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EcoMobility

FOR A SUSTAINABLE SOCIETY WITH INTELLIGENT MOBILITY SOLUTIONS

D7.8 Market Study

Harokopio University of Athens, Greece

July, 2023

Deliverable	**D7.8 – Market Study**
Work Package(s)	WP7 – Standardisation, Exploitation and stakeholders relation
Task(s)	T7.1 – Strategies for impact via effective communication, dissemination and exploitation
Dissemination Level	Restricted
Due Date	31-7-2023
Actual Submission Date	
WP Leader	Innovation Disco
Task Leader	Innovation Disco
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Document History			
Revision	**Date**	**Author(s)**	**Description**
V0.1	15-05-2023	Konstantina Karathanasopoulou, George Dimitrakopoulos, Elena Politi (HUA)	Document structure initialization, Editing
V0.2	19-05-2023	Konstantina Karathanasopoulou, George Dimitrakopoulos, Elena Politi (HUA)	Sections 1 and 2
V0.5	31-05-2023	Konstantina Karathanasopoulou, George Dimitrakopoulos, Elena Politi (HUA)	Editing
V0.7	31-6-2023	Konstantina Karathanasopoulou, George Dimitrakopoulos, Elena Politi (HUA)	Editing
V0.8	25-7-2023	Konstantina Karathanasopoulou, George Dimitrakopoulos, Elena Politi (HUA)	Editing
V1.0	31-7-2023	Konstantina Karathanasopoulou, George Dimitrakopoulos, Elena Politi (HUA)	Final Review

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This project has received funding from the European Union's Horizon Europe Research and Innovation Programme under Grant Agreement No 101112306.

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1 Executive Summary

The ***EcoMobility*** project aims to achieve a sustainable value chain and enabling technologies for door-to-door mobility of people and goods based on customized autonomous vehicles with agile life cycle management for continuous evolution of services and improved safety, security, efficiency and ecology. To realise this vision, **EcoMobility** will provide the appropriate methodology and tools for highly automated vehicles as well as for new business models for a new continuous deployment of in-vehicle and cloud-based services to address the technology gaps, which allow for introduction of new user functions on a frequent basis.

In light of the above, the present deliverable provides the baseline for the exploitation of the ***EcoMobility*** market analysis as well as its segments for the automotive industry with focus on the needs and requirements of consumers and relevant stakeholders. Specifically, it documents the financial and market parameters of the ***EcoMobility*** ecosystem through an in-depth analysis of the electric and autonomous vehicle market size and current trends, and determines the key drivers, the attractivity and the profitability of the market, its submarkets currently and in the future, while providing a holistic business model and key drivers of the European automotive industry. It also underlines the key digital technologies that are identified as facilitators for the further adoption of autonomous vehicles, electric vehicles and related services in the global economy and are expected to substantially alter the business and social environment of the automotive industry.

The results of this analysis aim to (a) to provide an integrated business model, (b) to identify the key financial challenges in the automotive industry and (c) to deliver a productization plan for the post project phase. Finally, this document provides valuable input in the work undertaken within the context of Task *7.5 Market study and Exploitation and* accommodates the initial groundwork to identify constraints in developing new business models within the framework of the ***EcoMobility*** project.

2 Introduction

2.1 Introduction - Purpose of this document

The present deliverable documents the efforts undertaken towards the definition of the ***EcoMobility*** market and market segment analysis in the frame of Task 7.5 - Market study and Exploitation. The objective of this deliverable is to provide an in-depth analysis of the market, offering the ***EcoMobility*** project consortium valuable information on changes in the economy, existing competition, current market trends, and patterns of potential customer spending in the targeted market.

Additionally, this deliverable will serve as a foundation for planning the utilization of the ***EcoMobility*** project outcomes and establishing the necessary agreements for exploitation among consortium partners.

Furthermore, it will aid in identifying future market opportunities and threats, growth markets, areas lacking sufficient market presence, and high-potential segments.

2.2 Definitions

Definitions, Acronyms, Abbreviations	Meaning
ACC	Adaptive cruise control
AI	Artificial Intelligence
BEVs	Battery electric vehicles
CAGR	Compound annual growth rate
CAGR	Compound annual growth rate
CAVs	Connected and Autonomous Vehicles
CO2	Carbon dioxide
DARPA	Defence Advanced Research Projects Agency
EVs	Electric vehicles
FCW	Front collision warning.

GPS	Description
GWh	Gigawatt-hours
ICE	Internal combustion engine
IoT	Internet of Things
km	Kilometers
kWh	Kilowatt-hours
LCA	Lane change assist
LDVs	Light-duty vehicles
LDW	Lane departure warning
LEVs	Light electric vehicles
MaaS	Mobility-as-a-service
OEMs	Original equipment manufacturers
PDC	Park distance control
PHEVs	Plug-in hybrid electric vehicles
PMT	Private motorized means of transport
UGVs	Unmanned ground vehicles
V2G	Vehicle-to-grid
V2V	Vehicle to Vehicle

SDGs	Sustainable Development Goals
SUV	Sport utility vehicle

Table 1: Definitions, Acronyms, Abbreviations

2.3 Applicable Documents

AD1: ECOMOBILITY Grant Agreement

2.4 Document Structure

The structure of this deliverable is as follows:

- Section 2 provides an overview of the digital technologies that are available for connected and shared, electrified mobility.
- In Section 3 an analysis of the market of autonomous vehicles, as well as the factors that drive current market trends is presented.
- Section 4 gives an overview of the global market trends as well as the market segmentation for electric vehicles.
- Section 5 underlines the approach of ***EcoMobility*** to the current trends in mobility and the automotive industry.
- In Section 6 the work within ***EcoMobility*** is linked with the identified markets and their segments, so as to pave the way for future project results exploitation.
- Finally, Section 7 concludes with the results and finding of this analysis.

3 Digital technologies for Connected, Autonomous, Shared and Electrified vehicles

3.1 Overview

Digital technologies play a vital role in the advancement and functioning of autonomous electrified vehicles. These technologies are responsible for enabling vehicle automation, connectivity, and electrification, which ultimately result in improved safety, efficiency, and user experience. Various digital tools such as autonomous driving systems, vehicle-to-vehicle and vehicle-to-infrastructure communication, EV charging infrastructure, battery management systems, and data analytics with machine learning contribute to the seamless operation of these vehicles.

Table 2 depicts an overview of the technological trends in electrification and automation that have reshaped the automotive industry as a whole at different innovation levels.

Table 2: Overview of technological developments for the electrified automotive industry

Innovation level	Technological trends
Vehicle innovations	○ Car connectivity ○ Autonomous driving ○ Battery Technologies ○ Energy intelligence
Production innovations	○ Smart factories ○ Industry 4.00 applications ○ EV Charging Infrastructures ○ Thermal Management Systems
New business models	○ After sales services ○ New car-ownership models ○ On-demand mobility services

Source: The digital innovation landscape[1]

Vehicle innovations refer to technological developments of the vehicle itself. Car connectivity features are enabled by technological advances in ad-hoc wireless networks, while vehicles are equipped with in-cabin and outside-cabin monitoring systems that perform real-time collection and processing of data that is shared and connected to other vehicles. This allows safer, greener, and more efficient road mobility, as well as the development of new services, such as automated emergency calls in case of an accident, real-time warnings of hazards, and optimal trajectory planning.

Autonomous driving relies on sensors, such as the global positioning system (GPS) and LiDAR installed in the vehicle that allows the perception of the surrounding environment. Sensors can record the position of the car and review other elements of traffic around the vehicle. The rapid developments in the possibilities of vehicle automation offer promising future prospects.

With the constantly growing demand for customized battery packs, startups further apply engineering analytics to cut development costs. In response to sustainability requirements, innovators are exploring battery chemistries that eliminate the use of heavy metals such as cobalt and cadmium. Thus leading startups to implement battery recycling or disposal practices to minimize environmental impact. All of these make innovations in battery technology a critical trend for widespread electrification.

Highly automated electrified cars feature electronic sensors, controls, and actuators along with software for data processing and computations that enables vehicle performance optimization, EV charging, and infrastructure maintenance. This leads to predictive analytics solutions based on data analysis techniques like machine learning and predictive modeling to manage large volumes of data which enable high-throughput data generation, gathering, and processing. [2]

Production innovations including technologies like connected robotics, data analytics, or high-performance computing in the area of smart factories and Industry 4.0 reshape the production processes and manufacturing of vehicles.

Highly automated and, most importantly, autonomous driving, brings about innovative applications for all involved stakeholders. Let it be noted that if we go back to its fundamentals, autonomous driving had been coined in order exactly to design, provide and also facilitate several (at that time) revolutionary applications.

Autonomous vehicles first appeared in the 1980s, with the first Navlab and ALV creations by Carnegie Mellon University in 1984 and the EUREKA Prometheus project, from Mercedes-Benz and the Bundeswehr University of Munich in 1987.

The Navlab is a series of autonomous and semi-autonomous vehicles developed by the team of the Robotics Institute in its Department of Computer Science at Carnegie Mellon University. The Navlab team builds robot cars, lorries, and buses capable of autonomous driving or driver support. The team has created a series of 11 vehicles from Navlab 1 to Navlab 11. The Navlab 11 is a Jeep Wrangler robot equipped with a wide variety of sensors, short and medium range as well as obstacle detection. Its functions include collision prevention and driver support for maneuvering in crowded areas of the city. Ongoing teamwork includes pedestrian detection and vehicle control area.

Eureka PROMETHEUS (1987-1995) is an important research project and development in the field of autonomous driving. Received funding of € 749 million of EUREKA Member States and determined its evolution technology of autonomous vehicles. Many universities and manufacturers of cars took part in this pan-European project on 18 October, in 1994 in Paris.

In this respect, the sections below seek to provide a structured view of applications that spring from the advent of autonomous driving, related to safety, emergency management, traffic flow, infotainment, etc., creating a more information-rich environment for drivers. Examples include reconfigurable driving styles, lane-keeping systems, variable speed limits, dynamic traffic light sequences, and collision avoidance systems.

Recently the EV charging Infrastructure have significant improvements in charging time and affordability affecting positively the adoption of electrified vehicles. Charging infrastructures equipped with high-wattage and ultra-fast chargers can substantially increase a vehicle's range within a matter of minutes.Furthermore, the charging infrastructures are equipped with inductive charging that enables wireless charging. The wireless energy transfer integration of vehicle-to-grid (V2G) technology at a charging station.

In respect of production innovations, the thermal management system that has been developed is crucial for electric devices to ensure their optimal performance and efficiency.The thermoelectric cooling system dissipates excessive heat from the electrical components and devices, maintaining batteries, power electronics, and electric motors at optimal temperatures.

3.2 Technological ´´pathways´´

The development of technology and automation systems is rapid and this brings the transition to autonomous vehicles and autonomous driving closer than expected. There are two technological alternatives for this transition, namely (a) the gradual evolution of traditional vehicles towards higher levels of automation, as well as (b) a radical technological change, which will lead to the short-term development of urban mobility through automated vehicles. The above two technological alternatives can be implemented through three ´´pathways´´, which are based on existing systems and technologies used today and commercially (at levels 0 and 1) and include:

a. No automation systems (level 0)

Those systems include (i) Lane change assist LCA, park distance control PDC, lane departure warning LDW, as well as front collision warning FCW.

b. Driver assistance systems (level 1)

Those systems include (i) adaptive cruise control (ACC) (adjustment of the speed in relation to the vehicles moving in front of him, using a sensor), (ii) ACC together with the stop and go function (maintaining a safe distance by automatically applying the brakes and decelerating), (iii) lane keeping assist LCA (a system that is automatically usually above 60 km/h, detecting the markings of the lanes and keeping the car within the markings, as well as (iv) park assist PA (essentially parking the vehicle alone without the intervention of the driver, after having found the available space).

The urban mobility pathway

This pathway mainly includes low-speed vehicle types, fully automated but with limited functions, which can mainly appear in urban areas. Such highly automated systems have developed in a few areas or in specially designed facilities. This will be the basis for increasing speed and the need for fewer changes in road infrastructure in the future [3].

The private vehicle pathway

This pathway leads from the existing systems that currently exist in the market, towards full automation through successive steps.

The automated trucks pathway

The development of the automated trucks pathway includes squads of trucks or road trains (truck platoons). These squads will be able to include not only trucks or vehicles only but also a combination of both.

3.3 Examples

To better understand the above technological development in the field of connected, autonomous, and shared vehicles, some examples are given with the applications of this technology.

a. Road works and parked vehicle zone warning

Although usually road projects are adequately signaled, data exchange between them and the car-carrier will transfer information to the driver in a timely manner on the distance, the speed to be observed, and even their length of work. Additionally, in the event of a traffic jam, you may provide estimates of the time required to cross them. Respectively, the system will be able to perceive parked vehicles in dangerous places, such as when cornering, updating again the driver through the corresponding, visual warning signals.

b. Giving priority to intersections

Either due to lack of visibility or due to carelessness of drivers, the violation priority at intersections is one of the leading causes of accidents. Thanks to V2V technology, vehicles perceive each other in time, a lot before making eye contact. In case the drivers do not comply with existing signage and move, without slowing down, on a collision course, the system automatically undertakes to warn them, visually and audibly signals. If they still do not react, then he will immediately take the initiative, interfering with the brakes of one or both vehicles, depending on the occasion.

c. Collision warning with a vehicle in front

A sharp braking of the vehicle in front automatically puts it to the test the reflexes of the guides that follow, while it may prove particularly dangerous when safety distances are not observed, in case of bad weather conditions, limited visibility, or at night. All cars equipped with the V2V system can perceive one situation at a distance of at least 300 meters, informing them in a timely manner their drivers. This also applies in cases where a fast-moving car moves in the same lane as a slower one. If the second driver does not change lanes, nor slow down, a visual signal, combined with some vibrations coming from the base of his seat draws attention.

d. Cooperation with emergency vehicles

The passage of emergency vehicles in conditions of increased traffic is enough problematic, as many drivers do not realize their presence in time and, therefore, delay in reacting. Through V2V technology the car will immediately inform the driver of their location and course ambulances, patrol cars, and fire trucks, transporting him in addition to "Move to the right" or "Open way between second and

third lane ".

e. Blind spot control / Lane change

An important function of the V2V system is that of switching support lanes. When two cars move in parallel, a short distance from each other, an optical signal near the corresponding side mirror warns proactively the leading driver. If now he does not realize it or ignores it and attempts to pass in the lane of the other car, immediately the signal begins to flash, while at the same time, a vibration on the right or depending on the left side of his seat draws attention.

4 Market analysis of Autonomous (highly automated) vehicles

4.1 Overview

Although the traditional automotive industry still plays an important role in the global economy, a number of challenges are changing production processes as well as vehicles themselves, forcing traditional carmakers and suppliers to adapt their business models. New players entering the automotive market, customers demand new services, and digital transformation creates new concepts like car sharing, connected cars, and autonomous driving.

Recent advancements in the vehicle industry have paved the way for the advent of Connected and Autonomous Vehicles (CAVs), changing the production process and the overall use of vehicles. CAVs are self-driving cars that require little assistance from the driver while being able to connect to external networks, whether for communication with other vehicles, infrastructure, or general information provision[1]. In comparison to human-driven vehicles, CAVs can achieve a wide range of benefits to end users such as cost savings, traffic congestion reduction, and improved road safety. As such, it is expected that CAVs will constitute a potential game-changer in the automobile industry.

The market for CAVs has been evolving, enabled by the development of digital technologies, such as smart sensors/computer vision, Robotics/Artificial Intelligence (AI) and high-performance computing, connectivity, and global positioning/HD maps technologies.

As per the Research Report published by Strategic Market Research, as of 2021, the global Autonomous vehicle market size was $25.14 billion, growing at an AGR of 25.7%, and it was forecasted to have a value of approximately $196.97 billion by 2030 [4]. In addition, the automotive sector provides direct and indirect jobs to 13.8 million Europeans today, representing 6.1% of total EU employment, while it is expected that autonomous vehicles will play a crucial role for the EU in seizing the opportunity of creating new jobs and generating profits of up to €620 bn by 2025.[5]

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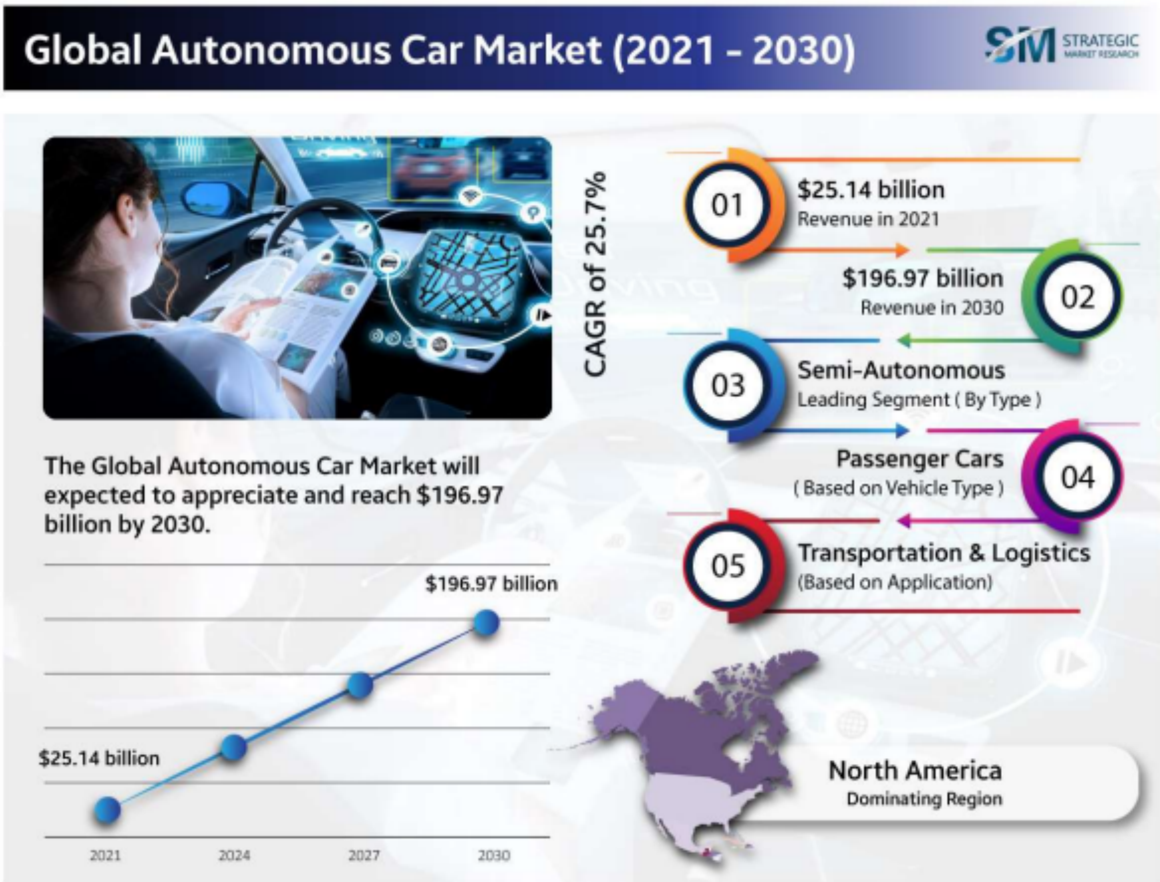

Figure 1 Global autonomous vehicles market

An autonomous car integrates multiple navigation and sensing technologies (high-definition cameras, LiDAR, GPS), artificial intelligence, and radar to travel across various places without any human operator. Autonomous vehicles can operate without any human interference and can use high-definition geospatial and street-level data to recognize their surroundings. Audi, Google, BMW, Ford, Tesla, General Motors, Volkswagen, and Volvo are among the companies testing and developing autonomous vehicles. What's more, the future AV market is evolving through inter-industry alliances and technological acquisitions across the globe, with IT leaders like Apple and Google, and Asian technology giants like Baidu, Softbank, and Tencent consolidating inter-firm networks of collaboration and competition with automaker incumbents such as General Motors, Daimler, and Ford.

Autonomous Car Market Insights:

- On the basis of type, the semi-autonomous segment held a significant position in the worldwide market.
- The passenger car segment ruled the overall autonomous car market in terms of vehicle type.
- In 2021, the transportation segment ruled the overall market with a revenue share of nearly 93.8% on the basis of application.
- North America ruled the overall market with the highest market share of about 45% in 2021 by region.

The industry's global dependence and complexity have grown substantially. The total value of the flow of automotive goods around the world, including motor vehicles and vehicle components, increased by 13 times since 1990.

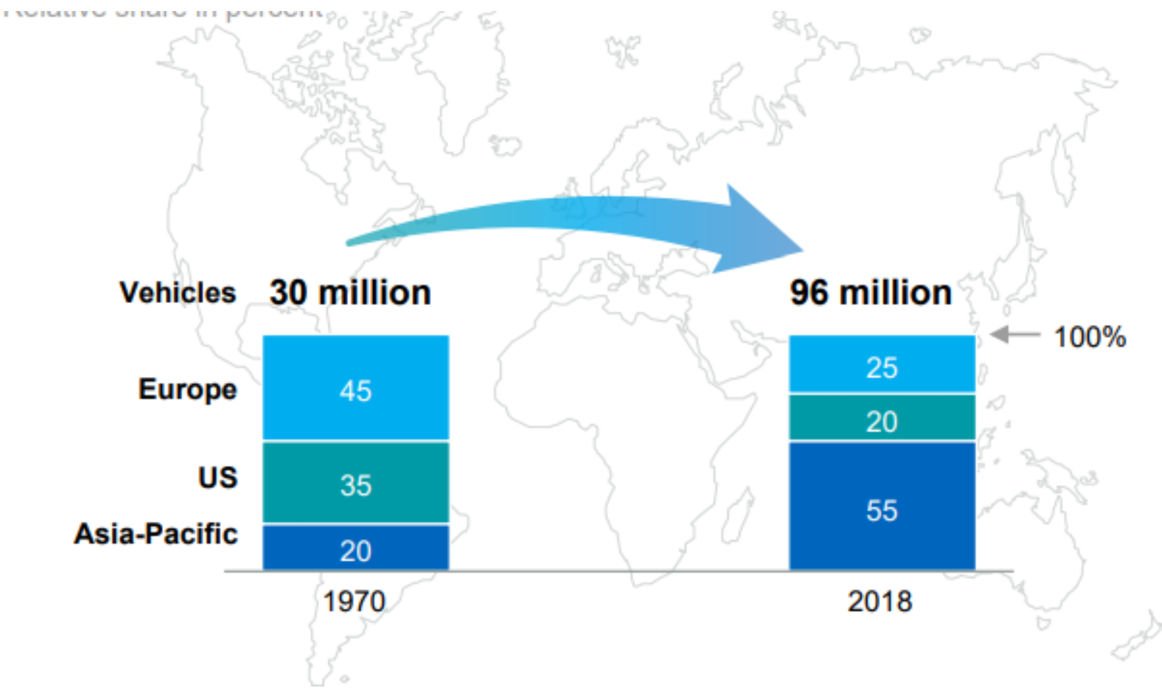

Figure 2 In automotive production, the economic center of gravity is shifting towards Asia

As it is feasible in Figure 2 there is a shift of the "economic center of gravity" from westernmost Europe to Turkey since 1970 has been continuing to move towards Asia.

Besides, the automotive industry has started to attract investors – such as tech companies as well as venture capital and private equity (VC/PE) players – from outside the industry. These players dominate the investment volume in automotive and mobility start-ups; since 2010, more than EUR 100 billion have been invested in mobility start-ups, of which 94 percent originated from players outside of the automotive industry.

On the basis of vehicle autonomy, the EU market consists of semi-autonomous and fully autonomous cars. The European autonomous car market is expected to reach up to four million units by 2030 growing at a CAGE 37,4% during the period 2023-2030 (Figure 3) . European Union supports research for the development of autonomous cars aiming for an evolution in connected and efficient mobility, as safe driving, is one of the major factors driving the growth of the EU automotive car market.[6]

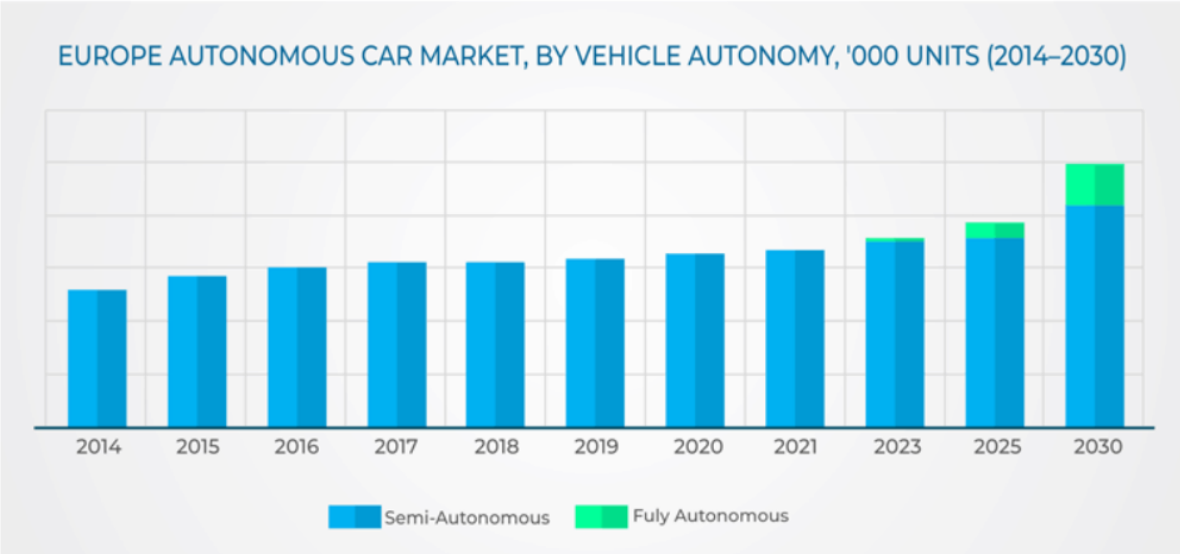

Figure 3 Europe Autonomous Car Market (2014-2030)

Besides this momentum beyond the traditional set of players and regions, four technology driven megatrends are disrupting the industry – Autonomous driving, Connectivity, Electrification, and Shared mobility (ACES) (Figure 4) [7]

The transition of markets and revenue pools towards new business models and technologies, such as data-enabled services, advanced driver assistance systems (ADAS) technologies, and alternative powertrains, is leading to the rise of new competitors in the form of tech players, start-ups, and digital/e-commerce companies, which are anticipated to experience rapid growth. However, this shift not only poses new threats but also brings forth new opportunities for established players. To effectively navigate these disruptive technologies, the industry will need to address a substantial employment transition, where the significance of software and electronics engineering skills will be accelerated.

Finally, Customers' mobility habits are being influenced by four major trends, which in turn are driving the demand for innovative and personalized products. Examples include pay-per-use mobility packages and mobility as a service (MaaS), which integrate various modes of transportation based on individual requirements.[8]

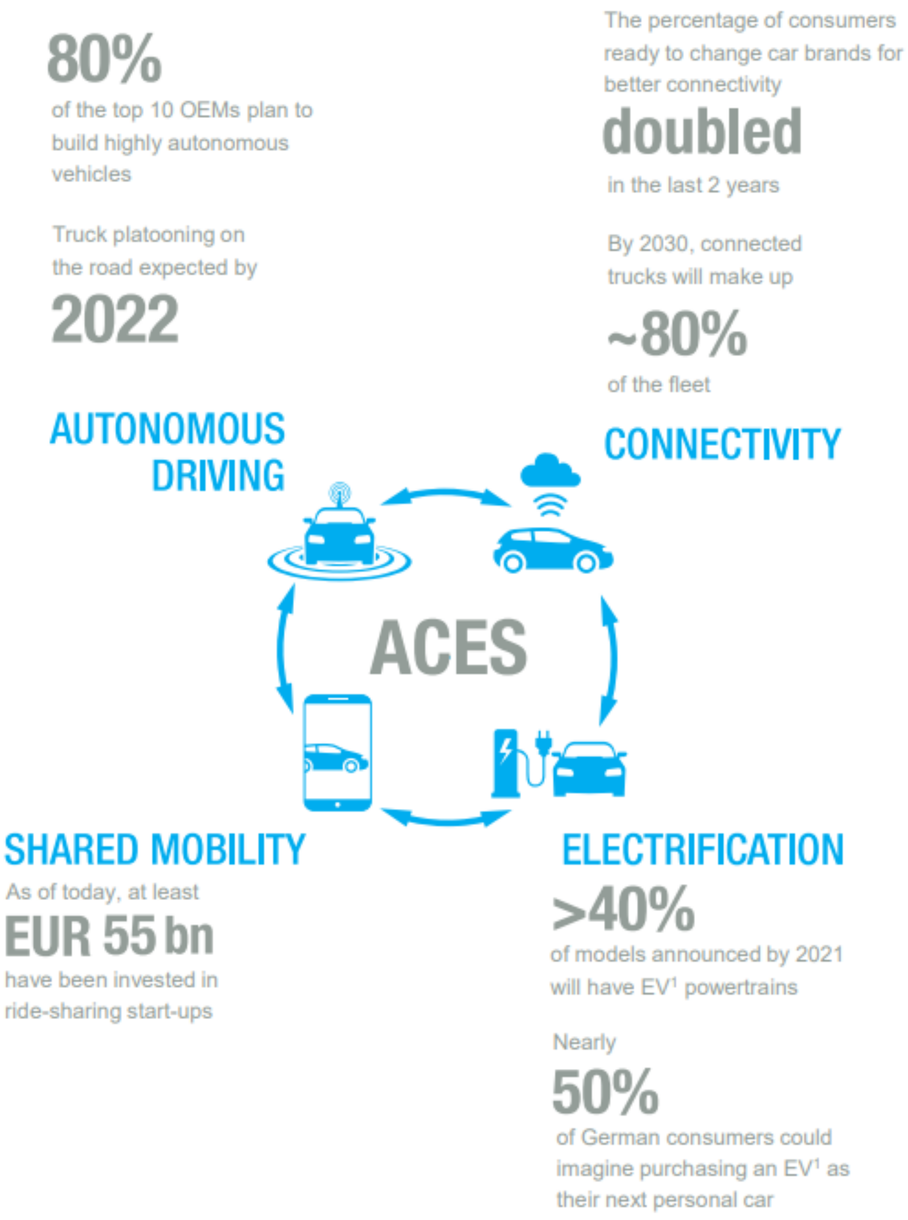

Figure 4 The 4 technology-driven ACES trends are reinforcing each other and will disrupt the automotive industry

4.2 Factors Influencing the Autonomous Car Market Growth

Factors such as the rise in the overall development of smart cities and the adoption of advanced technologies in vehicles are boosting its growth rate.

The rise in smart city development is a major factor stimulating the overall growth of the worldwide autonomous car market. Electric autonomous cars help to reduce air pollution in smart cities and combat climate change. Traffic accidents can be reduced by 90% by adopting driverless cars, considerably enhancing road safety. Several countries, including Mexico, Canada, and the United States, are building digital infrastructure to boost connectivity between networks and vehicles to gather crucial information, ultimately enhancing road safety and lowering traffic issues. As a result, the market for autonomous vehicles is anticipated to grow with the advancement of smart cities.

Leading car manufacturers are attempting to create driverless cars by integrating cutting-edge technologies like artificial intelligence and the Internet of Things. The rising demand to integrate new technologies in automobiles is driven mostly by government programs and measures to increase consumer safety and security. Additionally, the incorporation of AI-based cameras is increasing product demand and contributing to the expansion of the autonomous car market. The worldwide market for autonomous cars is expanding due to an increase in the adoption of cutting-edge technologies.

In 2021, the transportation segment ruled the overall market with a revenue share of nearly 93.8% on the basis of application owing to the increasing adoption of autonomous vehicles in transportation. However, over the predicted period, the defense segment will be the fastest-growing market. This is because more initiatives are being launched in places like North America. For instance, the United States and Sikorsky Defence Advanced Research Projects Agency (DARPA) stated in March 2020 that they would be testing autonomous flight software on the S-76 commercial helicopters and S-70 Black Hawk.

North America ruled the overall market with the highest market share of about 45% in 2021 by region because of its strong government support and positive consumer acceptance. The North American market is predicted to increase significantly due to the changes made in U.S. traffic laws to allow autonomous vehicles on public roads. In order to make transportation totally autonomous, the legislation is gradually being approved across all 50 states in the United States. Over the projection period, Asia Pacific is anticipated to increase significantly. China, Singapore, Japan, and South Korea are among the Asia-Pacific nations that have enacted laws and policies, including registrations, licenses, permits, and others, that will assist in the development of the autonomous car and are encouraging firms like Baidu, AutoX, Pony.ai, and others to test their vehicles on public roads.

A recent study conducted by the strategic consulting and market research firm, BlueWeave Consulting, revealed that the Europe Autonomous Cars Market is projected to grow at a CAGR of 28.4% by the end of 20282 . The Europe Autonomous Cars Market is booming because of the rising disposable income of consumers and changing living standards. Also, the increasing preferences of consumers for luxury, high-quality, and comfort of self-drive cars to decline the burden of driving. Moreover, autonomous cars help to reduce the number of crashes on roads and decrease the chances of accidents which fuels their demand in the region. Furthermore, Europe Autonomous Cars Market is one of the most emerging markets that grow continuously owing to the fast integration of new technologies like the Internet of Things (IoT), Artificial Intelligence (AI), cloud computing, and others. However, the additional cost is associated with connectivity solution charges, telecommunication services, and hardware systems as well as high purchasing prices which may act as a huge restraining factor for the market growth.[9]

The rising purchasing power of consumers, urbanization, and technological advancements act as major driving factors for the growth of the Europe Autonomous Cars Market. The escalation in demand for self-drive cars in European countries is due to their benefits such as the comfort to rest, reading, and working while traveling to make life easier. This acts as the key factor to attract consumers of all ages. Moreover, the increasing technological advancements and diversity in the automotive industry that introduced various autonomous cars are driving the market. Autonomous cars are a breakthrough technology after electric and hybrid cars. All these factors reinforce the Europe Autonomous Cars Market during the forecast period (2022-2028).

4.3 Market segmentation

The emergence of autonomous vehicles has opened up new opportunities and market segments in the transportation industry worldwide. Autonomous vehicles, commonly referred to as self-driving cars, are vehicles that can navigate and operate without human intervention. While still in the early stages of development and deployment, autonomous vehicles have the potential to revolutionize transportation and impact various market segments. Here, we will explore some of the main market segments for autonomous vehicles globally.

Consumer Market:

The consumer market segment is perhaps the most well-known and anticipated market for autonomous vehicles. This segment includes private car owners who are seeking the convenience and safety benefits of self-driving cars. Autonomous vehicles could enhance mobility for individuals who are unable to drive due to age, disability, or other reasons. Companies like Tesla, Waymo, and traditional automakers are targeting this segment by developing autonomous features and self-driving capabilities for their vehicles.

Ride-Hailing and Taxi Services:

Ride-hailing and taxi services are another major market segment for autonomous vehicles. Companies such as Uber and Lyft are investing heavily in self-driving technology to reduce labor costs and provide more efficient transportation services. Autonomous ride-hailing services could offer cheaper and more convenient rides, as well as potentially reduce traffic congestion by optimizing routes and vehicle utilization.

Goods Delivery:

The goods delivery market segment represents a significant opportunity for autonomous vehicles. E-commerce giants like Amazon are exploring the use of self-driving vehicles for last-mile delivery. Autonomous delivery vehicles can operate round-the-clock, potentially reducing delivery times and costs. Furthermore, autonomous trucks have the potential to revolutionize long-haul trucking by improving efficiency and reducing the need for human drivers.

Public Transportation:

Autonomous vehicles can also transform the public transportation sector. Self-driving buses and shuttles have the potential to provide convenient and cost-effective transportation solutions for urban areas. They can optimize routes, reduce congestion, and improve the overall efficiency of public transportation systems. Several pilot projects and trials are already underway in different cities around the world to test autonomous public transportation solutions.

Industrial and Logistics:

Autonomous vehicles have significant applications in industrial and logistics operations. Self-driving forklifts, drones, and robots can enhance efficiency and safety in warehouses and manufacturing facilities. Autonomous technologies can enable vehicles to navigate complex environments, transport goods within facilities, and optimize inventory management processes.

Agriculture:

The agriculture industry can benefit greatly from autonomous vehicles. Self-driving tractors, drones, and other agricultural machinery can automate farming operations, such as planting, harvesting, and spraying. These autonomous technologies can increase productivity, reduce labor costs, and improve precision in farming practices.

Defense and Military Applications:

Autonomous vehicles have potential applications in the defense and military sector. Unmanned ground vehicles (UGVs), drones, and other autonomous systems can be used for surveillance, reconnaissance, and logistics in military operations. They can reduce risks to human personnel and provide increased situational awareness.

These are just a few of the main market segments for autonomous vehicles worldwide. As technology advances and regulatory frameworks are established, we can expect to see further expansion and diversification of these market segments. Autonomous vehicles have the potential to reshape transportation and offer a wide range of benefits, from improved safety and efficiency to increased accessibility and reduced environmental impact.

5 Market analysis of Electric (Electrified) Vehicles

5.1 Overview

After a decade of rapid growth, in 2020 the global electric car stock hit the 10 million mark, a 43% increase over 2019, and representing a 1% stock share. Battery electric vehicles (BEVs) accounted for two-thirds of new electric car registrations and two-thirds of the stock in 2020. China, with 4.5 million electric cars, has the largest fleet, though in 2020 Europe had the largest annual increase to reach 3.2 million.

Overall, the global market for all types of cars was significantly affected by the economic repercussions of the Covid-19 pandemic. The first part of 2020 saw new car registrations drop about one-third from the preceding year. This was partially offset by stronger activity in the second-half, resulting in a 16% drop overall year-on-year. Notably, with conventional and overall new car registrations falling, global electric car sales share rose 70% to a record 4.6% in 2020.

About 3 million new electric cars were registered in 2020. For the first time, Europe led with 1.4 million new registrations. China followed with 1.2 million registrations and the United States registered 295 000 new electric cars.

Numerous factors contributed to increased electric car registrations in 2020. Notably, electric cars are gradually becoming more competitive in some countries on a total cost of ownership basis. Several governments provided or extended fiscal incentives that buffered electric car purchases from the downturn in car markets.

Europe

Overall Europe's car market contracted 22% in 2020. Yet, new electric car registrations more than doubled to 1.4 million representing a sales share of 10%. In the large markets, Germany registered 395 000 new electric cars and France registered 185 000. The United Kingdom more than doubled registrations to reach 176 000. Electric cars in Norway reached a record high sales share of 75%, up about one-third from 2019. Sales shares of electric cars exceeded 50% in Iceland, 30% in Sweden, and reached 25% in the Netherlands.

This surge in electric car registrations in Europe despite the economic slump reflect two policy measures. First, 2020 was the target year for the European Union's CO_2 emissions standards that limit the average carbon dioxide (CO_2) emissions per kilometre driven for new cars. Second, many European governments increased subsidy schemes for EVs as part of stimulus packages to counter the effects of the pandemic.

In European countries, BEV registrations accounted for 54% of electric car registrations in 2020, continuing to exceed those of plug-in hybrid electric vehicles (PHEVs). However, the BEV registration level doubled from the previous year while the PHEV level thripled. The share of BEVs was particularly high in the Netherlands (82% of all electric car registrations), Norway (73%), United Kingdom (62%) and France (60%).

Consumer spending

Consumers spent USD 120 billion on electric car purchases in 2020, a 50% increase from 2019, which breaks down to a 41% increase in sales and a 6% rise in average prices. The rise in average prices reflects that Europe, where prices are higher on average than in Asia, accounted for a bigger proportion of new electric car registrations. In 2020, the global average BEV price was around USD 40 000 and around USD 50 000 for a PHEV.

Government spending

Governments across the world spent USD 14 billion on direct purchase incentives and tax deductions for electric cars in 2020, a 25% rise year-on-year. Despite this, the share of government incentives in total spending on EVs has been on a downward slide from roughly 20% in 2015 to 10% in 2020. All the increase in government spending was in Europe, where many countries responded to the pandemic-induced[10] economic downturn with incentive schemes that boosted electric car sales. In China, government spending decreased as the eligibility requirements for incentive programs tightened. An important novelty in subsidy schemes was the introduction of price caps in Europe and China, i.e. no subsidy given for vehicles with prices above a certain threshold. This might be responsible for the average electric car price falling in Europe and China: BEV cars sold in China were 3% cheaper in 2020 than in 2019, while PHEV cars in Europe were 8% cheaper.

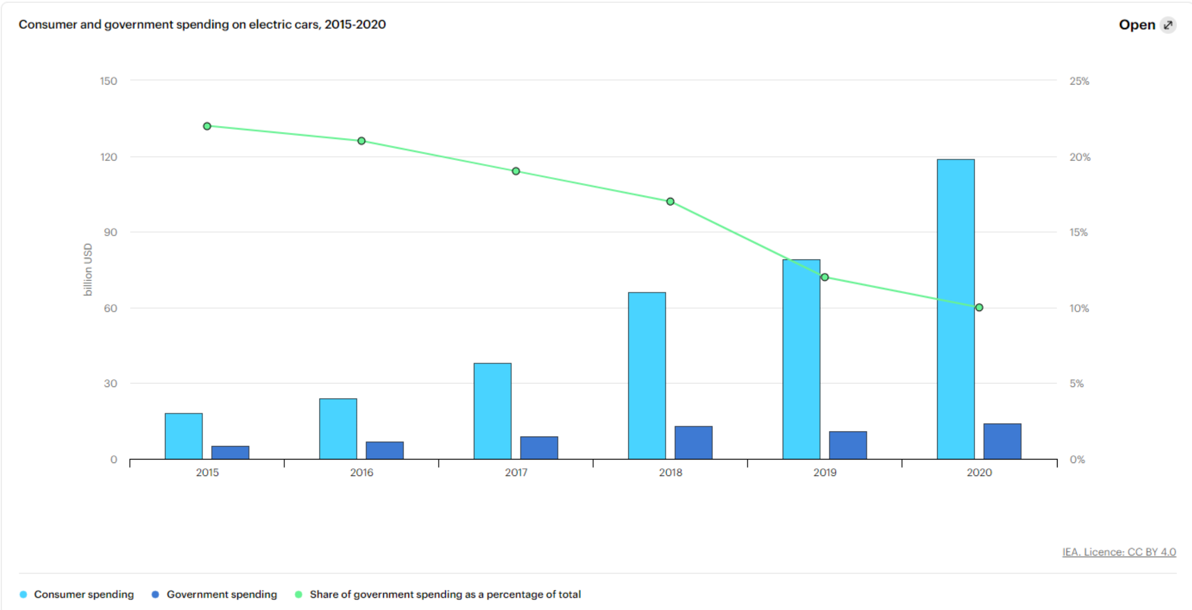

Figure 5 Consumers and government spending on electronic cars, 2015-2020

Worldwide about 370 electric car models were available in 2020, a 40% increase from 2019. China has the widest offering, reflecting its less consolidated automotive sector and that it is the world's largest EV market. But in 2020 the biggest increase in a number of models was in Europe where it more than doubled.

BEV models are offered in most vehicle segments in all regions; PHEVs are skewed towards larger vehicle segments. Sport utility vehicle (SUV) models account for half of the available electric car models in all markets. China has nearly twice as many electric car models available as the European Union, which has more than twice as many electric models as the United States. This difference can partially be explained by the comparatively lower maturity of the US EV market, reflecting its weaker regulations and incentives at the national level.

The average driving range of new BEVs has been steadily increasing. In 2020, the weighted average range for a new battery electric car was about 350 kilometers (km), up from 200 km in 2015.The weighted average range of electric cars in the United States tends to be higher than in China because of

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a bigger share of small urban electric cars in China. The average electric range of PHEVs has remained relatively constant about 50 km over the past few years.

The widest variety of models and the biggest expansion in 2020 was in the SUV segment. More than 55% of announced models worldwide are SUVs and pick-ups. Original equipment manufacturers (OEMs) may be moving to electrify this segment for the following reasons:

- SUVs are the fastest growing market segment in Europe and China, and by far the largest market share in the United States.
- SUVs command higher prices and generally offer higher profit margins than smaller vehicles. This means OEMs find it easier to bear the extra costs of electrification for SUVs since the powertrain accounts for a smaller share of the total cost compared with a small car.
- Electrifying the heaviest and most fuel-consuming vehicles [11] goes further toward meeting emissions targets than electrifying a small car.
- In Europe, the ZLEV credit scheme in the most recent CO2 emissions standards[12] offers strong incentives for selling electric SUVs from 2025, as it relaxes emissions standards in proportion to their potential to reduce specific CO2 emissions. In fact, in Europe, the share of electric SUV models is higher than for the overall market.

OEMs are expected to embrace electric mobility more widely in the 2020s. Notably 18 of the 20 largest OEMs (in terms of vehicles sold in 2020), which combined accounted for almost 90% of all worldwide new car registrations in 2020, have announced intentions to increase the number of available models and boost production of electric light-duty vehicles (LDVs).

A number of manufacturers have raised the bar to go beyond previous announcements [13] related to EVs with an outlook beyond 2025. More than ten of the largest OEMs worldwide have declared electrification targets for 2030 and beyond.

Significantly, some OEMs plan to reconfigure their product lines to produce only electric vehicles. In the first-trimester of 2021 these announcements included: Volvo will only sell electric cars from 2030; Ford will only electric car sales in Europe from 2030; General Motors plans to offer only electric LDVs by 2035; Volkswagen aims for 70% electric car sales in Europe, and 50% in China and the United States by 2030; and Stellantis aims for 70% electric cars sales in Europe and 35% in the United States.[14]

Overall, the announcements by the OEMs translate to estimated cumulative sales of electric LDVs of 55-72 million by 2025. In the short term (2021-2022), the estimated cumulative sales align closely with the electric LDV projections in the IEA's Stated Policies Scenario. By 2025, the estimated cumulative sales based on the OEMs announcements are aligned with the trajectories of IEA Sustainable Development Scenario.

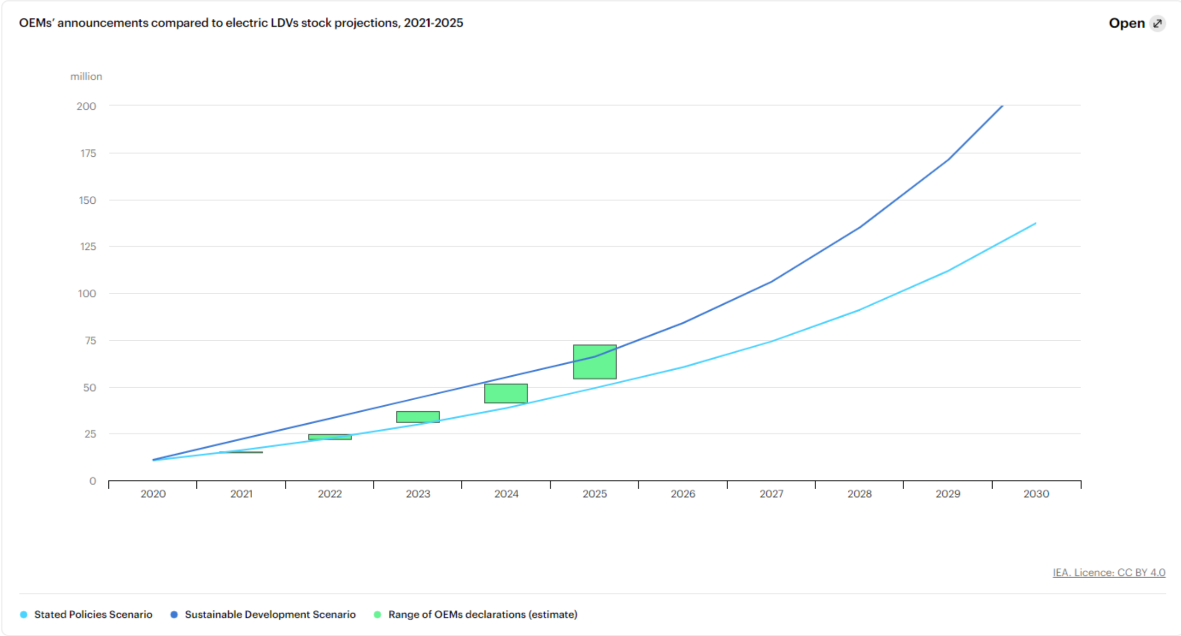

Figure 6 OEMs' announces compared to electric LDVs stock projections, 2015-2021

Automotive lithium-ion (Li-Ion) battery production was 160 gigawatt-hours (GWh) in 2020, up 33% from 2019. The increase reflects a 41% increase in electric car registrations and a constant average battery capacity of 55 kilowatt-hours (kWh) for BEVs and 14 kWh for PHEVs. Battery demand for other transport modes increased 10%. Battery production continues to be dominated by China, which accounts for over 70% of global battery cell production capacity.

China accounted for the largest share of battery demand at almost 80 GWh in 2020, while Europe had the largest percentage increase at 110% to reach 52 GWh. Demand in the United States was stable at 19 GWh.

Nickel-manganese-cobalt continues to be the dominant chemistry for Li-ion batteries, with around 71% sales share and nickel-cobalt-aluminum accounting for most of the rest. Lithium-iron-phosphate battery chemistry has regained sales share but is still under 4% for the electric car market.

According to the BNEF's yearly survey of battery prices,[15] the weighted average cost of automotive batteries declined 13% in 2020 from 2019, reaching USD 137/kWh at a pack level. Lower prices are offered for high-volume purchases, confirmed by teardown analysis[16] of a VW ID3 showing an estimated cost of USD 100/kWh for its battery cells.

In Europe, demand for batteries in 2020 exceeded domestic production capacity. Today Europe's main battery factories are located in Poland and Hungary. Production capacity is roughly 35 GWh per year, but the announced capacity could yield up to 400 GWh by 2025[17]. Momentum was evident in 2020 in Europe with many new battery plants announced or under construction with support from the European Investment Bank. In the United States, both Korean and domestic battery manufacturers have signaled large investments [18]in a market currently dominated by a Tesla-Panasonic joint venture.

5.2 Market Segmentation

This section discusses on the main market segments for electric vehicles (EVs) that are shaping the industry globally. The combination of technological advancements, declining battery costs, supportive government policies, and changing consumer preferences is propelling the rapid expansion of the electric vehicle market globally. As the transition to electric mobility accelerates, we can expect further developments and innovations within these market segments, leading to a more sustainable and efficient transportation future.

Consumer Market:

The consumer market segment for electric vehicles represents individual car owners who are looking to transition to more sustainable and environmentally friendly transportation options. This segment includes a diverse range of consumers, from early adopters and tech enthusiasts to environmentally conscious individuals. As EV technology advances, more consumers are considering electric vehicles as a viable alternative to traditional internal combustion engine (ICE) cars. Factors such as government incentives, improved charging infrastructure, and increased driving range have contributed to the growth of the consumer market for EVs. Additionally, automakers are launching a variety of electric models, catering to different consumer preferences and needs.

Fleet and Commercial Vehicles:

Fleet and commercial vehicles, including taxis, ride-hailing services, delivery vans, and trucks, represent a significant market segment for electric vehicles. Fleet operators are increasingly recognizing the economic benefits of electrification, including lower fuel and maintenance costs. Electric vehicles offer advantages such as reduced operational expenses, decreased emissions, and improved driver experience. Ride-hailing companies like Uber and Lyft, as well as delivery giants like Amazon and DHL, are actively adopting electric vehicles into their fleets. Governments and municipalities are also encouraging the transition to electric commercial vehicles by implementing incentives, regulations, and zero-emission zones.

Public Transportation:

Public transportation is a crucial market segment for electric vehicles, as it has a substantial impact on reducing urban emissions and improving air quality. Electric buses, trams, and trains offer quiet, clean, and efficient transportation options for both urban and suburban areas. Numerous cities worldwide have set targets to electrify their public transportation systems, and many are already introducing electric buses into their fleets. Electric buses provide benefits such as reduced noise pollution, improved air quality, and lower operating costs over their lifetime.

Government and Municipal Fleets:

Government agencies and municipal fleets are also a significant market segment for electric vehicles. These include police departments, municipal services, and other government entities that utilize vehicles for various purposes. Governments are increasingly adopting electric vehicles in their fleets to lead by example, reduce emissions, and demonstrate their commitment to sustainability. Electrifying government and municipal fleets can also have a cascading effect by creating demand and supporting the growth of charging infrastructure.

Luxury and Performance Cars:

Luxury and high-performance vehicles are an important market segment for electric vehicles, showcasing the capabilities and appeal of electrified powertrains. Luxury automakers such as Tesla, Audi, Jaguar, and Porsche have introduced electric models that offer high performance, advanced technology, and luxurious features. These electric vehicles target consumers who value sustainability and want a premium driving experience without compromising on power and style. The luxury segment plays a significant role in shaping perceptions and driving innovation in the overall EV market.

Shared Mobility:

Shared mobility services, including car-sharing, carpooling, and mobility-as-a-service (MaaS) platforms, provide an opportunity for electric vehicles to thrive. Companies like Zipcar, Car2Go, and Lime have incorporated electric vehicles into their fleets, providing sustainable transportation options to users. Electric cars and scooters are particularly well-suited for short trips and urban mobility, making them an ideal choice for shared mobility services. By integrating electric vehicles into shared mobility platforms, the market segment expands, offering convenient and eco-friendly transportation alternatives.

Emerging Markets:

Emerging markets present a significant growth opportunity for electric vehicles. Countries with large populations and rapidly expanding urban areas, such as China and India, are actively promoting electric mobility to combat pollution and reduce dependence on imported oil. Governments in these markets provide generous subsidies, tax incentives, and supportive policies to accelerate EV adoption. In addition to passenger cars, electric two-wheelers and rickshaws have gained popularity in these markets due to their affordability and suitability for urban transportation.

Charging Infrastructure:

Although not a traditional market segment for electric vehicles, the development of charging infrastructure plays a vital role in supporting EV adoption. Companies specializing in charging infrastructure, including public charging stations, home chargers, and fast-charging networks, are an essential part of the EV ecosystem. The growth of the charging infrastructure market segment is crucial for addressing range anxiety and enabling convenient charging options for electric vehicle owners.

6 EcoMobility work and competition analysis

EcoMobility is a new approach to mobility that underlines the importance of public and non-motorized transport and promotes the integrated use of all modes in a city. Still, EcoMobility is defined as the use of light electric vehicles (LEVs), provided that the source of electricity comes from renewable energy sources. It is vital to shift as much as possible of the private motorized means of transport (PMT) towards EcoMobility through environmentally friendly mobility offers. This will lead to a move away from internal combustion engines and will largely change mobility habits, thus SC1 and SC2 will integrate real-world experience with adaptive edge–cloud computing into a digital automotive value chain to enhance perception and localization- Intelligent embedded sensor systems (HW, SW & Tools). In addition, it is vital that economic and regulatory guidelines for increasing ***EcoMobility*** are aligned with the simultaneous and gradual reduction of private car use. Moreover, carpooling services, shared vehicles, and mobile stations need to be networked in order to make travel reliable and inclusive, and eco-friendly. It is noted that sustainable EcoMobility options have low to zero emissions compared to private cars powered by fossil fuels such as coal, petroleum, and heavy oils.

By integrating it into the development of traffic systems, road infrastructure will benefit local governments by contributing to the needs of commuters. Moreover, EcoMobility approaches to transportation, such as environmentally sensitive urban street solutions, which refer to the planning, design, construction, and operation of transportation facilities within communities, can create attractive neighborhoods and urban streets that also improve mobility and safety for street users and can enhance community sustainability. EcoMobility contributes to green transportation through integrated and environmentally friendly options independent of public and private vehicles.

The adoption of the EcoMobility framework also brings benefits such as reducing environmental impacts while reducing greenhouse gas emissions into the atmosphere. In addition, EcoMobility uses renewable energy resources below their production rates and uses non-renewable energy resources at or below the deployment rates of renewable energy substitutes, while also minimizing impacts on land use, water, air, and noise generation. More specifically SC5 wil develop an Automated map digitalization technology using modern perception techniques and the fusion of data from diverse sources is a transversal development in the implementation of efficient transportation models in urban environments. Through these vehicles and their future evolution to fully autonomous vehicles, the aim is to use the data collected by both them and the infrastructure to obtain automated digitalization of the environment in which the vehicles move, generating complete 3D maps of the environment on a large scale.

EcoMobility also gives cities the opportunity to access goods and services in a sustainable way, thereby improving the quality of life in cities, enhancing light green vehicles, increasing sustainable mobility options, reducing greenhouse gas emissions and congestion, and improving air quality. This boosts local green economies and makes cycling, traveling, and walking safer. Therefore, the need to rehabilitate cycle paths and introduce sustainable EcoMobility facilities is essential to improve people's quality of life and monitor road connectivity, as well as control the use of non-motorized transport infrastructure. Also, EcoMobility is used to minimize fleet operating costs (fuel consumption) while meeting customer travel time constraints. The Eco-MOD fleet assignment framework to minimize fleet fuel consumption.

More specifically ***EcoMobility*** in SC5 will chain develop information systems for multimodal transport of goods and passengers. These systems aim to provide more sustainable and efficient transportation through smart city solutions, featuring upgraded and resilient physical and digital infrastructures for intelligent vehicles and operations. The goal is the optimization of the system-wide transport network efficiency as well as fleet management and maintenance. SC5 will also provide 2 use cases based on Autonomous & Tele-operated land and sea assets & Precise Localization during difficult maneuvering and Holographic communication supported by 360 perceptions and operator assistance on car & sea vessels (Figure 7) to provide AI solutions to road operators that increase road safety and efficiency, reducing energy consumption and transport time.

Figure 7 Smart mobility with Multi-modal autonomous & tele-operated transport on land and sea

The need for sustainability solutions requires a shift towards renewable energy sources and less reliance on fossil fuels so ***EcoMobility*** has a great impact on the involved countries that are already committed to increasing sustainability and making Europe a competitive car industry.

Austria:

Vienna's coalition government has committed to some very decisive measures to ensure that Vienna achieves net zero by 2040 and to adapt the city to climate change and mitigate its effects. In fact, the share of trips in Vienna made by environmentally friendly means is expected to increase to 85% by 2030 and even more by 2050. Public transport is also being promoted so that residents can get around easily and without private cars. Furthermore, the ownership of private motor vehicles is estimated to decrease to 250 vehicles per 1,000 inhabitants by 2030, while the available parking space in public spaces will also decrease.

Germany:

Berlin has as primary goals the transformation of transport (with 82% EcoMobility by 2030, namely 23% cycling, 30% walking, and 29% public transport) and climate mitigation, with a 42% CO2 reduction of the sector of transport compared to 1990. It also aims to reduce traffic-related energy consumption by 34% by 2030 and minimize land use related to settlements and traffic infrastructure to 30 ha per day.

Spain:

In Spain there is also a national action framework for alternative actions in the transport sector. The share of LDV alternatives in Spain is still low, although there was a sharp increase during the period 2014-2018. Battery Electric Vehicles (BEVs) accounted for 0.11% of the 2018 LDV passenger fleet, while Hybrid Electric Vehicles (HEVs) and Plug-In Hybrid Electric Vehicles (PHEVs) made up 0.99% (Eurostat, 2019). However, in 2030 the minimum LDV share in Spain should be 36.3%.

Norway:

In the city of Alesund there is a high proportion of urban mobility with private vehicles rather than public transport, and for this reason, the city needs to improve EcoMobility, including access to eco-infrastructure. It must take steps to reduce the level of energy consumption and is encouraged to work with the government to develop and implement policy solutions and technologies that enable energy savings. Still Asker must implement the 2030 Agenda and integrate the Sustainable Development Goals (SDGs) into its policies and operations.

7 Strategy to Approach the Market within EcoMobility

7.1 Overview of market approach through EcoMobility

All ***EcoMobility*** partners have a strong interest in participating in this project, as they foresee strong potential for the exploitation of the project results and the creation of sustainable collaboration. They all share the vision of cooperating in a win-win manner. Although during the whole project's lifetime, novel business models for connected, shared, and electrified mobility will be defined and updated based on the market evolution, already in this early project stage, ***EcoMobility*** partners have enumerated a number of initial exploitation considerations.

Building upon Deloitte's program [19], the components of articulating the ***EcoMobility*** market investigation plan are

Step 1: Investigation of all relevant market segments, taking into account marketing studies and socioeconomic research, and looking into complementary primary research where required.

Step 2: Analysis of related, complementary, and competing products and services in the market and wider community.

Step 3: Setting up of deployment scenarios, market, and business models for individual exploitation as well as for joint exploitation of connected shared mobility, specifying collaboration roles, costs, and revenue flows, thus enabling calculation of the net return over time for each type of market player, being commercial or public.

Step 4: Validation of business models and deployment scenarios within the consortium.

Step 5: Organization, planning, and execution of wide impact communication activities to create full awareness of ***EcoMobility*** goals, approach, and results within various target groups; establishing contact with key third parties for exploitation.

Step 6: Regular review, revision, and refinement of partner-specific exploitation plans and joint collaborative business plans in the light of interim project results; as well as formalization of service level and other appropriate agreements for joint exploitation among partners and third parties, including possible creation of new legal entities (joint ventures). One of the main objectives of ***EcoMobility*** is to exploit the benefits and potentials of connected shared mobility by developing innovations that can be marketed individually or as a complete solution.

7.2 Complementary viewpoints and delivery channels to address the markets

a) Market potential – OEM point of view

For an OEM, safe and intelligent mobility can be a game changer and can open a wide area of revenue streams. The OEM key contributions for the ***EcoMobility*** project are manifold, ranging from test vehicles and test-tracks to fleets and fleet data, as well as, supplier management and unique distribution networks and impact on domain and standards. The technology developed under the ***EcoMobility*** project will in return be innovative and provide unique functionalities and customer services, which can be offered to the end customer of automated driving vehicles in general, and automated, connected, and electrified vehicles in particular.

b) Market potential – Supplier point of view

Following the automotive supply pyramid, Tier1 and Tier 2 come into play, which are also members of the ***EcoMobility*** consortium and the dedicated ***EcoMobility*** supply chains. While OEMs have their strength in designing cars, marketing cars, ordering the parts from suppliers, and assembling the final product. Tier 1 suppliers are specialized in making “automotive-grade” systems. Suppliers usually work with a variety of car companies, ensuring the brand identity of each customer. For automotive suppliers, key partners are, the semi-conductor partners, OEMs, and engineering/tool suppliers, which they are addressing directly via dedicated personal assistance (interaction with the customer) or creation of a community, or via deployment of technology solutions at the customer. The technology developed under the ***EcoMobility*** project will in return be unique value propositions in their specific business, which can be capitalized via revenue streams component and IP sale and engineering service provision.

c) Market potential – Technology/engineering providers' point of view

A third essential strategy to approach the automotive market is the technology, engineering, and tool provider's point of view. As mentioned, the automotive supply pyramid gives a clear structure for supplier management. Besides this, technology, engineering, and tool provider support all of these hierarchy levels. Key partners represent the whole automotive supply pyramid, from OEM to Tier X suppliers, and addressing directly via interaction with customers or the creation of a community is a key factor to success. The key contributions of automotive technology, engineering, and tool providers for the ***EcoMobility*** project are clearly related to specific domain know-how, tool development and support, and the variety of engineering portfolios these companies represent on different levels of the development lifecycle. In return, the technology developed under the ***EcoMobility*** project will further enhance the unique value propositions in their specific businesses or will be added to the current product portfolio under the same business model of licensing the technology.

8 Conclusions

This deliverable has provided an in-depth analysis of the market, offering the ***EcoMobility*** project consortium valuable information on changes in the economy, existing competition, current market trends, and patterns of potential customer spending in the targeted market.
For this purpose, it first provided an overview of the digital technologies that are available for connected and shared, electrified mobility. Then it analyzed the market of autonomous vehicles, as well as the market of electric vehicles.

Moreover, it tried to link the work within ***EcoMobility*** with the identified markets and their segments, so as to pave the way for future project results exploitation.

In doing so, we advocate that this deliverable will serve as a foundation for planning the utilization of the ***EcoMobility*** project outcomes and establishing the necessary agreements for exploitation among consortium partners.

Furthermore, it will aid in identifying future market opportunities and threats, growth markets, areas lacking sufficient market presence, and high-potential segments.

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