having a production scheme that ensures the supply of critical minerals and metals needed for their manufacturing.[40]

Energy storage systems are essential for fully electric vehicles, plug-in hybrid electric vehicles (PHEVs), and hybrid electric vehicles (HEVs). There are different types of energy storage systems:[41]

Lithium-ion Batteries: Lithium-ion batteries are currently used in most portable consumer electronic devices such as cell phones and laptops due to their high energy density in relation to other electric energy storage systems. They have a high power-to-weight ratio, high energy efficiency, good performance at high temperatures, and low self-discharge. Most components of lithium-ion batteries can be recycled, although the cost of material recovery remains a challenge for the industry. Nowadays, most fully electric vehicles and PHEVs use lithium-ion batteries, although the exact chemistry often differs from consumer electronic batteries. On-

40 IEA. (2022). Global Supply Chains of EV Batteries. August 2, 2022, from IEA website. Website: https://iea.blob.core.windows.net/assets/4eb8c252-76b1-4710-8f5e-867e751c8dda/GlobalSupplyChainsofEVBatteries.pdf

41 US Department of Energy https://afdc.energy.gov/vehicles/electric_batteries.html.

Table 1. Investment Amounts Obtained in 2022

Company	Investment Amount
BP and Iberdrola	One thousand million dollars to install 11,000 new chargers in Europe.
Blackrock, Daimler Truck and NextEra Energy Resources	Added $650 million dollars of investment in the U.S. charging network.
Electrify America	Received $450 million from VW and Siemens to strengthen its charging network in the United States.
NW Storm	€300 million euros
Freewire	$125 million dollars
EVCS	$69 million dollars
Raw Charging	£250 million pounds
Gridserver	£200 million pounds
Instavolt	£110 million pounds of debt funds.

Source: INA.

going research and development aim to reduce their relatively high cost, extend their lifespan, and address safety concerns related to overheating.

Nickel-Metal Hydride Batteries: Nickel-metal hydride batteries, which are commonly used in computer and medical equipment, offer reasonable specific energy and specific power capabilities. Nickel-metal hydride batteries have a much longer lifespan than lead-acid batteries and are safe and tolerant to abuse. These batteries have been widely used in HEVs (hybrid electric vehicles). The main challenges with this type of battery are their high cost, high self-discharge, heat generation at high temperatures, and the need to control hydrogen loss.

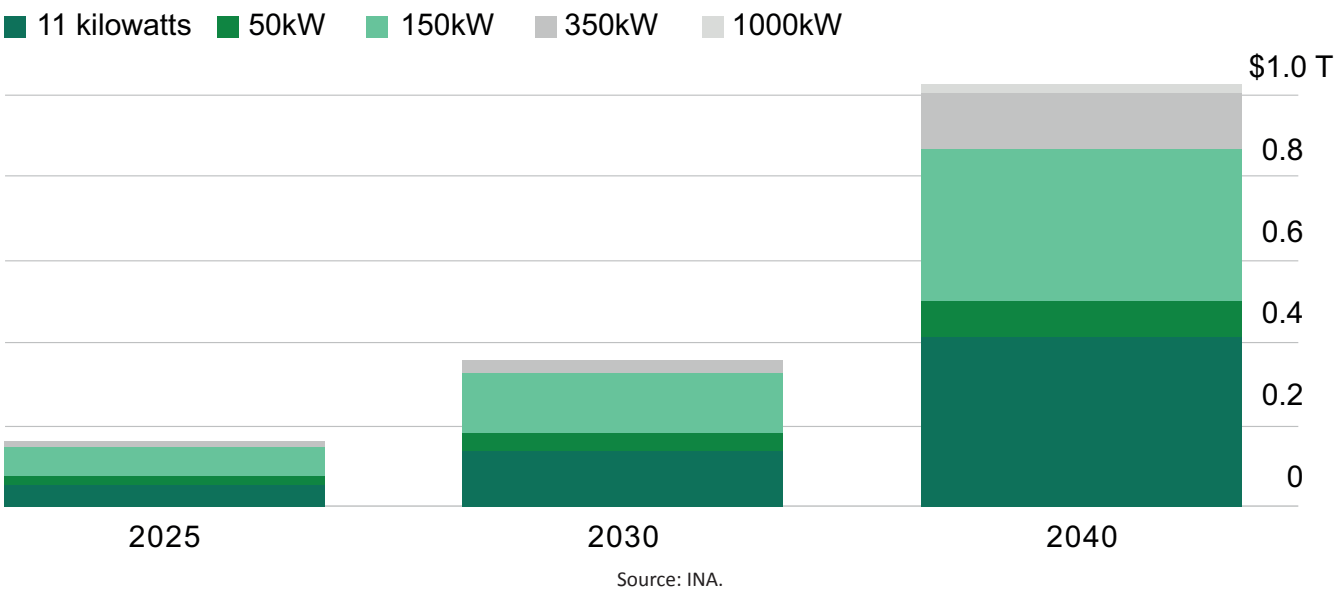
Lead-Acid Batteries: Lead-acid batteries can be designed to provide high power and are economical, safe, and reliable. However, their specific energy decreases, and their low performance at low temperatures, as well as their short calendar and cycle life, hinder their use. Advanced high-power lead-acid batteries are being developed, but these batteries are currently only used in electric vehicles for auxiliary charges.

Ultracapacitors: Ultracapacitors store energy in a polarized liquid between an electrode and an electrolyte. The energy storage capacity increases as the surface area of the liquid increases. Ultracapacitors can provide additional power to vehicles during acceleration and uphill climbs and help recover braking energy. They can also be useful as secondary energy storage devices in electric vehicles as they assist electrochemical batteries in balancing the charging power.

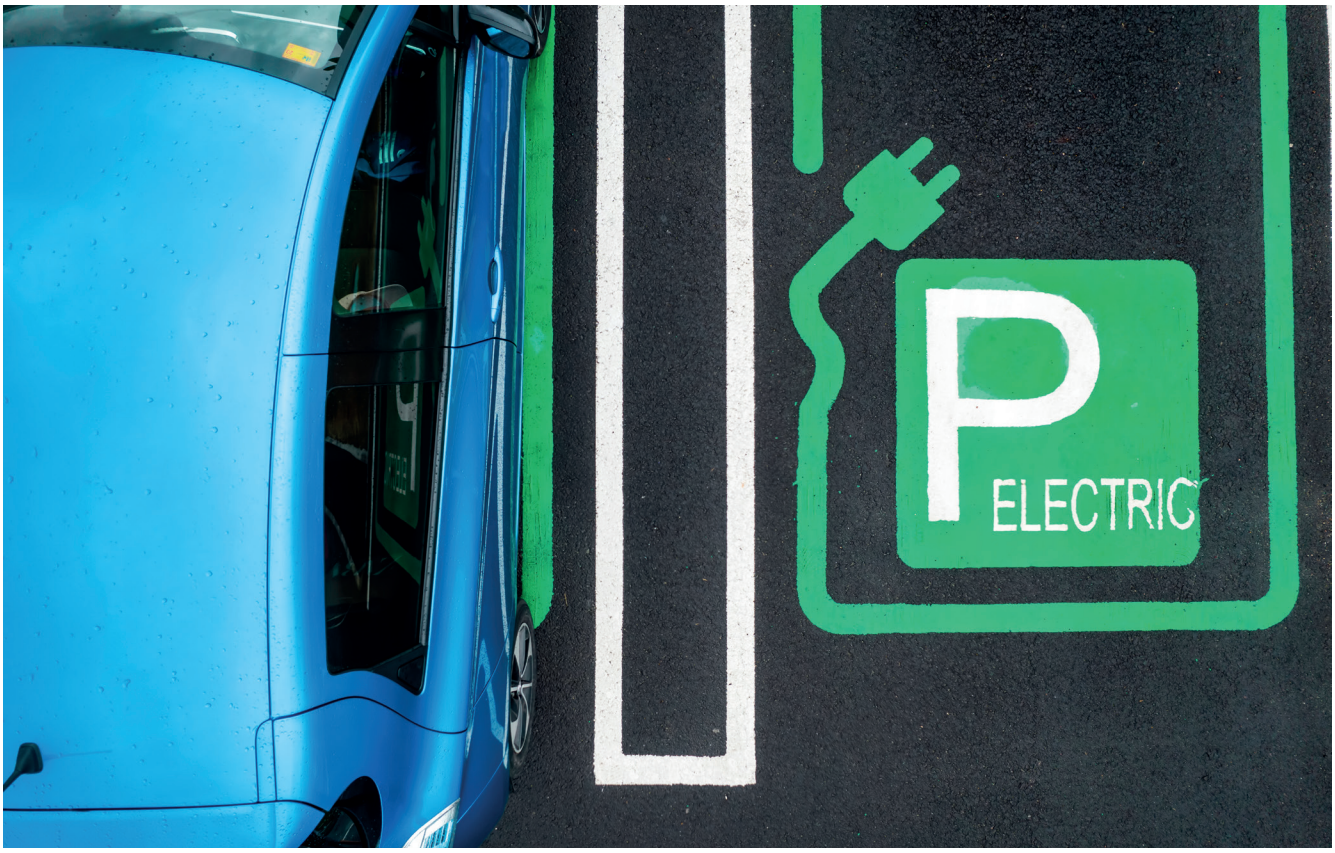
The current supply chains for batteries and minerals revolve around China, which produces three-quarters of all lithium-ion batteries and accounts for 70% of cathode production capacity and 85% of anode production capacity. More than half of the lithium, cobalt, and graphite processing and refining capacity is located in China.

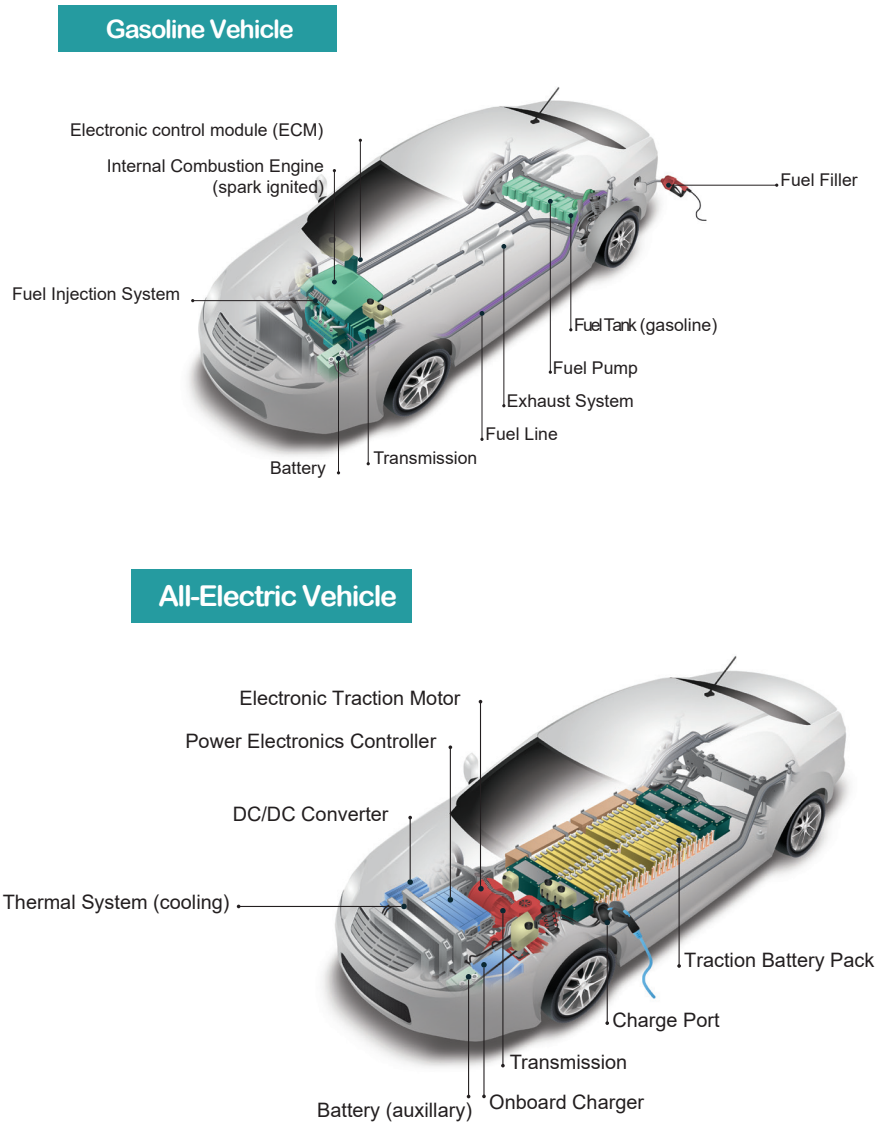
Europe accounts for over a quarter of global electric vehicle assembly but has limited involvement in the supply chain beyond processing 20% of cobalt. The United States plays an even smaller role in the global EV battery supply chain, with only 10% of electric vehicle production and 7% of battery production capacity. Korea and Japan have a significant presence in the lower end of the supply chain, particularly in the highly te-

Figure 9. Future Investment in Charging Infrastructure



Source: INA.





Source: INA.

chnical production of cathode and anode materials, as well as raw material processing. Korea holds 15% of cathode material production capacity, while Japan accounts for 14% of cathode and 11% of anode material production. Korean and Japanese companies are also involved in the production of other battery components, such as separators.

European and U.S. governments are implementing initiatives to develop supply chains that enable battery production in these regions, but it is likely that China will continue to control the majority of the supply chain until 2030: 70% of the announced capacity in battery production until 2030 is located in China.[42]

The pressure on the supply of critical materials will continue to increase as transportation electrification expands to meet zero-emission targets. The demand for batteries for electric vehicles (EVs) is currently around 340 GWh and is projected to exceed 3,500 GWh by 2030, based on commitments announced by different countries. The components of the cells and their supply will also need to expand in the same magnitude to meet this demand.

42 International Energy Agency. (2022). Global Supply Chains of EV Batteries. August 2, 2022, from IEA website: https://iea.blob.core.windows.net/assets/4eb8c252-76b1-4710-8f5e-867e751c8dda/GlobalSupplyChainsofEVBatteries.pdf

Comparative analysis between ICV and EV

	Internal Combustion Vehicle (ICV)	Electric vehicle (EV)
Powertrain	The powertrain of an internal combustion vehicle (ICV) converts fuel into kinetic energy through the engine.	In an electric vehicle (EV), direct current (DC) energy from the battery is converted into alternating current (AC) and supplied to the motor.
Energy Efficiency	The average energy efficiency is only around 40%; the remaining energy is lost with heat or friction.	Electric vehicles consume much less energy when covering the same distance compared to an internal combustion vehicle.
Fuel Cost	The average cost of a gallon of gasoline is around $3.8 dollars, and ICV has a capacity of approximately 14 gallons (53 liters). Therefore, the average cost to fill a tank is around $53 dollars.	The average cost of 1 kilowatt of electricity is $0.14 dollars/hour. A standard EV takes approximately 7.2 kWh to reach a full charge of 50 kWh, which means the average cost of a full EV charge is around $7 dollars.
Environmental Impact	ICVs emit CO2 and other greenhouse gases, contributing negatively to climate change.	The carbon emissions associated with EVs occur at centralized power plants. Electric vehicles require batteries made with a variety of chemical products. The extraction of these rare earth metals and their disposal remains a challenge.
Incentives	There are no government exemptions for ICVs.	There are several grants, subsidies, and government incentives available to help reduce the cost of owning an EV.
Product Cost	ICVs are cheaper to manufacture at scale.	BEVs are currently more expensive at scale than ICVs, and hybrids cost more than BEVs.

Source: INA with information from: RION (2022). Insider Industrial Automotive Electrification Transformation. July 25, 2022, by RION Global M&A Partners. Website: https://www.globalma.com/news/Automotive_Insider_Electrification_Transformation

Energy storage systems are essential for fully electric vehicles, plug-in hybrid electric vehicles (PHEVs), and hybrid electric vehicles (HEVs).

Additional investments in mining are needed in the short term, especially considering that mining delivery timelines are typically longer than other parts of the supply chain. In some cases, it can take over a decade from initial feasibility studies to production, and several more years to reach full production capacity.[43]

The supply chain of electric vehicles generally refers to a set of components in the process, including:

- Raw materials
- Specialized chemicals
- Battery components
- Batteries

The supply chain is under significant pressure. As the demand for vehicles increases, so does the demand for lithium-ion batteries, resulting in a more than fivefold increase in metals such as lithium, nickel, and copper in the coming years. According to Bloomberg estimates, between 2021 and 2030[44], certain raw material markets will experience strong pressures. This is primarily due to a narrow margin between supply and demand for key components of current batteries. On the other hand some experts from the IEA have commented that…

"A clean energy-powered system differs significantly from one fueled by traditional hydrocarbon resources. Electric vehicles (EVs) generally require more minerals than their fossil fuel-based counterparts. A typical electric car requires six times more mineral inputs than a conventional car".[45]

It is clear that the mineral resources used vary according to the technology, but the ones that always come into play are lithium, nickel, cobalt, manganese, and graphite, as they are crucial for the performance, longevity, and energy density of the battery. Rare earth elements are essential for the magnets in wind turbines and electric vehicle motors. Electrical grids use a significant amount of copper and aluminum. Finally, it is estimated that by 2040, 80% of batteries will be used in light electric vehicles, which will require a 40-fold increase in lithium and nickel production, and a 20-fold increase in copper, graphite, and cobalt production compared to 2020 levels[46].

The automotive industry will demand much more nickel, lithium, and cobalt. In each of these raw material markets, there are supply risk elements and unresolved issues regarding the environmental and social impact of mining.

Nickel is crucial for battery range. However, the metal is primarily used in stainless steel, and batteries represent a very small portion of global nickel demand (5%). There are supply risks that may arise in 2024. Russia plays an important role in the nickel supply chain, not in mining but in refining, and the ongoing conflict with Ukraine poses a risk to the chain.

Regarding lithium, most current PHEVs and EVs use lithium-ion batteries, which have high energy density. Some experts point to a possible supply source in the Salton Sea project in California[47]), relying on geothermal brines and the huge potential of that mine, which could meet up to 40% of global demand. However, the-

43 International Energy Agency. (2022). Global Supply Chains of EV Batteries. August 2, 2022, from IEA website: https://iea.blob.core.windows.net/assets/4eb8c252-76b1-4710-8f5e-867e751c8dda/GlobalSupplyChainsofEVBatteries.pdf

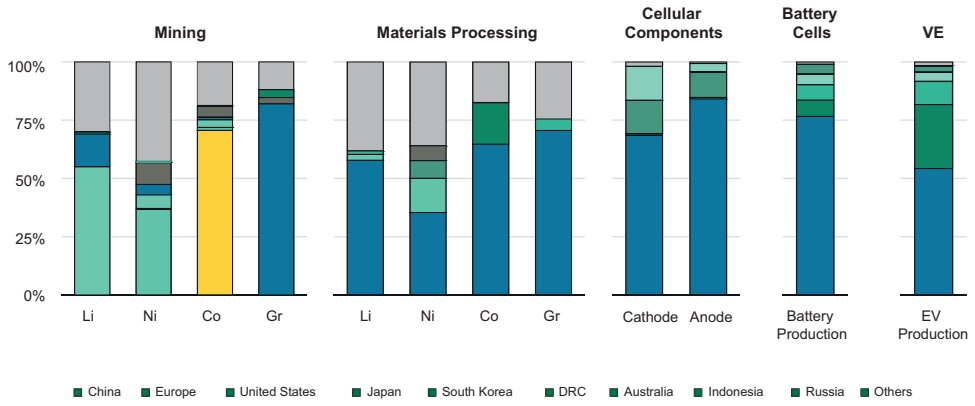
44 Bloomberg, based on information from the webinar "The rise of electric vehicles and the impact on commodity markets" on September 22, 2022.

45 International Energy Agency. (2022). Global EV Outlook 2022: Accelerating ambitions despite the pandemic. July 15, 2022, from IEA website: https://iea.blob.core.windows.net/assets/ed5f4484-f556-4110-8c5c-4ede8bcba637/GlobalEVOutlook2021.pdf

46 International Energy Agency. (2022). Global Supply Chains of EV Batteries. August 2, 2022, from IEA website: https://iea.blob.core.windows.net/assets/4eb8c252-76b1-4710-8f5e-867e751c8dda/GlobalSupplyChainsofEVBatteries.pdf

47 Taylor, T. (2022). 101: Raw Materials and EV Supply Chains. September 15, 2022, from EV HUB. Website: https://www.atlasevhub.com/weekly_digest/101-raw-materials-and-ev-supply-chains/#:~:text=In%20particular%2C%20let's%20look%20at,electric%20vehicle%20(EV)%20batteries

Figure 10. Geographical distribution of the supply chain of electric batteries



Notes: Li=Lithium, Ni=Nickel, Co=Cobalt, Gr=Graphite, DRC=Democratic Republic of Congo.
The geographical breakdown refers to the country where production takes place. Mining is based on production data.
Materials processing is based on refining capacity production data.
Cellular component production is based on cathode and anode materials production capacity data.
EV battery cell production is based on battery cell production capacity data.
EV production is based on EV production data.

Source: INA with information from the International Energy Agency.

re is still resistance to lithium mining, and it is growing, including opposition to a proposed mine in Nevada.

Cobalt is crucial for supporting the cathode in lithium-ion batteries for EVs, and cobalt is almost always a byproduct of larger nickel and copper minerals. This means that it is not independent in the process and requires significant processing to be useful for the battery. Almost all of the processing takes place in China.

Advances in public policy in the United States in this area (analyzed in chapter 2) represent a significant step forward, as it focuses on specific issues within the battery supply chain, which faces challenges related to practical implementation. “Considering that it takes seven years to build a mine and refining plant, but only 24 months to build a battery plant, it takes most of this decade to establish a completely new industry in the United States,” said Simon Moores, CEO of Benchmark. “It is nearly impossible for any country in the Fair Trade Alliance, including Australia and Chile, to fill the raw material gap from China for the demand of electric vehicles in the United States between now and 2024. For the incentive to truly work, it needs to be extended for 4 years and allow for the development of the supply chain”.[48]

Public policies on electric vehicles.

The rise of electric vehicles, as we have seen in previous chapters, is being driven by various factors, with the new paradigm of public policies regarding the automotive industry standing out. Traditionally, policies have focused on raising awareness and providing information to the population to promote certain issues; in contrast, governments now need to respond to environmental activism and consumer concerns by generating specific regulations, as well as providing incentives and infrastructure. Nowadays, public policies "create supply and support demand" (see diagram 4 on page 38)[49]. We have witnessed worldwide the announcements of governmental policies, strategies, and budget com-

48 Benchmark Mineral Intelligence. (2022). "What does the US Inflation Reduction Act mean for the EV battery supply chain?" August 12, 2022, from Benchmark Mineral Intelligence Website: https://www.benchmarkminerals.com/membership/what-does-the-us-inflation-reduction-act-mean-for-the-ev-battery-supply-chain/

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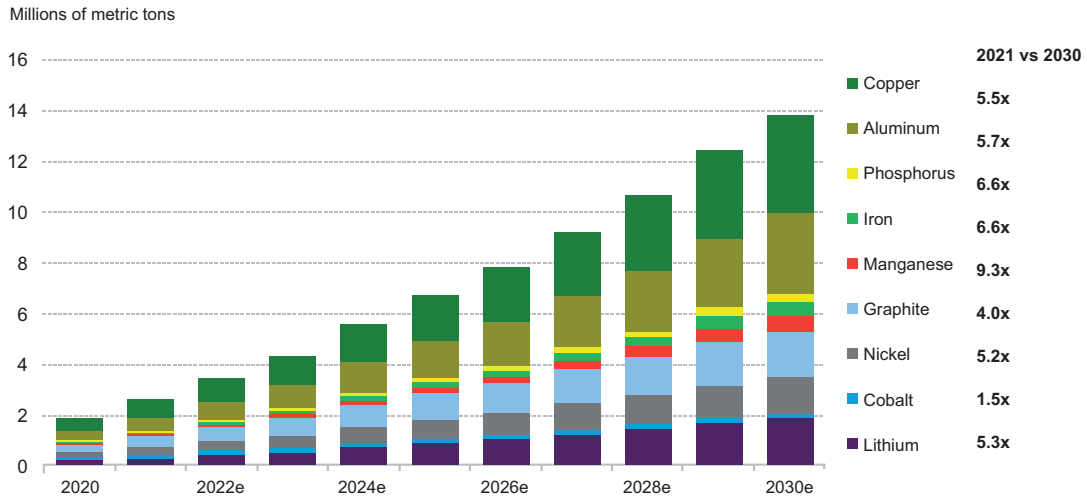
Figure 11. The demand for lithium-ion battery metals will also increase



Source: INA with information from BloombergNEF.

mitments that have characterized the developments of electric vehicles (EVs) in recent years (see Figure 13 on page 39). Government spending on subsidies for electric vehicles doubled in the year 2021, reaching $30 thousand million dollars, through a wide range of policies aimed at promoting their market acceptance. An increasing number of countries have committed to gradually phasing out internal combustion engines or have significant vehicle electrification goals for the coming decades.

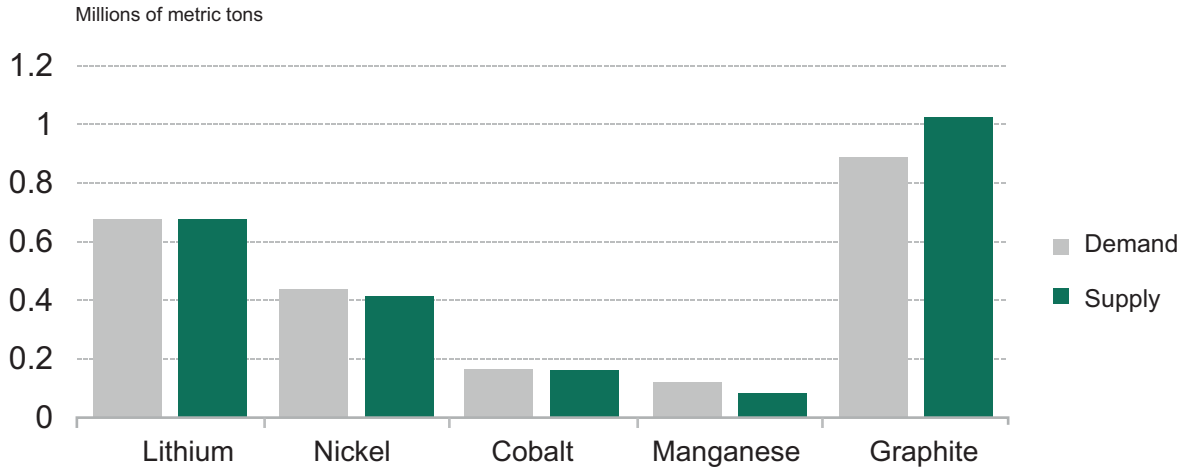
This trend is increasing: in recent months, governments around the world have announced the most ambitious zero-emission vehicle (ZEV) objectives and policies ever recorded (see Figure 13). In addition to pioneering countries in ZEV deployment, others have joined with a commitment to gradually phase out internal combustion engines. Some have set goals for CO2 reduction that would effectively ban internal combustion vehicles, while others have ambitious goals for electric vehicle manufacturing in the coming decades. It has become increasingly clear that governments have incorporated vehicle electrification as a key part of their strategy to reduce emissions, whether in their nationally determined contributions or net-zero goals.

Global public policies are now focusing on creating an environment that supports the growth of demand and establishes the conditions for a ZEV supply. The challenge is significant. Although global EV sales continue to rise, much more needs to be done to have a market with the necessary infrastructure for production, distribution, and charging of heavy-duty vehicles. The Sars-Cov-2 pandemic and the Russia-Ukraine war have disrupted global supply chains, impacting the automotive industry. In the near future, delays in delivering electric vehicles to customers may hinder sales growth in some markets.[50]

Despite this challenging environment, it seems that long-term governmental and corporate efforts to electrify transportation are establishing a solid foundation for further growth in electric vehicle (EV) sales. The strategic direction and incentives provided by national

50 International Energy Agency. (2022). Global EV Outlook 2022: Accelerating ambitions despite the pandemic. July 15, 2022, from IEA Website: https://iea.blob.core.windows.net/assets/ed5f4484-f556-4110-8c5c-4ede8bcba637/GlobalEVOutlook2021.pdf

Figure 12: Supply and Demand Balance of Metals for Batteries in 2022.



Note: The supply of lithium and cobalt is mining capacity, nickel and manganese are in sulfate form, and graphite is anode capacity. Lithium is measured in lithium carbonate equivalent.

Source: INA with information from BloombergNEF.

and state governments can send crucial signals to shift investment and secure EV supply chains, as well as drive original equipment manufacturers to develop a wide range of affordable ZEV car and truck models as manufacturing companies aim to meet stricter regulatory requirements. It is important to note that while the main consumer markets globally maintain this trend, there are uneven efforts in regions such as Latin America.

Some markets, such as China, Korea, and the United Kingdom, are consistently reducing direct vehicle subsidies, acknowledging the narrowing price gap between electric and conventional vehicles, and as a strategy to encourage automobile manufacturers to reduce costs. Others, like the EU, are implementing regulatory measures such as stricter CO2 emission standards. The European Union, India, and Japan are increasing subsidies for electric vehicles, in some cases as part of post-Sars-Cov-2 recovery packages.

United States of America

The case of the United States stands out in terms of public policy. According to Deloitte, consumers in this country tend to prefer driving gasoline-powered vehicles because their prices are significantly lower than in many other markets worldwide. In this context, the United States government had focused on more flexible emission standards and tax credits, policies that hindered the adoption of electric vehicles. Old perceptions regarding driving range, cost, and charging time are proving difficult to change, despite exponential technological improvements in a very short period of time[51].

As a result of the Sars-Cov-2 pandemic and the economic crisis, public policies appear to be changing. President Joe Biden enacted various initiatives in 2021 that seek a comprehensive approach by his administration to assess vulnerabilities and strengthen the resilience of critical supply chains for the U.S. economy. These strategies acknowledge that years of prioritizing efficiency and low costs over security and sustainability have resulted in significant risks that require a renewed focus. Thus, the supply chain and vulnerabilities are being evaluated in four key products: semiconductor manufacturing and advanced packaging, high-capacity batteries such as those used in electric vehicles, critical minerals and materials, and advanced pharmaceutical products and ingredients (APIs).[52]

51 Robinson, R and Tummalapalli, S. (2018). Plugging into the future. Electrifying the global automotive industry. July 15, 2022, from Deloitte Website: https://www2.deloitte.com/content/dam/insights/us/articles/4931_plugging-in-to-the-future/DI_Plugging-into-the-future.pdf

52 The White House . (2021). Building resilient supply chains. 15 July 2022, from White House Website: https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf

Measures are being defined for management to double the innovation infrastructure, reinvesting in research and development (R&D) and accelerating the capacity to bring innovations from the laboratory to the market, and strengthening the skills of human capital.

The recent approval of the legislative package "Inflation Reduction Act of 2022" in the United States Senate marks a milestone in the country's energy policy. The package aims to help the country achieve its energy transition goals by 2030. It commits $369 thousand millions USD to climate policies, clean energy, and includes significant goals for local extraction and processing of key minerals for batteries.[53]

This initiative represents a comprehensive approach as it includes measures to decrease energy costs for consumers, decarbonize the economy, promote U.S. energy security, and support domestic manufacturing. The bill provides significant momentum for various sectors of the green economy, including electric vehicles, as it incorporates multiple themes such as incentives for vehicle purchases and credits for North American producers. It is also linked to the commitment to content requirements, particularly in relation to batteries.

While this initiative represents a significant boost to address the lag in the development of the electric vehicle market in the United States, it also presents significant challenges in practice for domestic manufacturers in terms of accelerating and reorienting their production chain in the coming years, which will allow them to generate a new industry and capitalize on the incentives that are established.

Inflation Reduction Act: Impacts on the Electric Vehicle Market in the USA

Support for Consumption:

- Commercial electric vehicles weighing less than 14,000 pounds can access a $7,500 USD tax credit for clean vehicles (eliminates the current cap of 200,000 eligible subsidized vehicles). Heavier vehicles may receive the lesser of two amounts: 30% of the difference between the clean vehicle and a comparable internal combustion engine vehicle, or an incentive of $40,000 USD.

- Limits on vehicle cost apply: incentives apply to sedans that cost no more than $55,000 and trucks, vans, or SUVs that cost up to $80,000.

- There are also income restrictions for buyers.

- Dealerships can receive $4,000 dollars for used electric vehicles, with few conditions.

The incentive would be available starting in 2023 and would allow consumers to access the benefit at the point of sale instead of during tax filing season.

The proposed bill would extend the availability of the EV tax credit until 2032.

Content Requirements:

The requirement for subsidies is that the battery materials and a portion of other components are manufactured in the United States or countries with a free trade agreement.

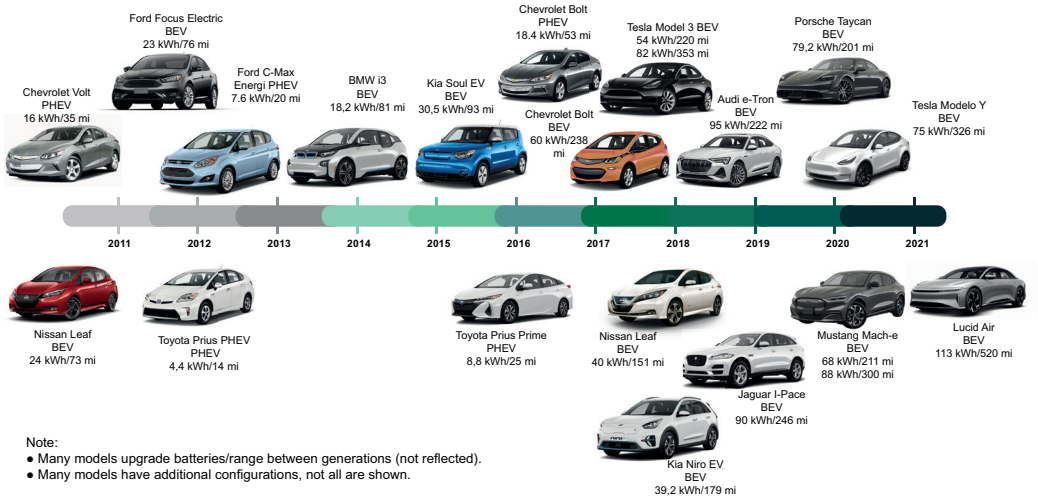
The subsidy is based on the vehicle having at least 40% of its critical battery minerals from North America or countries with a free trade agreement. The requirement increases to 80% in 2026 and 100% in 2028.
Starting in 2025, any vehicle with battery minerals will exclude components from a foreign entity of interest from the tax credit.

Credit and Tax Support Programs for Manufacturers and Supply Chain:

The package also includes $2 thousand million dollars to assist automakers in restructuring and converting existing facilities to produce clean vehicles, and allows for up to $20 thousand million in loans to help automotive companies build new clean vehicle facilities across the country.

53 The White House. (2022). Bill Signed: H.R. 5376. August 17, 2022, from The White House Website: https://www.whitehouse.gov/briefing-room/legislation/2022/08/16/bill-signed-h-r-5376/

Diagram 3. Trends in Battery Ranges and Sizes.



Source: INA with information from the University of California.

The project also includes a 10% tax credit for advanced manufacturing throughout the lithium-ion supply chain, which would help alleviate cost burdens for battery and automobile manufacturers.

The package also includes an investment tax credit for energy storage and production for battery cell manufacturing at a cost of $35 per kilowatt-hour.

Domestic market:

The bill also includes $3 thousand million dollars to help the country's Postal Service decarbonize its fleet and transition to electric vehicles.

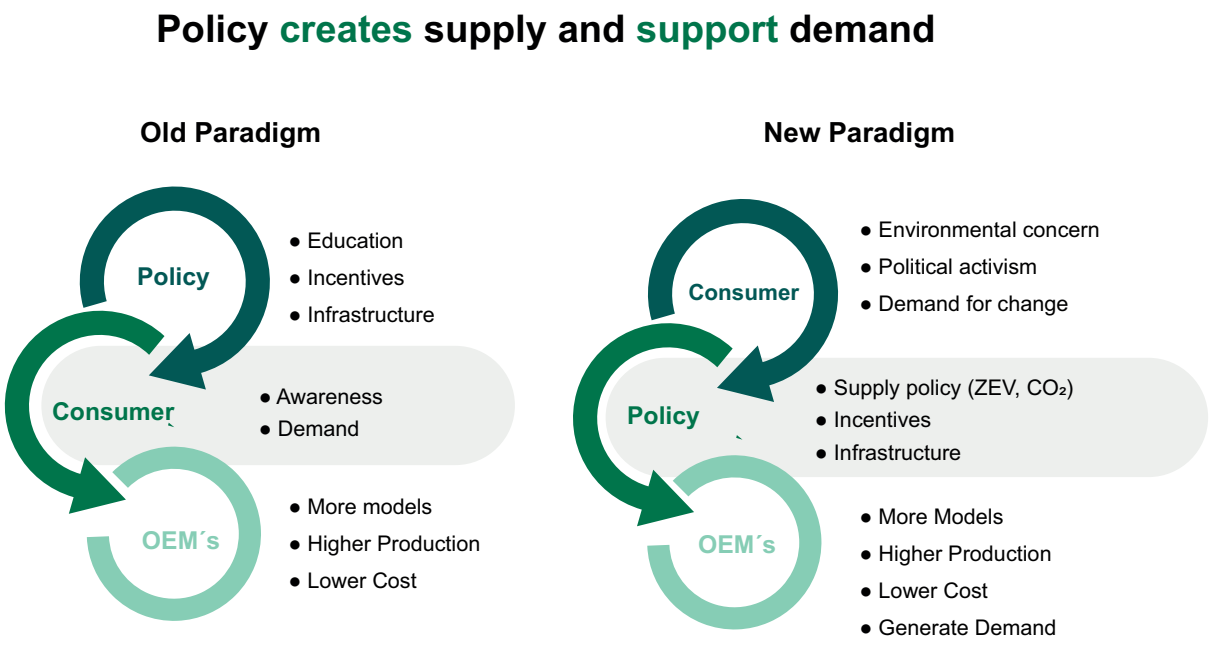
China

China has been at the forefront of promoting the use of electric vehicles for various reasons: to combat pollution, reduce dependence on imported oil, or simply to achieve leadership in the upcoming era of global mobility. To meet its goal of becoming the undisputed champion of electric vehicles by 2025, China is implementing a dual approach by offering subsidies to buyers of these vehicles and requiring automakers to accumulate credits from the sale of electric vehicles that later can be transferred or traded.

Particularly, China had extended subsidies for electric vehicles for two years following the pandemic, with a 20% reduction plan in 2021 and a 30% reduction plan in 2022. There are also a number of subnational regulations that provide preferential treatment to electric vehicles, such as local subsidies or tax exemptions, financial incentives, and exemptions from purchase limitations. The growth in 2021, despite the decrease in subsidies, indicates the maturity of this market in China. It can be expected that the market will further expand in 2023 and beyond, as investments from previous years increase production capacity.[54]

54 Robinson, R., and Tummalapalli, S. (2018). "Plugging into the future: Electrifying the global automotive industry." Retrieved July 15, 2022, from the Deloitte website: https://www2.deloitte.com/content/dam/insights/us/articles/4931_plugging-in-to-the-future/DI_Plugging-into-the-future.pdf

Diagram 4. Public Policies for Electric Vehicles



Source: INA with information from the University of California.

India

India is another country that heavily relies on imported petroleum. In an attempt to manage its massive oil import bill while simultaneously addressing a growing pollution issue, the government is encouraging the adoption of electric vehicles. Its goal is for electric vehicle sales to account for 30% of all new vehicle sales by 2030.[55]

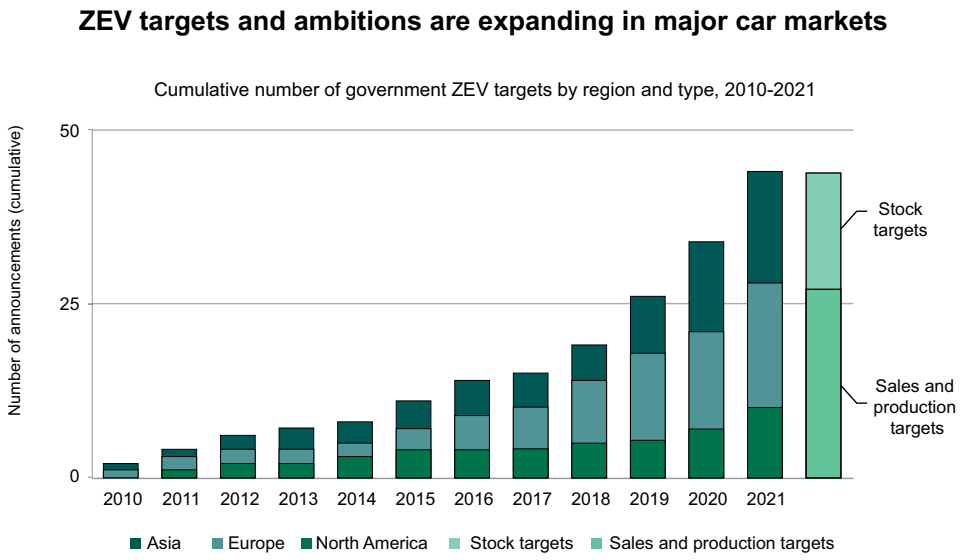
Europe

The adoption of electric vehicles (EVs) is gaining momentum in Europe, leading to a decrease in the proportion of diesel-powered vehicles and showing a significant decline in recent years. This decline was triggered by consumer backlash following the Volkswagen scandal and the subsequent decision by the German Federal Court to allow individual cities to ban diesel vehicles. Additional taxes on diesel vehicles in countries like the United Kingdom have also contributed to consumers considering alternative engine technologies. Furthermore, several countries, including Norway, the United Kingdom, France, and the Netherlands, have already announced plans to ban the sale of conventional gasoline and diesel-powered vehicles within the next 2 to 3 decades. This bodes well for the future of electric vehicles.

In fact, Norway is at the forefront of the movement to adopt a greener vehicle strategy, as evidenced by the increasing sales of battery electric vehicles (BEVs) and electric hybrid vehicles (HEVs). Together, they accounted for 52% of all new car sales in 2017, compared to 40% in 2016. The overall shift towards EV technology that has taken hold in the market can be attributed to the

55 Robinson, R., and Tummalapalli, S. (2018). "Plugging into the future: Electrifying the global automotive industry." Retrieved July 15, 2022, from the Deloitte website: https://www2.deloitte.com/content/dam/insights/us/articles/4931_plugging-in-to-the-future/DI_Plugging-into-the-future.pdf

Figure 13. Carbon Neutrality Goals



Source: INA with information from the International Energy Agency.

generous government subsidies in Norway, including tax exemptions, subsidized parking, and the availability of charging stations.[56]

Japan

Japan has approved the Strategic Energy Plan to support its 2050 "net zero energy" goal. One of the key updates sets targets for 2030 to decarbonize its energy generation mix, which is relevant to achieving Japan's goal of electrifying its vehicle fleet by 2035.

Latin America

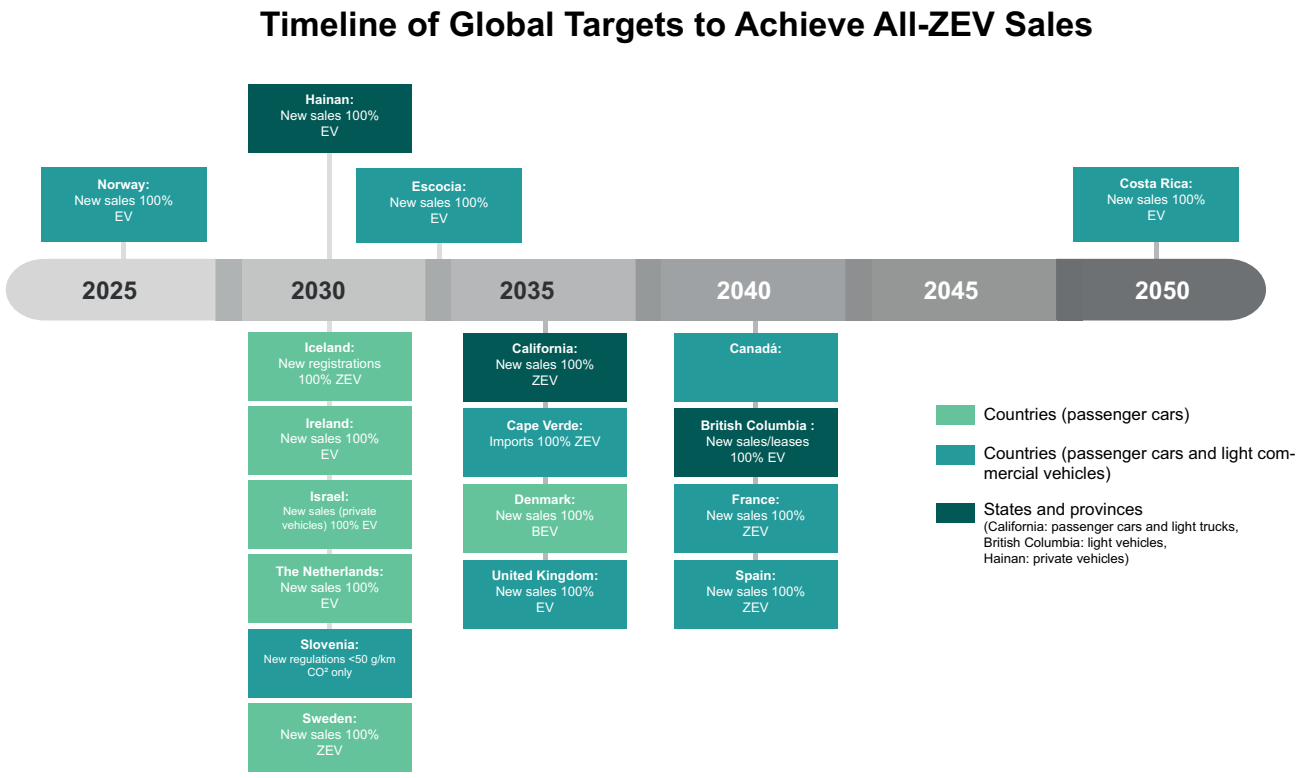
In Latin America, Chile is a leader in policies regarding Zero Emission Vehicles (ZEVs) and electric vehicles. Its capital city, Santiago, boasts one of the world's largest fleets of electric urban buses. Chile recently announced its "National Electromobility Strategy," which sets goals to achieve 100% ZEVs by 2030 and 100% ZEVs in public transportation by 2035.
Costa Rica offers fiscal benefits and support through an acquisition program to back its 100% ZEV objectives for commercial vehicles and a 100% ZEV target for all buses and taxis by 2050.

Several cities in Colombia have support programs for the acquisition of electric buses, aiming for 10% of urban bus sales to be ZEVs by 2025 and 100% by 2035.

In Mexico, there is currently no national policy specifically focused on ZEVs. Beyond this, various analysts argue that, "driven by President Andrés Manuel López Obrador's historic objective of wresting control of the energy sector from private companies in favor of state dominance in the market, the government is undermining efforts to expand renewable energy and betting the country's future on fossil fuels.[57] In July 2022, based on the provisions of Chapter 31 of the United States-Mexico-Canada Agreement (USMCA), the United States and Canada requested consultations with Mexico to address issues facing their companies regarding Mexico's energy reform, as well as changes in policies and practices related to permits for the importation, transportation, and commercialization of gas, fuel, and electricity supply.

56 Ibid.
57 López, O. (2022). México bets its energy future on oil, not renewable energy. August 18, 2022, from The New York Times website: https://www.nytimes.com/es/2022/08/17/espanol/mexico-petroleo-amlo-pemex.html

Diagram 5. Carbon Neutrality Goals 2025-2050



Note: The objectives reflect those that are accompanied by an official policy document, such as action plans on climate change and executive orders. Discussions of objectives that have not yet been accompanied by policy documents or legislation (e.g., Egypt, Germany, Portugal, New Jersey, New York, Sri Lanka, Taiwan) are not included. If a country has set multiple objectives, the most comprehensive one is included (e.g., the objectives of the United Kingdom and Denmark include a separate timeline for diesel and gasoline vehicles [2030] and hybrid vehicles [2035]).

Source: INA with information from the International Energy Agency.

Key Challenges and Trends in Electromobility:

Changes in consumer perceptions, public policies, and automotive industry innovations are indicating a substantial shift in the market. According to the World Economic Forum, we are witnessing a transformation in how societies manage their transportation systems. "Mobility will change rapidly in the coming years as electric vehicles (EVs) proliferate, shared mobility continues to grow, and autonomous vehicles (AVs) enter urban fleets." This transformation will be most evident in cities that concentrate new mobility forms and invest in supportive infrastructure to adapt to this growth. These changes align with the evolution towards cleaner, decentralized, and digitized systems, as well as the increasing electrification trend.[58]

The 2021 KPMG Global Automotive Executive Survey revealed for the first time that by 2030, the majority of vehicles will no longer be solely powered by internal combustion engines (ICE). This aligns with this year's Deloitte consumer study, which shows a combination of vehicle types varying by region.[59]

These changes can be viewed from a comprehensive technological perspective. A study by the European Union demonstrates that not only is the manufacturing process in the automotive industry affected by emerging technologies, but the vehicle itself is shaped by digital innovation. There are four well-known trends known as CASE: Connected, Autonomous, Shared, and Electric.[60]

58 World Economic Forum. (2018). Electric Vehicles for Smarter Cities: The Future of Energy and Mobility. August 15, 2022, from WEF website: https://www3.weforum.org/docs/WEF_2018_%20Electric_For_Smarter_Cities.pdf

59 2022 Global Automotive Consumer Study Key findings: Global focus countries

60 Advanced Technologies for Industry – AT WATCH

The challenge is significant. Although global sales of electric vehicles (EVs) continue to rise, much more needs to be done to establish a market with the infrastructure for the production, distribution, and charging of heavy-duty vehicles.

The following examples illustrate the impact of these trends on the automotive market:[61]

Around one-fourth of all passenger vehicles in use worldwide will be connected by 2023. This indicates that the automotive product is changing with the increasing importance of electronics and software. It is estimated that by 2030, vehicle software will account for 30% of its value, while electronic and electrical components will make up 25% of the vehicle's value.

Digitalization provides opportunities for shared mobility initiatives, and companies have already found ways to monetize this. McKinsey predicts that by 2030, 10% of cars sold could be shared vehicles.

There has been an increase in IoT (Internet of Things) endpoints in the automotive industry, aiming to enable the concept of "vehicle-to-everything" (V2X), which refers to the ability to wirelessly connect to multiple sources of information.

Connectivity, among all these sources, requires the transmission of large amounts of data. 5G technology is key to transmitting large amounts of data with greater reliability, lower latency, and faster speeds than other solutions, and it is believed to be the future of communication in the automotive sector.

Artificial intelligence (AI), defined by the European Commission as a set of technologies that combine data, algorithms, and computing power, plays an important role in the industry. AI technologies, such as machine learning, enable machines to perform more complex tasks, and automotive companies are harnessing this to enhance the driver's experience. The number of AI systems used in information, entertainment, advanced drivers, and assistance systems (ADAS) is projected to increase from 7 million in 2015 to 122 million by 2025, according to a report by IHS Technology.

The transformation of the industry is becoming increasingly evident. The "Global Automotive Executive Survey 2021", conducted by KPMG worldwide based on responses from executives in the automotive industry and adjacent sectors, highlights the following points:[62]

- The technology and automotive sectors are converging and giving rise to new alliances.
- Intense competition and cooperation between established and new players.
- New manufacturers are outsourcing the production of their vehicles to third parties.
- Executives predict that technology companies such as Google, Apple, Amazon, or Huawei will enter the market.
- A trend of reuse and recycling in the advanced battery market, driven by regulations and market saturation.
- Advanced manufacturing, based on AI, machine learning, and IoT, will provide a competitive advantage in production and quality.

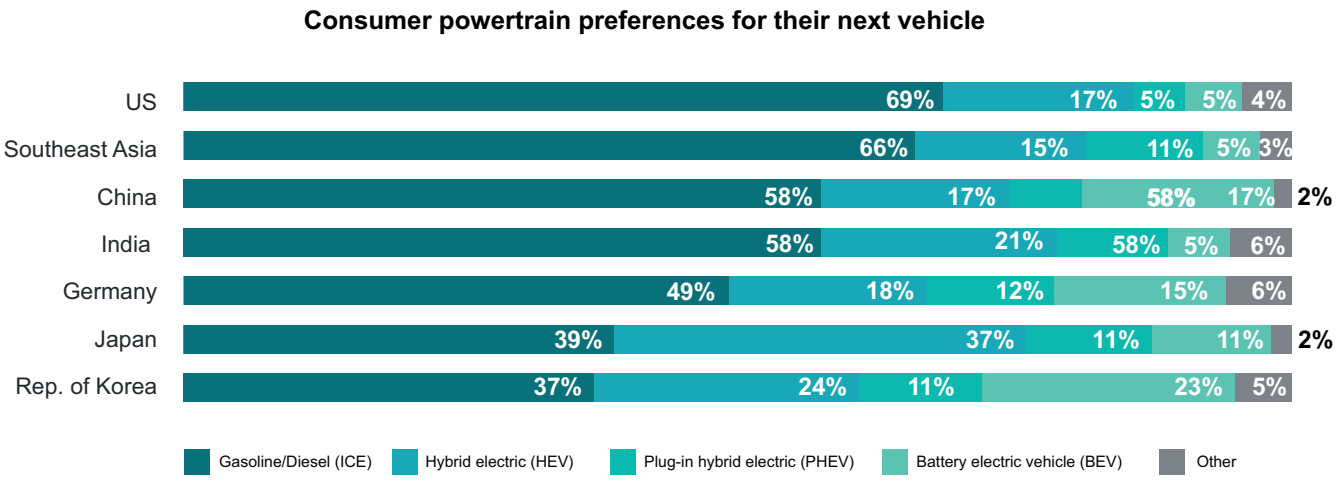
These trends highlight the importance of analyzing innovations in the automotive industry from an integral perspective that considers related technological applications. Diagram 6 (see page 45) presents a prospective view of the path of disruptive innovation represented by electric vehicles. While we can already see their impact on various manufacturers and the supply chain, their full effects and developments are yet to be seen in the coming years, considering the synergies with other advancements.

61 Advanced Technologies for Industry – AT WATCH. UE https://ati.ec.europa.eu/reports/technology-watch/technology-focus-sustainability-automotive-industry-europe

62 KPMG Global Automotive Executive Survey 2021 (GAES 2021)

It can be expected that the market will expand even further in 2023 and beyond, as investments from previous years increase production capacity.

Figure 14. Consumer preferences for their next vehicle.



Note: "Others" includes engine types such as compressed natural gas, ethanol, and hydrogen fuel cells.
Sample size: China=881, Germany=1150, India=895, Japan=608, South Korea=843, Southeast Asia=5070, United States=918.

Source: INA with information from KPMG.

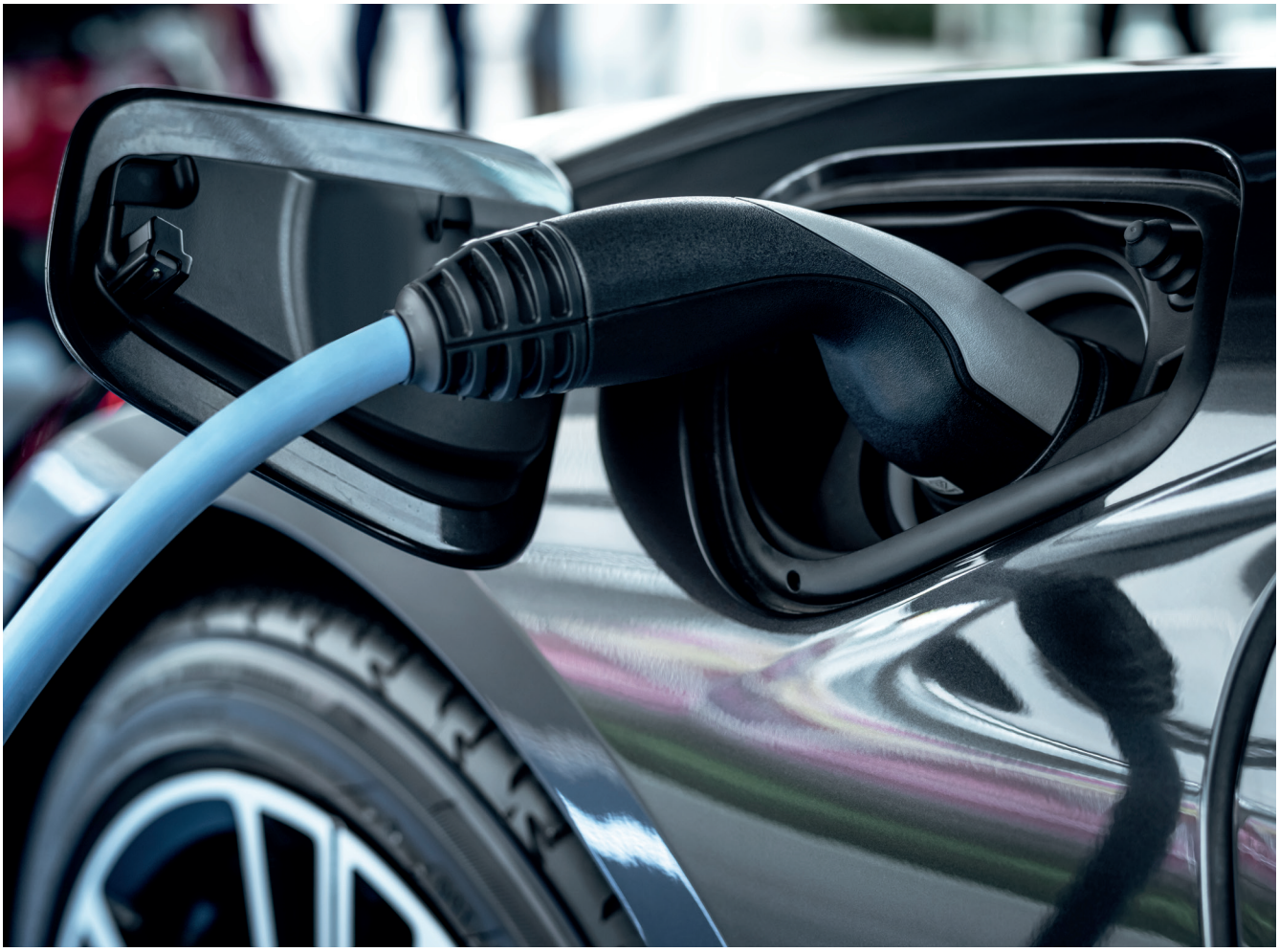
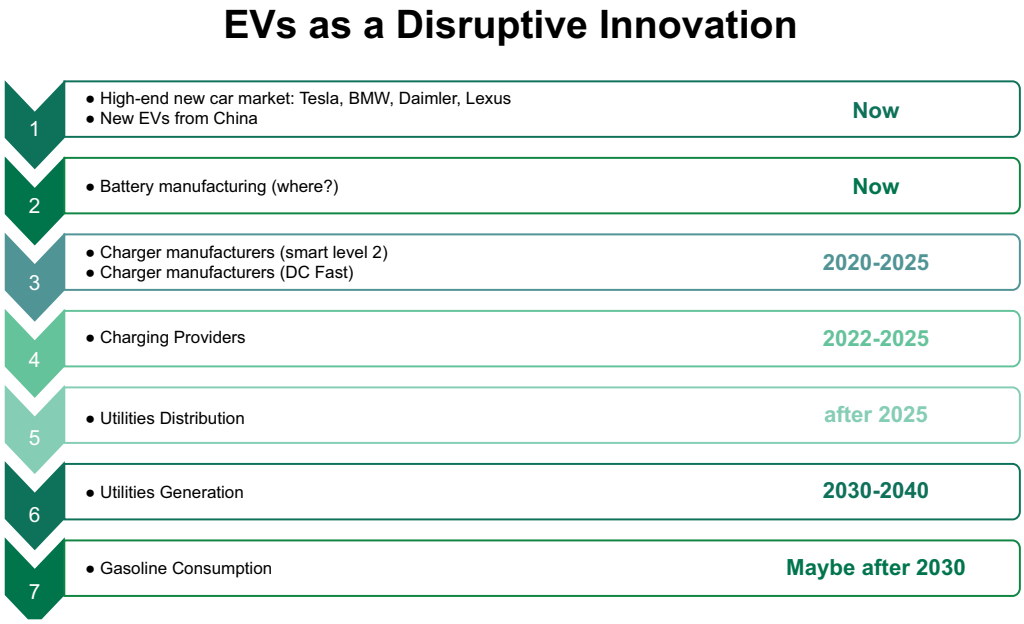
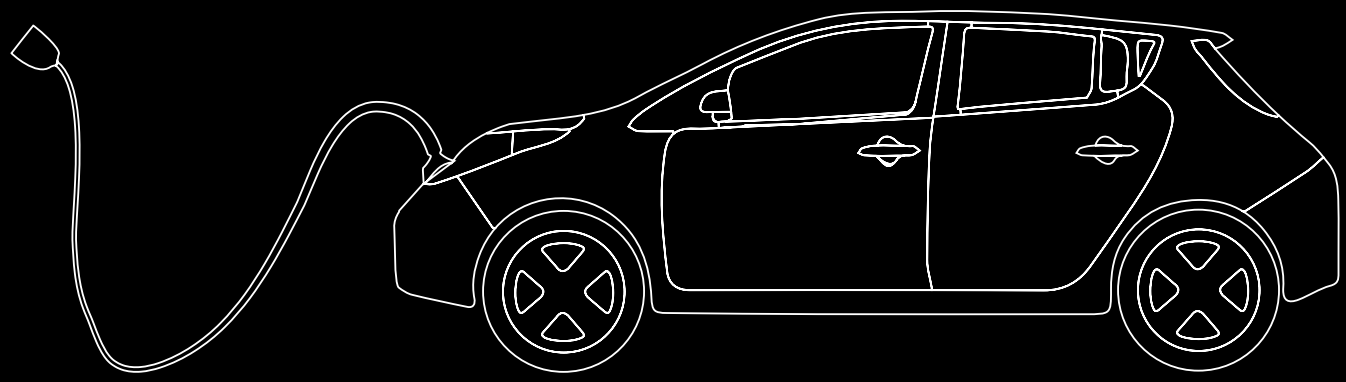


Diagram 6. Innovation in EVs.



Source: INA with information from the University of California.



Chapter 3.

Status of Electromobility in Mexico.

Automotive Manufacturing Industry

According to INEGI[63], the automotive industry comprises the following branches of activity: manufacturing of automobiles and trucks, manufacturing of bodies and trailers, manufacturing of parts for motor vehicles, and manufacturing of other transport equipment. This classification *is based on the North American Industry Classification System (NAICS)*.

Over the past 25 years, this industry has been one of the most active components of Mexico's manufacturing industry. From an economic standpoint, the automotive sector contributed 3.5% to the Gross Domestic Product in 2021. It generated approximately 930,000 direct jobs and attracted over $5.3 thousand million dollars in foreign direct investment associated with new production projects[64]. In that year, Mexico ranked 7th as a producer of light vehicles in the world, 1st in Latin America, and 4th as a producer of auto parts.

In recent decades, the federal government in Mexico has developed instruments to promote and support the automotive industry, among which the Decree to support the competitiveness of the terminal automotive industry and the promotion of the domestic automobile market (Automotive Decree) stands out. Additionally, through the Registry for automotive companies manufacturing light vehicles[65], companies in the sector benefit from tariff reductions that allow the importation of light vehicles from third countries without trade agreements, enabling them to complement their domestic offerings competitively, among other benefits.

However, these definitions related to the production of light and heavy vehicles and their components, the automotive sector's value chain is broader and includes vehicle dealerships as well as component and spare parts companies. In this way, we can see the overall impact of this industry on the Mexican economy.

Starting in 2019, the automotive industry, both in the light and heavy vehicle segments, experienced a break in the trend of growth in production and exports, which had been steadily increasing for almost 8 years (see figures 1 and 3). The causes that can be identified for this behavior were the public health issue caused by the SARS-CoV-2 pandemic in late 2019 and the subsequent demand and supply shock in the early months of 2020. Additionally, over the past 24 months, significant disruptions have been observed in the supply chain of critical components in the production of both heavy and light vehicles, such as semiconductor shortages and scarcity of certain raw materials like neon gas, palladium, and carbon black. Volatility in the price of components like steel and aluminum has also affected vehicle supply. On the other hand, the persistence of global and Mexican inflation levels has posed a challenge on the demand side, resulting in the industry's performance still being below pre-2019 levels. The relationship between units produced and exported for light vehicles has varied between 80% and 89% during the period from 2012 to 2022, with the United States being the main export market.

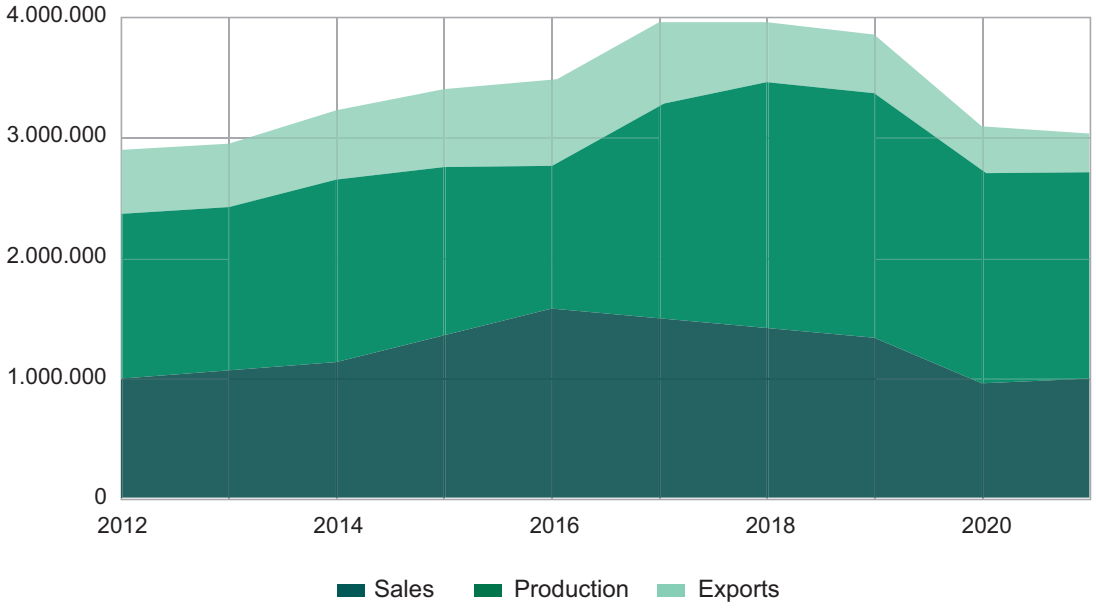
In 2021, 2,071,668 units were exported to that market, representing 77% of total exports. The total exports

63 INEGI and AMIA. (2016). Statistics about the Automotive Industry. August 15, 2022, from INEGI website: https://www.inegi.org.mx/contenidos/productos/prod_serv/contenidos/espanol/bvinegi/productos/nueva_estruc/702825079963.pdf

64 Mexican Association of the Automotive Industry. (2022). Industry data. August 15, 2022, from AMIA website: https://www.amia.com.mx/

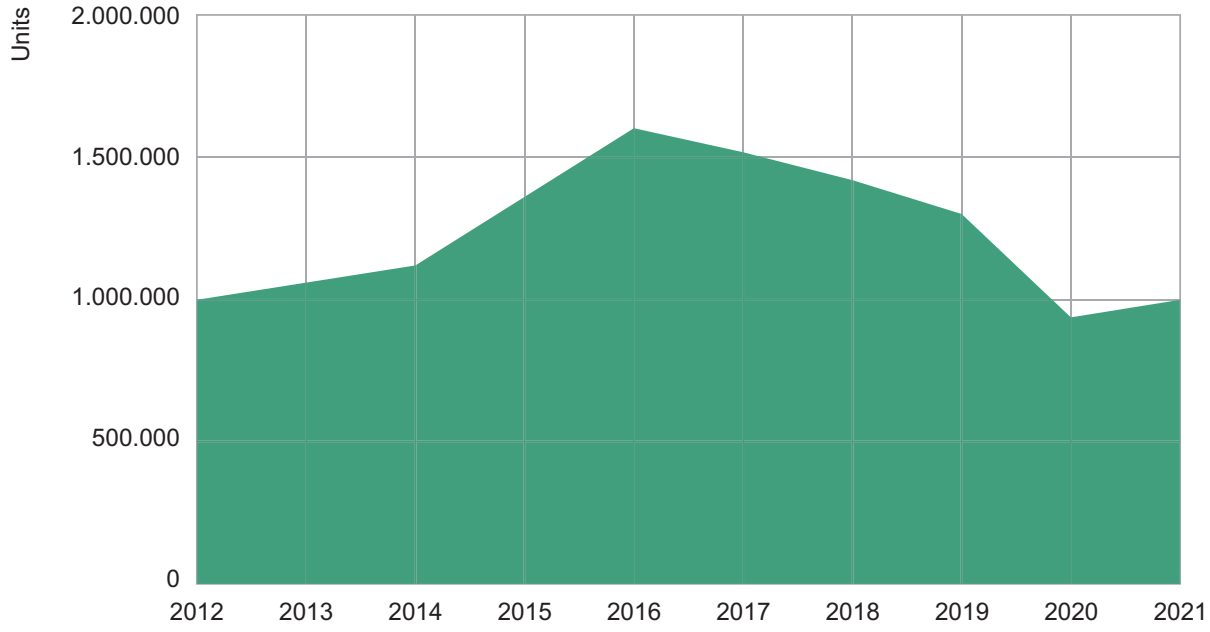
65 Automotive manufacturers must comply with strict requirements for investment amounts in production plants or supply chain development in Mexico, as well as compliance with all safety and commercial requirements.

Figure 1. Sales, production, and exports of light vehicles in Mexico.



Source: INA with information from INEGI.

Figure 2. Sales of light vehicles in Mexico.



Source: INA with information from INEGI.

Table 1. Sales of Electric and Hybrid Vehicles in Mexico.

Year	Electric Vehicles (EV)	Plugin-in Hybrids (PHEV)	Hybrids (HEV)
2021	1140	3492	42447
2020	449	1986	21970
2019	305	1365	23938
2018	201	1584	16022
2017	237	968	9349
2016	254	521	7490

Source: INA with information from INEGI.

amounted to 2,706,980 units with an approximate value of $40 thousand million dollars.[66]

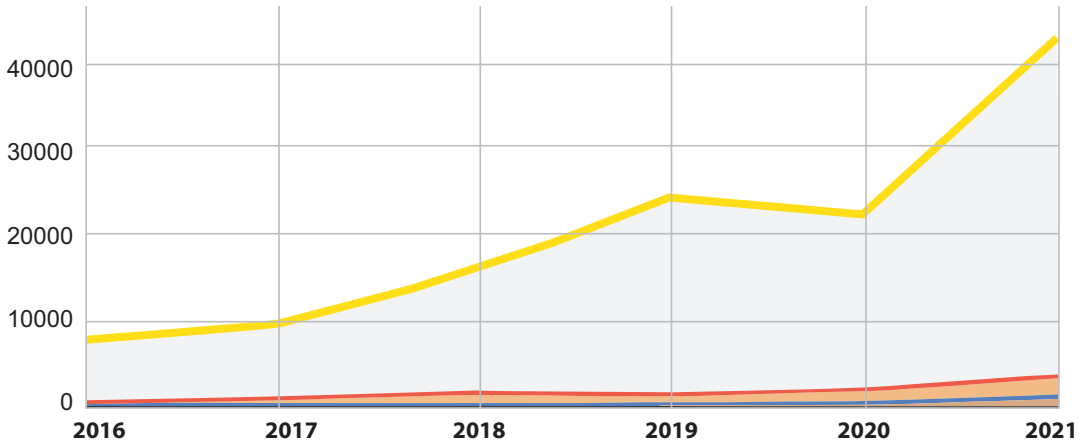
According to INEGI[67] data, in 2020, total sales of light vehicles in the country reached 950,063 units, which was the period with the greatest economic impact during the pandemic. In 2021, there was a slight increase with the sale of 1,014,735 vehicles; however, this figure remained far below the sales recorded in 2019, when 1,317,931 cars were sold. Certainly, 2022 has been a year with similar challenges to 2021, as observed in the sales figures up to July, which are very similar: 601,561 and 602,681 in terms of units.

On the other hand, the sale of electric vehicles, while it has grown in the last 3 years and particularly between 2020 and 2021, doubled the number of vehicles sold. However, the total numbers of electric and plug-in hybrid categories reached a total of 4,623 units[68], representing just 11% when compared to the number of hybrid vehicles sold in the same year. According to some experts, the sale of electric vehicles is expected to grow in the next 5 years.[69]

In the heavy-duty vehicle segment, the behavior of the main variables is similar to that of light vehicles. The decline in 2020 and the growth in 2021 are similar, but the numbers have not yet reached pre-pandemic levels.

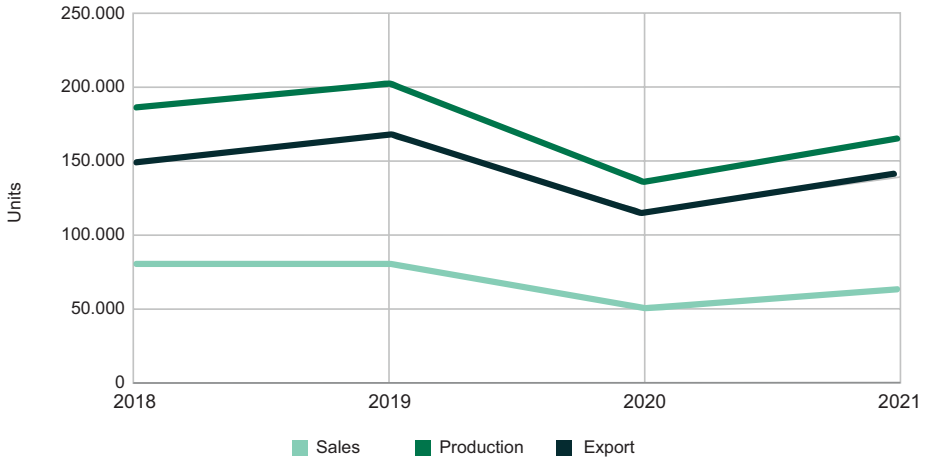
66 INA (2022). Perspectives of the automotive industry in Mexico. August 30, 2022, from INA Website: https://ina.com.mx/?p=11070
67 INEGI. (2022). Administrative registry of the automotive industry for light vehicles. August 20, 2022, from INEGI Website: https://www.inegi.org.mx/datosprimarios/iavl/#Informacion_general
68 INEGI. (2022). Administrative registry of the automotive industry for light vehicles. August 20, 2022, from INEGI Website: https://www.inegi.org.mx/datosprimarios/iavl/#Informacion_general
69 Deloitte. (2022). Green cars: Can the production of their components accelerate in Mexico?. August 15, 2022, from Deloitte Website: https://www2.deloitte.com/mx/es/pages/dnoticias/articles/produccion-de-autos-verdes-en-mexico.html

Figure 3. Sales of electric vehicles, plug-in hybrids, and hybrids in Mexico.



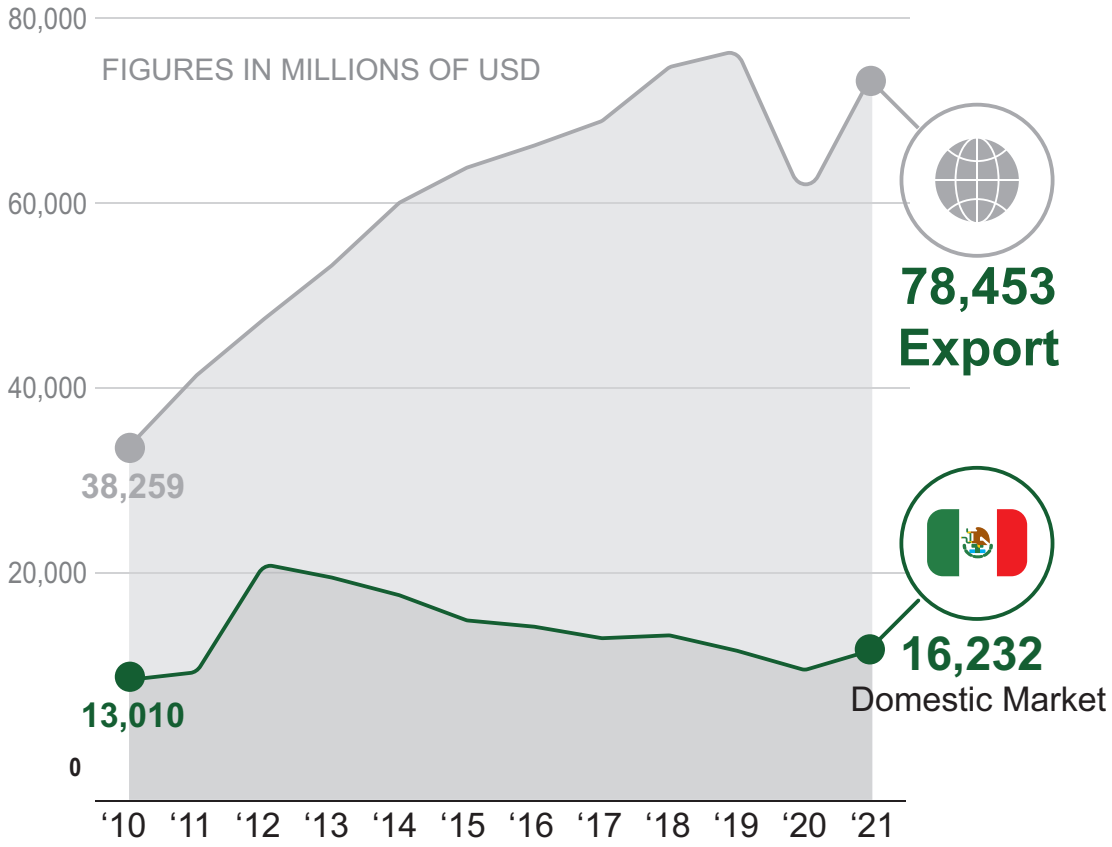
Source: INA with information from INEGI.

Figure 4. Sales, production, and exports of heavy-Duty vehicles in Mexico.



Source: INA with information from ANPACT and INEGI.

Production of Auto Parts



Source: INA with information from INEGI.

Auto Parts Industry

The auto parts industry in Mexico is composed of around 2,000 companies and produced a total of 94,685 million dollars in 2021. It ranked first as a supplier of automotive parts to the United States.

The value of exports represented 83% of the total production, with our northern neighbor being the main destination.

Mexico is part of a sophisticated supply chain in the North American region, being a significant contributor of auto parts and with processes that represent high value in the content of vehicles. This is also explained by the origin of foreign investment in the sector, which mainly comes from the United States.

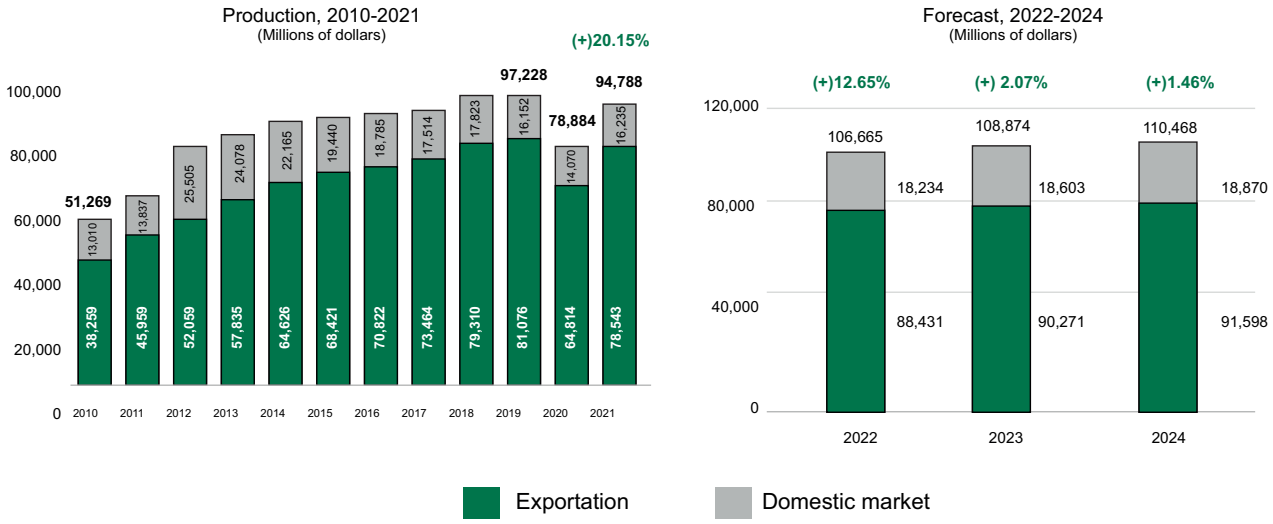
Map of the Electric Vehicle Industry in Mexico and its Key Players

Mexico is a key player in the global automotive industry, with a well-established manufacturing and components sector. Currently, a large percentage of vehicles produced in Mexico, both for the domestic and export markets, are still powered by internal combustion engines (ICE). However, it is estimated that within the next 10 years, at least 50% of the total vehicles consumed worldwide will be hybrids and electric vehicles (EVs)[70].

Despite North America's lag in the global electric vehicle market, it is expected that the manufacturing of electric vehicles will have an upward trend, surpassing 2 million units in 2024 in the United States, Mexico, and

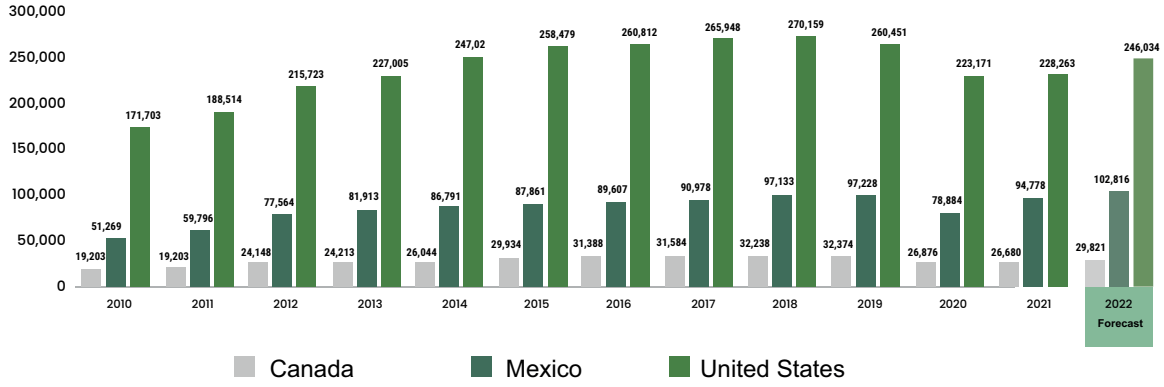
70 Deloitte. (2022). "Autos 'verdes' ¿Podrá 'acelerar' la producción de sus componentes en México?" [Green cars: Can the production of their

The production of auto parts in Mexico



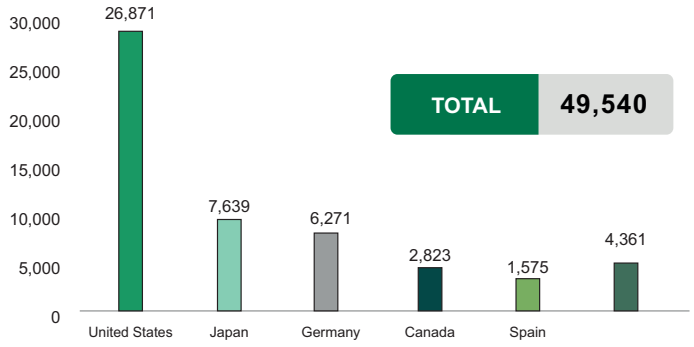
Source: INA with information from INEGI, including auto parts that are classified under other SCIAN codes (2019-2020).
*2022 forecast based on data from IHS Markit.

North American Auto Parts Production, 2010 - 2022
(Millions of dollars)



Source: INA with information from INEGI, StatCan, Census Bureau.

Origin of Foreign Direct Investment (FDI) in the Mexican Auto Parts Sector
(Millions of Dollars) Accumulated 1999 - Sep 2022



Source: INA with information from the Ministry of Economy 2022 - Investment withdrawals are not considered.

Canada. By 2029, the figure is projected to reach 5 million electric vehicles. INA predicts that between 2035 and 2040, 50% of the vehicles manufactured in the region will be zero-emission vehicles. This significant technological shift will be witnessed not only in Mexico but worldwide. Currently, approximately 17 million internal combustion engine vehicles are manufactured in North America. After 2035, it is possible that 50% of those vehicles will be zero-emission vehicles, although not necessarily electric[71]. Driven by consumer demand, government commitments and incentives, and technological advancements, the production forecast for electric vehicles in North America shows a positive trend in the coming years.

Currently, there are 32 plants in the United States producing electric vehicles of some kind, while Canada has three plants. Undoubtedly, the U.S. market is strategic, and some brands have been trying for decades to position themselves in a territory where foreign brands face significant challenges in penetration.

Let's take the case of the Hyundai Group, which includes the brands Genesis, KIA, and Hyundai itself, all interested in dominating the electric sector. Hyundai recently presented its agenda for the near future and aims to capture a 7% market share of global electric vehicles before the end of the decade. This represents a sales volume of nearly two million vehicles by 2030. To meet the market demands, Hyundai plans to open a factory in the United States, which would be their first plant dedicated to electric vehicles in the American territory. The original plan was to start production by 2025, but the construction of the plant is expected to begin earlier, with a planned investment of $5,500 million dollars.[72]

There is strong competition for the top positions in electric vehicle manufacturing and the competitiveness of each brand. The commercial viability of electric vehicles is growing steadily and combines companies that produce only electric cars as well as manufacturers with a long history.

Due to the competitiveness and presence of the global automotive industry, there are currently 11 companies

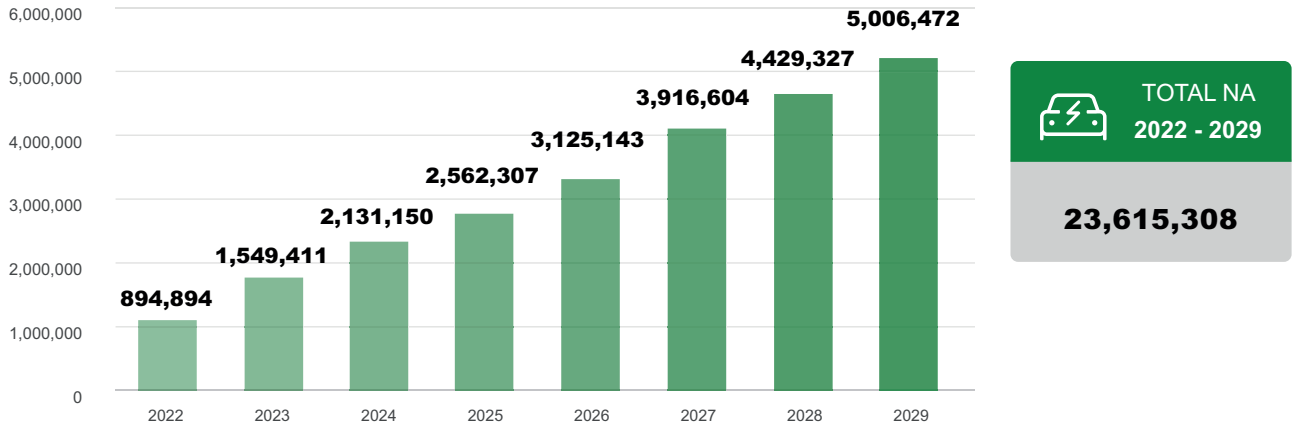
components accelerate in Mexico?]. August 15, 2022, from Deloitte website: https://www2.deloitte.com/mx/es/pages/dnoticias/articles/produccion-de-autos-verdes-en-mexico.html

71 Mexico Industry. (2022). Production of electric vehicles to grow by 242.3% in North America between 2022 and 2023: INA. August 15, 2022, from Mexico Industry website: https://mexicoindustry.com/noticia/produccion-de-autos-electricos-crecera-2423-en-norteamerica-entre-2022-y-2023-ina

72 Hybrids and Electrics. (2022). Hyundai seeks to accelerate the production of electric cars in the United States. August 28, 2022, from HyE Híbridos y Eléctricos website: https://www.hibridosyelectricos.com/articulo/actualidad/hyundai-produccion-coches-electricos-estados-unidos/20220823082907061630.html

Mexico is a key player in the global automotive industry, with a well-established manufacturing and component sector.

Forecast of electric vehicle production in North America (Units)



Source: INA with information from IHS Markit.

in Mexico[73] engaged in electric vehicle production or in the process of initiating operations.

Mexican company Questum (a subsidiary of Quimmco Group) announced its plans to open a new electric vehicle microfactory in 2024 with the help of its German ally E-Go, an experienced car manufacturer based in Germany, with whom they are conducting tests and prototypes for the creation of a delivery vehicle.[74]

With its models, the company aims to enter the professional fleet market, and its first model is called the e.Go Life, an urban car specialized in transporting people for work supervision in cities.[75]

Ford has set the goal of becoming the leading American brand in electric vehicle production by 2026, and Mexico will play a key role in achieving this. Starting in 2023, Ford will triple its production of electric vehicles at its plant in Cuautitlán, State of Mexico, increasing the output from 70,000 to 210,000 electric vehicles.[76]

Chevrolet, a brand owned by General Motors, has unveiled its Blazer EV model to expand its offerings in the mid-size electric crossover category. They have also announced that two more models, Silverado EV and Equinox EV, will be available next year as part of their ambitious plan to become carbon neutral by 2040. This plan includes the development of at least 30 electric and autonomous vehicles by 2025, with an investment of $35 thousand million dollars.

73 It should be noted that some of the manufacturing companies listed as new players in electric vehicle production do not have the registration as assembly plants under the Automotive Decree mentioned earlier.

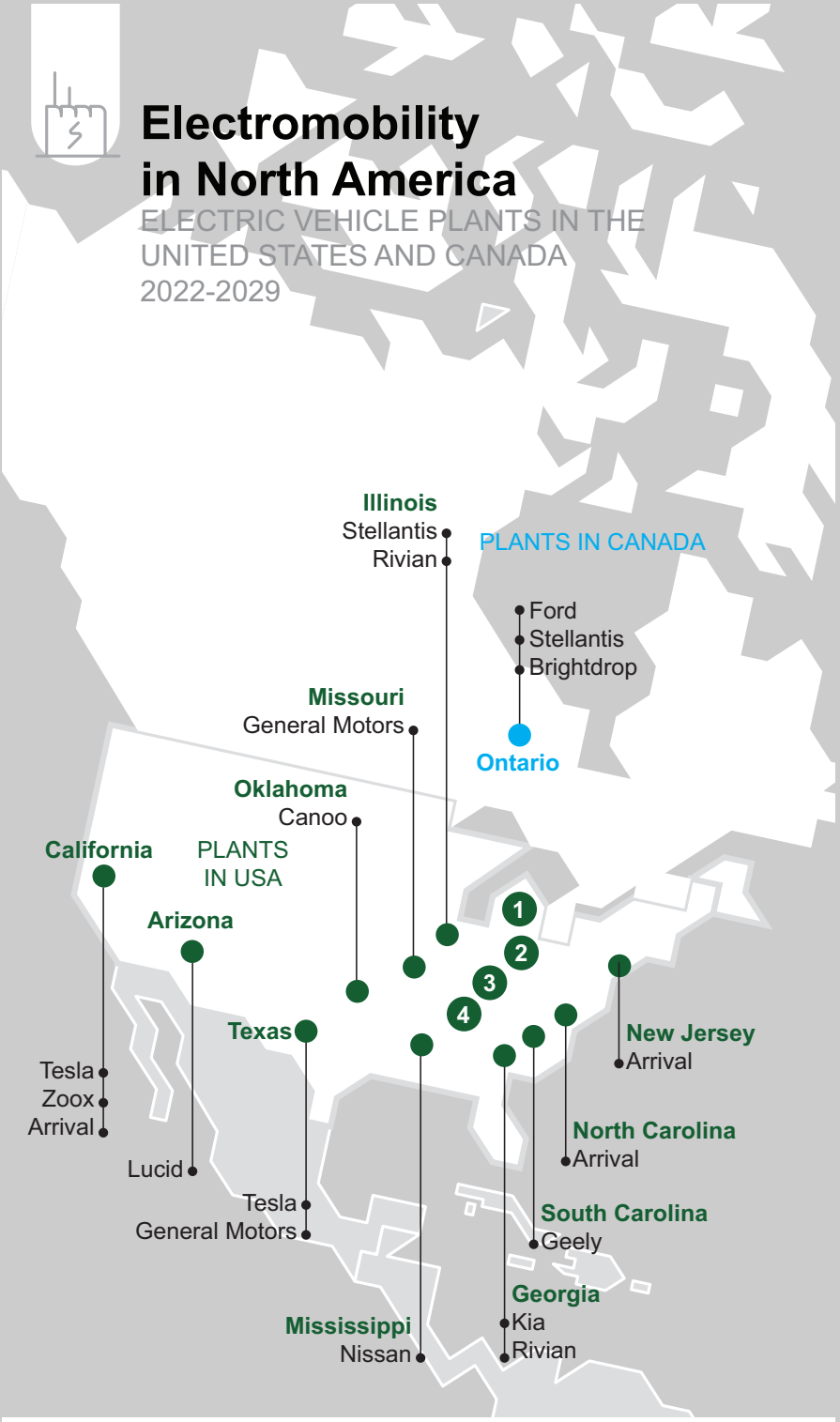
74 Arena Pública. (2022). "Producción de vehículos eléctricos en México, limitada por ausencia de incentivos" [Production of electric vehicles in Mexico limited by lack of incentives]. August 15, 2022, from Arena Pública website: https://www.arenapublica.com/politicas-publicas/produccion-de-vehiculos-electricos-en-mexico-limitada-por-ausencia-de-incentivos

75 Somos Industria. (2022). "Fabricarán vehículos eléctricos en México" [Electric vehicles to be manufactured in Mexico]. July 17, 2022, from Somos Industria website: https://www.somosindustria.com/articulo/fabricaran-vehiculos-electricos-en-mexico/

76 El Economista. (2022). "Ford triplicará su producción de autos eléctricos en México en 2023" [Ford to triple its electric vehicle production in Mexico in 2023]. August 15, 2022, from El Economista website: https://www.eleconomista.com.mx/empresas/Ford-Mexico-triplicara-produccion-de-autos-electricos-en-2023-20220801-0020.html

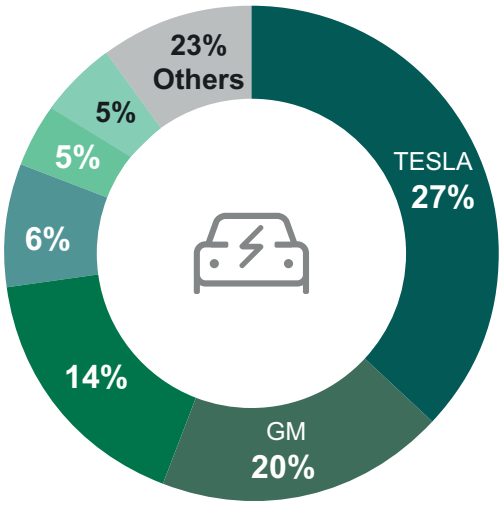
Electromobility in North America

ELECTRIC VEHICLE PLANTS IN THE UNITED STATES AND CANADA 2022-2029



Source: INA with information from IHS Markit.

Forecast of electric vehicle production in NA, 2023-2030
(Vehicles)



TESLA	8,034,439
GM	5,851,354
Ford	4,029,374
STELLANTIS	1,775,748
VOLKSWAGEN	1,588,700
HYUNDAI	1,340,996
Others	14,822,498
TOTAL NA 2023 - 2030	**29,408,670**

Source: INA with information from IHS Markit.

The new Chevrolet Blazer EV model will be produced at the Ramos Arizpe Plant in Coahuila, Mexico, where the gasoline-powered Chevrolet Blazer is already being manufactured. The plant is currently undergoing minor refurbishment to begin production.

In April 2021, General Motors announced a $1 thousand million dollars investment to expand the capabilities of its Ramos Arizpe complex and prepare it for electric vehicle production, making it the fifth manufacturing site in North America for GM to produce such vehicles.[77]

Stellantis is also considering refurbishing a plant in Mexico to manufacture hybrid and electric vehicles while transforming its production line to meet the growing demand for battery-powered transportation. The company is exploring the possibility of renovating its production site in Saltillo, Coahuila, and investing in its plant in Toluca, State of Mexico.[78]

Moldex, a subsidiary of Bimbo Group, through its Evolte line dedicated to sustainable mobility with electric utility vehicles, focuses on light cargo and consumer products distribution functions. Their VDT2 model features a Mexican electric motor, as well as an energy management system, safety monitoring, and a digital dashboard. Its production capacity is 20 units per week, but it has the capability to double that capacity.[79]

WTech has investment plans for a plant in Jalisco, which will be dedicated to the production of tactical, security, and transportation vehicles. The assembly of these units will be done by the Dutch company Defenture B.V., which will assist in the transfer of specialized technology for the development of these vehicles. The new factory of the Mexican company will produce over 1,000 tactical vehicles in its first stage.[80]

Zacua is the first Mexican brand of electric cars (named after Emperor Moctezuma's favorite bird). It was

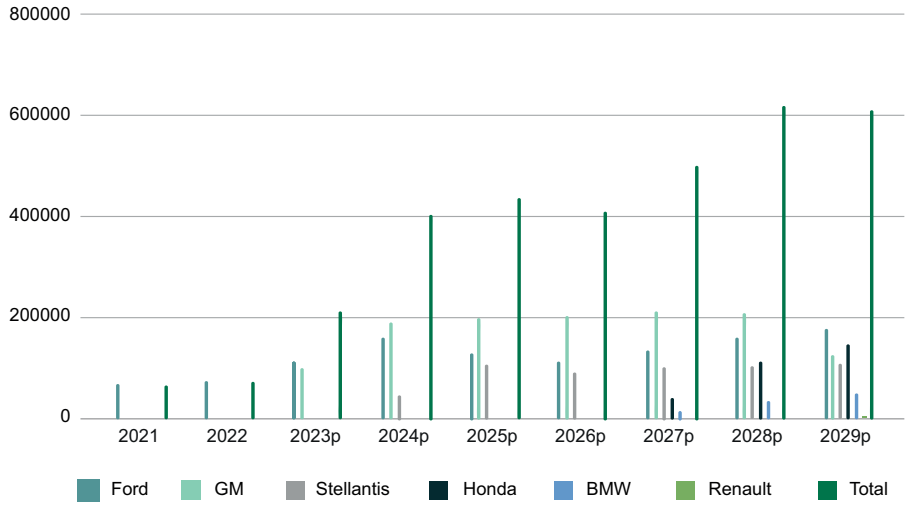
77 Forbes. (2022). Growing attractiveness of Mexico for electric vehicle manufacturing. August 4, 2022, from Forbes website: https://www.forbes.com.mx/crece-atractivo-de-mexico-en-fabricacion-de-autos-electricos/

78 PUNTODINCONTRO. (2022). Stellantis evaluates investment for electric vehicle production in Mexico. August 25, 2022, from PUNTODINCONTRO website: https://puntodincontro.mx/es/2022/08/14/stellantis-evalua-inversion-para-producir-vehiculos-electricos-en-mexico/

79 Metalmecánica. (2022). Electric vans with 100% Mexican motor. August 15, 2022, from Metalmecánica website: https://www.metalmecanica.com/es/noticias/camionetas-electricas-con-motor-100-mexicano

80 Mexico Industry. (2022). WTech will assemble tactical vehicles in Jalisco; will invest $180 million. August 15, 2022, from Mexico Industry website: https://mexicoindustry.com/noticia/wtech-ensamblara-vehiculos-tacticos-en-jalisco-invertira-180-mdd

Production of electric vehicles in Mexico



Source: INA with information from IHS Markit.

established over twenty years ago and has sold its first 100 compact electric vehicles. In 2018, it opened its first production plant in the state of Puebla. Zacua currently has two models in its production line, the MX2 and the MX3, both priced at 599,000 Mexican pesos ($30,500 dollars), with the possibility of subsidizing a portion of the price for its users (around $2,500 dollars). Their compact cars are presented as urban vehicles with a range of 160 km and batteries that are claimed to be capable of completing 3,000 full charging cycles, resulting in an estimated lifespan of eight years.[81]

As for heavy vehicles, such as buses and class 4 or higher cargo vehicles, cumulatively from January 2019 to July 2022, 68 electric units were produced, mainly for export to the U.S. market[82], the producing companies that reported figures to INEGI are Dina and Kenworth.

The domestic market in Mexico

While the global electric vehicle market continues to experience significant growth, one of the key issues is the disparity in the adoption processes of zero-emission vehicles in different countries. The adoption gap between emerging markets and developed countries is expected to increase significantly in the coming years if current factors persist, rather than narrowing.

This phenomenon holds significance for Mexico. Despite the presence of global automotive manufacturers, the market and presence of electric vehicles in Mexico are still limited.

Public policy on electromobility: North American integration

The Mexican government has made commitments in environmental matters, particularly in mobility and clean energy. In 2022, at the Forum of the Major Economies on Energy and Climate, the ten actions carried out by this administration to address climate change were announced.

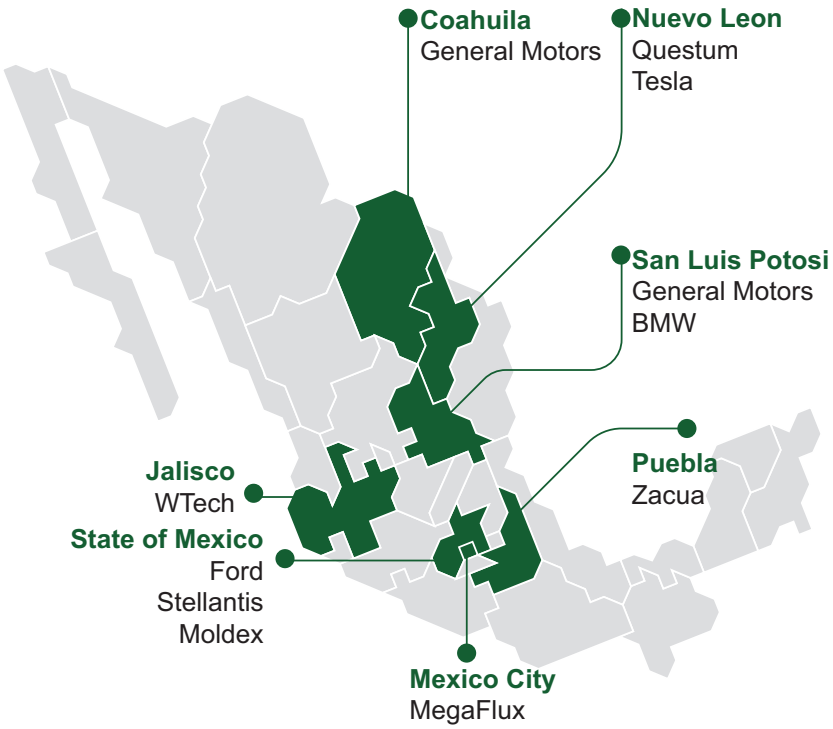
The third point of this decalogue refers to Mexico joining the collective commitment of the world's major economies to achieve the goal of producing 50% of zero-emission vehicles by 2030. It also mentions that in 2022, the country nationalized lithium, a strategic mineral used in battery manufacturing.

The tenth point pertains to the commitment to produce, by 2024, at least 35% of all energy consumed in the country from clean and renewable sources.

81 Diálogo Chino. (2022). [Interview] Meet Zacua, Mexico's first electric car brand. August 15, 2022, from Diálogo Chino website: https://dialogochino.net/es/clima-y-energia-es/54752-entrevista-conoce-a-zacua-la-primera-marca-de-autos-electricos-de-mexico/

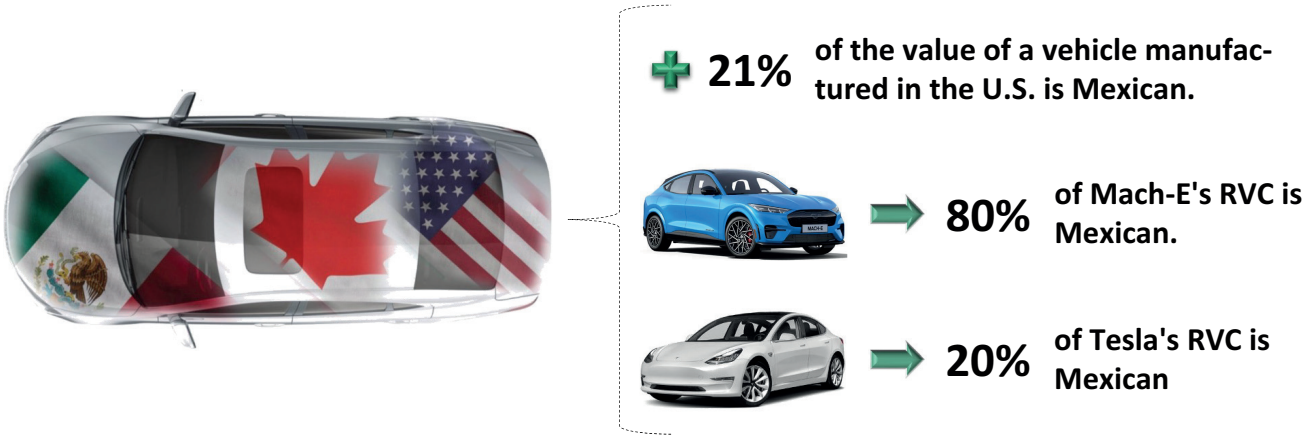
82 INEGI. Registro Administrativo de la Industria Automotriz de Vehículos Pesados (Administrative Register of the Heavy Vehicle Automotive Industry). Publication date: 09/08/2022

Electromobility in Mexico
Electric Vehicle Manufacturing Plants, 2022 - 2029



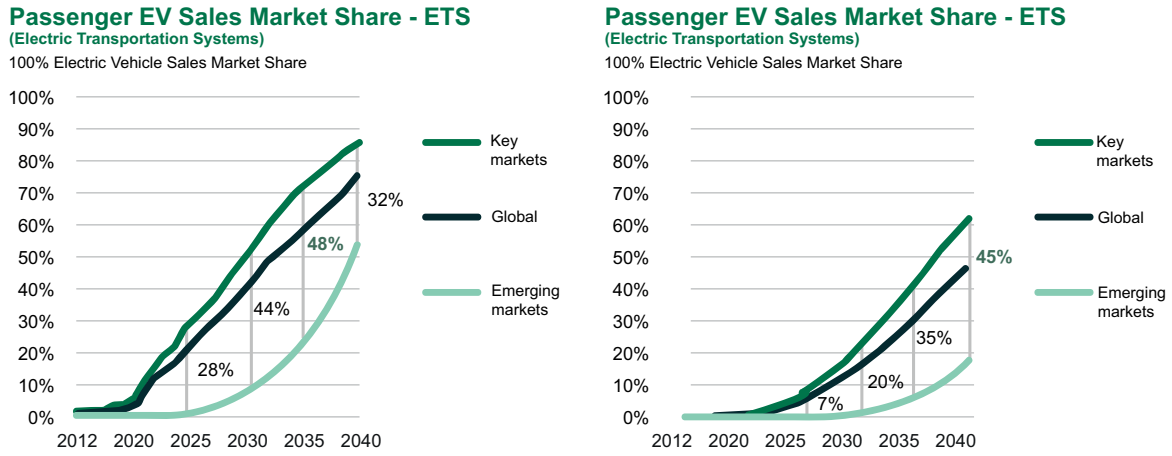
Source: INA with information from IHS Markit.

Mexico boosting electromobility and North America's regional content value (RVC)



Source: INA with information from the United States Department of Transportation.

The gap in the adoption of zero-emission vehicles between leading and emerging countries is increasing.



Source: INA with information from BloombergNEF.

It is worth noting that President Joe Biden expressed appreciation for Mexico's collaborative work and assured that the United States and Mexico will continue to work together in tackling climate change.[83]

This commitment stems from earlier efforts by this administration. In February 2022, the Mexican government launched the "Mexico-United States Working Group for Transportation Electrification" in response to requests from major automobile manufacturers to invest in infrastructure, renewable energies, and regulations.

The group originated from a meeting held in Washington (November 2021) where the Presidents of Mexico and the United States, along with the Prime Minister of Canada, agreed to collaborate on supply chains and climate goals. The aim is to halve emissions by 2030 and achieve net-zero emissions by 2050. Additionally, it is expected that half of the vehicles sold in the United States by 2030 will be electric.

"In particular, we have the shared goal of making supply chains in North America more resilient as we seek to bring them closer to home, and these current and future supply chains require a clean electricity supply," noted David Turk, Deputy Secretary of Energy of the United States.[84]

Similarly, the Secretary of Foreign Affairs, Marcelo Ebrard Casaubon, led the presentation of the "Diagnosis and Recommendations for the Transition of the Automotive Industry" in February 2023. This report was prepared by the Mexico-United States High-Level Working Group on Transportation Electrification. According to the Ministry of Foreign Affairs, this initiative serves as the roadmap for Mexico's initial steps towards transitioning its automotive industry to the production of less polluting vehicles.

In this regard, the evolution of the economic policy of the United States becomes relevant, starting with the "Build Back Better Plan" proposed by President Biden

83 National Institute of Ecology and Climate Change. President presents a decalogue of actions against climate change at the Forum of the Major Economies on Energy and Climate. June 17, 2022. Website: https://www.gob.mx/inecc/articulos/presidente-presenta-decalogo-de-acciones-contra-el-cambio-climatico-en-foro-de-las-principales-economias-sobre-energia-y-clima

84 Agencia EFE. (2022). Mexico launches initiative for electric cars amid requests from manufacturers. August 15, 2022. Website: https://www.efe.com/efe/usa/economia/mexico-lanza-iniciativa-para-autos-electricos-entre-peticiones-de-productores/50000106-4735704

in recent months. This proposal included important incentives, such as a current $7,500 dollars tax credit for purchasing an electric vehicle, as well as an additional $500 dollars if the vehicle's battery was manufactured in the United States. It also considered a $4,500 dollars tax credit if the vehicle was assembled in the country using union labor. The Mexican government and major industrial organizations conducted significant lobbying to ensure that this proposal by the Biden administration would not exclude countries with which the United States has a trade agreement, especially the members of the USMCA (T-MEC in Spanish).

In August of this year, the United States Congress approves the "Inflation Reduction Act" (see page 37), an initiative with a comprehensive focus on energy that reinforces the production chain with US trading partners while maintaining incentives for American consumers and expanding manufacturing options for vehicles to countries with which trade agreements are in place. Currently, global automotive companies are in the process of analyzing the necessary adjustments to their production schemes to access the fiscal benefits proposed by this law.

In our country, the Federal Government's interest in harnessing natural resources used in battery manufacturing is notable. In this regard, the publication of the decree for the creation of the public organization called "Lithium for Mexico" (acronym "LitioMx") under the coordination of the Ministry of Energy stands out.

The new Mexican state-owned company aims to "explore, exploit, benefit from, and utilize lithium located within national territory," as well as "manage and control the economic value chains of this mineral."

The state-owned company, "Lithium for Mexico", is the result of reforms approved by the Mexican Congress in 2022, which "declared lithium as a public utility". These provisions also state that "no concessions, licenses, contracts, permits, or authorizations will be granted in this matter and designate areas containing lithium deposits as mining reserves".

According to the Mexican Mining Chamber (Cámara Minera de México, Camimex), "there are currently no identified lithium reserves in the country that can be processed", and there is a lack of technology and cost-effective methods for processing lithium deposits. This highlights the significance of the functions of the state-owned company LitioMx, as it will be responsible for developing and executing engineering projects, conducting geological activities, and all activities related to the exploration, exploitation, beneficiation, and utilization of lithium. It will also collaborate with the Mexican Geological Service in locating and identifying potential lithium-rich geological areas, as well as researching and developing the technology required for industries utilizing lithium, among other responsibilities.[85]

Challenges for the Mexican market: Government-Industry Collaboration

As a result of the Mexican government's commitment to achieving a 50% share of zero-emission vehicles in the country by 2030, it is necessary to identify the challenges involved in meeting this goal, including the need to supply the domestic market with a variety of models and prices.

Additionally, it is crucial to have a policy that ensures the competitiveness of the national production plant within global production chains and develops human capital in the new manufacturing processes.

The Mexico-US Working Group on Transportation Electrification faces an important challenge in integrating relevant stakeholders and developing a national agenda that addresses the following issues:

Domestic Production

- Domestic Market: It is necessary to incentivize the offering of a wide variety of models and prices in the domestic market in the coming years, while ensuring compliance with national regulations.

85 Agencia EFE. (2022). Mexican Government creates state-owned company to exploit lithium. August 25. Website: https://www.efe.com/efe/america/economia/gobierno-de-mexico-crea-empresa-estatal-para-explotar-el-litio/20000011-4871605

- Export Market: Collaborative efforts with trading partners are essential to maintain and strengthen Mexico's role in global supply chains, as well as to transform domestic processes towards new technologies and the development of human capital.

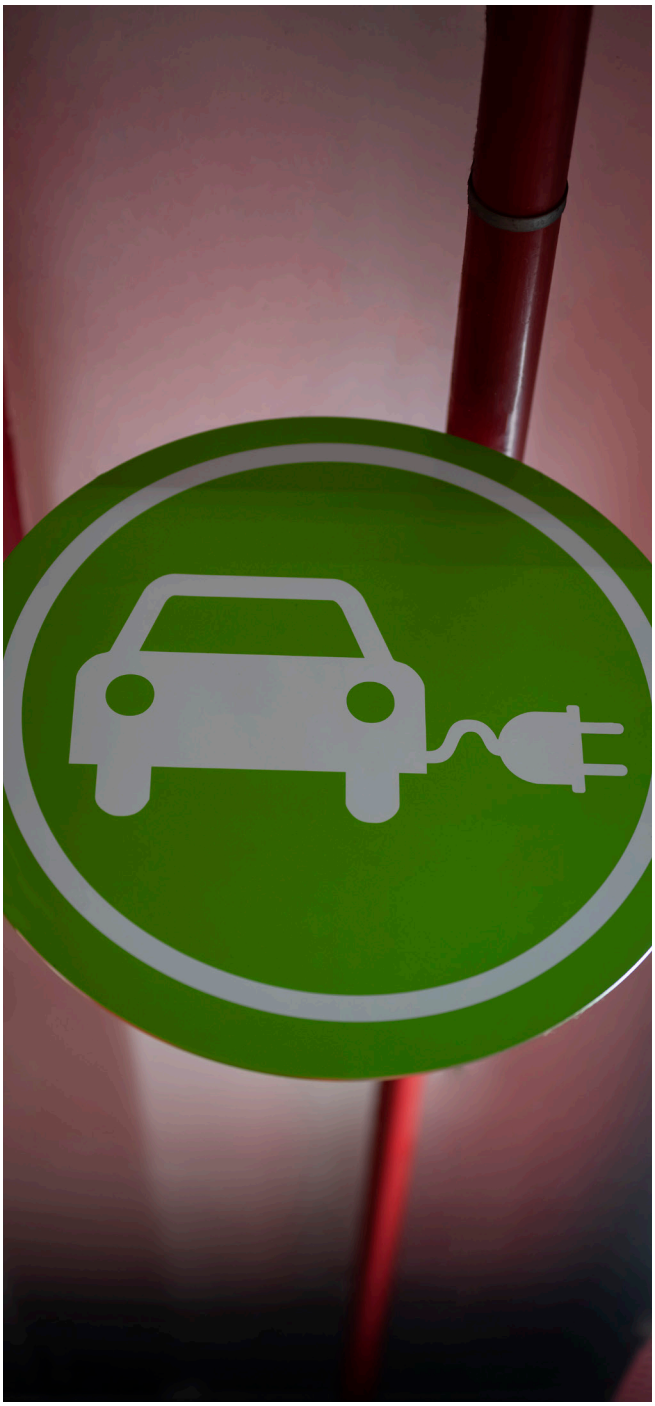
Imports: Take advantage of incentives for zero-emission vehicles to complement domestic production.

Avoid displacing domestic production with low value-added imports in the national industry.

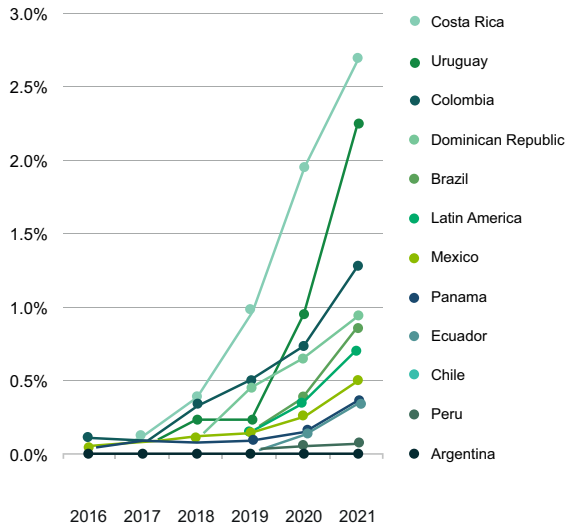
Infrastructure: Develop a network of charging stations, which presents an opportunity for the Federal Electricity Commission and private companies under a competitive pricing model.

Tax incentives and public investment: Align incentives with our trading partners through fiscal incentives for consumers, producers, and investments in zero-emission vehicles and public transportation, among others.

Vehicle fleet analysis and planning: Conduct a comprehensive analysis of the vehicle fleet, including more polluting internal combustion engine vehicles, average vehicle age (16 years), importation of used vehicles, and vehicle scrapping, among others.

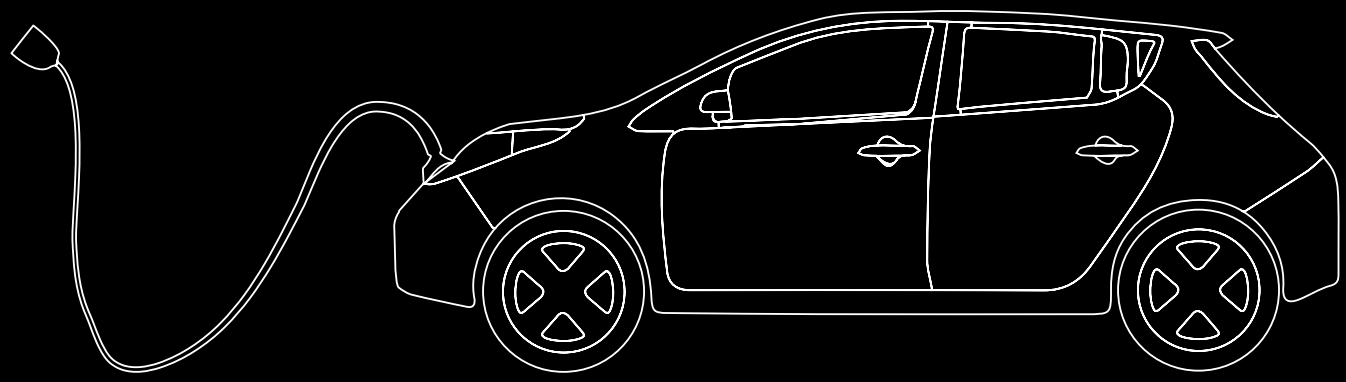


Sales of Electric Vehicles as a Percentage of Total Vehicle Sales, by Country



Outlook for 2025 by country

Source: INA with information from BloombergNEF.



Chapter 4.

Value Chain Development: Technological Requirements

5G and the digitalization of the auto parts industry.

It is necessary to highlight the changes in the production scheme of electric vehicles. Today we know that the supply chain is even more complex, as manufacturers require greater technology to provide intelligent, practical, and efficient solutions within their production systems.

Furthermore, supply chains have a more unpredictable trend in acquiring inputs, materials, and components, and there is pressure to maintain high levels of quality with shorter production lines previously designed for standardized mass production processes.[86]

The way vehicles are assembled has impacted value chains. Carlos Meneses, coordinator of the automotive program at the Mexico-United States Foundation for Science (FUMEC), states that:

"The original equipment manufacturers were accustomed to high volumes, imposing entry barriers, and mega-factories in complex geographic areas. But suddenly, a series of competitors (Lucid, Rivian, Canoo, Nikola, Arrival) arrive with a new style, not the traditional automotive one, but a completely technological one, with electronics, computing, and reinventing the concept of the vehicle. The product now is a sort of powerful robot and computer on wheels."

These disruptive companies have generated different supply ecosystems, with manufacturing centers close to consumer markets and new suppliers and materials for the automotive industry.[87]

Meneses also emphasized the need to analyze the role of our country in these supply chains: "Mexico can be in the Tier 1 market, companies that have possibly evolved and will demand new things, thinner and lighter laminates, casings. There are other composite materials and carbon fibers. Companies that were manufacturing different applications of carbon fibers for the aerospace sector can enter this chain. Mexican research and design centers have the potential to design interiors, electrical and electronic parts, and air conditioning, to name a few areas."

It is worth noting that Mexico is one of the best-prepared countries in the field of auto parts and is rapidly evolving towards hybrids and electrification. Francisco González Díaz, Executive President of INA, states: "When we talk about hybrids, the companies that benefit the most are auto parts manufacturers because they sell internal combustion and electric motors. But this moment is very important for the industry because it understands that it has to migrate, and there are several ways to do it." One way to migrate in the industry is to produce new parts within the existing infrastructure: "In that context, in the year 2021, Mexico reached a figure of nearly 95 thousand million dollars, which represents a 20% increase compared to the previous year. We truly have solidity from the supplier perspective."[88]

Electronic industry

The electronic industry in our country ranks first in Latin America and is the eighth exporter of computer data storage units. Mexico stands out as the country with the lowest operating costs in the manufacturing of electronic equipment and components in the Americas.[89]

Like many industries, this sector is going through a global turning point: reshoring. COVID-19 has posed to the world and accelerated the need to relocate production centers and create sustainable and competitive clusters with guarantees of operational continuity.

These conditions represent an opportunity for Mexico to strengthen the electronic industry in our country, given our geographical location, the preferential access

86 Katsouris, A. (2022). El futuro de los autos eléctricos está en las cadenas de suministro mexicanas [The future of electric cars lies in Mexican supply chains]. Europartners Group. https://www.europartnersgroup.com/blog/autos-electricos-futuro-em-las-cadenas-de-suministro-mexicanas/

87 Vázquez, Víctor. (2022). Autos eléctricos ¿Cómo entrar a su cadena de proveeduría? [Electric cars: How to enter their supply chain?]. Mexico Industry. https://mexicoindustry.com/noticia/autos-electricos-como-entrar-a-su-cadena-de-proveeduria

88 Pineda, M. (2022). México: Oportunidad para la manufactura de autos eléctricos [Mexico: Opportunity for electric car manufacturing]. Modern Machine Shop. https://www.mms-mexico.com/noticias/post/mexico-oportunidad-para-la-manufactura-de-autos-electricos s

89 Cámara Nacional de la Industria Electrónica, de Telecomunicaciones y Tecnologías de la Información (CANIETI) [National Chamber of the Electronic, Telecommunications, and Information Technology Industry].

Mexico stands out as the country with the lowest operating costs in the manufacturing of electronic equipment and components in the Americas.

offered by the USMCA, and the trade conflict between China and the United States.

The electronic industry has the opportunity to trigger a productive chain that attracts investments in highly specialized technological products and develops the talent to do so. The national content index in this sector is currently only around +/- 9%.

The interdependence between the electronic industry and the automotive industry is increasing, the integration of electronic components in a vehicle has gone from 20% to 70% in various models, and the evolution of the industry will undoubtedly accentuate this trend. Asian countries, in particular, have managed to retain and increase market share and investments in highly specialized products. Experts in the sector suggest that it is necessary to leverage Mexico's export-oriented nature and generate talent to attract more investments and increase the productive chain.

Telecommunications industry

The telecommunications industry is currently undergoing a technological shift with the emergence of 5G, the next generation of mobile technology, building upon the previous generations of 3G and 4G. As a historical context of network evolution, 2G introduced messaging, 3G provided internet access, and 4G, which emerged around 2009, brought increased data download speeds, enabling users to, for example, stream movies on mobile devices.

Now, 5G systems bring new possibilities, including higher bandwidth, greater data transmission capacity, and lower latency or waiting times. These advancements collectively will create new opportunities for wireless access for all types of users and various needs, as they facilitate massive machine-type communications.

Furthermore, these networks will have the capability for all fifth-generation devices to connect with each other, turning the mobile radio communications ecosystem into a "connected world" .[90]

5G technology is considered the architecture that consolidates the potential of Industry 4.0 in Mexico. The Industrial Internet of Things (IIoT) will only be enabled and fully utilized when the 5G network is deployed throughout the country. 5G networks in Mexico will enable remote monitoring of smart factories, creating safer conditions for operational personnel and increasing plant productivity.

The evolution of connectivity in plants will also enhance the collection of equipment information in industrial clouds, facilitating greater monitoring of conditions such as temperature, pressure, humidity, among others, and the development of more accurate digital twins.

The concept of "wireless production," which integrates humans and collaborative robots, can only be achieved in operational terms when we have even faster connectivity systems and greater data processing capacity than those currently installed in manufacturing plants in the country.[91]

Therefore, the need to enable better-connected plants with 5G technology becomes almost an urgency for Mexico, considering the demand for industrial operations that will come to the country through "near shoring" or the relocation of industrial processes and supply chains, as well as the need to increase electric vehicle production in response to new regulations in the United States, Mexico's main trading partner.

The 5G technology will also enable the digital transformation of small and medium-sized enterprises (SMEs) and will facilitate the exchange of information in complex or extensive supply chains, such as those in the

90 Federal Telecommunications Institute. (2020). Vision and Prospects of 5G Connectivity. IFT. [Online]. Available at: https://www.ift.org.mx/sites/default/files/comunicacion-y-medios/otros-documentos/visionyprospectivadelaconectividad5g.pdf

91 Ogazón, A. (2022). 5G is the Architecture to Consolidate Industry 4.0 in Mexico. Cuatro Cero. [Online]. Available at: https://cuatro-cero.mx/ideas/5g-es-la-arquitectura-para-consolidar-la-industria-4-0-en-mexico/

Wireless communication of 5G enables smart factories and Industry 4.0 by providing reliable, widespread, and scalable connectivity, which are particularly important qualities when it comes to industries.

automotive or aerospace sectors. With the help of 5G technology, small suppliers in these large industries can easily share relevant data that is valuable to major automakers or service integrators.

It is important to note that the deployment of the fifth-generation or 5G network is still in its early stages in Mexico. While it will certainly have an impact on the user experience of mobile devices, its greatest potential lies in the industry, as the 5G network will enable the consolidation of manufacturing industries in the automotive sector.

Wireless communication of 5G enables smart factories and Industry 4.0 by providing reliable, widespread, and scalable connectivity, which are particularly significant qualities when it comes to industries[92]. According to Dr. Andreas Müller, Vice President of the Mexico 4.0 Commission and Deputy Director of CAMEXA, 5G is already a reality but still has a long way to go in vertical industries. Currently, there are 213 active 5G networks worldwide, and estimates from Ericsson indicate that 35% of the global population had 5G coverage by the end of 2022. Explained that for the industry to embrace 5G, one of the challenges is to break down barriers between different industries to test the potential of industrial 5G.

Despite various efforts made this year to promote the adoption of the latest generation technology (5G) in Mexico, experts emphasize the need to work together to make the benefits and capabilities of 5G available to businesses and users in the country.

Today, the discussion needs to focus on the early development of use cases for 5G in ten priority industries for the country, including manufacturing, energy, public transportation, and automotive. This will help position Mexico as an attractive destination for investors, resulting in economic and social growth and development.[93]

Automotive industry investments

The future of the automotive industry will be based on vehicles that use cleaner sources of energy, either due to consumer preference for renewable energy or because authorities mandate a shift in paradigm for the industry and consumers.

The industry recognizes that investments in technology and new production lines will be substantial and long-term. Traditional automotive companies will make these investments by adapting their production lines, and also the companies that were born electric will also contribute.

There are other necessary investments that, if made, will enable the widespread adoption of electric vehicles in both advanced and emerging economies. These investments include the expansion and strengthening of public charging infrastructure and the expansion of the 5G network for managing electric charging stations, among others.

In the electric vehicle (EV) sector, 5G network is critical to ensure the safety and reliability of EV charging. The market for electric vehicles is already growing rapidly, and some even see the inevitable tipping point when more people will be driving electric vehicles than vehicles with internal combustion engines. ABI Research[94] forecasts that by 2030, there will be 41 million 5G-connected cars on the roads, and this number could double by 2035.

92 Cuatro Cero. (2022). Industrial 5G: Where Are We and Where Are We Going? Cuatro Cero. https://cuatro-cero.mx/noticias/5g-industrial-donde-esta-mos-y-a-donde-vamos/

93 El Economista. (2022). Mexican Industry Wants a 5G Revolution. El Economista. https://www.eleconomista.com.mx/empresas/Indus-tria-mexicana-quiere-una-revolucion-5G-20220915-0092.html

94 ABI Research (2020). 5G Impulsará C-V2X a Altas Velocidades. ABI Research. https://www.abiresearch.com/press/5g-will-shift-c-v2x-high-gear/

Due to the increased usage of electric vehicles on the roads, reliable network infrastructure is necessary to support the charging stations for these vehicles. Therefore, operators will need to provide always-on and reliable connectivity that is not susceptible to interruptions or failures. Unfortunately, fixed networks cannot always guarantee this, and this is where 5G can play a crucial role as a backup for fixed connectivity.

However, for 5G to be an effective backup tool, operators need to adapt to emergency events, such as power outages caused by a storm or in rural areas with weak connectivity, and seamlessly switch to 5G as a backup communication channel between the charging stations and the charging management system.[95] In the case of Mexico, the deployment of 5G technology requires the existence of a regulatory framework that promotes investment, as well as regulatory issues such as spectrum allocation for its development and its cost.

Recently, some leaders in the automotive industry in Mexico have highlighted the country's capacity to participate in the global supply chain of electric vehicles. While acknowledging the need for investments, Jorge Vallejo, CEO of Mitsubishi Mexico, stated that "from a production point of view, Mexico is prepared. It requires a series of significant investments to transform that manufacturing and the way of managing production towards a fully electric technology," and also mentioned that "supplier networks, significant investment, training, development, and workforce are needed. I'm talking about at least $7 thousand million to start manufacturing electric vehicles."[96]

While the Mexican Association of the Automotive Industry (AMIA) believes that certainty and clear regulations towards sustainable mobility are necessary to ensure the adoption of new technologies, they have recently stated that "There are already announcements, there are already established companies in Mexico manufacturing electric vehicles, and there are public announcements of new investments. However, what we have been seeking in our approaches to the federal government is a clear, defined public policy that provides guidance for this transition towards electromobility." [97]

Although in recent months some automakers have made announcements about starting the production of electrified vehicles in the country, the production line is still not significant, and as seen in the previous section, the

95 Stein, Y. (2021). ¿Cómo pueden los operadores de 5G impulsar un futuro eléctrico? Automotive World. https://www.automotiveworld.com/articles/how-can-5g-operators-enable-an-electric-future/

96 Guglielmetti, F. (2022). Mitsubishi: "Mexico needs at least $7 billion to start manufacturing electric vehicles". Portal Movilidad. https://portalmovilidad.com/mitsubishi-mexico-necesita-al-menos-usd-7-000-millones-para-iniciar-manufactura-de-vehiculos-electrico

97 Cantú, C. (2022) Electric Cars, the Other Apple of Discord Between Mexico and the US. Ensamble Global. https://www.clautedomex.mx/ensambleglobal/autos-electricos-la-otra-manzana-de-la-discordia-entre-mexico-y-eu/

The future of the automotive industry will be based on the technology of vehicles that use cleaner sources of energy.

production figures for vehicles are still focused on internal combustion and hybrid units.

Recently, the automotive industry has made announcements regarding the production of electric vehicles[98], For example:

• MegaFlux has started assembling electric delivery trucks with a 100% Mexican-manufactured powertrain using national technology, targeting the local market.

• General Motors announced that its plant in Ramos Arizpe, Coahuila, will begin production of its new electric vehicle, the Chevrolet Blazer EV 2024.

• Ford has initiated production of the Mustang Mach-E since 2021 at its plant in Cuautitlán Izcalli.

• Audi announced that starting in 2027, it will produce its Q5 model at its plant in San José Chiapa, Puebla, as part of its strategy to electrify its entire production and offerings by 2033, as it will cease production of internal combustion vehicles starting in 2026.

• In the heavy-duty vehicle segment, Navistar announced plans to establish the first plant in the state of Nuevo León that will produce electric trucks with a capacity of 37,000 pounds (16,782.92 kilograms) in the North American region. Additionally, the Mexican company WTech, through technology transfer agreements with the Dutch company Defenture and KIA's military division, plans to invest 180 million dollars to manufacture tactical, security, and passenger transport vehicles.

• LG Electronics and Magna International have formed LG Magna e-Powertrain with the aim of manufacturing motors, chargers, and other components for electric vehicles. They announced the establishment of a plant in Ramos Arizpe, Coahuila, which will commence operations in 2023.

• German automaker BMW has revealed its plans to integrate its plant in San Luis Potosí into the global electromobility network by manufacturing high-voltage batteries for the Neue Klasse model.

• Tesla Motors announced the construction of a mega-plant or "gigafactory" for the production of electric vehicles in Nuevo León.

98 El Economista, Modern Machine Shop, Imagen, etc. [These are the names of various sources.]

Prospects and Investment Announcements in Mexico.

Company	Country of Origin	Announcement Date	Project	Investment Amount	Location	Product
Link EV Electric Vehicles	U.S -	January 2022	Manufacturing plant with four production lines to manufacture 1,400 vehicles per year and create 400 direct jobs and 1,250 indirect jobs.	$265 million dollars	Puebla	Utility vehicles.
NEMAK	Mexico	February 2022	3 plants to produce casings for electric batteries. Supplying Ford for the production of the Mustang Mach-E vehicle.	$200 million dollars	Nuevo Leon / Europe	Casings for electric vehicle batteries.
Magna y LG	Canada and South Korea	April 2022	The 260,000 square-foot plant will be the first production base for both brands in North America and will create around 400 new jobs.	Not disclosed (ND)	Ramos Arizpe, Coahuila	Integrated motors, inverters, and chargers.
WTech	Mexico	May 2022	Electric tactical buses. Mexican company in alliance with Defenture and KIA's military division. The market for tactical vehicles is the Federation, the Ministry of National Defense (Sedena), the Navy (SEMAR) and state and municipal prosecutors' offices.	180 million dollars	Jalisco	First stage: Production of 1,000 buses in 2023.
Stellantis	U.S -	July 2022	Plant renovation to change assembly line for production to begin in 2024.	Not disclosed (ND)	Saltillo, Coahuila	Jeep Compass VE
Contemporary - Amperex Technology	China	July 2022	80 gigawatt-hour battery production plants for TESLA and Ford electric vehicles.	- 5,000 Million dollars	Ciudad Juarez, Chihuahua o Saltillo, Coahuila.	Batteries.
Navistar	U.S	August 2022	Creation of a production line for electric semi-trucks.	Not disclosed (ND)	Escobedo, Nuevo Leon.	Electric trucks with a capacity of 37,000 pounds (16,782.92 kilograms).
PPG	U.S -	August 2022	Expansion of the plant.	11 million dollars	Queretaro	Industrial powders for the automotive industry.
LS e-Mobility Solutions	South Korea	September 2022	Electric switches for electric vehicles manufacturing plant.	50 million dollars	Durango	Electrical components for vehicle batteries.
GM	U.S	September 2022	Production line for electric vehicles. SUV Chevrolet Equinox EV (electric).	1,000 millon dollars	Coahuila	Electric vehicles.
Bombardier Recreational Products	Canada	October 2022	Plant for manufacturing electric vehicle batteries and producing electric motorcycles.	65 million dollars	Queretaro	Batteries for electric vehicles and electric motorcycles. Production of electric motorcycles.
BMW	Germany	February 2023	High-voltage battery manufacturing plant.	800 million euros	San Luis Potosi	High-voltage batteries for Neue Klasse electric vehicle models.
TESLA	U.S	March 2023	Construction of a *Gigafactory.*	5,000 mdd	Nuevo Leon	Electric vehicle production plant.

Source: INA with various media sources.

Human capital needs.

The transition from a combustion engine vehicle to an electric vehicle in production lines will require skilled technicians in electric mobility and, above all, specialized mechanics in electric vehicles, both for their production and maintenance. There is likely to be a demand for experts in battery management systems, powertrain optimization, battery chemistry, electrical harnesses, and safety systems. This is just within the manufacturing line. This is because electric vehicles share many of the basic components found in traditional automobiles but have unique components that differentiate them from conventional vehicles, such as the lithium-ion battery and electric motor.

What technical profiles will be needed in the future of the electric vehicle?

According to the US Bureau of Labor Statistics[99], the automotive industry in the electric vehicle segment employs workers from a wide range of educational and professional backgrounds, including scientists conducting research in electric drive technology, manufacturing workers involved in vehicle construction, and automotive maintenance technicians who repair the vehicles. The study on the necessary careers for the automotive industry in its electric variant highlights the need to promote careers such as chemical engineering, electrical engineering, materials engineering, among others.

The profile of engineers is as follows:

Chemical engineers apply the principles of chemistry to design or improve equipment or processes for chemical and product manufacturing. Since electric vehicle batteries store energy through chemical processes, chemical engineers are responsible for developing new battery designs and improving current battery technologies. They are also vital in designing equipment and processes for large-scale manufacturing and in planning and testing battery manufacturing methods.

Electrical engineers design, develop, test, and oversee the manufacturing of electrical components. They are responsible for designing the electrical circuit that allows a gas engine to charge the battery and distribute electricity from the battery to the electric motor. Electrical engineers may also work on heating and air conditioning systems, vehicle lighting, and visual displays.

Electronic engineers design, develop, and test electronic components and systems for vehicles. These engineers primarily focus on control systems and additional electronic components for the vehicle. They differ from electrical engineers in that they do not primarily focus on electricity generation and distribution.

Materials engineers are involved in the development, processing, and testing of materials used in electric vehicles. Many electric vehicles are made with newer materials that are lighter and stronger than those used in traditional vehicles. Materials engineers may also incorporate eco-friendly materials derived from plant-based sources or recycled materials.

Mechanical drafters prepare detailed drawings that show how to assemble machinery and mechanical devices. They are responsible for producing visual guidelines that illustrate the construction methods of vehicle mechanical components. Most drafters use Computer-Aided Design & Drafting (CADD) systems to prepare drawings.

Software developers design and create software. They apply theories from computer science and mathematical analysis to create and evaluate applications and software systems that operate computers. Modern vehicles are heavily computer-controlled, and software developers create the software that controls these vehicles. In addition, hybrid and electric vehicles use onboard computers to generate and distribute the appropriate amount of electricity to power the vehicle under specific conditions. The onboard computer also determines when to use the gasoline engine to propel the vehicle and when to use the engine to recharge the battery.

Among the set of technicians, the following stand out:

Electrical and electronic equipment assemblers manufacture products such as electric motors, computers, electronic control devices, and sensing equipment.

99 Hamilton, J. (2011). Careers in Electric Vehicles. US Bureau of Labor Statistics. https://www.bls.gov/green/electric_vehicles/

Some of these components may be too small or fragile for manual assembly, so they are assembled using automated systems. Electrical and electronic equipment assemblers join larger component parts or control automated systems used for smaller parts.

Electromechanical equipment assemblers use a variety of tools to construct and assemble electromechanical components used in electric vehicles, such as gasoline engines, electric motors, and generators. This occupation is similar to that of electrical and electronic equipment assemblers. However, these workers focus more on mechanical components than electronics.

Computer-controlled machine tool operators use machines to fabricate metal and plastic components for vehicles. To set up the machine for specific operations, they load a program and arrange the appropriate tools in the machine. After positioning the workpiece, computer-controlled machine tool operators start the machine to perform the necessary tasks.

Machinists use machine tools such as lathes, milling machines, and grinders to produce precision metal parts. The production of large quantities of a single piece can be partially or fully automated, and machinists are responsible for monitoring the machines and the quality of production. They are also responsible for producing small batches or manufacturing unique parts for prototypes or testing. If a large number of parts are needed, they are often mass-produced using computer-controlled machines.

While in Mexico graduates from universities, both at the engineering and technical levels, already have a presence in the automotive industry, the need to enhance their profiles and make them more relevant to meet industry requirements is an ongoing task that will require collaboration among three key stakeholders: academia, industry, and government.

Public policies.

In general, Latin America faces a lag in terms of public policies and incentives for the development of the zero-emission automotive industry and domestic market. Different global economies are implementing aggressive schemes to strengthen their industries. Historically, the United States has been the main destination for Mexican-made automobile exports, and President Joe Biden has initiated various initiatives to promote electric mobility.[100]

According to the industry, for Mexico to benefit from the opportunities presented by this historic juncture, it must "maintain its existing capabilities in the R&D, design, testing, and assembly. Additionally, Mexico needs to create new opportunities by stimulating investment, nurturing talent, and improving access to energy services.".[101]

100 Valladolid, M. (2022). Mexico will anticipate its production and use of electric cars, influenced by the US: expert. Forbes Mexico. https://www.forbes.com.mx/mexico-anticipara-su-produccion-y-uso-de-autos-electricos-influenciado-por-eu-experto/

101 González, H. (2022). Semiconductors and industrial policy: all set. El Universal. https://www.eluniversal.com.mx/opinion/hugo-gonzalez/semiconductores-y-politica-industrial-todo-listo

The national industry considers Mexico to be highly competitive due to its size, geographic location, and industrial development. Furthermore, it has a high availability, though not unlimited, of qualified engineers and an export-oriented approach. However, they acknowledge that they compete for investments with several countries that have designed programs offering returns, exemptions, and tax credits in the semiconductor field.

In Mexico, the federal government's efforts to promote strategies for electric vehicle manufacturing have been approached from an analytical and collaborative perspective involving industry, academia, and the government.

In early 2022, the work of the Mexico-United States Working Group for the Electrification of Transportation (GTE) began. This high-level binational initiative is characterized by technical analysis groups focusing on the following topics:

- Innovation
- Human capital
- Supplier development
- Infrastructure development
- Governance structures

This initiative has a pluralistic nature as it includes government agencies (such as the Ministry of Economy, Ministry of Infrastructure, Communications and Transportation, Ministry of Public Education, Ministry of Labor and Social Welfare, Federal Electricity Commission, among others), state governments, automotive sector companies, universities, and research centers.

In the field of telecommunications, there is a notable current debate on the adoption of 5G technology in our country. Javier Juárez Mojica, Chairman Commissioner of the Federal Institute of Telecommunications (IFT), states that some of the challenges identified for 5G development are the cost of spectrum, which is 60% more expensive than in the rest of the world, impacting the sector's development and public finances.[102]

Investments are seeking locations that provide the best conditions for investment, and as long as Mexico does not lower the cost of spectrum, it will not be competitive. This was observed in the IFT-10 auction, where spectrum blocks remained unsold, resulting in a loss of 1,300 million pesos per year. Additionally, one operator has already returned this resource to the state, causing losses of 4,500 million pesos annually to public finances.

Rogelio Jiménez Pons Gómez, Undersecretary of Transportation at the Ministry of Communications, Infrastructure, and Transportation (SCIT), emphasized the importance of having appropriate public policies for the implementation of 5G. He also highlighted that the development of the 5G network faces challenges such as ensuring legal certainty and cybersecurity.[103]

Domestic market.

According to industry experts, although Mexico has proven capable of manufacturing quality electric vehicles, the sales and market development process has been slow.

According to José Zozaya, president of the Mexican Association of the Automotive Industry (AMIA): “The number of electric vehicles sold in Mexico remains very small, and there are several reasons for this, such as fiscal and non-fiscal incentives, as well as the existing infrastructure for these types of vehicles to circulate.”[104]

On the other hand, Jorge Vallejo from Mitsubishi Motors Mexico states that Mexico is indeed lagging in terms of commercialization: “I wouldn't say that we will be one of the last countries to adopt this technology, mainly because of our significant manufacturing and investment footprint. However, when it comes to commercialization alone, we would be among the last countries to implement this technology.” He explained that the country lacks charging infrastructure, supply centers, electric corridors, as well as fiscal and non-fiscal

102 El Economista. (2022). Mexican industry wants a 5G revolution. El Economista. https://www.eleconomista.com.mx/empresas/Industria-mexicana-quiere-una-revolucion-5G-20220915-0092.html
103 IBID.
104 Pineda, M. (2022). Mexico: Opportunity for Electric Vehicle Manufacturing. Modern Machine Shop. [Online] Available at: https://www.mms-mexico.com/noticias/post/mexico-oportunidad-para-la-manufactura-de-autos-electricos

incentives, credit, and other key aspects for the commercialization of these vehicles.[105]

Current incentives.

In Mexico, the current fiscal incentives for the use of hybrid and electric vehicles are as follows: [106]

- 20% discount on toll booths and second floors in Mexico City (CDMX) and the State of Mexico.
- Preferential electricity rates for home charging stations.
- Free installation of meters for home charging stations.
- Exemption from payment of the New Car Tax (ISAN).
- Exemption from payment of vehicle ownership tax in states where the tax exists.
- Deductibility of up to $250,000 pesos for legal entities (corporations).

Other incentives for the use of hybrid or electric vehicles include:

- Exemption from Vehicle Inspection in the CAMe Zone (Megacity Environmental Commission): Electric vehicles, plug-in electric vehicles, and strong hybrids.
- Taxi fleet renewal: Scrap bonus for each unit delivered to be replaced, providing a down payment of $100,000 for hybrid or electric vehicles.

The development of charging infrastructure is one of the key points to consider for policymakers involved in promoting electromobility. Various studies have shown that the availability of charging infrastructure at homes, workplaces, shopping centers, highways, and public spaces reduces user anxiety about running out of charge. Additionally, it serves as an incentive in itself to purchase an electric or plug-in hybrid vehicle.

In Mexico, there are currently a total of 2,089 public charging stations for electric vehicles. However, officials and sector experts estimate that by 2041, an additional 38,000 stations will be needed, as it is projected that around 43,000 electrified vehicles will be in circulation. “Based on the growth in recent years, it is estimated that by 2041, there will be nearly 700,000 electric vehicles on the roads in the country. This means that 40,000 charging stations will be required to meet the energy demand,” said Enrique Álvarez, Manager of the Energy Savings Program at the Federal Electricity Commission (CFE).[107]

Specialists emphasize the need to prepare more charging stations and ensure their safety for both users and vehicles. Víctor Villalobos, Board Member of the Electric Mobility Section of the National Chamber of Electrical Manufacturers (CANAME), suggests that the installation of necessary charging stations should already be considered in residential constructions to accommodate the upcoming electric vehicle usage. Although there are already regulations for appropriate charging installations in homes, there is a risk of inadequate supervision. “The challenge for Mexico is to have sufficient resources to ensure that everyone does things properly. You can establish regulations and initiatives, but if everyone does as they please, there is a risk of unsafe installations,” he explained. The risks of installing a charging station without complying with regulations include the potential for fires or damage to the home's electrical installation or even the power grid.[108]

105 IBID.

106 AMIA. (2022) Transition to Electromobility in Mexico. [Online] Available at: https://amia.com.mx/wp-content/uploads/2022/03/electromovilidad28022022-V2.pdf

107 Forbes. (2022). Urgent Need for Electric Vehicle Charging Stations, But They Must Be Safe, Say Experts. [Online] Available at: https://www.forbes.com.mx/urgen-estaciones-de-carga-para-autos-electricos-pero-deben-ser-seguras-dicen-expertos/

108 Valladolid, M. (2022). Mexico Will Anticipate Its Production and Use of Electric Vehicles, Influenced by the US: Expert. Forbes Mexico. [Online] Available at: https://www.forbes.com.mx/mexico-anticipara-su-produccion-y-uso-de-autos-electricos-influenciado-por-eu-experto/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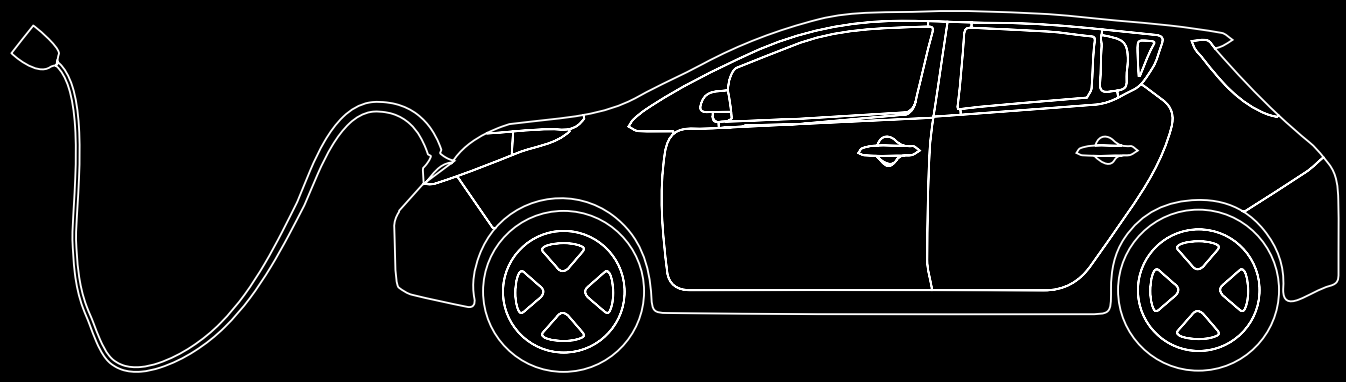
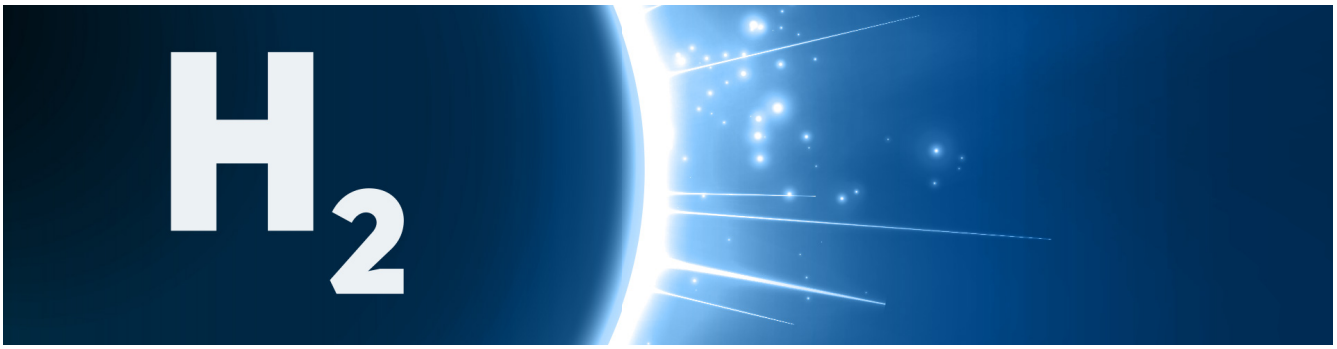


Chapter 5.

Technology Trends and Expert Opinions.



Alternatives to battery electric cars.

With the increase of zero-emission vehicles, new technological options for mobility are emerging: fuel cell electric vehicles (FCEVs), which utilize hydrogen as a fuel source. Unlike traditional battery electric vehicles (BEVs), an FCEV uses a fuel cell to generate electric energy. It has a tank where hydrogen is stored, which is combined with oxygen from the air in an oxidation process that releases electrical current to power the motor [109].

According to a recent report by PreScouter Intelligence, due to the lack of infrastructure supporting FCEV development, battery electric vehicles remain the more attractive option currently. However, this situation could change in the next five to ten years as investments in hydrogen production and infrastructure increase. This could lead to FCEVs surpassing battery electric vehicles in certain segments and becoming the more sustainable alternative.[110]

How does an FCEV work? [111]

FCEVs are vehicles that derive their power from a hydrogen fuel cell instead of a battery. Electricity is generated through electrochemical reactions between hydrogen and oxygen supplied from the hydrogen tanks of the FCEV. The only byproduct produced is pure and distilled water.

FCEVs use this electricity for propulsion and rely on a battery for auxiliary operations such as starting and storing energy obtained through regenerative braking. Unlike conventional electric vehicles that depend on energy stored in a battery, FCEVs rely on the energy stored in the vehicle's fuel cells, which offer several advantages over batteries. As long as there is available fuel to power the fuel cell, it can generate energy. This is one of the most significant advantages of fuel cells.

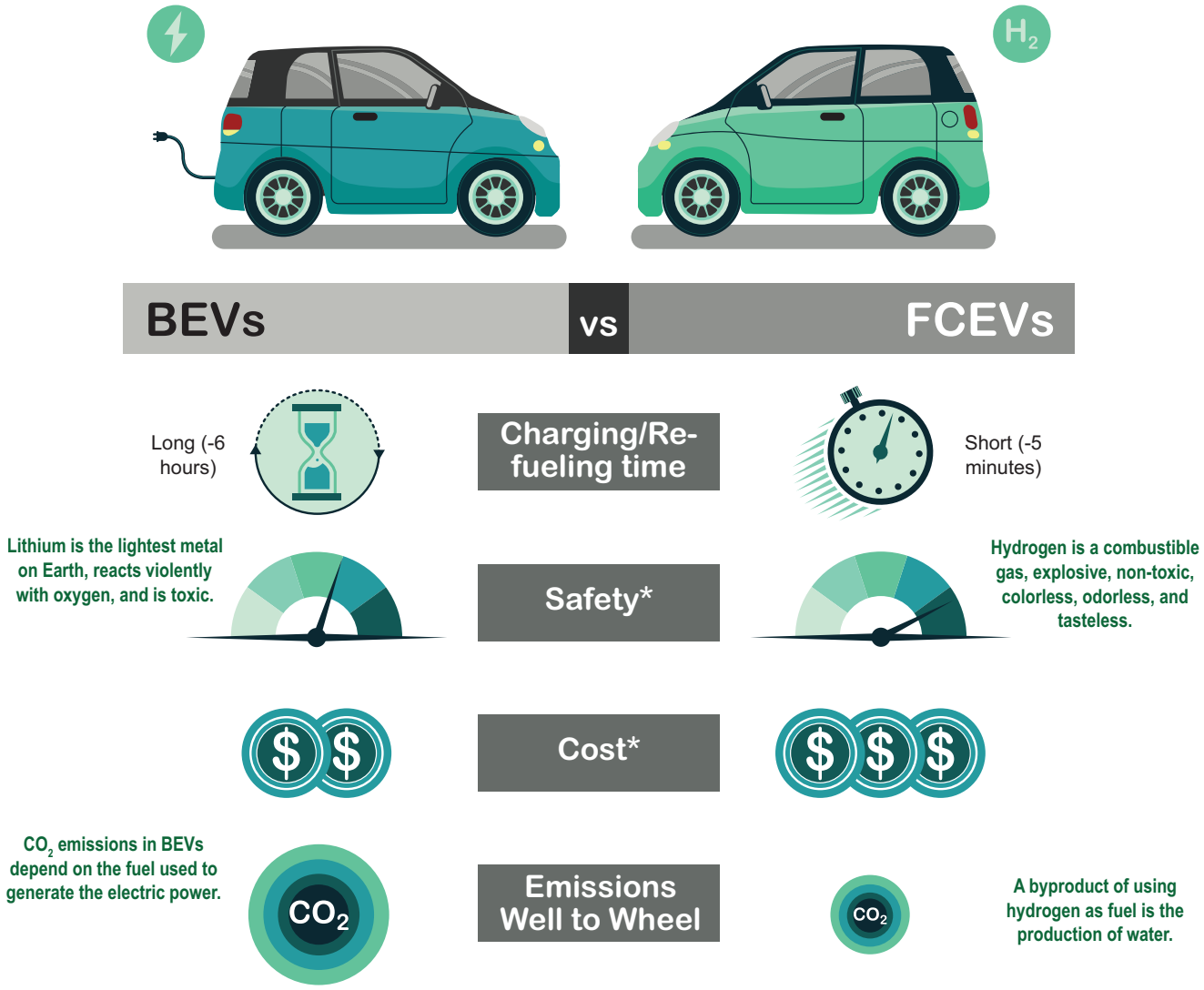
A typical electric vehicle can be fully charged in a little over six hours (varying depending on available technologies), while an FCEV can be refueled in five minutes and have a range of over 350 miles. It takes only a small amount of hydrogen to go further.

Hydrogen fuel cell options.[112]

Even within hydrogen fuel cell technology, there are two options: the hydrogen fuel cell (FCEV) and hot hydrogen (H2-ICE). Despite hydrogen being the key player in both cases, they have very different approaches. Although they are considered electric vehicles, FCEVs or fuel cell vehicles do not have a plug under the “fuel” cap. Instead, they have a filling nozzle similar to those used for gasoline cars, which is used for hydrogen refueling. The propulsion system consists of hydrogen storage tanks, a fuel cell stack, an electric motor, and a high-voltage battery primarily made of lithium-ion.

109 Otero, A. (2018). Hydrogen Cars: How this Zero-Emission Technology Works. Motorpasión. https://www.motorpasion.com/tecnologia/coches-de-hidrogeno-asi-funciona-esta-tecnologia-de-cero-emisiones
110 World Energy Trade. (2022). In the Battle of Electric Vehicles, Could Hydrogen be the Winner? WET. https://www.worldenergy-trade.com/innovation/mobility/in-the-battle-of-electric-vehicles-could-hydrogen-be-the-winner
111 IBID
112 Fernández, A. (2022). Hydrogen: Differences between fuel cell and H2-ICE. Motor.es. https://www.motor.es/noticias/hidrogeno-pila-combustible-h2-ice-202289262.html

Comparison between BEVs and FCEVs



* In comparison to internal combustion engines.

Hydrogen is highly powerful: it has three times more energy than gasoline, but unlike gasoline, it is a clean source of energy as it only releases water (H^2O) in the form of vapor and does not produce carbon dioxide (CO_2).

The hot hydrogen (H2-ICE)

On the other hand, the hot hydrogen or H2-ICE engine is, as the acronym suggests, an internal combustion engine that has been properly adapted to use hydrogen as fuel instead of traditional fuels like gasoline or diesel. The main modifications are made to the fuel injection and ignition systems, while the fuel tank must also be prepared for hydrogen storage. This technology is rapidly gaining popularity as it allows manufacturers to extend the life of the internal combustion engine.

Currently, there are no hydrogen-powered cars available on the market. However, brands like Toyota have already developed functional prototypes that are being used, for example, in sports races to further develop the technology and apply it in the future.

Advantages of hydrogen fuel cell:

- Zero harmful emissions
- Silent and comfortable driving experience
- No limitations on range and charging times

Advantages of hot hydrogen:

- Driving experience comparable to gasoline or diesel cars
- Extends the life of the internal combustion engine
- Low emission levels (no CO_2 generation)

Hydrogen: The Energy of the Future[113]

Hydrogen is the most abundant chemical element in the universe. It can exist as a gas (stars, like the sun, are mainly composed of this gas) or in a liquid state. Hydrogen is extremely powerful, containing three times more energy than gasoline. However, unlike gasoline, it is a clean source of energy as it only releases water vapor (H2O) and does not produce carbon dioxide (CO_2).

Nevertheless, despite the existence of technologies for using hydrogen as a fuel for many years, its high flammability makes transportation and safe storage complex. The most challenging aspect is the difficulty in producing hydrogen. On Earth, hydrogen only exists in combination with other elements. It is found in water, combined with oxygen, and it combines with carbon to form hydrocarbons such as gas, coal, and oil. Therefore, it is necessary to separate hydrogen from other molecules in order to use it as a fuel. This process requires large amounts of energy and is also expensive.

A few years ago, hydrogen production began using renewable energies such as solar and wind through a process called electrolysis. Electrolysis uses an electric current to split water into hydrogen and oxygen in a device called an electrolyzer. For many, the result is known as green hydrogen, which is 100% sustainable but much more expensive to produce than traditional hydrogen. However, many believe it could offer an eco-friendly solution for some of the most polluting industries, including transportation, chemical and steel production, and power generation.

Currently, 99% of the hydrogen used as fuel is produced from non-renewable sources. Meanwhile, less than 0.1% is produced through water electrolysis, according to the International Energy Agency. Many energy experts anticipate that this will change soon as various countries and companies are embracing this new form of clean energy, which many believe will be key to decarbonizing the planet.

113 Smink, V. (2021). Green Hydrogen: 6 countries leading the production of one of the "energies of the future" (and the only Latin American one). BBC News https://www.bbc.com/mundo/noticias-56531777

Although some car manufacturers currently sell or lease FCEVs, the technology is still new.

Oil companies such as Repsol, BP, and Shell are among those that have launched green hydrogen projects, and several nations have already announced their plans for the production of this renewable fuel.

Hydrogen storage and car refueling[114]

Given hydrogen's low volumetric energy density, storing a sufficient amount on board poses challenges in terms of weight, volume, kinetics, safety, and cost. Hydrogen can only be stored at high pressure, at extremely low temperatures as a liquid, or in metal hydride systems to maximize volumetric energy density.

Compressed hydrogen is the most commonly used method for storing hydrogen in vehicles. Compressed hydrogen tanks in passenger FCEVs are complex and occupy a lot of space. This is a drawback of the current generation of hydrogen fuel cell-powered electric vehicles. In the future, non-metallic or metallic hydrides could potentially replace the heavy hydrogen tanks. This is beginning to take shape, as the evaporation of hydrogen remains a key technical challenge that needs to be overcome.

Therefore, even though some automobile manufacturers currently sell or lease FCEVs, the technology is still relatively new. FCEVs will not be commercially viable unless buyers are confident that they will have easy access to refueling stations. Consequently, the adoption of fuel cell vehicles must be complemented by enabling infrastructure. According to H2 Tools, by the end of 2021, there were over 492 operational hydrogen refueling stations worldwide. Japan had around 141 stations, followed by South Korea (112) and Germany (91).

Market Trends[115]

Several studies, including one from the Argonne National Laboratory, have shown that the creation and use of hydrogen for fuel cell vehicles is more environmentally friendly than using grid electricity to power battery electric vehicles. FCEVs are also the best option in terms of environmental impact, as fuel cells can be a 100% renewable and environmentally friendly energy system. The lack of proper recycling systems can lead to a severe environmental crisis when lithium-ion batteries used in BEVs reach the end of their life cycle.

During operation, the vehicle emits water vapor and filters ultrafine dust from the atmosphere. This fundamental feature of FCEVs has attracted public attention as the future of eco-friendly mobility. This technology can have a significant impact on our lifestyle in terms of sustainability, due to the abundance of hydrogen on Earth and the environmentally friendly production process itself.

In general, FCEVs are cleaner than both BEVs and internal combustion vehicles, with further room for improvement as hydrogen generation and distribution advances. The production of FCEVs is also cleaner than that of BEVs because fewer raw materials are required compared to the extraction of minerals for BEVs and the consumption of heavy metals such as lithium and cobalt. FCEVs are also easier and cheaper to recycle than BEVs.

Toyota, Hyundai Motor Group, and General Motors have been the main manufacturers that have embraced hydrogen fuel cell technology as a sustainable mobility solution. The geographic distribution of FCEVs varies significantly. Korea, the United States, and Japan have focused on passenger vehicles, with a small number of buses and commercial vehicles. On the other hand, with

114 World Energy Trade. (2022) In the battle of electric vehicles, could hydrogen be the winner? WET. https://www.worldenergytrade.com/innovacion/movilidad/en-la-batalla-de-los-vehiculos-electricos-podria-el-hidrogeno-ser-el-ganador

115 World Energy Trade. (2022) In the battle of electric vehicles, could hydrogen be the winner? WET. https://www.worldenergy-trade.com/innovacion/movilidad/en-la-batalla-de-los-vehiculos-electricos-podria-el-hidrogeno-ser-el-ganador

its policies on fuel cell buses and commercial vehicles, China currently dominates global stocks in these segments.

This trend is expected to continue as China's subsidy policy for fuel cell vehicles by 2020 focuses on the use of fuel cells in medium and heavy-duty commercial vehicles. China has set a target of using over one million FCEVs for commercial purposes by 2030. In Europe, there will be more fuel cell buses and trucks in the near future, with over a thousand buses expected in the next decade. Today, it is estimated that both technologies will coexist in the future due to their evident similarities, with BEVs being more suitable for short-range and small vehicles, while FCEVs are the best option for medium and long-range vehicles.

Expert Interviews.
Electric vehicle paradigm

Indeed, we are in a transition period towards electromobility, which implies the coexistence of different technologies in the coming years. This includes vehicles with internal combustion engines (ICE) that will cease production completely by 2040, hybrid vehicles (HEV) that combine an internal combustion engine with a battery that assists the vehicle in combination with the ICE and recharges through kinetic energy when braking or decelerating, using gasoline for the ICE engine. There are also plug-in hybrid vehicles (PHEV) that combine an ICE engine with a battery that assists the vehicle in combination with the ICE, but can be recharged by connecting it to an electric charging station, also using gasoline for the ICE engine. Additionally, there are battery electric vehicles (BEV) that are powered by one or more electric motors fueled by electric energy stored in a battery, which can be recharged by connecting it to an electric charging station. Lastly, there are fuel cell electric vehicles (FCEV) powered by one or more electric motors fueled by electric energy stored in a battery that is recharged by transforming hydrogen into the electric energy required by the battery *(José Zozaya, executive president of AMIA)*.

Opportunities for Mexico in the electric vehicle value chain

Mexico has significant opportunities in the electric vehicle value chain, particularly in the high-tech industry and information technology services, including software development. This industry has consistently grown at a rate two to four times higher than the rest of the economy. With 1.2 million jobs generated by the industry, the software development segment alone employs between 300,000 and 400,000 people with salaries well above the national average. Mexico is a global player in the gaming niche, ranking among the top ten exporters of gaming software and at times even reaching the top three. This demonstrates that Mexico is moving in the right direction, although perhaps not at the desired speed.

Given the expected growth of the electric vehicle sector, it is estimated that the software industry has the potential to grow three to four times its current level. The software industry is well-prepared to compete for new projects, which works in Mexico's favor to attract new investments or expand existing ones. This is a positive

factor that positions the country for further growth and development in the sector *(Alfredo Pacheco, General Director of CANIETI)*.

The main advantage is that we have a value chain from the manufacturing of automotive parts and components to the production of finished vehicles with proven standards of quality, efficiency, and competitiveness, as demonstrated by the fact that our country ranks seventh among the world's leading vehicle manufacturers.

Additionally, the network of trade agreements that has led us to become the fifth-largest vehicle exporter globally *(José Zozaya, executive president of AMIA)*.

In Mexico, there are companies taking the lead in different materials. I'll start with aluminum, companies that are transforming and shifting from manufacturing components for internal combustion engines to producing what electric vehicles require, such as battery trays and other types of extrusions. These products require a much more delicate and precise manufacturing process. Other materials such as carbon and graphene are also

being processed, and there is significant investment in technological research by some companies to improve vehicle connectivity because electric vehicle battery connectivity demands more graphene than copper. Automotive industry companies are seeking ways to produce these materials in the best possible manner in Mexico. Another example are the companies that produce fluids used in internal combustion vehicles; now they have expanded their products to include materials that help solve the issue of high temperatures generated in electric batteries *(Francisco González, Executive President of INA)*.

It can be mentioned that there are other milestones in this matter: one of them was the meeting between Mexican Chancellor Marcelo Ebrard and U.S. Secretary of State Antony Blinken on September 12, 2022, where Mexico presented an initial summary of these efforts. In November, the COP27 meeting took place in Egypt, and within that framework, Mexico presented the first progress of the roadmap for the electrification of transportation. However, it should be noted that the work in this field in our country will be ongoing and will continue in 2023 *(Iker Jiménez, former Director General of Global Economic Promotion at the Ministry of Foreign Affairs)*.

Challenges of the automotive industry

In the future, the industry will need to comply with the agreements set forth in the USMCA. As you may recall, in heavy vehicles, we are currently meeting the 60% regional value content requirement, but by 2024, we will increase it to 64%, and then to 70% by 2027. Therefore, while there will be a need to meet higher regional content requirements based on the rules of origin, technological advancements will give greater value to the engine and batteries in the vehicle. Thus, it will be necessary to further strengthen the supply chain in the North American region, particularly considering that 95% of our industry's production is directed towards the United States, with only 2% or 3% going to Canada. In this context, the incentives contemplated in President Biden's anti-inflation plan, specifically for auto parts originating from the region, will be highly relevant. Increasing regional content in batteries and engines, mainly, is crucial *(Miguel Elizalde Lizárraga, Executive President of ANPACT)*.

"Infrastructure is the main challenge, and we see hydrogen as the primary solution for long-haul cargo vehicles," as "it can provide a range of 320 to 640 kilometers, something we haven't been able to achieve with electrification due to the weight, consumption, and energy evaporation in batteries" *(Javier Valadez Ortega, Director of Operations at Kenworth Mexicana)*.

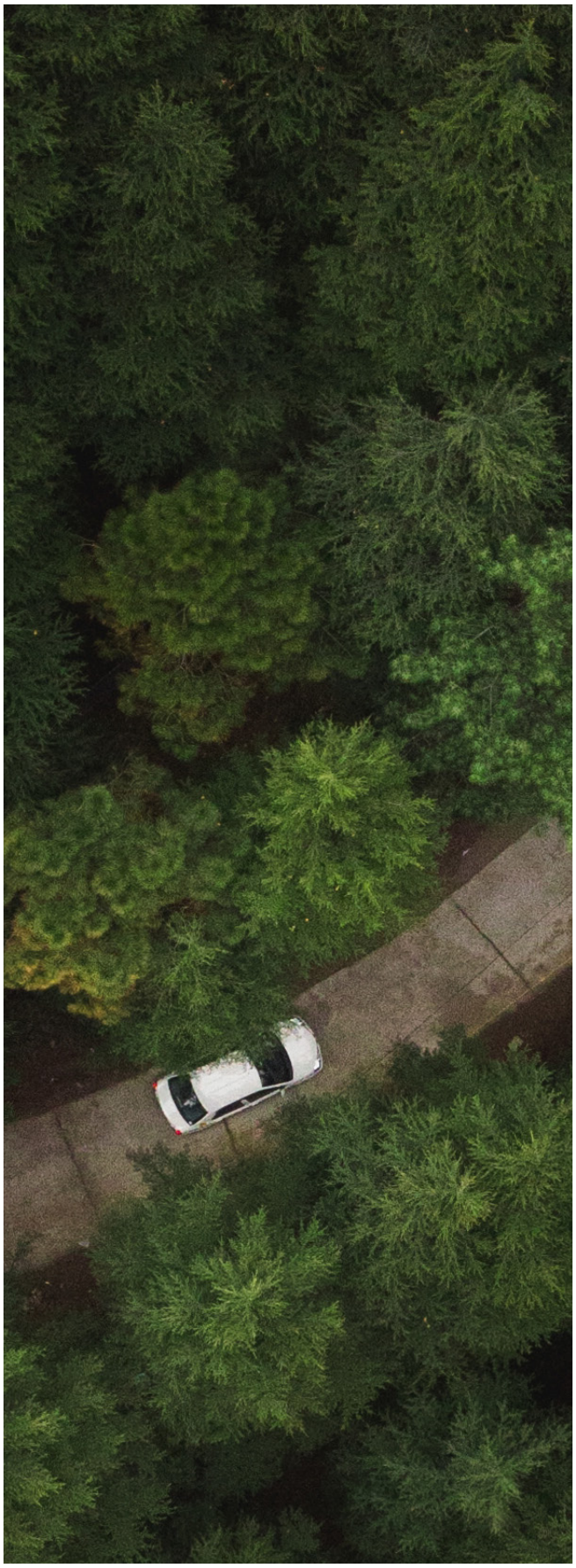
What should not be overlooked is that for automotive manufacturers, it can be very challenging to have production lines for internal combustion vehicles and electric vehicles simultaneously. We must ensure that this does not become too complicated for the manufacturers; otherwise, Mexico could lose electric vehicle platforms. With highly automated plants, manufacturers could migrate to countries where electric vehicles are consumed without the concern of labor costs. A business-friendly environment is the true incentive, as well as promoting the development of the talent required for these new technologies from technical schools and universities *(Abraham Tijerina, leader of business development strategies at the Tecnológico de Monterrey)*.

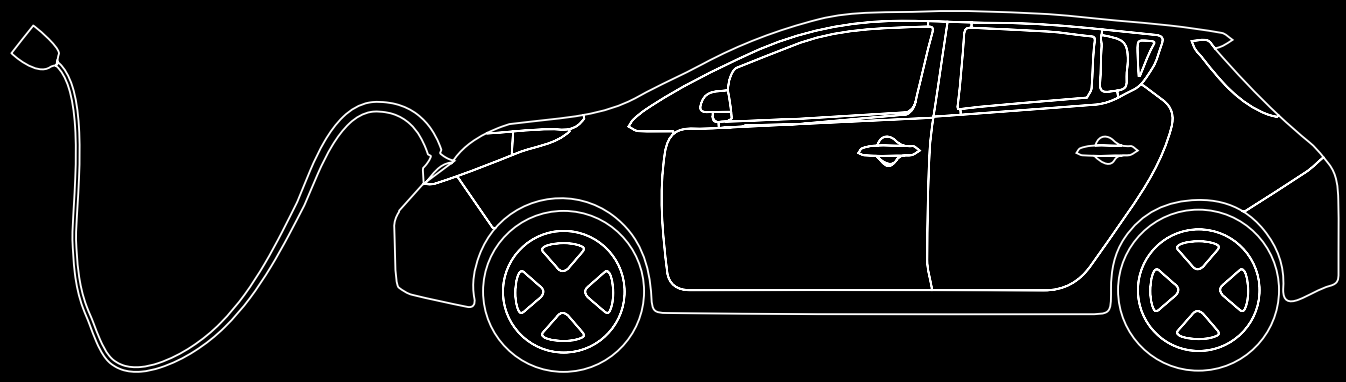
What remains to be done?

One of the components of an electric vehicle that adds the most weight is the battery. The supply chain competition will be in the battery system, both in terms of seeking efficiency and reducing costs. I believe it is important to explore alternative energy sources for electric vehicles. In the field of battery development, I think Mexico has opportunities, particularly in scientific research and improving the traction system for greater efficiency. Another crucial element in the supply chain is the origin of electricity. It is evident that it is not congruent to purchase electric vehicles that run on fossil fuel-derived electricity. Additionally, reducing the weight of the vehicle presents an opportunity for suppliers to create components with new materials and properties *(Abraham Tijerina, leader of business development strategies at the Tecnológico de Monterrey)*.

Human resources in Mexico are definitely a plus, and we need to focus on research and development. It must

be acknowledged that there have been efforts, but they have been isolated. For example, in Jalisco, there are excellent projects and world-class companies. In other states like Guanajuato, Querétaro, Yucatán, and, of course, Mexico City, there are significant initiatives. As an industry and as a country, it is necessary to standardize and homogenize these initiatives and projects. They should no longer be isolated success stories but rather become the standard *(Alfredo Pacheco, General Director of CANIETI)*.





Acronym

Glossary

ACRONYM GLOSSARY

A

ANPACT– Asociación Nacional de Productores de Autobuses, Camiones y Tractocamiones (National Association of Bus, Truck, and Tractor Manufacturers)

AMIA – Asociación Mexicana de la Industria Automotriz (Mexican Association of the Automotive Industry)

AV – Vehículo Autónomo (Autonomous Vehicle)

B

BEV – Vehículo Eléctrico de Batería (Battery-powered Electric Vehicle)

C

CA – Corriente Alterna (Alternating Current)

CADD – Diseño y Dibujo Asistido por Computadora (Computer-Aided Design & Drafting)

CAMe – Comisión Ambiental de la Megalópolis (Environmental Commission of the Megalopolis)

CC – Corriente Continua (Direct Current)

CFE – Comisión Federal de Electricidad (Federal Electricity Commission)

F

FUMEC – Fundación México-Estados Unidos para la Ciencia (Mexico-United States Foundation for Science)

G

GTE – Grupo de Trabajo México-Estados Unidos para la Electrificación del Transporte (Mexico-United States Working Group for Transportation Electrification)

H

HEV – Vehículo Híbrido Eléctrico (Hybrid Electric Vehicle)

I

IA – Inteligencia Artificial (Artificial Intelligence)

ICE – Motor de Combustión Interna (Internal Combustion Engine)

IEA – Agencia Internacional de Energía (International Energy Agency)

IED – Inversión Extranjera Directa (Foreign Direct Investment)

IFT – Instituto Federal de Telecomunicaciones (Federal Institute of Telecommunications

IIoT – Internet de las cosas en el sector industrial (Industrial Internet of the Things)

IoT – Internet de las Cosas (Internet of Things)

INA – Industria Nacional de Autopartes (National Automotive Industry)

N

NA – Norteamérica (North America)

O

ONU – Organización de las Naciones Unidas (United Nations)

P

PHEV – Vehículo Híbrido Enchufable (Plug-in Hybrid Electric Vehicle)

PNUMA – Programa de las Naciones Unidas para el Medio Ambiente (United Nations Environment Programme)

PyMEs – Pequeñas y Medianas Empresas (Small and Medium-sized Enterprises)

S

SCIT – Secretaría de Comunicaciones, Infraestructura y Transportes (Secretariat of Communications, Infrastructure, and Transportation)

T

T-MEC – Tratado entre México, Estados Unidos y Canadá (Treaty between Mexico, the United States, and Canada)

U

UE – Unión Europea (European Union)

V

V2X – Vehículo para todo (Vehicle-to-everything)

VCR – Valor de Contenido Regional (Regional Content Value)

VE – Vehículo Eléctrico (Electric Vehicle)

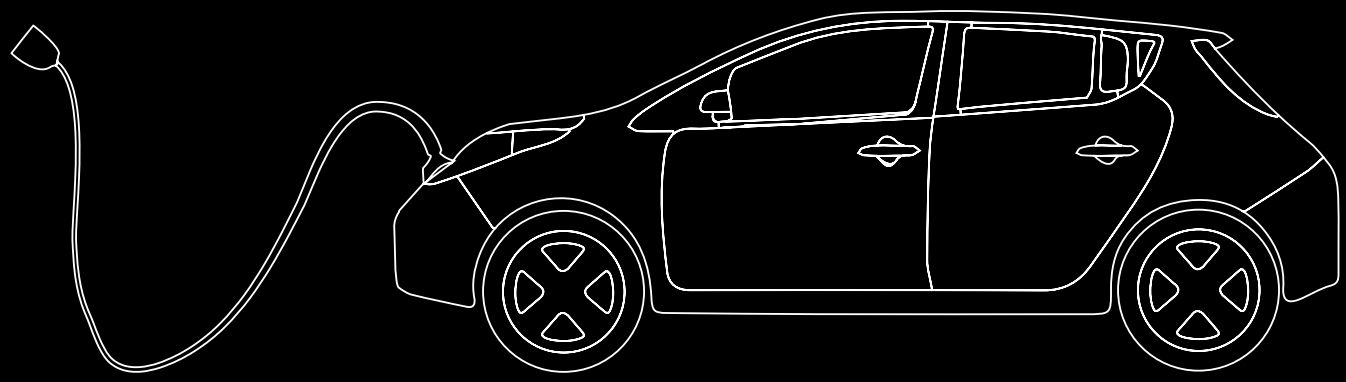
VCI – Vehículo de Combustión Interna (Internal Combustion Vehicle)

W

WEF – Foro Económico Mundial (World Economic Forum)

Z

ZEV – Vehículo de Emisión Cero (Zero-Emission Vehicle)



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