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World Automotive Powertrain Outlook 2023

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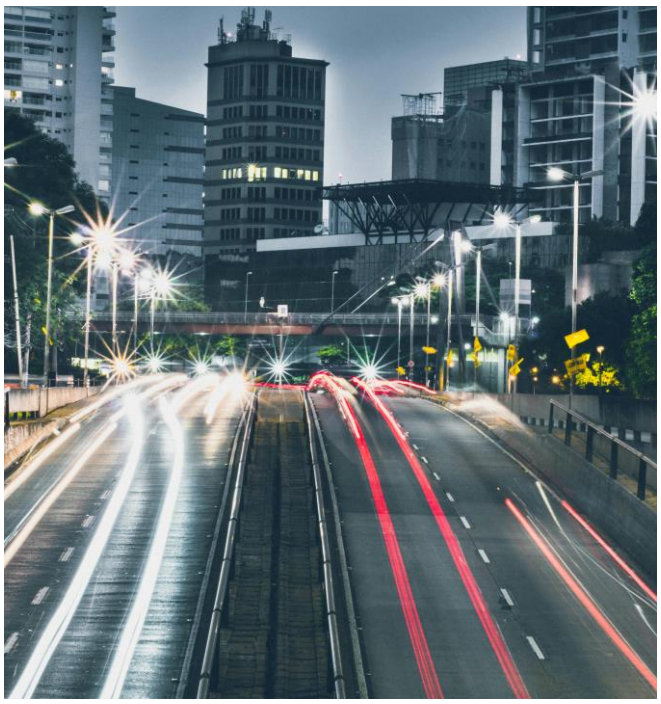
BDO

Automotive & Mobility Practice

Content



Foreword

Your challenges

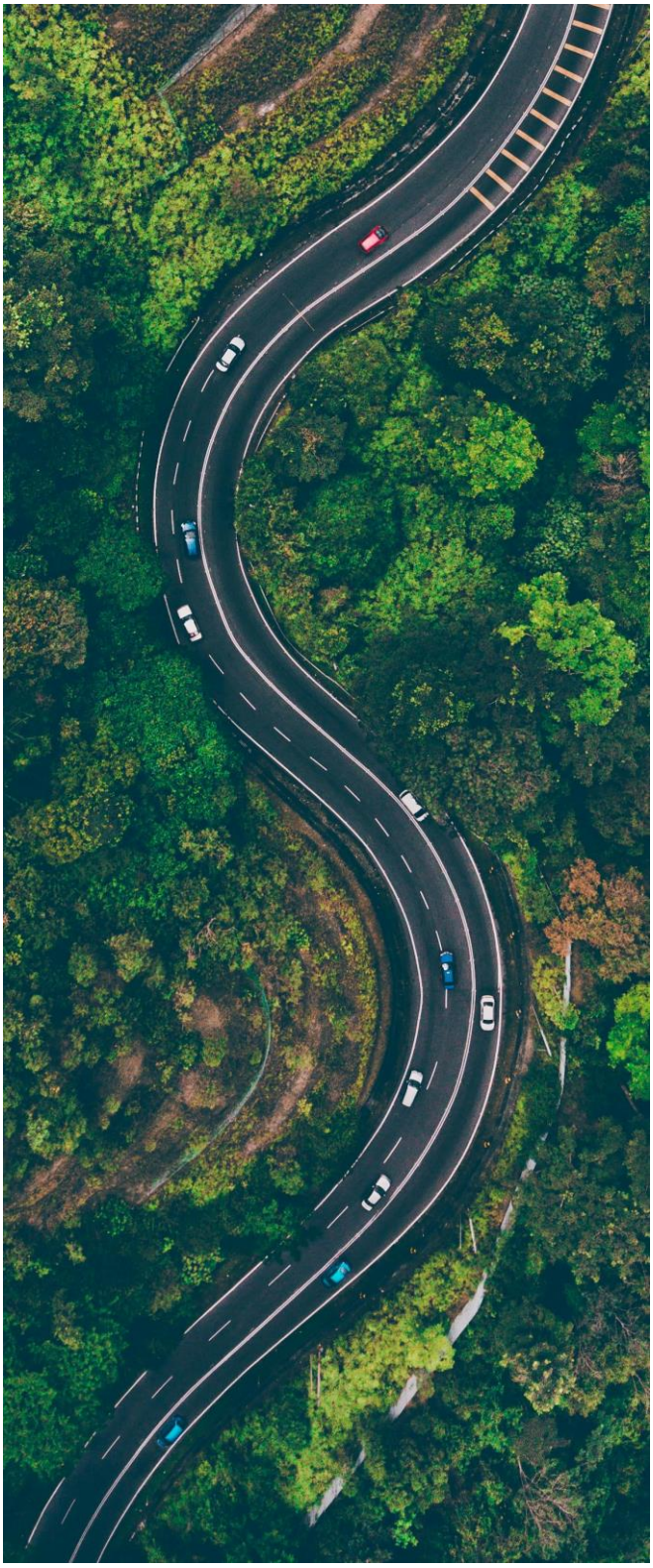
Against a tense geopolitical and supply backdrop, with regulatory requirements tightening across the board, particularly in Europe - Fit For 55 package, carbon neutrality by 2050 - the automotive industry is more than ever facing structural upheaval. From the accelerating mass electrification of vehicle ranges to evolving user habits, all players are affected: traditional manufacturers of all types of vehicle - both private and industrial - becoming suppliers of sustainable mobility, faced with the challenges and new competition of digital technology and China's electrification industry; equipment manufacturers driven by innovation and new features; the industry impacted at every level… The entire automotive sector, which is and will remain fundamental to everyone's mobility, and more broadly the transport sector, must therefore transform, with models to be revamped and considering uncertainties and upcoming instabilities.

Our services

BDO Advisory's teams bring their expertise and strategic vision to industry players undergoing major transformations, from business model changes to new growth drivers: from ad-hoc market studies to validate a technology roadmap to new services analysis, by way of the roll-out strategy for a new product. For years, our work has also relied on the creation and use of mathematical models to support analyses and recommendations. Since 2009, BDO Advisory is therefore a preferred partner of **PFA** (***Plateforme Filière Automobile & Mobilités***) and all its members, thanks to a proven forward-looking model - the World Automotive Powertrain Outlook **WAPO** - a powerful adaptive tool for steering and strategic planning of Light Vehicle markets, at both European and global level. With its recent alter ego for road industrial vehicles - **VIsion'AIR** - which offers forecasts of engine development up to 2040, according to different uses and vehicle categories, BDO Advisory has also become a reference partner of ***Fédération Française de la Carrosserie*** **FFC**.

Glossary

BEV	Battery Electric Vehicle
BOP	Balance of Plant
CNG	Compressed Natural Gas
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
FCEV	Fuel Cell Electric Vehicle
Gasoline HEV	Hybrid Electric Vehicle (Gasoline)
Gasoline MHEV	Mild-Hybrid Electric Vehicle (Gasoline)
Gasoline PHEV	Plug-in Hybrid Electric Vehicle (Gasoline)
GHG	Green House Gas
ICE	Internal Combustion Engine
LCOE	Levelized Cost Of Energy
LCV	Light Commercial Vehicle
LEV	Low Emission Vehicle
LEZ	Low Emission Zone
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LV	Light Vehicle
Gasoline microHEV	micro-Hybrid Electric Vehicle (Gasoline)
OEM	Original Equipment Manufacturer
PC	Passenger Car
PHFCEV High	Plug-in Hybrid Fuel Cell Electric Vehicle with High battery range
PHFCEV Low	Plug-in Hybrid Fuel Cell Electric Vehicle with Low battery range
TCO	Total Cost of Ownership
TtW	Tank-to-Wheel Emission
WAPO	World Automotive Powertrain Outlook
ZEV	Zero Emission Vehicle



Main Findings - Executive Summary

Global Outlook

China and Europe leading the EV transition

The Light Vehicle LV market is undergoing one-of-a-kind transition to reduce the carbon footprint of the transport sector. OEMs, tier suppliers, energy providers and governments are rethinking how to conduct this transition in a turbulent environment of technology changes, behavioral changes, sustainable goals, geopolitical uncertainties and new economic panorama post-COVID.

There are several regions in the world that have been driving the EV transition in the recent past, the lead that they gained is key to understand what drivers are successful to foster EV adoption. Some countries with a high volume or share of EV are supported by policies that help moving the market to electrification.

At a global scale we see that in 2022, EV sales have passed 10% share confirming that the EV transition is advancing. BDO Advisory has developed the tools and knowledge to work on the future of the global powertrain mix with the help of industry experts.

The results of our foresight work show that EV would represent 37% and 54% by 2030 and 2040 respectively of Light Vehicle sales (Passenger Cars and Light Commercial Vehicles).The global mix hides a wide gaps between different areas. China and Europe are the leading markets for EV transition with the highest share of EV by 2030 52% and 41%. By 2040, Europe is the only large market with a highly binding policy to ban all ICE vehicles thus resulting in a powertrain mix composed of EV and Fuel Cell vehicles only.

Powertrains

OEMs have a large palette of technology options

The fuel economy targets and zero emission ambitions from governments have pushed car manufacturers to develop new technologies to reduce fuel consumption and carbon emissions. There are different development strategies adopted with the electric vehicle powertrain being largely diffused. Despite a wide strategy focused on EV, the industry has developed new ICE technologies and fuel cell powertrains. Emerging markets that are reluctant to change to EV technologies will benefit from efforts made to ICE powertrains.

In mature markets, there is a high uncertainty on whether the EV will be able to cover all usages. There are several reasons that will limit the EV adoption such as consumer willingness to buy and access to affordable charging, high demanding usage profiles that require a high-power output or daily usage with high mileage. Some advanced battery technologies might solve some of these issues with higher energy densities, lower costs and overall higher performance. Nonetheless there would be a cluster of individuals or companies not able to make the EV transition who need an alternative solution.

There are other low carbon options available when the EV is not suitable for a specific usage, namely a fuel cell powertrain which also produces zero emission. Fuel cell technology for light vehicles has been introduced since the early 2000s. WAPO has studied new developments on the fuel cell technology that focus on different architectures. We see that such Fuel Cell powertrains could be a good fit for Light Commercial Vehicles, depending on their mission(s).

Main Findings - Executive Summary

The long-term perspective

The future might not be 100% EV

New/recent policy frameworks from several countries include a ban on ICE vehicle sales, to transition from fossil fuels to low emission energies in a speedy manner. There are two main solutions that are not concerned by the ban namely the EV and the Fuel Cell powertrains. Both powertrains do not have tail pipe emissions but they are significantly different in the infrastructures needed, the range provided and component costs.

The choice between these two technologies is today in favor of the EV powertrain because of much lower component and energy costs. By 2035 when the early ICE bans will be fully applied in Europe, fuel cell component costs will have significantly decreased. If the production cost of hydrogen drops too, there will be a case for fuel cell powertrains specially for those high demanding customers: high loads or/and very long trips.

CO_2 emissions

EU LV emission reduction will deal with a large legacy of ice vehicles

A rapid decrease in CO_2 emission from the transport sector is needed to keep global warming below 2°C. The dynamics of the low carbon transition for light vehicles mean that only the most ambitious scenarios are aligned with the climate change objective. In Europe the ICE ban and CO_2 standard facilitates the transition giving a clear objective for the industry. The ICE ban means that by 2050 the renewal of the fleet will translate in a close to zero emissions fleet. What might delay this ambitious goal is how to convert the legacy fleet of ICE vehicles.

There is a growing interest in buying used vehicles due to a lower purchase power and more expensive new vehicles. The consequence in terms of renewing the fleet in use is that older vehicles are still running so that the average age of a vehicle is constantly increasing. There is a risk that this trends continues, and the fleet renewal will happen at a much slower pace meaning that there will be less emissions reduction in the future. We have studied different trends and established a scenario of increased aging of vehicles to quantify this effect.

Electric Vehicle Supply Equipment

In line with a rapid EV adoption, EVSE will need a high speed of deployment

A large EV fleet will require both private and public charging points with high volumes. Even if most users will charge their vehicles at home, public EVSE will be key to mobilize those who do not have access to private charging and those who are away from home. More usage cases will emerge when the base of EV users grows demanding more flexibility in terms of EVSE. It is difficult to estimate how much consumer behavior will adapt to a limited access of EVSE.

We have found that a number of 12,2 M public charging points will be needed in Europe to supply the EV fleet by 2035. This results comes with an assumption that both consumers and operators will develop an optimal use of the infrastructure to allow for lower charging points with a higher occupancy rate for each charging point. This assumption is more significant for high-speed charging.

Methodology

Introduction to the TCO model based on a fine segmented market including the entire ownership scope and market constraints of our forecast approach

BDO approach to evaluate the dynamics of the light vehicle energy transition is based upon a socio-technical economic model which has been developed to reflect the trends on adoption of alternative powertrains. The WAPO is based on this approach with a dedicated framework to cover a worldwide perspective and the differences within regions. The foundation of the model is a logistic function that selects a powertrain upon the total cost of ownership of each powertrain option available for a specific use. The ultimate choice is limited by a set of constraints that cover all sort of barriers such as policy instruments, local restrictions, failure to comply with regulations, lack of compatibility between user and powertrain and lack of OEM offer. The main steps of our methodology are presented below.

1. Customer segmentation

A customer segment depends on:

- the country / area
- the vehicle type
- the mission profile (detailed usages)

Within a customer segment, the market shares of the associated **customer clusters k** are distributed according to the daily and yearly mileage around the mean value using a normal distribution.

2. TCO framework

$$TCO_i = I - Res.Value + \sum_{k=0}^{n} usage\ costs\ (fuel, maintenance\ldots)$$

Calculation of the Total Cost of Ownership (TCO)

for each

Powertrain i x Customer cluster segment k

3. Purchase choice

$$\frac{MSH_i}{MSH_k} = \left(\frac{TCO_i}{TCO_k}\right)^{\alpha}$$

Powertrain Market Share (MSH) based on TCO choice and Market Constraints

for each

Powertrain i x Customer cluster segment k

Market Constraints

TCO arbitration is limited by policy, technology and supply constraints

CO_2 regulation framework

- **Zero** and **Low Emissions sales targets** such as Mandates and ICE bans

> Limit the technology offer to ZEV or LEV only

- **Fuel Economy Policy** applied to OEM in most automotive markets

> Main driver for fuel efficient technologies but does constraint TCO arbitration

Air Pollution Policy

Air Quality standards in most advanced countries are very stringent…

BUT

Developing countries do not have strong air pollutant policies!

The WAPO technology portfolio is limited by the stringency of air pollutant policy. The application of new air pollution policy is gradual, considering the maturity of the market. As a result, the ban of the most polluting technology only occurs late for emerging markets

Taxes and Subsidies

There are fiscal incentives or taxes applied to vehicle purchase and usage depending on a wide range of criteria: fuel type, vehicle body, vehicle length, vehicle weight, engine size, vehicle price, fuel consumption, CO_2 emissions and customer (private or professional use)

WAPO assumes an average vehicle characteristic for each segment, country and powertrain that defines the tax level

Pushing for ZEV sales of every region in the world

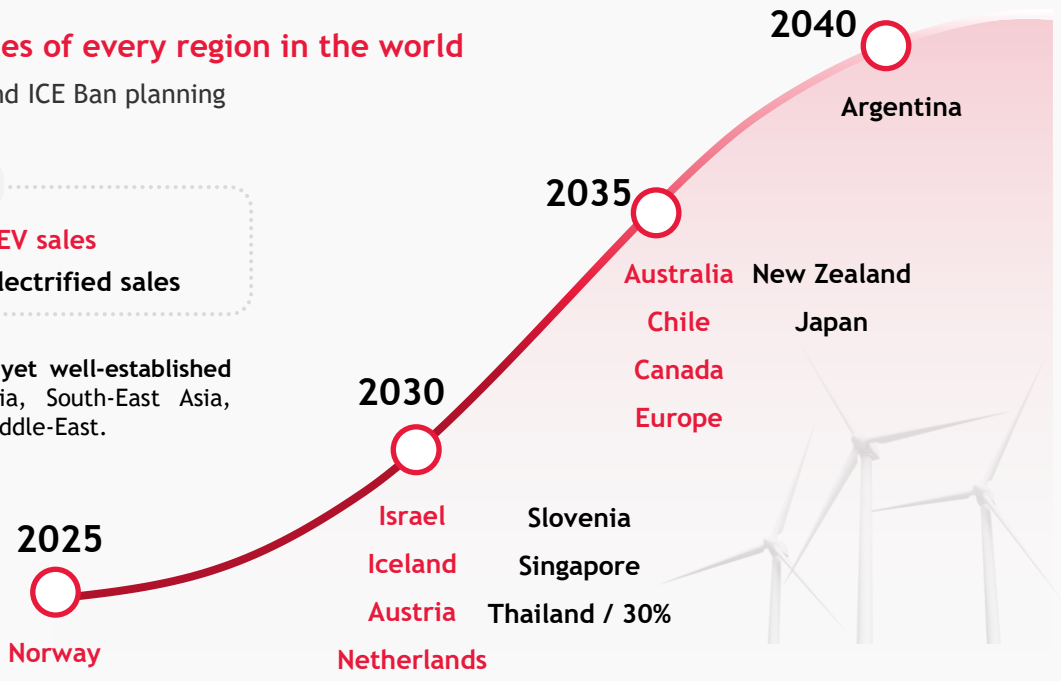
Global ZEV Mandates and ICE Ban planning

Legend

Country with 100% ZEV sales

Country with 100% electrified sales

There are **not yet well-established targets** in India, South-East Asia, Russia or the Middle-East.



Economic Assumptions

Energy cost are constantly evolving with an uncertain geopolitical context

Fossil fuels

All fossil fuels price in the model are based on the oil price evolution. There is a high variability in the oil price today which makes the long-term projection difficult. However, there is a consensus among experts that a long-term oil price considering a decrease in demand by developed countries and an increase in demand by emerging markets will maintain oil price at around 70 to 80 €/barrel. For the final price per fuel type (diesel, gasoline, CNG, LNG) we base the long-term evolution upon change in oil price and in the energy taxes that might evolve to increase the carbon tax or keep the same level as today.

To do so, we have created four scenario that include a variation of economic growth and environmental policy intensity. We present in this keynote the Green Constraint scenario which has a high intensity on environmental regulation and a low economic growth. Each country has a different level of taxes applied to public consumption of fossil fuels.

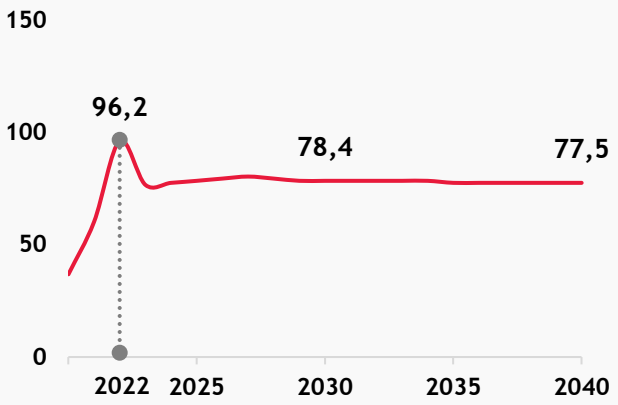
Electricity and H2

Electricity Prices are analyzed according to evolution in the LCOE (levelized cost of energy) that will occur to make the energy transition to renewable energy in the electricity sector. There will be significant investments that will translate in an increase in the LCOE that will drive electricity prices up in the future although the gap will be not as steep and since there is a target of clean energy, we do not have a penalty coming from carbon tax in the future.

As hydrogen cost remains highly volatile and makes the assumption difficult, we have increased the cost compared to previous years based on recent information from experts and publication about higher costs from production costs.

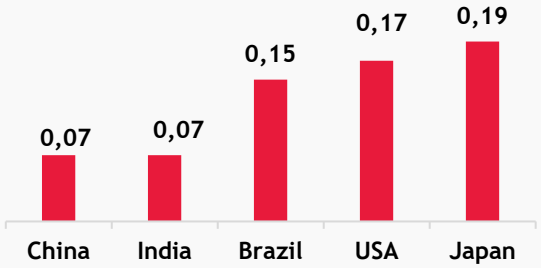
Charging prices final users of EVs is obtained by a combination of usage between private and public charging.

Oil Price Evolution (€/barrel)

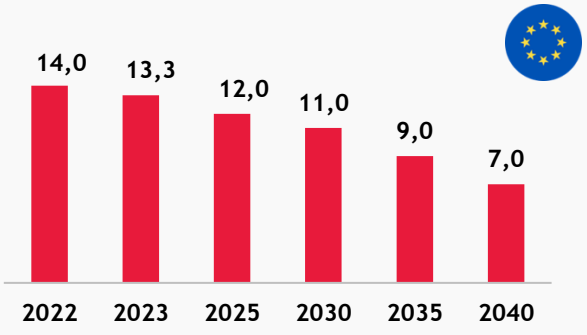


- According to the latest projection reviews, the price of oil is expected to decrease in the next three years and then stabilize
- All other fuel prices, including gasoline, diesel, CNG, LPG, and electricity prices, are correlated with and determined by the projection of oil price

Household Electricity Price in 2023 (€/kWh)



Green H2 price (€/kg)



Vehicle Assumptions

Granular representation of vehicle market with customized powertrain dimensions for each country and segment including trends on key features

Powertrain sizing

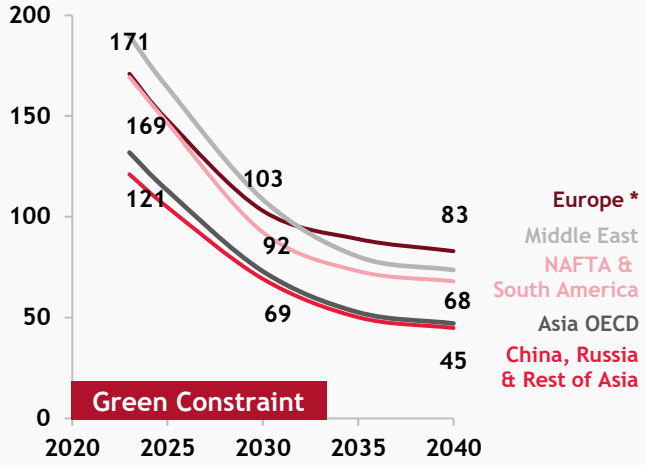
There are two main characteristics defining a vehicle in terms of powertrain: cost and fuel consumption. We can consider a third one for EV, which is its range. Powertrain cost is obtained by the sum of all component costs: engine, energy storage and transmission. There are different types of engines from ICE to electric motor with all hybrid architecture in between as described in the list of the Annex. We consider three types of energy storage systems: fuel or gas tanks, electric batteries and hydrogen tanks. Finally, there are two types of transmissions for ICE vehicles: manual and automatic. Fuel cell vehicles include a four element which is the fuel cell system.

Each powertrain is sized for a given segment using the reference engine power of a segment. Thus, the component size of a powertrain is unique.

Main cost assumptions

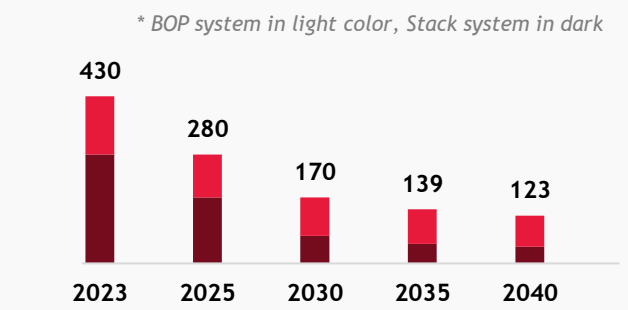
The ICE powertrain is a mature technology that do not involve major change in cost except for the depollution technology to comply with more stringent air policy in the future. Thus, our main focus is on alternative fuel powertrains using electric batteries and/or fuel cell systems. The electric battery price has significantly decreased in the recent past although is remains highly dependent on the cost of raw materials which can be volatile. We have assumed the battery price below for main automotive markets with China having the lowest prices compared to other regions. The fuel cell system has very low volumes which explains the high cost in the near future. For the long term we assume that sufficient volumes drive the technology cost down as seen below. Since there is a high uncertainty of price, we did not make a specific price pear region.

Battery pack evolution price (€/kWh)

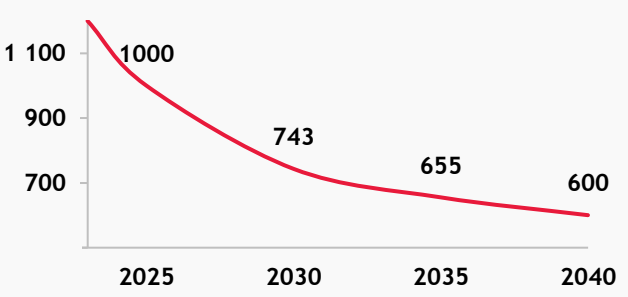


- The **price of batteries is experiencing a long-term downward trend**, primarily due to economies of scale resulting from increased battery production.
- By comparison, the Green Growth scenario estimates a **decrease of 12% in 2030 and 17% in 2040** in comparison to the green constraint scenario.

Price of fuel cell stack & BOP* (€/kW)



Price of H2 fuel tank (€/kW)



Guide to Understand WAPO Results

What is truly driving the powertrain choice?

The key guidelines to understand our results are based on the constraints applied on top of the TCO model. A TCO rationale provides an economic comparison of purchasing options for an individual, these options are limited by specific consumer needs or policy instruments that act on specific powertrains.

Policy Instruments

The ZEV incentives available in most mature markets are key to launch the EV market however they will be phased out in the 2025-2030 period for all countries. Thus, the removal of this aid will decrease the advantage compared to ICE vehicles, but it does not mean that BEV will be more expensive. A BEV will still overall have an important cost reduction in batteries that will keep prices stable. The removal of this aid will slow the EV transition.

Low equipment of EVSE and EV awareness

There is no limitation on BEV to emerge in regions with a lack of charging infrastructure, as in the model, BEV sales are not correlated to the existence of such EVSE. In real life, some buyers are sensitive to the availability of public charging while some others do not determine their purchase choice solely on the availability of public EVSE, because many can access to private charging points at home.

Driving itineraries incompatible with EV

The customer clusters that we described has a fine granular segmentation of clients act also as a compatibility filter on the autonomy range of BEV. Some customer clusters will have highly demanding daily or exceptional mileages that will be incompatible with some or all BEV offer. Only when there is no other powertrain choice left for a given segment in cases such as the ICE ban, consumers must adapt to an EV only offer for all usages.

Regions of the world advance in the ZEV transition at different speeds

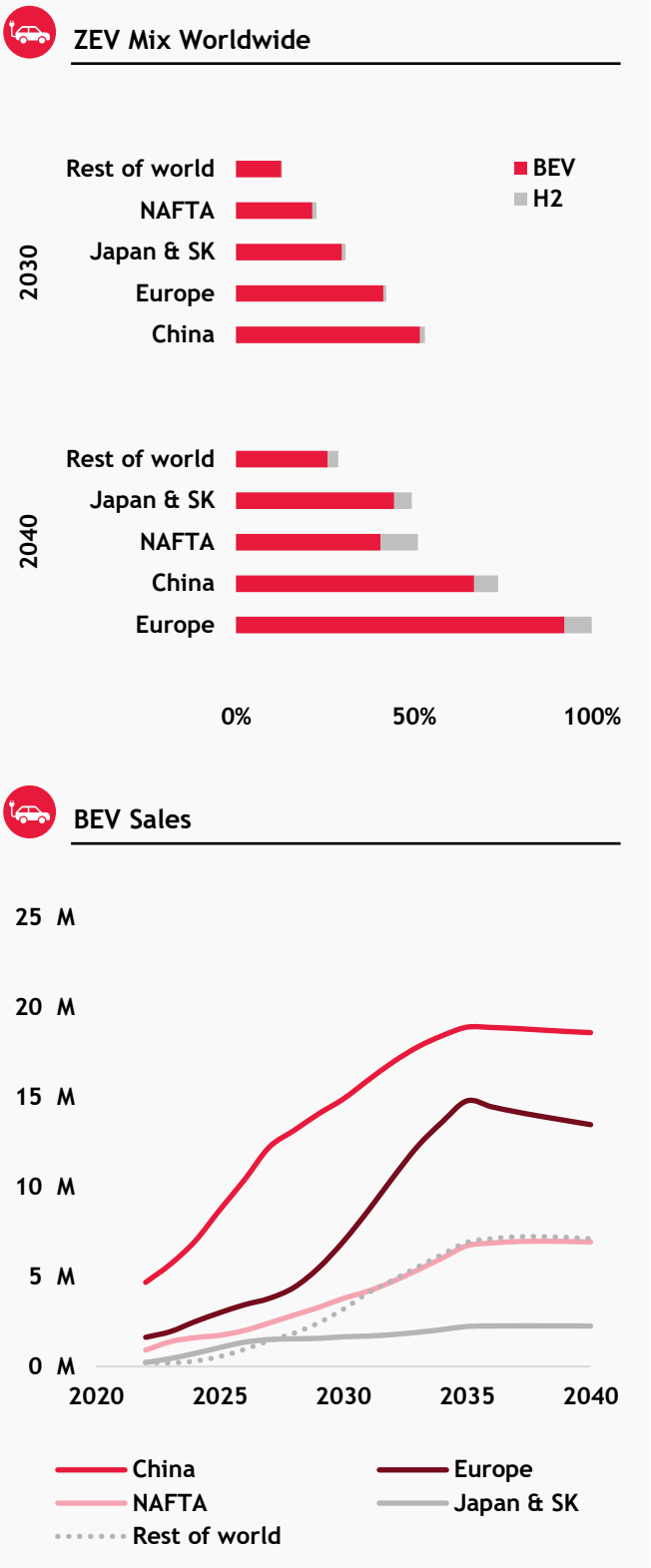
In our Green Constraint scenario, the main automotive markets develop a high share of ZEV sales by 2030. China leads with the largest BEV and H2 numbers. There is a very strong dynamic in China to reach more than half of light vehicles sales with a zero emissions powertrain. By 2030 it is quite uncertain that some other main market catches Chinese momentum on EV. Therefore, North America and Europe need to step up to keep the gap as small as possible with the Chinese market.

By 2040, China remains the top market for ZEVs, with the largest BEV and H2 volumes and potential growth by 2040. However, there is no upcoming ICE ban thus in terms of share there will still be a significant volume of ICE sales. Preparing the ICE ban, Europe will have to exponentially increase EV sales in all countries. Reaching such a goal will be very challenging considering a 2030 share that is around 40%. A future where Europe has a lower EV share by 2030 will compromise the ICE ban.

In North America, the economic advantage of EV depends highly on subsidies and tax credits. Removing policy aids reduces the dynamics and the ZEV mandate becomes the driving force of having high EV share in ZEV mandate states. Therefore, there will be a heterogenous development of EV sale in North America. In all cases the policy targets for the regions will keep EV volumes and share low compared to Europe and China

After the ICE ban, Europe is shifting towards the development of more hydrogen-powered vehicles than electric vehicles having a complete ZEV offer suitable for all usages. North America, where many segments are upper and premium and usage is intensive, develops the highest share and volume of hydrogen vehicles by 2040.

The market may not be exclusively comprised of ZEVs In 2040.Some regions like South America, the Middle East, lag in ZEV powertrain adoption.



Emerging markets showing little signs of a transition in the near future

Slower transition to EV

Emerging markets are reluctant to adopt EV in the near term because there is a lack of incentives in most countries with the exemption of India and there is a cheap fossil fuel with no to little fuel tax. Therefore, the advantage to transition is EV is significantly lower in these regions. If the policies to support EV do not change, there is no clear sign on whether consumer will transition to ICE vehicles without government aids.

Strong market demand for ICE

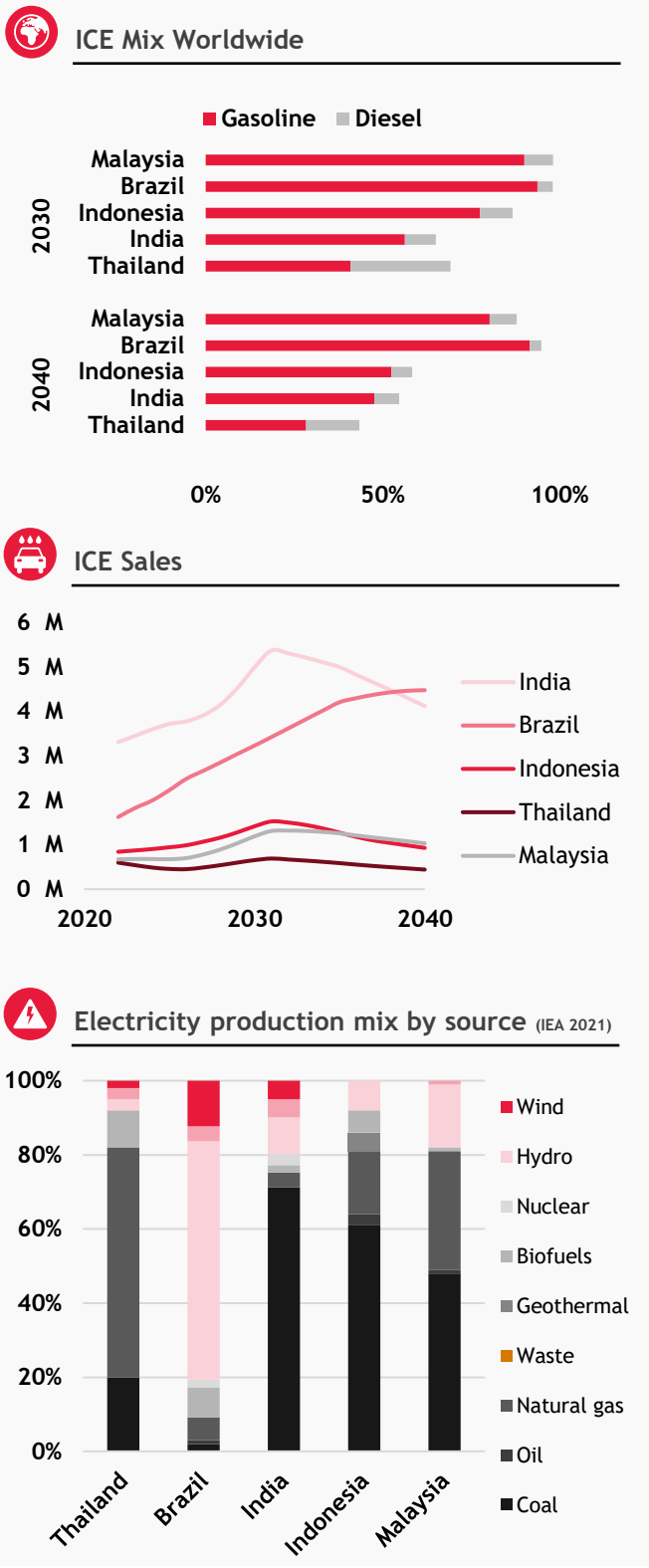
The ICE vehicle demand in emerging countries will keep growing up to 2030. In a scenario where the demographic and economic growth decreases after 2030 we found that the total volume of ICE will remain relatively stable in the 2030-2040. By then some emerging markets will have an advanced EV transition such as India and Thailand.

Electric Grid upgrade required for some countries

There is a less dense and weaker electric grid in these emerging countries which can led to a smaller customer niche capable of installing charging point at home. The work needed to provide a robust grid to everyone is a high barrier to allow everyone to buy an electric vehicle. Thus, the effort of more developed metropolitan areas that provide an adequate ecosystem for EV will be key to push the remaining of the country in the EV transition. As a reminder, the emerging countries have a high concentration of inhabitants in a few very populated urban areas.

Emissions reduction on emerging markets

To make the most of the EV transition in these emerging markets, the energy mix from electricity production will have to be low carbon. Some countries have already a low carbon electricity mix such as Brazil and some other don't thus the Ev transition will be more successful if the electricity mix reduces its GHG emissions as well. The Brazilian automotive industry has developed biofuels such a s ethanol that are widely available for all type of vehicles whereas the main offer of EV is premium imported vehicles. A local an affordable EV offer will be needed to compete with the existing bi-fuel powertrains.

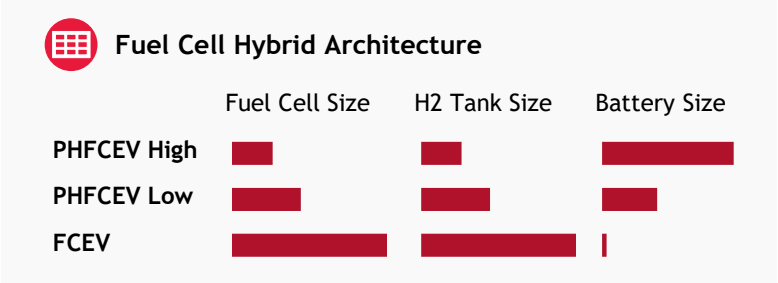


Growing interest on Fuel Cell vehicles

New product developments and foreseeable decrease in component costs open an opportunity from hydrogen-based vehicles for specific niches

Current Status

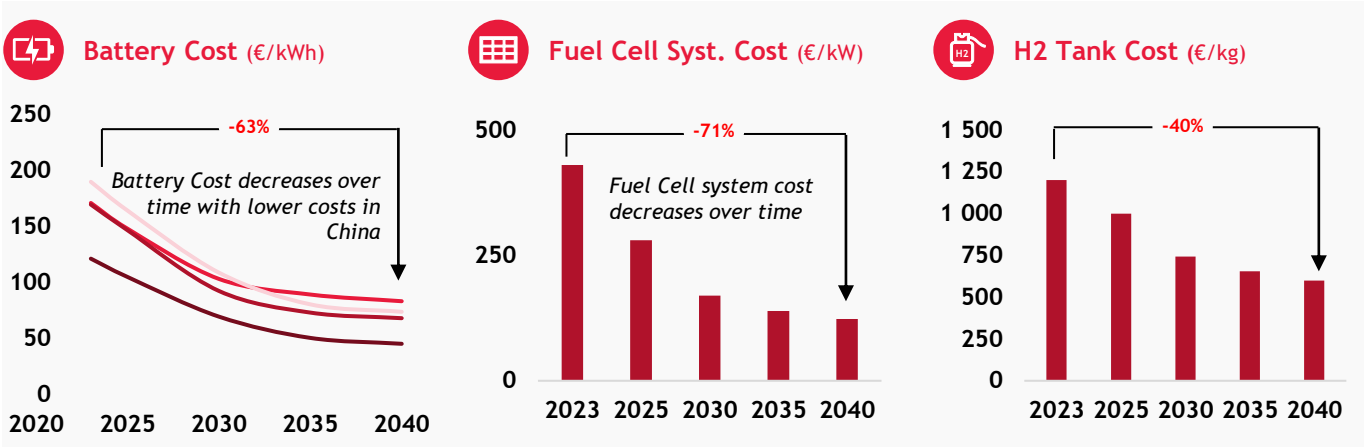
A fuel cell vehicle has been tested for passenger cars and light commercial vehicles in recent years, however there are strong barriers delaying massive diffusion of this technology. The case for passenger cars has been slowed mainly by a premium and high-performance offer of EV with long range and an increasing number of high-speed charging available.



Some highly intensive use of passenger cars such as taxis are now the focus of fuel cell technology. Similarly, light commercial vehicles need high range and have to carry heavy loads requiring a large, heavy and costly battery. For these type of vehicles there is a case for fuel cell technology that has an advantage on range and can allow higher power output with a powerful fuel cell stack. However, there is a large hydrogen tank that can not be reduced despite developing high pressure vessels.

Future developments

OEMs have developed an opportunistic product that has a hybrid approach between a fuel cell powertrain and a battery electric powertrain. We have modelled three different types of architectures that produce different levels of adoption depending on cost curve of key components, energy costs and government subsidies.



Optimal architecture choice

What makes an architecture more attractive in terms of costs is the relative gain that it can benefit from 3 components cost reduction: the fuel cell system, the hydrogen tank and the battery cost. A hybrid technology with a small battery but a large fuel cell stack will be more sensitive to fuel cell cost evolution than a hybrid with a large battery and a small fuel cell stack. Give the uncertainty on both battery, tank and specially fuel cell system there could be a different sweet spot for a given architecture that makes the most of the cost reductions.

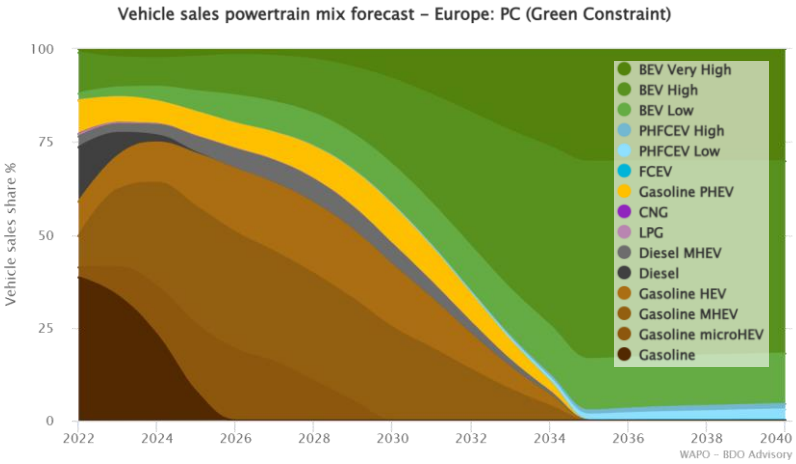
On top of this comparison, the energy cost of electricity and hydrogen follows a very different trend: electricity is going to have a slight increase due to high investments on renewables in the near future whereas hydrogen might have a high decrease from the surge of large-scale projects to produce green hydrogen.

Europe Results in detail

The ICE ban will reconfigure the automotive market in a very short timelapse

Europe EV light vehicle market is today highly subsidized to help consumers buy their first EV. In the near term these schemes will be phased out in favor of taxes on most polluting vehicles. Despite higher taxes for vehicles with high consumptions, the ICE vehicle market do not fall simultaneously. It will significantly change in structure. Mild and full hybrid powertrains will replace the dying Diesel offer on the passenger car segment. Following this early phase of electrification, BEV in Europe experiences a high increase due to 3 main levers:

- Policy schemes for Air pollution from 2026 limiting some ICE technologies and a full ICE ban in 2035.
- A significant decrease on electric vehicle component costs.
- A diverse EV offer with different levels of autonomy and prices



Inside Europe we have different dynamics on EV sales in the 2020s. There are some countries are far ahead of the transition: Norway, Sweden, Iceland, Finland and Denmark; they have started the EV transition sooner than the average European country. Some other countries are lagging behind: for Bulgaria, Poland, Slovakia, Croatia, etc., the ICE ban target will be challenging.

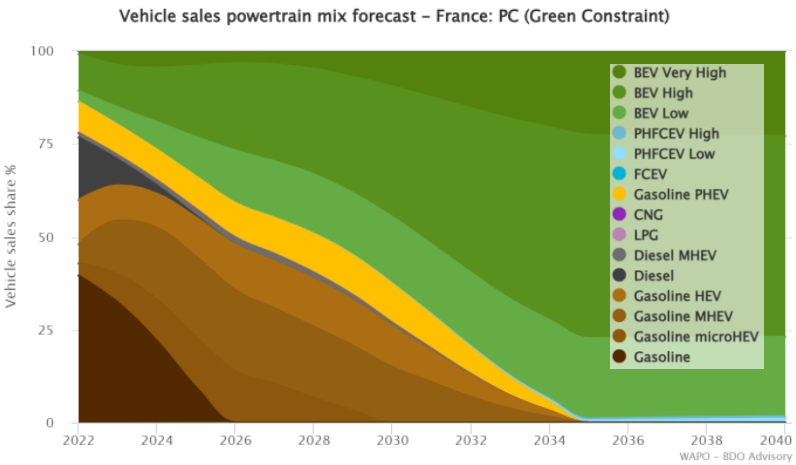
France Results in detail

The French feebate scheme and attractive energy prices allow a smoother transition to ZEV sales by 2035

The adoption of EV in France might happen faster than the average European country for 3 reasons:

- A bonus-malus scheme that is taxing heavily high emitting vehicles combined with a bonus applied to zero emission vehicles that is making EV affordable
- A comparative energy price that favors electricity. The fuel price of gasoline and diesel due high levels of taxes.
- A LEZ restriction on first diesel and then the most polluting Ice vehicles in urban areas that will prohibit the usage of some powertrains in city centers.

The segment composition in France with many C and B segment volumes make the EV affordable for most buyers. The current product line develop by European OEMs in these segments will help achieve a mass market adoption of EV.



The ICE powertrain outlook in France follows the extinction of Diesel offer for passenger cars replaced by Gasoline Hybrids.

Europe's Light Vehicle Emissions

$$\text{CO}_2 \text{ of light vehicles} = \sum_i \text{Fleet in Use} + \text{Vehicle mileage} + \text{Vehicle energy efficiency} + \text{Energy carbon intensity}$$

CO_2 of light vehicles	Fleet in Use	Vehicle mileage	Vehicle energy efficiency	Energy carbon intensity
The carbon emissions of the entire fleet of light vehicles	Number of vehicles in use (veh)	Vehicle usage specific for each segment and age (km/veh)	Efficiency of powertrain, fuel type, vehicle size (kWh/km)	Carbon factor in TtW scope= tailpipe emissions (gCO_2/kWh)

CO_2 Reduction effects

1. **Renewal of old vehicles**

   Powertrain mix is closer to new vehicle powertrain sales than older mix due to the survival rate.

2. **More frequent use of low emission vehicles because they are newer**

   Mileage reduces with vehicle ageing amplifying new vehicle usage from low emission powertrains on overall mileage.

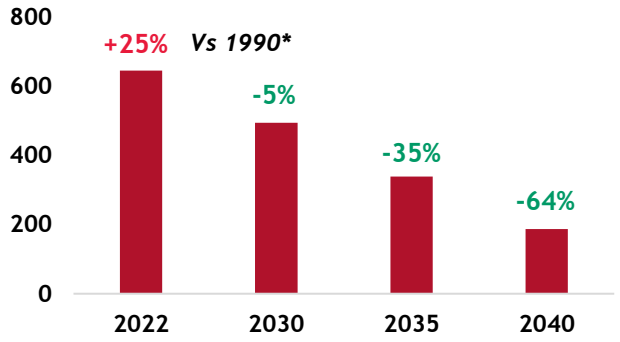
3. **In Tank-to-Wheel scope, the emission factor for ZEV is 0**

   Both BEV & Fuel Cell powertrain do not contribute to tail pipe CO_2 emissions despite having positive energy consumptions.

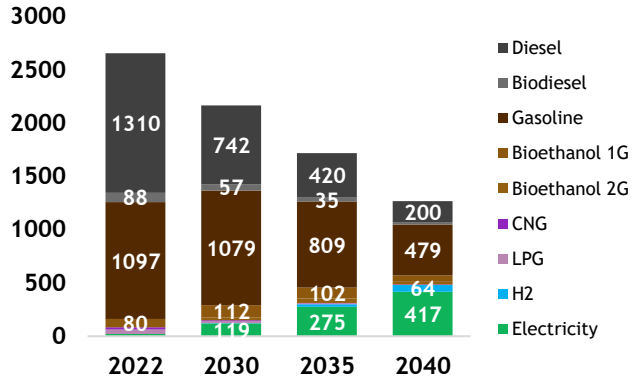
4. **Lower consumption of new ICE vehicles**

   Fuel consumption from future ICE vehicles includes some improvement mainly due to hybridization

CO2 emissions TtW - fleet (PC + LCV)
In MtCO2 - Green Constraint



Energy demand forecast - fleet
In TWh - Green Constraint



incl. and	2022	2030	2035	2040
LV fleet	333 M	308 M	302 M	294 M
PC fleet	293 M	260 M	256 M	252 M
BEV+H2	4 M	34 M	93 M	156 M

**Volumes détaillés disponibles sur la plateforme WAPO Analytics, onglet "Vehicle fleet"*

*** Référence 1990 (EU 27 + UK) : émissions totales 519 Mt, source : Eurostat / EEA*

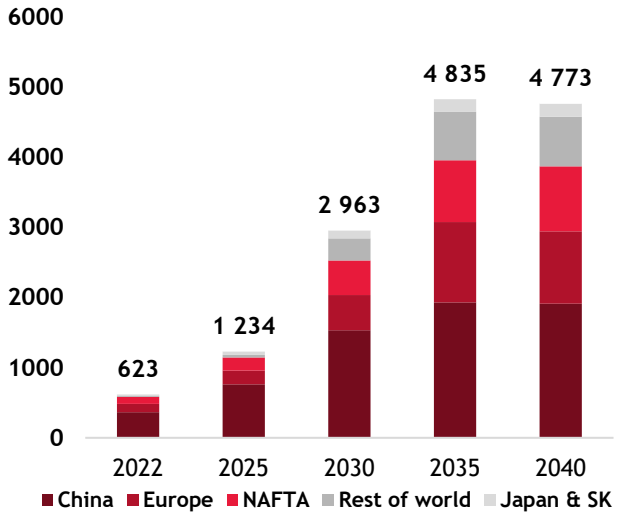
EVSE & Battery Demand

Battery demand may reach 4,8 to 5,5 TWh worldwide

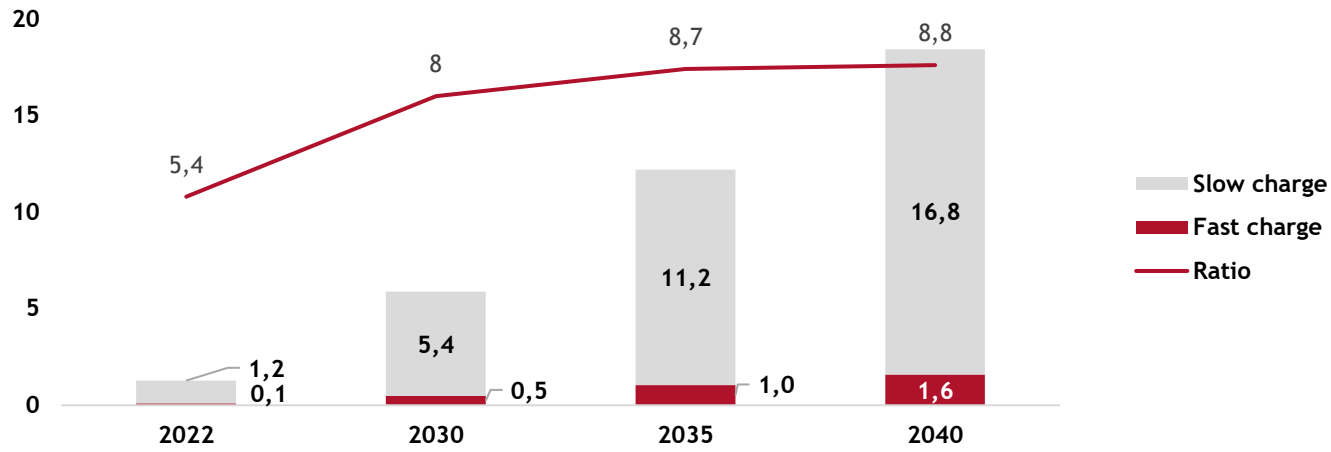
High Volumes of EV Sales mean that the battery demand will exponentially increase by 2030 and stabilize by 2035, most of the demand is located in China and will still be the main market in 2040. Unlike China, all other regions in the world do not have the same capacity of producing large volumes of passenger car batteries. A challenging future awaits the European and American battery industry to be able to compete with Chinese battery producers.

With a global demand reaching 5 TWh of battery production, there will be a high pressure on raw materials demand. Despite important developments on battery technologies that are now capable of using different battery materials, there still a deficit of raw material extraction that is urgent to anticipate to avoid shortages and a spike on mineral price as seen in the post pandemic battery market. The equilibrium of mineral demand and battery demand will be key to the success of EV.

Battery demand wordwide
In GWh - Green Constraint



Public charging point needs forecast (In Millions, Europe - Green Constraint)



The growing electric fleet in Europe through the next two decades will require a never seen effort on infrastructure. In terms of public charging points the number of charging points must be 13 times more than the number of charging points existing today.

Despite a higher occupancy rate per charging point the volume of charging points keep increasing. In the future with a higher share of long rage EV, there will be a higher need for fast charging.

Conclusion /Last Words / Next Steps

This WAPO report presented by BDO Advisory and PFA shows the diversity of conditions that lay ahead the EV transition in the world. Some regions have a very favorable setup to have a rapid and smooth transition to EV whereas some other regions do not show signs of upcoming changes and could be far behind such transition to EV. The automotive industry must adapt to both conditions: on the one hand, delivering an ever-strong market demand for ICE vehicles; on the other hand, developing new electric powertrain technologies that will transform all stakeholders, industry players as well as end users.

At BDO Advisory, we are thrilled to work in this rapidly-evolving environment, supporting the French Automotive Industry through data and in-depth analyses, and make our partners better prepared for the upcoming challenges. Our work and approach have a very fine structure, allowing each stakeholder to also focus on its own specific matters of interest. Our goal is to provide both a macroscopic view of how the market transition will unfold, but also a more pragmatic grasp of current and projected market changes in smaller, more specific areas.

Our roadmap for the next WAPO release is focusing on the potential gaps in the characterization of the customers' nature that go beyond the economic rationale and are slowing down their switch to EV. This ongoing work is dedicated to the identification of the main customer aspects that matter the adoption of an EV and its purchase.

Annex – Data for Europe and France

Scenario: Green Constraint
Area: Europe
Category: PC

Year	BEV	Fuel Cell	PHEV Gasoline	CNG & LPG	Diesel All	Hybrid Gasoline	Non Hybrid Gasoline	Total
	Units/ Market Share in %							
2025	2 499 749	210	961 057	19 971	664 361	9 424 088	1 123 486	14 692 922
	17%	0%	7%	0%	5%	64%	8%	
2030	6 155 233	58 871	1 513 322	11 061	806 340	6 131 130	-	14 675 957
	42%	0%	10%	0%	5%	42%	0%	
2035	13 298 900	365 986	-	-	-	-	-	13 664 886
	97%	3%	0%	0%	0%	0%	0%	
2040	12 170 652	569 952	-	-	-	-	-	12 740 604
	96%	4%	0%	0%	0%	0%	0%	

Scenario: Green Growth
Area: Europe
Category: PC

2025	2 763 042	279	983 291	19 932	648 436	9 051 577	1 111 476	14 578 033
	19%	0%	7%	0%	4%	62%	8%	
2030	7 709 991	163 068	1 369 627	8 739	684 830	4 691 576	-	14 627 831
	53%	1%	9%	0%	5%	32%	0%	
2035	13 313 845	492 191	-	-	-	-	-	13 806 036
	96%	4%	0%	0%	0%	0%	0%	
2040	12 267 352	703 567	-	-	-	-	-	12 970 919
	95%	5%	0%	0%	0%	0%	0%	

Scenario: Green Constraint
Area: France
Category: PC

Year	BEV	Fuel Cell	PHEV Gasoline	CNG & LPG	Diesel All	Hybrid Gasoline	Non Hybrid Gasoline	Total
	Units/ Market Share in %							
2025	725 208	7	187 171	2 167	47 061	980 538	200 664	2 142 816
	34%	0%	9%	0%	2%	46%	9%	
2030	1 315 792	5 043	218 058	1 074	18 708	543 559	-	2 102 234
	63%	0%	10%	0%	1%	26%	0%	
2035	1 927 887	20 479	-	-	-	-	-	1 948 366
	99%	1%	0%	0%	0%	0%	0%	
2040	1 777 733	30 857	-	-	-	-	-	1 808 590
	98%	2%	0%	0%	0%	0%	0%	

Scenario: Green Growth
Area: France
Category: PC

2025	745 734	12	183 544	1 890	40 333	952 653	201 897	2 126 063
	35%	0%	9%	0%	2%	45%	9%	
2030	1 509 770	11 037	179 769	818	13 046	380 899	-	2 095 339
	72%	1%	9%	0%	1%	18%	0%	
2035	1 941 685	26 806	-	-	-	-	-	1 968 491
	99%	1%	0%	0%	0%	0%	0%	
2040	1 801 377	39 910	-	-	-	-	-	1 841 287
	98%	2%	0%	0%	0%	0%	0%	

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