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NEW MOBILITY

MATCHING THE DATA REVOLUTION AND THE SUSTAINABILITY CHALLENGE

EU STUDY 4.18

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EXECUTIVE SUMMARY

During the next decades the mobility sector will go through some dramatic changes because of several factors such as the growing number of people moving to (and within) urban areas, the shift toward an even more individual and personalized mobility and the growth of tourism flows. The ecological and environmental problems are also changing people's behavior due to more awareness. One of the positive externalities is probably an increased willingness to the sharing of resources and goods. The growing demand for sharing mobility services are attracting an increasing number of entrepreneurs investing in this sub-sector, multiplying the number of services, the city coverage, as well as their quality.

As shown in **Chapter 1**, being aware of the challenges affecting the mobility sector, European institutions launched several important proposals, mainly the **European Strategy on Cooperative Intelligent Transport Systems (C-ITS)** (30 November 2016), the **European Strategy for Low-Emission Mobility** (20 July 2016) and the **EU mobility packages,** a collection of three initiatives released in May 2017, November 2017 and May 2018, respectively, concerning the governance of commercial road transport in the European Union**.**

The first represents a milestone initiative towards cooperative, connected and automated mobility and aims at facilitating the convergence of investments and regulatory frameworks across the EU, in order to see the deployment of mature C-ITS services in 2019 and beyond.

The European Strategy for Low-Emission Mobility considers that a more efficient transport system would facilitate the transition to low-emission mobility, therefore, the Strategy underlines the importance of ensuring fair and efficient pricing in transport and promoting multi-modality such as inland waterways, short-sea shipping and rail. In order to increase the use of low-emission alternative energy for transport, the Commission emphasizes the importance of advanced biofuels for aviation, as well as for lorries and coaches, and natural gas as an alternative for marine fuels in shipping and for diesel in lorries and coaches. Specific infrastructures should be created and interoperability and standardization for electro-mobility should be developed in order to encourage the use of alternative fuels.

Concerning the EU mobility packages, on 31 May 2017, the European Commission presented the Communication, **Europe on the Move. An agenda for a socially fair transition towards clean, competitive and connected mobility for all**, aiming to ensure that Europe plays a leading role in clean, competitive and connected mobility, supporting the adoption of the best low-emission mobility solutions, equipment and vehicles and the development of modern infrastructures to support them. This Communication focuses on the key contribution that must be made by road transport and it is accompanied by several proposals to support the rollout of infrastructure for road charging, alternative fuels and connectivity, better information for consumers, a stronger internal market and improved working conditions for the road haulage sector, as well as steps to lay the ground for cooperative, connected and automated mobility.

On 8 November 2017, the Commission launched the Second Mobility Package, focusing on clean mobility and consisting of: 1) the Communication, **Delivering on Low-emission Mobility – A European Union that protects the planet, empowers its consumers and defends its industry and workers,** outlining the steps to make clean mobility a reality. It explains three key political priorities: Europe that protects the planet, Europe that empowers its citizens and Europe that defends its industry and workers; 2) the Communication, **Towards the Broadest Use of Alternative Fuels – an Action Plan on Alternative Fuel Infrastructures, under Article 10(6) of Directive 2014/94/EU, including the assessment of national policy frameworks under Article 10(2) of Directive 2014/94/EU**. It established a common framework of measures for the deployment of alternative fuel infrastructures in the Union in order to minimize dependence on oil and to mitigate the environmental impact of transport. It sets out minimum requirements for the building-up of alternative fuel infrastructures, including recharging points for electric vehicles and refueling points for natural gas (LNG and CNG) and hydrogen, to be implemented by means of Member States' national policy frameworks (to be notified to the Commission by 18 November 2016), as well as common technical specifications for such recharging and refueling points, and user information requirements; 3) a set of **4 legislative initiatives**, targeting road and combined transport, which aim at strengthening CO2 emission standards for new cars and vans from 2020, promoting clean mobility through public procurement, stimulating combined use of trucks and trains, barges and ships for the transport of goods and, finally, promoting the development of bus connections over long distances.

Finally, on 17 May 2018, the Commission presented the Third Mobility Package, supporting a safe, clean and connected mobility completing the process launched with the 2016 Low Emission Mobility Strategy and consisting of: 1) the Communication, **Europe on the Move. Sustainable Mobility for Europe: safe, connected, and clean,** presenting a strategic Action Plan on road safety for 2020-2030, including two legislative initiatives on vehicle and pedestrian safety and on infrastructure safety management. Considering that driverless vehicles and advanced connectivity systems could make vehicles safer and easier and address many of the major challenges facing today's road transport system, such as road safety, traffic congestion, energy efficiency and air quality, the Commission underlines the importance of developing key technologies in Europe to ensure the safety of automated and autonomous driving and a modern legal framework able to support technological progress. In response to the new challenges and to reap the full benefit of the new opportunities offered by these technological developments, the Commission proposed an EU approach built on three interrelated strategic objectives: a) developing key technologies and infrastructure to strengthen EU competitiveness; b) ensuring safe and secure deployment of connected and automated driving; c) addressing the socio-economic impacts of driverless mobility. Annex 1 explains the **Strategic Action Plan on Road Safety** identifying several initiatives to ensure enhanced road safety governance, stronger financial support for road safety, safe roads and roadsides, safe vehicles and safe road use, fast and effective emergency response, future-proofing road safety. This Communication is also accompanied by a **Strategic Action Plan for Batteries** (Annex 2), setting out concrete measures that will contribute to creating an innovative, sustainable and competitive battery "ecosystem" in Europe; 2) the Communication, **A Europe that Protects: Clean Air for All**, sets out wide-ranging EU policy efforts to support and facilitate the necessary measures for Member States to meet their targets and the enforcement action being taken to help ensure that the common objective of clean air for all Europeans is achieved and maintained across the EU. The Commission envisages measures to reduce emissions from the transport sector, from the power and heat sector, from industry and from the agricultural sector; 3) the Communication, **On the Road to Automated Mobility: An EU Strategy for Mobility of the Future**, proposes a comprehensive EU approach towards connected and automated mobility setting out a clear, forward-looking and ambitious European agenda. This agenda provides a common vision and identifies supporting actions for developing and deploying key technologies, services and infrastructures. This proposal is accompanied by two legislative initiatives: a) a proposal for a regulation establishing a **European Maritime Single Window environment and repealing Directive 2010/65/EU** establishing a framework for a harmonized and interoperable European Maritime Single Window environment ('EMSWe'), based on National Single Windows, in order to facilitate electronic transmission of information concerning reporting obligations for ships arriving, staying in and departing from a Union port; b) introduces a **framework of an electronic communication system for freight transport**. The proposal specifically lays down the conditions under which Member States' competent authorities are required to accept regulatory information when made available electronically by those economic operators concerned and rules for the provision of services related to making regulatory information available electronically by the economic operators; 4) a proposal for a **regulation setting a CO2 emission performance standard for new heavy-duty vehicles.** The proposal prescribes that the specific CO2 emissions of the Union's fleet of new heavy-duty vehicles must be reduced (compared to the reference CO2 emissions) by 15% from 1 January 2025 to 31 December 2029 and by at least 30% from 1 January 2030 onwards. The Commission also proposed a regulation on the labelling of tires regarding fuel efficiency and other essential parameters and repealing Regulation (EC) No 1222/2009 and a proposal for amending Council Directive 96/53/EC on the time limit for the implementation of the special rules regarding maximum length in case of cabs delivering improved aerodynamic performance, energy efficiency and safety performance; 5) a legislative initiative to **streamline procedures for advancing the trans-European transport network**. Considering that many investments aimed at completing the TEN-T are confronted with complex permit granting procedures, cross-border procurement and other procedures, the proposal for the regulation is to establish requirements applicable to the administrative procedures followed by the competent Member State authorities for the authorization and implementation of all projects of common interest on the core network of the trans-European transport network.

The final paragraph, instead, briefly describes the National Policy Frameworks (NPF) adopted by France, Germany, Italy, Spain and the United Kingdom according to Directive 2014/94/EU which prescribed that Member States notify the European Commission of their National Policy Frameworks (NPF) by November 2016.

Chapter 2 provides an overview on **sustainable mobility**. According to the European Commission study "EU Reference Scenario 2016: energy, transport and GHG emissions trends to 2050", by 2030, fossil fuels will hold 70% of the energy share in the transport sector, and 66% by 2050. The most common fuel is and will still be diesel, however, petrol will also hold an important share, even if the alternative energy share will increase. **Despite the development of new renewable energy sources, liquid hydrocarbons will continue to play a fundamental role in the future mobility system**. In fact, according to the latest report released by the European Automobile Manufacturers Association, **in the first semester of 2018, new vehicles registered in the EU, powered by petrol and diesel, accounted for 93% of the total**. Therefore, investing in the research and development of **Low Carbon Liquid Fuels is essential to reducing greenhouse gas emissions**. Biofuels have an especially low environmental impact and unlike other alternative fuels do not need new infrastructures to be built. The promotion of biofuels is a political priority of the EU energy-climate policy. Directive 2009/28/EC on the promotion of the use of energy from renewable sources and amending and, subsequently, repealing Directives 2001/77/EC and 2003/30/EC introduces a binding target for a 10% share of renewable energy in transport by 2020, with biofuels also making a substantial contribution to this aim. According to a test carried out by the United States Environmental Protection Agency, **the use of biodiesel – one of the most common biofuels in Europe – in diesel engines results in substantial reductions in unburned hydrocarbons, carbon monoxide and particulate matter**. Emissions of nitrogen oxides remain the same or slightly increase. The exhaust emissions of sulphur oxides and sulphates (major components of acid rain) from pure biodiesel are essentially eliminated. The ozone forming potential of the speciated hydrocarbon emissions is 50 % less than that measured for diesel fuel.

The chapter continues with a focus on how **electric vehicles play an important role in reducing air pollution, however, they still represent a small part of**

the car fleet. In the first half year of 2018, the European market of electric cars – including BEVs, PHEVs, REEVs, FCEVs – amounted to 143,017 registrations, increasing by 46% relative to the first half year of 2017. The growth of the electrically chargeable vehicles in the EU is mainly led by plug-in hybrid vehicles, growing at a higher rate (+51%) than battery electric vehicles (+40%).

Moreover, the chapter deals with **natural gas** and **fuel cell vehicles**. Natural gas is an important part of the EU's energy mix and will play a significant role in the mobility of the future. According to a study by NGVA Europe, the number of CNG (Compressed Natural Gas) cars in Europe will increase 10 times, reaching a market share of 12%. CNG and LNG (Liquefied Natural Gas) are a real alternative to conventional diesel, even for long distance transport.

Fuel cell vehicles use hydrogen to power an electric engine and, for this reason, they are considered electric vehicles, even if their range and refuelling make them more similar to traditional fuel vehicles. According to an Information Trends study in 2017, 6,475 hydrogen vehicles were sold worldwide. The majority of these were sold in the US and Japan, with only 9% in Europe. The lower sales of hydrogen vehicles are mainly due to their price and the lack of filling stations.

Finally, the chapter describes **synergies between the energy and mobility sectors**, especially on the development of batteries.

Chapter 3 describes services and characteristics of **shared mobility**, as well as autonomous and connected vehicles and the impact of 5G on the transport sector. Among shared forms of transportation, car sharing is very successful. In 2016, car sharing was operating in 46 countries and six continents, with an estimated 2,095 cities and approximately 15 million members sharing over 157,000 vehicles. Both members and vehicles increased exponentially between 2014 and 2016, with a growth rate of 211% and 51%, respectively. **Asia is the largest car sharing region, in terms of members and vehicles, followed by Europe and North America**. In Europe, car sharing is widespread especially in Paris, London, Berlin, Milan, Rome, Madrid, Turin and Florence, where a high number of sharing vehicles is available. **According to ING Bank (2018), interest in car sharing is present amongst many Europeans but there are some barriers that need to be overcome** (such as costs of car sharing services).

While proficient integration into the transport sector of the one-to-one communication scheme introduced by the Internet has brought significant improvements for shared mobility, smart routing, as well as providing real time information about public transport, the dissemination of smart sensors in the surrounding environment and in the objects are paving the way for a new digital revolution called Internet of Things. Within this new framework, the Internet has become a network connecting objects, robots and most other machines allowing them to mainly act in two ways – following a direct human request or "autonomously". The latter implies these actions are related to a large amount of data elaborated by sophisticated algorithms which guide the machine's behavior in relation to the information input and behavior patterns. The main impact of this new framework on the mobility sector is that it makes self-driving vehicles possible.

Connected Vehicles (CV) are provided with technologies that allow them to communicate with the environment as well as between each other, supplying useful information to the driver (or a vehicle) to help them take more informed decisions.

Autonomous Vehicles (AV) imply that machines, provided with proper equipment and real time information flows, can take decisions and carry out their own actions, such as self-parking, avoiding collisions, autonomously and driven.

The Society of Automotive Engineers (SAE) found 6 different levels of automation, from level 0 (no driving automation) to level 5 (Full Driving Automation).

According to PWC estimates, **all the cars sold by 2025 will be connected vehicles**. In 2017, out of about 63 million cars sold in the US, EU and China, the number of connected cars exceeded 55 million, while the non-connected cars sold were 7 million. In 2020, the connected cars sold should reach the 65 million threshold, up to 82 million by 2030.

Semi-autonomous (Level 2) should reach 5 million units sold by 2020, up to 33 million by 2025. **The fully autonomous cars (level 5) will be available only after 2025**, reaching 12 million units sold per year by 2030.

Only a part of Connected and Autonomous Vehicles will be electric. According to the International Council on Clean Transportation, the ratio should be one out of three cars sold, while the other 2 could be powered with another type of energy.

One of the main challenges related to the adoption of Autonomous Vehicles is connected to its possible **energy impacts**. Caltrans Division of Research analyzed 13 reports and studies on this topic, showing how **the effects may vary and have a very wide range of outcomes.** Factors such as reduced travel costs, higher highway speeds, longer commute distances and inclusion of previously underserved user groups could have the greatest impact on increasing energy consumption. Some authors conclude that AVs might reduce GHG emissions and energy use by nearly half—or nearly double them—depending on which effects end up dominating.

NREL also made a comparison between different studies, identifying up to 8 different scenarios, showing that the **overall impact on fuel demand may vary from – 83% up to +217%, according to 10 different indicators**.

These transversal analyses indicate that an impact estimate on pollution reduction is still extremely complicated to define, and that final outcomes will strongly depend on how autonomous vehicle's will be used and regulated.

The chapter ends with a paragraph on the **blockchain in the automotive industry**. Connected cars will generate a huge amount of data and blockchain could be the simplest and safest way to share it. Another possible application powered by the blockchain in this sector is linked to the automotive leasing market. Moreover, the future integration of artificial intelligence and blockchain will allow self-driving cars, thanks to the use of smart contracts, to manage all the transactions carried out every day by a road user, such as paying a tolls or refuelling.

In the **conclusions and policy recommendations**, all possible scenarios have to take into account that during the next decades the mobility sector will undergo marked changes because of several important factors, such as the growing number of people moving to (and within) urban areas, the shift toward an even more individual and personalized mobility and the growth of tourism flows. This will all be accompanied by the necessity to contain and reduce greenhouse gas emissions and local pollution to reduce climate change and the increase in non-communicable diseases such as cancers, diabetes and cardiovascular pathologies.

With regard to **sustainable mobility,** ambitious goals need to be met by investments in a **wide array of low-emission technologies**, taking into account the starting point and the main barriers for the adoption of new solutions:

A. Vehicles driven by traditional engines (e.g. petrol or diesel) are and will be the most widespread in the next few years and liquid hydrocarbons will continue to play an important role in the future mobility system. Therefore, investing in **Low Carbon Liquid Fuel** R&D is essential to reducing greenhouse gas emissions. The development of low-emission hydrocarbon liquid fuels offers an important opportunity to effectively meet market demand while also contributing to addressing the risks of climate change. Collaboration across industries and sectors will be key to bringing innovative technologies for low-carbon liquid fuels and other products to market. Therefore, establishing an EU industrial symbiosis across the chemical and fuel production sectors, as well as the transport sector, will become essential to accelerating the market readiness of low-carbon technologies. Finally, public policies to support the transition to low carbon fuel technologies should promote:
   - a market-based approach allowing the market to pick the best opportunities
   - increased market demand for low carbon fuels
   - investment and support for innovation and R&D
   - clear standards for sustainability criteria based on emission reduction performance.

B. **Electric mobility** provides an important potential to reducing pollution in urban areas. However, "green vehicles" still represent a small part of the car fleet, especially in certain countries. Consumers will not move automatically to electric vehicles if their costs remain high, if the network of charging stations is not ready, or if new technologies are not easily usable. Therefore, car producers, battery manufacturers, energy suppliers and distributors and, of course, decision-makers will have to work together to promote the electric mobility take-up. Effective public policies need to tax negative environmental practices and favor low-emission technologies. Moreover, EV investment in the generating and recharging infrastructures and battery R&D is urgent in order to reduce costs, improve performance in terms of autonomy and capacity and decrease the long-term environmental impacts resulting from the use and processing of raw materials.

C. Natural gas is seen as an important part of the EU's energy mix and will play an important role in the mobility of the future. Compressed Natural Gas and Liquefied Natural Gas offer a real alternative to conventional fuels for light and heavy vehicles over long distances, as well as for maritime transport. Member States need to encourage this shift adopting adequate regulations.

D. Hydrogen fuel is also considered an important part of the EU energy mix, contributing to the decarbonization of the transport sector. The main advantages of fuel cell electric vehicles are the zero emission of CO2 and pollutants (tailpipe emission is only water) and the higher fuel cell efficiency compared to internal combustion engines. However, the higher car prices, safety concerns and the absence of an adequate infrastructure limit the potential for this technology. Government policies need to foster consumer acceptance and encourage more private investments from companies seeking to establish a global network of fuel cell refilling stations.

Concerning **ICT-based mobility**, different challenges need to be addressed in order to advance the access to more efficient and less costly technologies and, at the same time, ensure solutions consistent with the ambitious EU environmental goals:

A. Shared mobility is characterized by the sharing of a vehicle instead of owning it, and the use of technology to connect users and providers. As shown, there are four main models: the **peer-to-peer platform**, where individuals can rent their cars when not in use (Model 1); the **short-term rental of vehicles** managed and owned by a provider (Model 2); companies owning no cars themselves, but signing up ordinary car owners to act as drivers offering a **taxi-like service** (Model 3); and **on-demand private cars**, **vans or buses and other vehicles**, such as big taxis, **shared by passengers** going in the same direction (Model 4). Models 1, 2 and 3 can yield profits for private parties, but from the evidence available, do not seem to have the potential to substantially reduce congestion or CO2 emissions, though this needs further research. Moreover, these models (especially1 and 2) will never replace the modes currently used for commuting. As for Model 2 (e.g. Car2Go), although apps are clearly helping boost this model, evidence shows that households may be inclined to give up a second or third car rather than become car-less and completely rely on these services. Model 4, which entails individuals not only sharing a vehicle, but actually travelling together at the same time, is promising in terms of congestion and CO2 emission reduction. However, it is also the most challenging, given the disadvantages in terms of waiting and travel time, comfort and convenience, compared to private car use[1]. EU local governments need to work together to

1 MDPI, *Sustainability and Shared Mobility Models*, 2018

exchange best practices and offer a similar regulatory framework to players in order to minimize costs for both companies and consumers but also ensure that shared mobility works towards reducing congestion and pollution.

B. Currently, the dissemination of smart sensors in the surrounding environment and in objects, as well as in wearable and similar devices, are paving the way for the **Internet of Things**. Internet is upgrading from its former status of a computer network where information is available for individuals on request, becoming a network connecting objects, robots and other devices allowing them to mainly act in two ways: following a direct human request, that can be communicated to multiple channels and devices, such as voice command or "autonomously". For example, **autonomous vehicles (AV)** are machines, provided with proper equipment and real time information flows, that can decide on and carry out their own actions – self-parking, avoiding collisions and driving. However, crucial issues such as liability, interoperability and cybersecurity need to be urgently addressed before autonomous vehicles can begin to operate on EU roads.

C. With the spreading of **5G**, communication amongst objects will markedly improve in capacity and latency reduction, making interaction possible in real time. EU investments in 5G networks need to be supported by an appropriate regulation able to encourage a fast roll-up and allow for a realistic return on private investments, maintaining a competitive framework.

D. Further research must be carried out to support the EU legislators in correctly assessing the future of mobility and drawing up the appropriate measures for a development which balances the benefits and challenges for this transformation.

PART 1

THE NEW MOBILITY ERA

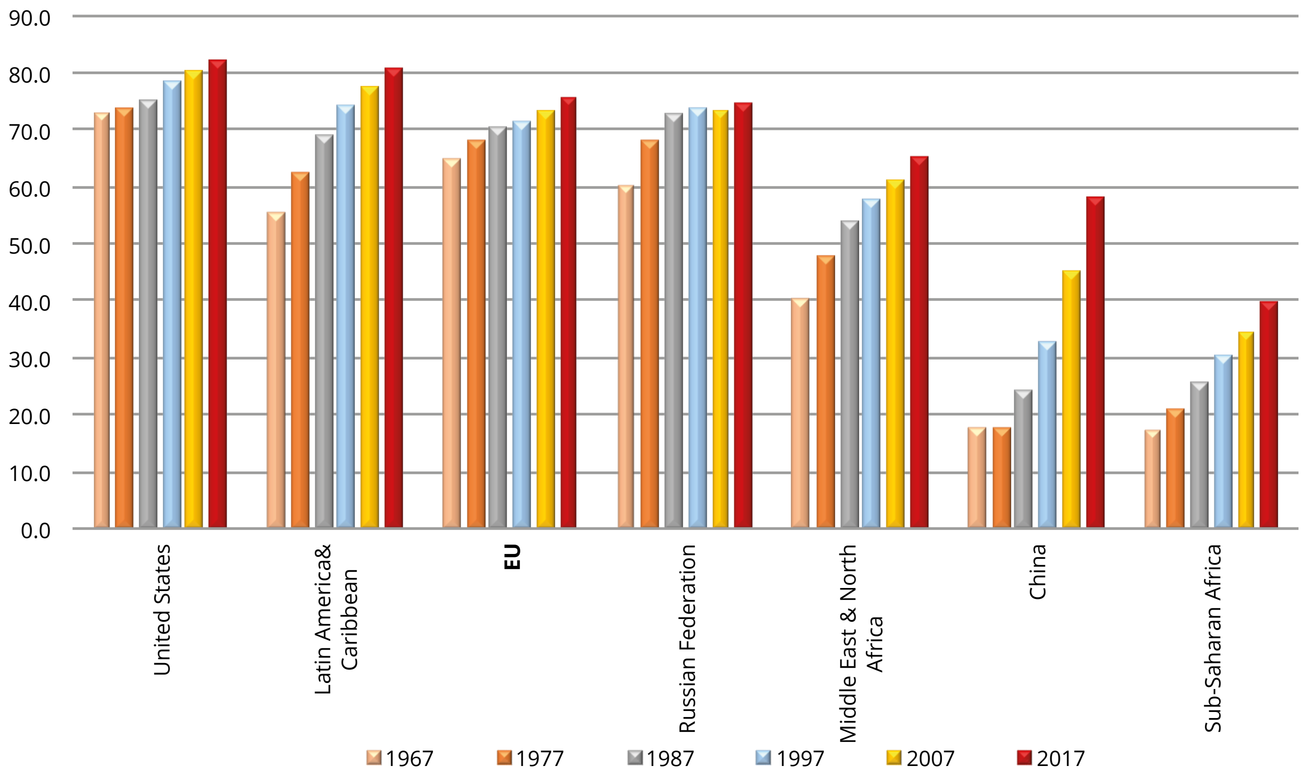
1. THE NEW MOBILITY ERA

1.1. THE INCREASING DEMAND FOR MOBILITY AND THE NEED FOR SOCIAL CHANGE

During the next decades the mobility sector will go through some dramatic changes because of the changes in people's behavior, as well as other external factors. From a social point of view, several trends will require an actual adaptation of the mobility sector. These trends involve the growing number of people moving to (and within) urban areas, the shift towards an even more individual and personalized mobility – due to the growing number of single-person households and people's longer life expectancy – and the increase in tourism flows.
In the last 50 years, the percentage of the population moving to urban areas has significantly increased in every part of the world (Fig. 1.1).

Fig. 1.1 Percentage of population living in urban areas (% of total)

Source: The World Bank, 2018

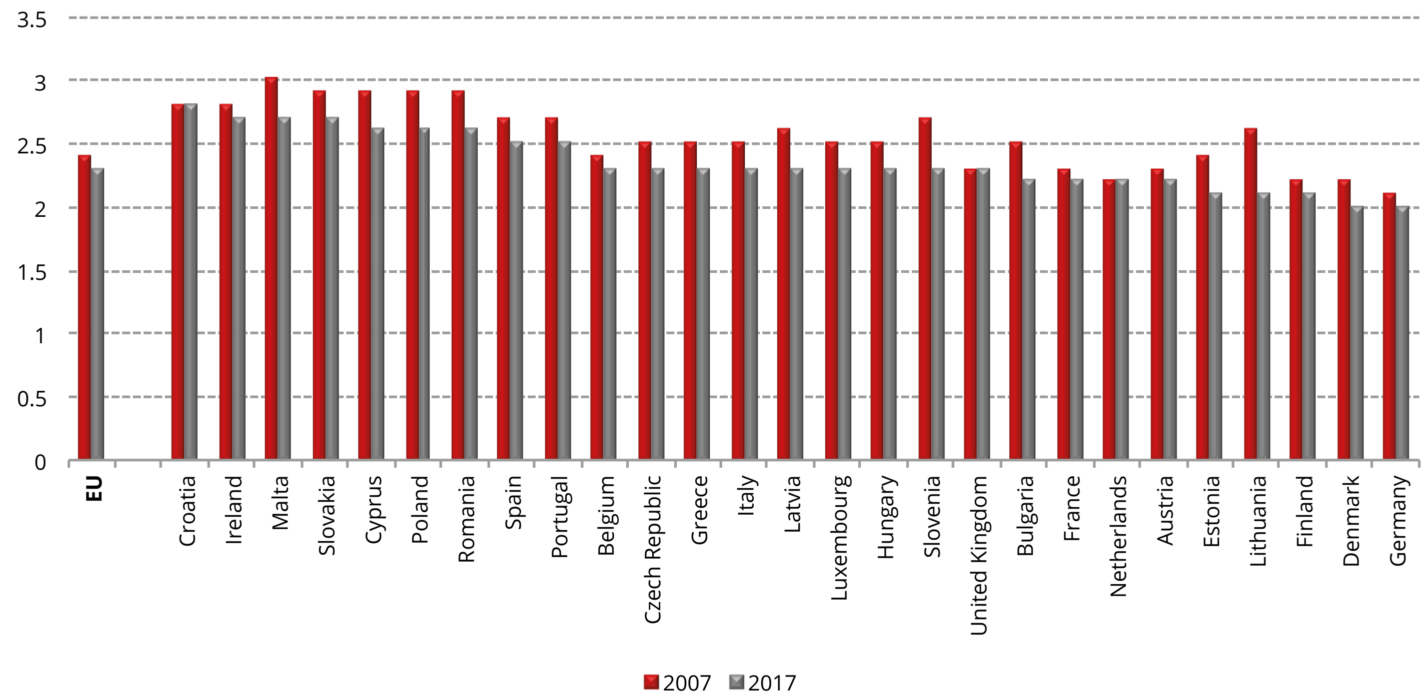


China and Sub-Saharan Africa are the regions where there has been the largest growth, while the United States and Latin America show the highest percentage of people currently living in urban areas. The European Union has had a smaller growth, even though more than 75% of its inhabitants live in urban areas and this trend, also on a global level, is destined to rise. Arthur D Little's elaboration on UN data estimates a growth from 6.7 billion in 2010 to 9.5 billion inhabitants by 2050 while, in the same period, the percentage of those living in urban areas will increase from 52% to 66%[2].

The second social factor that will affect the transport sector will be the growing request for a more individual and personalized mobility, also due to an increasing

Fig. 1.2 Average number of people in EU private households

Source: Eurostat



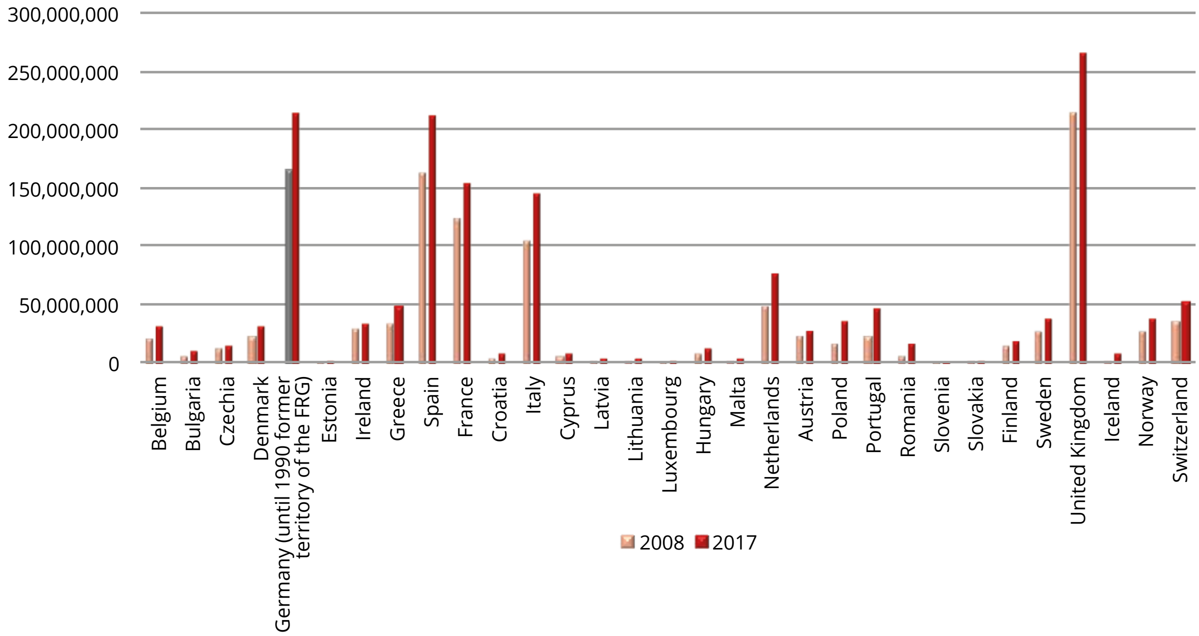
2 Arthur D. Little, *The Future of Mobility*, March 2018, p. 11.

number of single-person households (Fig. 1.2). Indeed, data on European Union countries shows the decrease in the number of individuals per family in almost every Member State. The bigger drops are recorded in Lithuania, Slovenia, Romania, Bulgaria and Poland, as well as in Malta and Cyprus. In 2017, the average European household was made up of 2.3 persons (-0.1% compared to 2007).

The third factor, the increase in tourist flows, is shown by comparing the number of air transport passengers between 2008 and 2017 (Fig. 1.3). According to the last data available (2017), the total number of passengers carried in Europe reached 1 billion units, an increase of 30% on 2007. The countries recording the biggest growth in absolute terms are the most populated ones, such as the United Kingdom (about 50 million more passengers per year), Spain (48 million), Germany (46 million), Italy (39 million) and France (31 million), while those showing the highest percentage increase are Romania (+123% passengers per year), Luxembourg (+107%), Lithuania (+105%) and Poland (+101%).

Fig. 1.3 Air transport of passengers in the EU (no. of passengers per country per year)

Source: Eurostat



Note: Total number of passengers carried in the EU (arrivals plus departures).

On the other hand, an evolution in the mobility sector is also essential to face the problem of increasing traffic and congestion, as well as the need for pollution reduction.
Concerning the former, according to TomTom data, Europeans spent up to 45 hours per year stuck in traffic, and this trend seems to be increasing (Tab. 1.1). Of the 28 Member States considered, only 10 showed a reduction in hours from 2014 to 2016, led by Croatia (-2.7), Greece (-2), Finland (-2) and Estonia (-1.7) while a reduction of half an hour or less was seen in Slovenia (-0.5), Latvia (-0.5) Poland (-0.3), the Czech Republic (-0.1) and Sweden (-0.1). Instead, 18 countries showed an increasing time spent in traffic congestions, with a significant increase in the UK (+4.8), Luxembourg (+4), Belgium (+3), Ireland (+2.4) and Italy (+2.3). Generally speaking, the data seems to show that countries with less congested routes result in a reduction in the number of hours its inhabitants spend in traffic, while in the Member States where traffic was already heavy the traffic conditions tended to worsen.
Where pollution is concerned, the data on greenhouse gas emissions seems to show some improvement in the EU, especially in the last 10 years (Tab.1.2), the period in which the total tons of CO2 dropped from 5.351 million to 4.440 million per year. As expected, the EU countries with the highest emissions are the most populated ones – Germany, the United Kingdom, France and Italy.
The transport sector is responsible for 24% of the total greenhouse gas emissions, a significant increase from 1990 (15%), raising issues related to the usage optimization of transport means (Fig. 1.4).
It is worth noting here that ecological and environmental problems are also changing people's behavior due to more awareness. One of the positive externalities is probably an increased willingness to the sharing of resources and goods. The growing demand for sharing mobility services is attracting an increasing number of entrepreneurs in investing in this sub-sector, multiplying the number of services, the city coverage as well as the quality (see Chapter 3).
In addition, data also reveals a growing number of people using apps for traffic optimization. Moreover, a new digital revolution will have a radicall impact on mobility, due to the introduction of the 5G transmission standard – which will increase the bandwidth and almost nullify the latency – and to the spread of the Internet of Things. The latter involves the spread of smart sensors along highways, railways, ports and related infrastructures, as well as in smart vehicles. The future means of transport will be able to communicate, at the same time, with eachother and with those infrastructures in place, improving traffic and security issues, responding to the growing demand for more personalized and optimized transport services[3].

3 The main technological trends implied by the increasing role of ICT will be analyzed in Chapter 3.

Tab 1.1 Hours spent in road congestion annually in the EU (breakdown per country per year)

Source: I-Com elaboration on JRC, TomTom

	2014	2015	2016	Ranking	Diff. Rkg 2014-16	Diff. Hours 2014-16
UK	40.3	41.0	45.1	1	0	4.8
BE	35.8	35.9	38.8	2	1	3.0
IT	35.5	35.8	37.9	3	1	2.3
EL	37.6	38.0	35.6	4	-2	-2.0
LU	31.2	31.8	35.2	5	1	4.0
IE	31.0	31.5	33.3	6	1	2.4
BG	30.4	31.1	31.9	7	1	1.4
RO	31.7	31.9	31.7	8	-3	0.1
NL	30.4	30.5	31.5	9	0	1.2
FR	29.1	29.3	29.9	10	1	0.9
DE	29.5	29.6	29.5	11	-1	0.0
PT	27.5	28.0	29.3	12	0	1.8
AT	27.0	27.1	27.2	13	1	0.2
ES	26.5	27.4	27.0	14	1	0.4
SI	27.4	27.5	26.9	15	-2	-0.5
HU	26.2	26.1	26.4	16	0	0.2
PL	25.2	25.4	25.0	17	1	-0.3
SK	23.0	23.2	23.7	18	2	0.6
HR	25.8	25.7	23.5	19	-2	-2.4
CZ	23.3	23.6	23.2	20	-1	-0.1
DK	21.5	20.8	22.1	21	1	0.6
LV	21.8	22.4	21.3	22	-1	-0.5
SE	21.3	21.3	21.2	23	1	-0.1
LT	21.4	21.9	20.7	24	-1	-0.7
EE	20.3	20.0	18.7	25	0	-1.7
FI	19.9	19.6	17.9	26	0	-2.0

Tab 1.2 Total greenhouse gas emissions, by country (million tons of CO_2 equivalents)*

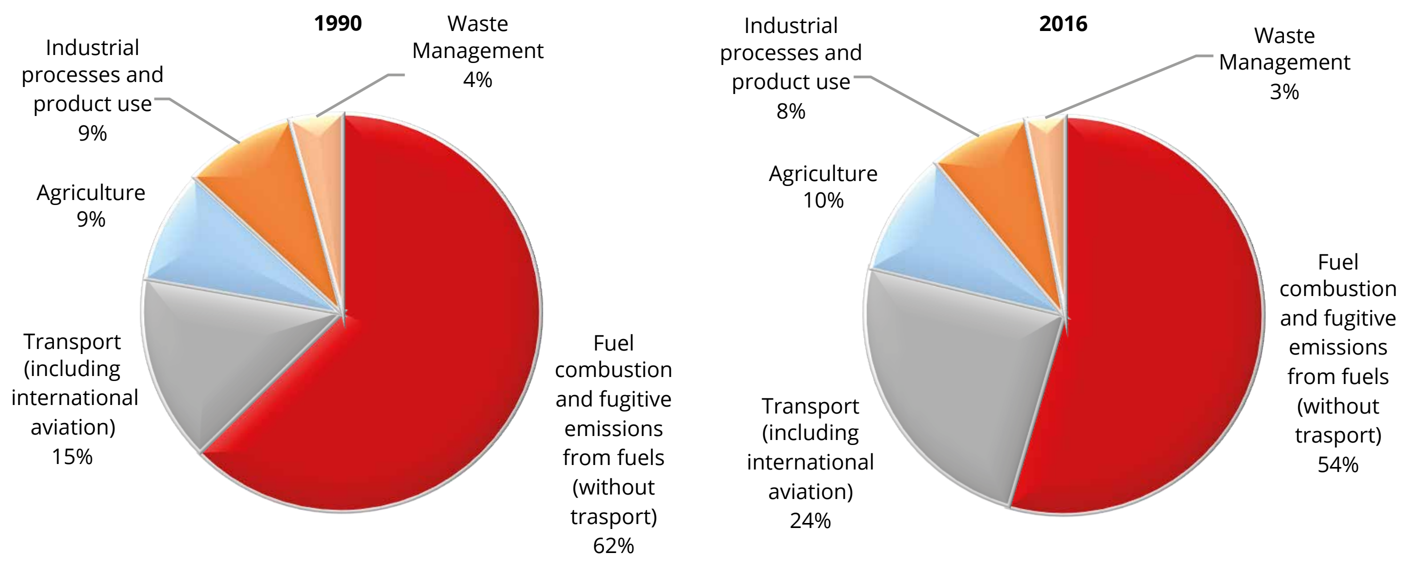
Source: European Environment Agency

	1990	1995	2000	2005	2010	2016	Share in EU
EU	5719.6	5386.7	5277.7	5351.2	4909.1	4440.8	100.0%
Belgium	149.8	157.7	154.5	149.0	136.9	122.1	2.8%
Bulgaria	104.7	75.5	59.8	64.5	61.1	59.7	1.3%
Czech Republic	200.1	159.4	150.8	149.0	141.5	131.3	3.0%
Denmark	72.2	80.2	73.1	68.9	65.8	53.3	1.2%
Germany	1263.7	1138.3	1064.3	1016.0	967.0	935.8	21.1%
Estonia	40.5	20.3	17.4	19.3	21.2	19.7	0.4%
Ireland	56.6	60.3	70.4	72.1	63.6	64.2	1.4%
Greece	105.6	111.8	128.9	138.9	121.0	94.7	2.1%
Spain	292.5	334.0	395.2	450.6	368.3	340.5	7.7%
France	555.1	552.1	565.3	568.6	527.7	475.4	10.7%
Croatia	32.4	23.2	26.0	30.2	28.3	24.7	0.6%
Italy	522.7	538.5	562.5	589.4	512.9	438.2	9.9%
Cyprus	6.3	7.8	9.1	10.1	10.3	9.7	0.2%
Latvia	26.7	13.0	10.6	11.6	12.7	11.7	0.3%
Lithuania	48.5	22.4	19.5	23.0	20.9	20.4	0.5%
Luxembourg	13.2	10.7	10.6	14.3	13.4	11.5	0.3%
Hungary	94.3	76.0	74.1	76.6	66.1	62.1	1.4%
Malta	2.3	3.0	3.1	3.2	3.3	2.3	0.1%
Netherlands	225.9	238.9	229.4	225.4	223.7	207.0	4.7%
Austria	79.6	81.1	82.1	94.6	87.0	82.0	1.8%
Poland	467.9	438.9	390.4	398.6	407.4	397.8	9.0%
Portugal	61.5	72.1	85.4	89.3	72.8	71.2	1.6%
Romania	247.5	181.1	141.2	148.2	122.7	113.4	2.6%
Slovenia	18.7	18.8	19.1	20.6	19.7	17.8	0.4%
Slovakia	74.0	54.0	49.6	51.3	46.4	41.2	0.9%
Finland	72.3	72.8	71.2	71.1	77.2	60.8	1.4%
Sweden	72.9	75.0	70.6	68.7	66.5	55.5	1.2%
United Kingdom	812.1	769.6	743.4	728.1	643.7	516.8	11.6%

** Note: Includes international aviation, indirect and excluding LULUCF*

Fig. 1.4 Greenhouse gas emissions in the EU, by sector (% of total)

Source: European Environment Agency



1.2. THE EUROPEAN UNION TOWARDS SAFE, CLEAN AND CONNECTED MOBILITY

1.2.1. The Cooperative Intelligent Transport Systems: a European strategy for the future

The development of digital technologies is revolutioning the transport sector. Digital connectivity is expected to significantly improve road safety, traffic efficiency and comfort of driving, by helping the driver to take the right decisions and adapt to traffic conditions. Communication between vehicles, infrastructures and with other road users is also important for increasing the safety of automated vehicles and their full integration into the overall transport system. Considering that several countries around the world (e.g. US, Australia, Japan, Korea and China) are moving rapidly towards deploying digital technologies, and in some countries vehicles and C-ITS services are already available on the market, the European Commission, on 30 November 2016, launched a **European Strategy on Cooperative Intelligent Transport Systems (C-ITS), a milestone initiative towards cooperative, connected and automated mobility**. It aims at facilitating the convergence of investments and regulatory frameworks across the EU, in order to see the deployment of mature C-ITS services in 2019 and beyond. The document identifies the priorities for deployment of C-ITS Services underlining the importance to ensure continuity of service, i.e. the availability of C-ITS services across the EU for end-users, to develop in Europe a common security and certificate policy for C-ITS, to ensure privacy, data protection and interoperability at all levels, to encourage international cooperation promoting international standardization, protecting the privacy of individuals and their personal data and cyber security, addressing legal aspects and enabling the coordination of research.

1.2.2. EU mobility packages

The European Union was the first major economy to present its climate plan on 6 March 2015, reflecting the 2030 climate and energy policy framework set by the October 2014 European Council and the European Commission's blueprint for tackling global climate change beyond 2020. The EU has set an ambitious economy-wide domestic target of at least 40% greenhouse gas emission reduction for 2030.

In December 2015, the Paris Agreement was stipulated. It is the first multilateral agreement on climate change covering almost all of the world's emissions and a confirmation of the EU's path to a low carbon economy. In the **Communication on the Implementation of the Paris Agreement Commitments** in March 2016, the European Commission explains that this Agreement sets out an ambitious long term goal to limit the temperature increase to 1.5°C; provides for a dynamic mechanism based on a meeting every five years (from 2023) to consider progress in emission reductions, adaptation and support provided and received in view of the long-term goals of the Agreement; fixes the obligation to pursue domestic mitigation measures, with the aim of achieving the objectives of their contributions; prescribes a biennial submission by all parties of greenhouse gas inventories; and establishes for the first time a global goal with the aim to enhance capacity, climate resilience and reduce climate vulnerability encouraging greater cooperation among parties to share scientific knowledge on adaptation as well as information on practices and policies.

European Institutions are aware of the importance of implementing policies able to facilitate the transition to a cleaner economy. For this purpose, on 20 July 2016, the Commission presented a **European Strategy for Low-Emission Mobility**.

Considering that a more efficient transport system would facilitate the transition to low-emission mobility and provide certainty for investors and that new technologies, business models and mobility patterns are increasingly impacting the sector, the document highlights the importance of ensuring fair and efficient pricing in transport and promoting multi-modality such as inland waterways, short-sea shipping and rail. In order to increase the use of low-emission alternative energy for transport, the Commission emphasizes the importance of advanced biofuels for aviation, as well as for lorries and coaches, and natural gas as an alternative for marine fuels in shipping and for diesel in lorries and coaches. Specific infrastructures should be created and interoperability and standardization for electro-mobility should be developed in order to encourage the use of alternative fuels. The Commission also foresees the following objectives and actions at all levels to support the transition to low emission mobility:

1. linking the transport and energy systems, encouraging charging at times of cheap electricity when demand is low or supply high and reducing barriers to the self-generation, storage and consumption of renewable electricity;
2. encouraging research, innovation and competitiveness to support the long-term transition towards zero-emission mobility;
3. creating the regulatory frameworks to provide incentives for the development and market uptake of digital technologies and setting standards to ensure interoperability, including across borders, and to enable data exchange while, at the same time, addressing data protection and cyber-security issues;
4. promoting the acquisition of new skills;
5. investing to support a more technologically neutral efficient transport system with low-emission alternative energy for transport and low- and zero-emission vehicles;
6. supporting local authorities' initiatives to encourage a modal shift to active travel (cycling and walking), public transport and/or shared mobility schemes, i.e. bike- and car-sharing and car-pooling, to reduce congestion and pollution in cities;
7. identifying global actions for international transport to address international aviation emissions and achieve carbon neutral growth from 2020 and to set an emission reduction objective for the shipping sector, which should be followed by measures to mitigate emissions in the international maritime sector (the EU already has in place legislation that requires ships that use EU ports to monitor, report and verify emissions).

Considering that road transport employs 5 million Europeans and contributes to almost a fifth of the EU's greenhouse gas emissions, the European Commission crafted a series of **Mobility Packages** to improve the functioning of the road haulage market and help improve workers' social and employment conditions. It is a collection of three initiatives released in May 2017, November 2017 and May 2018, respectively, concerning the governance of commercial road transport in the European Union.

Specifically, on 31 May 2017, the European Commission presented the Communication, **Europe on the Move. An agenda for a socially fair transition towards clean, competitive and connected mobility for all**. This paper aims to ensure that Europe plays a leading role in clean, competitive and connected mobility, supporting the adoption of the best low-emission mobility solutions, equipment and vehicles and the development of modern infrastructures to support them. Considering that the mobility sector is a driver for the global competitiveness of the wider economy and that a modern mobility system is also a prerequisite for a successful transition to a low-carbon economy in Europe, the Commission underlines the need to move from fragmented transport networks to integrated and sustainable mobility. This Communication focuses on the key contribution that must be made by road transport and it is accompanied by several proposals to support the rollout of infrastructure for road charging, alternative fuels and connectivity, better information for consumers, a stronger internal market and improved working conditions for the road haulage sector, as well as steps to lay the ground for cooperative, connected and automated mobility.

Road transport is a major contributor to air pollution and greenhouse gas emissions (posing a serious threat to public health) and transport activity across Europe is expected to keep growing, so the mobility sector is at the forefront in the EU's efforts to maintain the momentum towards the goal of a low carbon economy. The paper underlines that citizen mobility demand is growing and the attitude to mobility is changing, focusing on better quality, convenience, flexibility and affordability. Therefore, it emphasizes the importance of ensuring that the EU transport sector should embark on innovation and the deployment of new technologies quickly, supporting the rollout of cooperative, connected and highly automated mobility solutions and the emergence of new mobility concepts such as car-sharing and new solutions for optimizing logistics.

The Commission also underlines the impact of clean, connected and automated vehicles on labour intensity in manufacturing, focusing on the deployment of new skills and the necessity to ensure a stronger social dialogue as well as support mechanisms to help people make the best of the new opportunities, such as the importance of taking advantage of the opportunities created by digital technologies. Connectivity and social media are indeed radically transforming the traditional concepts of mobility and new business models are emerging and giving rise to innovative mobility services, including new on-line platforms for freight operations, car-pooling, car or bicycle sharing services, or smartphone applications offering real-time analytics and data on traffic conditions. Vehicles themselves are also being impacted by digital technologies, becoming increasingly smart. In this context, 5G will represent an important opportunity to support the development of new digital services and their application to the mobility sector.

Considering that Europe's ambition must be a rapid progress towards a clean, competitive and connected mobility system, integrating all means of transport by 2025, the Commission highlights the importance of setting common rules and standards with a wide range of support measures including infrastructure investments, research and innovation projects, cross-border trials for interoperable deployment and platforms for cooperation between stakeholders. In this context, promoting sustainable mobility through improved emission standards, ensuring informed consumer choices, and using public procurement as a market-driver for clean transport are important tools.

To achieve these objectives, the Commission expresses the will to:

1. strengthen its support for large-scale cross-border

projects and trials for connected and automated driving and the deployment of cooperative intelligent transport systems by 2019;
2. encourage the availability of alternative fuel infrastructures, such as electric charging and maintenance facilities;
3. support an industry-led initiative and develop support measures for research, development and manufacturing of the next generation of battery cells and battery packs in the EU.

The proposal presented by the Commission in May 2017 covers the following areas:

1. **access to the road haulage market and to the profession of passenger and freight transport operators**. The Commission presented a proposal for a regulation amending Regulation n. 1071/2009 (which lays down the provisions that undertakings must comply with in order to become a road transport operator and also certain provisions to regulate and enable enforcement by Member States) and Regulation n. 1072/2009 (which lays down the provisions that undertakings intending to operate in the international road haulage market and national markets other than their own (cabotage) must include provisions related to the documents to be issued to such undertakings by the Member State of registration as well as to drivers from third countries) with a view to adapting them to sector developments. In particular, concerning Regulation n. 1071/2009, the Commission proposed to introduce some changes to: **a)** subject matter and scope, excluding hauliers operating solely with LCVs from some, but not all of the requirements of the Regulation; **b)** requirements for engagement in the occupation of road transport operator, deleting par. 2 setting additional conditions on access to the occupation; **c)** conditions relating to the requirement of establishment, clarifying the terms of art. 5 to ensure that undertakings established in a Member State have a real and continuous activity there; **d)** conditions relating to the requirement of good repute, clarifying and further harmonizing the assessment of good repute and extending the list of infringements which may lead to loss of good repute; **e)** conditions relating to the requirement of financial standing, introducing less demanding,conditions to be fulfilled by hauliers operating solely with LCVs; **f)** the procedure for the suspension and withdrawal of authorizations, clarifying the position of competent authorities where undertakings no longer comply with the requirement of financial standing and prescribing that the undertaking is expected to demonstrate that the requirement is again satisfied and will be satisfied in the future; **g)** the declaration of unfitness of the transport manager, specifying that, after having lost good repute, a transport manager cannot be rehabilitated by the competent authority earlier than one year from the date of loss of good repute; **h)** national electronic registers, adding elements of information to be included in the national electronic registers; **i)** administrative cooperation between Member States, specifying the terms of the

cooperation between Member States. In particular, it is proposed to set a maximum time period for Member States to reply to reasoned requests from other Member States and an obligation for Member States to conduct inspections concerning non-compliance with the criteria on establishment by undertakings established in their territories on the basis of evidence provided by other Member States; **j)** reporting, requiring that Member States report to the Commission information about the activities of hauliers operating with LCVs in their territory. Instead, concerning Regulation n. 1072/2009, the Commission proposed to introduce some changes to: **a)** the scope, clarifying that the carriage of empty containers or pallets is to be considered as a carriage for hire and reward only if it is subject to a transport contract between a consignee and a consignor; **b)** definitions, specifying that a cabotage operation can involve several loading points, several delivery points or several loading and delivery points; **c)** cabotage – general principle*:* the maximum number of cabotage operations which may be carried out in a host Member State following an incoming international carriage is removed, the maximum number of days for carrying out such cabotage operations is reduced and the requirement to produce evidence of each cabotage operation is removed; **d)** cabotage – checking systems, requiring that Member States carry out a minimum amount of checks of compliance with the cabotage provisions (i.e. 2% of cabotage operations from 1 January 2020 and 3% from 1 January 2022) and requiring Member States to carry out a minimum number of concerted roadside checks per year on the cabotage provisions of the Regulation; **e)** liability, specifying that shippers and freight forwarders shall be subject to sanctions when they knowingly commission transport services which involve infringements of the provisions of the Regulation; **f)** reporting, specifying the date by which Member States are required to report to the Commission on the number of Community licences, certified true copies and driver attestations issued in the previous calendar year, i.e. by 31 January of the following year. The discussion within the Council is ongoing;

2. **hired freight transport vehicles**. The Commission presented a proposal for a Directive amending Directive 2006/1/EC on the use of vehicles hired without drivers for the carriage of goods by road. Considering that the use of hired vehicles can reduce the costs of undertakings carrying goods on their own account or for hire and reward and, at the same time, increase their operational flexibility, also being safer and less polluting, the proposal wishes to delete the regulations that allow Member States to restrict the use, by their undertakings, of hired vehicles with a maximum permissible laden weight of more than six tonnes for their own account operations and also the use of a hired vehicle in their respective territories if the vehicle has been registered or put into circulation in compliance with the laws in a Member State other than the one of

establishment of the undertaking hiring it. The discussion within the Council is ongoing;

3. **road charging and electronic tolling**. The Commission launched a proposal for a Directive on the interoperability of electronic road toll systems and facilitating cross-border exchange of information on the failure to pay road fees in the Union. It lays down the conditions necessary to ensure the interoperability of electronic road toll systems and to facilitate the cross-border exchange of information on the failure to pay road fees in the European Union specifying that Member States shall ensure that processing of personal data necessary for the operation of the European electronic toll service is carried out in accordance with the Union rules protecting the freedom and fundamental rights of individuals, including their privacy. The document also describes the procedure for the exchange of information between Member States – committing them to identifing a national contact point and taking all the necessary measures to ensure that the exchange of information is carried out by interoperable electronic means without exchange of data involving other databases which are not used for the purposes of the Directive – and sets the contents of the information letter on the failure to pay a road fee and the submission procedure. The discussion within the Council is ongoing;
4. **driving & rest time rules.** The Commission presented a proposal for a Regulation amending Regulation n. 561/2006 as regards to minimum requirements on maximum daily and weekly driving times, minimum breaks and daily and weekly rest periods and Regulation (EU) 165/2014 as regards positioning by means of tachographs. It specifies that private individuals using vehicles which would fall within the scope of Regulation n. 561/2006, to carry private belongings for their own purposes, are not obliged to record their driving times and rest periods and are therefore not obliged to have or use a tachograph or a driver's card. As well, it defines the notion of "non-commercial" carriage and underlines that full records of all driver's activities, and not only driving, which is automatically recorded by a tachograph, is important to effectively monitor a driver's working patterns, which may lead to fatigue and create risks to road safety. It also specifies that drivers driving in a team may take their obligatory break in a vehicle which is driven by another driver. The proposal prescribes that in any four consecutive weeks a driver shall take at least four regular weekly rest periods, or two regular weekly rest periods of at least 45 hours and two reduced weekly rest periods of at least 24 hours specifying that the regular weekly rest periods and any weekly rest of more than 45 hours taken in compensation for previous reduced weekly rest shall not be taken in a vehicle. They shall be taken in a suitable accommodation, with adequate sleeping and sanitary facilities. For the digital tachograph, the proposal obliges the driver to enter the country symbols in the digital tachograph – where the daily working period started

and finished, as well as where and when the driver crossed a border in the vehicle on arrival at the suitable stopping place;

5. **posting of workers.** The Commission presented a proposal for a Directive amending Directive 2006/22/EC as regards enforcement requirements and laying down specific rules with respect to Directive 96/71/EC and Directive 2014/67/EU for posting drivers in the road transport sector. In particular, the proposal establishes specific rules regarding certain aspects of Directive 96/71/EC for the posting of drivers in the road transport sector and of Directive 2014/67/EU of the European Parliament and Council for the administrative requirements and control measures for the posting of those drivers;
6. **enforcement**. The Commission launched a proposal for a Directive amending Directive 2006/22/EC regarding enforcement requirements and laying down specific rules with respect to Directive 96/71/EC and Directive 2014/67/EU for posting drivers in the road transport sector. It prescribes that each Member State shall organise checks so that at least 3% of days worked by drivers of vehicles falling within the scope of Regulation (EC) No 561/2006, Regulation (EU)165/2014 and Directive 2002/15/EC are checked, specifying that the information submitted to the Commission shall include the number of drivers checked at the roadside, the number of checks at the premises of undertakings, the number of working days checked and the number and type of infringements reported, together with a record of whether passengers or goods were transported. The proposal also fixes a specific term – 25 working days from receipt of the request from other Member States – to submit the information requested and an – other term – 10 working days – to communicate to other Member States that the request is insufficiently reasoned or impossible to be satisfied. The text introduces an obligation for the Member States to introduce a risk-rating system for undertakings based on the relative number and severity of any infringement of Regulation (EC) No 561/2006 or of Regulation (EU) No 165/2014 or of national provisions transposing Directive 2002/15/EC that an individual undertaking has committed (the Commission shall, by means of implementing acts, establish a common formula for calculating a risk-rating of undertakings), defines the calculation method of the periods of posting and identifies the administrative requirements and control measures that Member States can impose;
7. **vehicle taxation.** The Commission presented a proposal for a Council Directive amending Directive 1999/62/EC on the charging of heavy goods vehicles for the use of certain infrastructures, as regards certain provisions on vehicle taxation. The amendment proposed consists in a gradual reduction of the minima to zero, namely in 5 steps taken over 5 consecutive years and accounting each for 20% of the current minima. The intention is to provide for an incentive to move to distance-based road charging, i.e. the application of tolls;

8. **CO2 monitoring and reporting of Heavy Duty Vehicles**. On 28 June 2018, Regulation 2018/956 on the monitoring and reporting of CO2 emissions from and fuel consumption of new heavy-duty vehicles was approved. It lays down the requirements for the monitoring and reporting of CO2 emissions from and fuel consumption of new heavy-duty vehicles registered in the Union. It prescribes monitoring and reporting by Member States and manufacturers and the conservation by the Commission of a public Central Register for the data on heavy-duty vehicles reported by Member States and manufacturers. It sets the responsability of the competent authorities and manufacturers for the correctness and quality of the data they report and the power of the Commission to impose an administrative fine (that shall not exceed EUR 30,000 per heavy-duty vehicle concerned by deviating or delayed data). The Regulation prescribes that the procedure established by the Commission shall respect the right to good administration and, in particular, the right to be heard and the right to have access to the file, while respecting the legitimate interests of confidentiality and of commercial secrets. It also fixes the principles to be observed by the Commission in calculating the appropriate administrative fine (principles of effectiveness, proportionality and dissuasiveness, taking into consideration, where relevant, the seriousness and effects of the deviation or delay, the number of heavy-duty vehicles concerned by the deviating or delayed data, the good faith of the manufacturer, the degree of diligence and cooperation of the manufacturer, the repetition, frequency or duration of the deviation or the delay, as well as prior sanctions imposed on the same manufacturer). By 31 October every year, the Commission shall publish an annual report with its analysis of the data transmitted by Member States and manufacturers for the preceding calendar year.

On 8 November 2017, the Commission launched the **2nd Mobility Package**, focusing on clean mobility. It consists of:

1. the Communication, **Delivering on Low-emission Mobility – A European Union that protects the planet, empowers its consumers and defends its industry and workers**, outlining the steps to make clean mobility a reality. The Commission identifies the objective to strengthen Europe's ability to confront the challenge of climate change and improve the quality of life of citizens, maintaining and extending the competitive edge of industries to create jobs, generate sustainable economic growth and drive innovation in renewable energy technologies. The Commission explains that this Second Package addresses three key political priorities: **a)** Europe that protects the planet, promoting the next generation of CO2 emission reduction standards for transport, encouraging multimodality and efficiently combining different kinds of transport, stimulating the development of bus connections, thereby offering alternative options to private car use and increasing the use of sustainable public

transport modes; **b)** Europe that empowers its citizens, putting in place a robust testing framework for type-approval based on new testing procedures that will ensure effective compliance with the rules, facilitating consumers' access to affordable new and cleaner forms of mobility and making sure that the benefits of these new mobility services are available to all and boosting investment in alternative fuel infrastructures; **c)** Europe that defends its industry and workers, promoting the production of connected and automated vehicles, establishing a complete value-chain for the development and manufacturing of advanced batteries in the EU and supporting the resilience and competitiveness of labour markets, addressing skill gaps and mismatches and supporting the development of new skills through learning abroad;

2. the Communication, **Towards the Broadest Use of Alternative Fuels – an Action Plan on Alternative Fuel Infrastructures, under Article 10(6) of Directive 2014/94/EU, including the assessment of national policy frameworks under Article 10(2) of Directive 2014/94/EU**. The Directive 2014/94/EU of 22 October 2014, on the deployment of alternative fuel infrastructures, established a common framework of measures for the deployment of alternative fuel infrastructures in the Union in order to minimize dependence on oil and to mitigate the environmental impact of transport. It sets out minimum requirements for the building-up of alternative fuel infrastructures, including recharging points for electric vehicles and refuelling points for natural gas (LNG and CNG) and hydrogen, to be implemented by means of Member States' national policy frameworks, as well as common technical specifications for such recharging and refuelling points, and user information requirements. Art. 3 of the directive prescribes that Member States adopt a national policy framework – to be notified to the Commission by 18 November 2016 – for the development of the market as regards alternative fuels in the transport sector and the deployment of the relevant infrastructure containing an assessment of the current state and future development of the market as regards alternative fuels. This includes, in light of their possible simultaneous and combined use and of the development of alternative fuel infrastructures, national targets and objectives and measures necessary to ensure that the national targets and the objectives contained in the national policy framework are reached and that can promote the deployment of alternative fuel infrastructures in public transport services. It also involves the designation of the urban/suburban agglomerations, of other densely populated areas and of networks which, subject to market needs, are to be equipped with CNG refuelling points, and an assessment of the need to install refuelling points for LNG in ports outside the TEN-T Core Network and consideration of the need to install electricity supply at airports for use by stationary airplanes.

On the electricity supply for transport, the directive sets an obligation for Member States to ensure an appropriate number of recharging points accessible to the public are put in place by 31 December 2020, in order to ensure that electric vehicles can circulate at least in urban/suburban agglomerations and other densely populated areas. As well and, where appropriate, within networks determined by the Member States, it encourages and facilitates the deployment of recharging points not accessible to the public. While regarding hydrogen supply for road transport, the same directive attributes to Member States the power to include hydrogen refuelling points accessible to the public in their national policy frameworks, fixing a term – 31 December 2025 – to ensure the availability of an appropriate number of such points. Concerning natural gas supply for transport, the regulation prescribes Member States to ensure, by means of their national policy frameworks, that an appropriate number of refuelling points for LNG are established in maritime ports, to enable LNG inland waterway vessels or seagoing ships to circulate throughout the TEN-T Core Network by 31 December 2025. Analyzing the Action Plan, describing the current situation and needs' estimates, the Commission underlines the necessity to accelerate deployment in the TEN-T core and comprehensive network (the Communication 'Europe on Move' of May 2017 has set a target for a backbone infrastructure to be in place for the core network by 2025 at the latest) and in urban and sub-urban areas, where vehicles are being used for most of the time. To accelerate the transition to low and zero emission mobility, the Action Plan identifies some actions and initiatives, Specifically, they involve spurring NPF completion and implementation, supporting investment to provide TEN-T core network corridors with a full backbone of alternative fuel infrastructures by 2025, increasing the scale and impact of finance, making better use of EU financing support, encouraging capacity-building in public authorities, companies and financing institutions, enabling actions in urban areas, increasing consumer buy-in (ensuring seamless, interoperable e-mobility payment services that should be based on standards which are open and free from intellectual property rights and royalties and predictability of cost) and integrating electric vehicles into the electricity system (through the promotion of the deployment of charging points and the pre-cabling of parking spaces in residential and non-residential buildings and the adoption of the technologies that enable smart charging);

3. a set of **4 legislative initiatives**, targeting road and combined transport, which aim at strengthening CO2 emission standards for new cars and vans from 2020, promoting clean mobility through public procurement, stimulating combined use of trucks and trains, barges and ships for the transport of goods and, finally, promoting the development of bus connections over long distances.

Finally, on 17 May 2018, the Commission presented the **3rd Mobility Package**, supporting a safe, clean and connected mobility completing the process launched with the 2016 Low Emission Mobility Strategy.

This package consists of:

1. the Communication, **Europe on the move. Sustainable Mobility for Europe: safe, connected, and clean,** presenting a strategic Action Plan on road safety for 2020-2030, including two legislative initiatives on vehicle and pedestrian safety and on infrastructure safety management. In this Communication, the Commission underlines that even if road safety in the EU has greatly improved in recent decades, thanks to actions at EU, national, regional and local levels, opportunities to further improve safety performance must be seized. In fact, technological advances, first and foremost in connectivity and automation, create new opportunities to eliminate or compensate for human error and a shift to driverless vehicles should bring more safety for citizens in the long run. However, they also create new risks related to the functioning of highly automated vehicles in mixed traffic and the complex interaction between the driver and the vehicle (Human-Machine Interface), as well as cybersecurity issues. The Commission describes the EU's long-term goal that is moving as close as possible to zero fatalities in road transport by 2050 ("Vision Zero") while reducing the number of road deaths and serious injuries by 50 % between 2020 and 2030 are the new interim targets. To achieve these ambitious goals, the Commission launched two proposals, the first aimed at transforming EU **vehicle safety standards**, the second to improve **safety management of road infrastructure**. Regarding the first proposal, the Commission launched a comprehensive package of new mandatory vehicle safety measures – such as more advanced restraint systems, new collision detection capabilities and improved direct vision by truck drivers – that bundles the new accident avoidance systems with updated active and passive safety measures to improve the overall road casualty situation on EU roads. The new vehicle safety features are cost-effective, feasible and show high potential for significantly reducing the number of fatalities and serious injuries for road users, both inside and outside the vehicle and encouraging the roll-out of automated vehicles. As for the second proposal, the Commission aims to improve road infrastructure safety management, to reduce both the number of accidents and their severity. The proposal improves the transparency and follow-up of road safety procedures (impact assessments, audits, inspections) and introduces a new procedure to map the risks of accidents across the entire network. Considering that driverless vehicles and advanced connectivity systems could make vehicles safer and easier and address many of the major challenges facing today's road transport system, such as road safety, traffic congestion, energy efficiency and air

quality, the Commission underlines the importance of developing key technologies in Europe, to ensure the safety of automated and autonomous driving and a modern legal framework able to support technological progress. In response to the new challenges and to reap the full benefit of the new opportunities offered by these technological developments, the Commission proposed an EU approach built on three interrelated strategic objectives: a) developing key technologies and infrastructure to strengthen EU competitiveness; b) ensuring safe and secure deployment of connected and automated driving; c) addressing the socio-economic impacts of driverless mobility. Annex 1 explains the **Strategic Action Plan on Road Safety** identifying several initiatives to ensure: **a)** enhancer road safety governance where the Commission proposes a list of key performance indicators to be connected to target outcomes, established in close cooperation with Member States, an enhanced mandate of the High Level Group on Road Safety (made up of high ranking representatives of national administrations) to include strategic advice and frequent feedback and the new role of European Road Safety Ambassador, a well-known personality, to coordinate road safety efforts with Member States and spread good practices both within the EU and internationally; **b)** stronger financial support for road safety, encouraging the use of EU financial support from the European Structural and Investment Funds for road safety upgrades of infrastructure, strengthening funding support for road safety actions in the next Multiannual Financial Framework, investigating how to provide stability in funding support for road safety actions under the next Multiannual Financial Framework and investigating possibilities to financially support capacity-building at Member State level; **c)** safe roads and roadsides, carrying out preparatory work and establishing an expert group whose task will be to elaborate a framework for road classification that better matches speed limit to road design and layout in line with the Safe System approach and facilitating exchange of experience on Safe System methodologies between practitioners; **d)** safe vehicles, assessing whether retrofitting the existing fleet (particularly buses and trucks) with Advanced Driver Assistance Systems is feasible and cost-effective and encouraging Member States to consider, whilst preserving competition in the internal market, national incentives to fast-track proven technologies by a range of means including procurement, safe travel policies, tax and insurance incentives; **e)** safe road use, launching a study into the feasibility of a possible legislative initiative on the mutual recognition of driving disqualification, working with Member States to enable necessary conditions for the functioning of overridable Intelligent Speed Assistance, including the availability of speed limits in a digital format, and the feasibility and acceptability of non-overridable Intelligent Speed Assistance in the future; **f)** fast and effective emergency response starting to assess the effect of eCall and evaluate the possible extension to other categories of vehicles (heavy goods vehicles, buses and coaches, motorcycles, and agricultural tractors) and facilitating closer contacts between road safety authorities and the health sector to assess further practical and research needs; **g)** future-proofing road safety, adopting specifications on cooperative intelligent transport systems, including vehicle-to-vehicle and vehicle-to-infrastructure communication, working closely with stakeholders to launch a process towards developing a code of conduct for the safe transition to the higher levels of automation, to make sure that requirements and procedures take road safety considerations (mixed traffic, interaction with other road users, platooning) fully into account, ensuring coherence among national traffic rules and avoiding contradiction with EU vehicle rules and setting up a Safe City challenge or award. This Communication is also accompanied by a **Strategic Action Plan for Batteries** (Annex 2), setting out concrete measures that will contribute to creating an innovative, sustainable and competitive battery "ecosystem" in Europe. Specifically, this Plan aims to: **a)** secure access to raw materials from resource-rich countries outside the EU, facilitate access to European sources of raw materials, as well as accessing secondary raw materials through recycling in a circular economy of batteries; **b)** support European battery cell manufacturing at scale and a full EU competitive value chain bringing key industry players and national authorities together and working in partnership with Member States and the European Investment Bank to support innovative and integrated manufacturing projects at scale, with an important cross-border and sustainability dimension; **c)** strengthen industrial leadership through stepped-up EU research and innovation support to advanced (e.g. Lithium-ion) and disruptive (e.g. solid state) technologies; **d)** develop and strengthen a highly skilled workforce in all parts of the battery value chain in order to close the skills gap through actions at EU and Member State level providing adequate training, re-skilling and upskilling, and making Europe an attractive location for world class experts in battery development and production; **e)** support the sustainability of the EU battery cell manufacturing industry with the lowest environmental footprint possible, setting out requirements for safe and sustainable battery production; **f)** ensure consistency with the EU broader regulatory and enabling framework;

2. the Communication, **A Europe that Protects: Clean Air for All,** sets out wide-ranging EU policy efforts to support and facilitate the necessary measures for Member States to meet their targets and the enforcement action being taken to help ensure that the common objective of clean air for all Europeans is achieved and maintained across the EU. EU policy efforts rest on three main pillars. The first, involves the ambient air quality standards set out in the Ambient Air Quality Directives for

ground level ozone, particulate matter, nitrogen oxides, dangerous heavy metals and a number of other pollutants. The second involves national emission reduction targets established in the National Emissions Ceiling Directive for the most important trans-boundary air pollutants (sulphur oxides, nitrogen oxides, ammonia, volatile organic compounds and particulate matter). The third involves emission standards for key sources of pollution, from vehicle and ship emissions to energy and industry. The Commission envisages measures to reduce emissions from the transport sector (such as technical improvements, behavior change and demand management or infrastructure investment), from the power and heat sector (such as an increased use of renewable combustion-free power sources, cogeneration of heat and power, distributed energy generation, schemes, including fiscal incentives to replace older and less efficient boilers in households, district heating and cooling, or – in some cases – solid fuel bans), from industry (through the application of the most effective techniques for preventing or reducing emissions that are technically feasible and economically viable within the sector) and from the agricultural sector (such as reducing nitrogen fertilisers, closed storage of manure, improved application of manure and urea fertiliser, improved livestock feeding strategies so that animals produce less ammonia-rich manure, as well as anaerobic digestion for large farms, the development of photovoltaic installations or the reduction in fuel consumption). To achieve the goal to ensure clean air, the Commission emphasizes the importance of strengthening Member State cooperation via Clean Air Dialogues, bringing together Member States, regions and cities, making EU funding available to support measures to improve air quality, and state aid to facilitate domestic investments in low and zero emission mobility;

3. the Communication, **On the Road to Automated Mobility: An EU Strategy for Mobility of the Future,** proposes a comprehensive EU approach towards connected and automated mobility setting out a clear, forward-looking and ambitious European agenda. This agenda provides a common vision and identifies supporting actions for developing and deploying key technologies, services and infrastructures. It will ensure that EU legal and policy frameworks are ready to support the deployment of safe connected and automated mobility, while simultaneously addressing societal and environmental concerns which will be decisive for public acceptance. To support the development of automated mobility, the Commission underlines the importance of innovation, making automated mobility safe, addressing liability issues (the Commission proposes that automated vehicles are fitted with data recorders to clarify who was driving during an accident), fostering vehicle connectivity for automation considering that the ability of vehicles to communicate will be key to integrating

automated vehicles in the overall transport system and ensuring cybersecurity, data protection and data access. The Commission also describes the effects of automated mobility on society and the economy. For employment, itconsiders that the development of new technologies and services will require new skills and highly paid jobs (engineers, researchers), together with new medium-skilled jobs to maintain these new technologies. Supporting worker up-skilling and training appears to be highly important. This proposal is accompanied by two legislative initiatives. The first is a **proposal for a regulation establishing a European Maritime Single Window environment and repealing Directive 2010/65/EU.** It establishes a framework for a harmonized and interoperable European Maritime Single Window environment ('EMSWe'), based on National Single Windows, in order to facilitate electronic transmission of informationconcerning reporting obligations for ships arriving, staying in and departing from a Union port. The proposal prescribes that the Commission lays down a complete list of data elements (the 'EMSWe data set') based on the reporting obligations set out in the Union and international legal acts listed, and the national legislation referred to (in the Annex) allowing Member States to request the Commission to introduce data elements in the EMSWe data set, on the basis of the national legislation reporting obligations. The same proposal prescribes that each Member State establishes a National Single Window being responsible for its development, availability, maintenance, security and operation, while the Commission develops and updates a harmonized reporting interface module for the National Single Windows. Art. 7 sets the once-only principle prescribing that Member States ensure that the declarant is requested to provide the information pursuant to this Regulation only once per port call and that the relevant information is made available or reused. The same regulation sets the liability of the declarant for ensuring the timely submission, accuracy and completeness of the information provided in accordance with the Regulation, and its compliance with any technical requirements of National Single Windows. As for coordination of the EMSWe activities, the proposal attributes to Member States the power to designate a competent authority to act as a national coordinator for the EMSWe, coordinating the application of this Regulation by the competent national authorities within a Member State and acting as a single contact point with the Commission for all matters relating to the EMSWe. Discussion on this proposal within the Council is ongoing. The second proposal, instead, introduces a **framework of an electronic communication system for freight transport**. It identifies some barriers to the digitalization of freight transport papers and options to a support wider use of electronic documents and information exchange. The Commission highlighted that there is a fragmented legal framework with inconsistent obligations for authorities when accepting electronic information or documents and a fragmented IT environment characterized by a multitude of non-interoperable systems/ solutions for electronic transport information and documentation exchange, both for business-to-administration and business-to-business communication resulting in their implementation with different administrative practices. These critical issues discourage investment in digital solutions for electronic documents and authorities from trusting in the use of electronic documents with the consequence that most EU freight transport operators and other transport business stakeholders continue to use paper. The proposal specifically lays down the conditions under which Member States' competent authorities are required to accept regulatory information when made available electronically by those economic operators concerned and rules for the provision of services related to making regulatory information available electronically by the economic operators;

4. reaffirming the EU's objective of reducing transport greenhouse gas emissions and meeting the Paris Agreement commitments, the Commission presented a proposal for a regulation **setting CO2 emission performance standards for new heavy-duty vehicles**. In order to fully achieve the energy efficiency potential and ensure that the road transport sector as a whole contributes to the agreed on greenhouse gas emission reductions, the Commission decided to complement the already existing CO2 emission standards for new passenger cars and light commercial vehicles by setting CO2 emission performance standards for new heavy-duty vehicles. The proposal prescribes that the specific CO2 emissions of the Union's fleet of new heavy-duty vehicles must be reduced (compared to the reference CO2 emissions) by 15% from 1 January 2025 to 31 December 2029 and by at least 30% from 1 January 2030 onwards. To determine a manufacturer's compliance with its specific emission targets in the period 2025 to 2029, the proposal introduces a system based on emission credits or emission debts setting that emission credits/debts acquired in 2025 and any of the subsequent calendar years until 2028 shall be carried-over from one calendar year to another until 2029 when any remaining emission debts shall be cleared. The same proposal prescribes the verification of data monitoring by type approval authorities – which must immediately report to the Commission any deviations found in the CO2 emissions of heavy-duty vehicles in service as compared to those values that are indicated in certificates of conformity or in the customer file as a result of verifications performed in accordance with the procedure – and the publication by the Commission of data and manufacturer performance. The Commission also proposed a regulation on the **labelling of tyres** regarding fuel efficiency

and other essential parameters and repealing Regulation (EC) No 1222/2009 and a proposal for amending Council Directive 96/53/EC on **the time limit for the implementation of the special rules regarding maximum length in case of cabs delivering improved aerodynamic performance, energy efficiency and safety performance**;

5. a legislative initiative to streamline **procedures for advancing the trans-European transport network**. Considering that many investments aimed at completing the TEN-T[4] are confronted with complex permit granting procedures, cross-border procurement and other procedures, the proposal for the regulation is to establish requirements applicable to the administrative procedures followed by the competent Member State authorities for the authorisation and implementation of all projects of common interest on the core network of the trans-European transport network. On permit granting, the proposal prescribes that each project of common interest on the TEN-T core network shall be subject to an integrated permit granting procedure managed by a single competent authority designated by each Member State and that project promoters and all authorities concerned shall ensure that the most rapid treatment legally possible is given to these projects, including the resources allocated. To ensure a rapid procedure, the same proposal prescribes duration and implementation of the permit granting procedure and a coordination of cross-border permit granting procedures for projects that involve two or more Member States.

4 The trans-European transport networks (TEN-T) have a dual layer structure: the comprehensive network ensures connectivity of all regions of the Union whereas the core network involves those elements of the network which are of the highest strategic importance for the Union.

1.2.3. National plans for alternative fuel infrastructure

The Directive 2014/94/EU prescribes that Member States notify the European Commission of their National Policy Frameworks (NPF) by November 2016, containing their national targets and objectives and any supporting actions for the development of their alternative fuel market. All Member States have adopted their NPF, differently addressing the Directive's requirements, therefore, it is interesting to analyze some Member States' NPFs, in particular, Germany, the United Kingdom, Italy, France and Spain.

The Commission has summerized national NPFs in the paper accompanying the already analyzed Communication, "Towards the broadest use of alternative fuels – an Action Plan on Alternative Fuels Infrastructure, including the report on the implementation of Directive 2014/94/EU", highlighting the different national approaches and verifying if targets are sufficient for future development.

France

The French NPF, adopted in 2017, fully addresses the Directive's requirements containing an extensive discussion on the current state and future development of alternative fuels and corresponding infrastructures in the transport sector.

The French NPF includes a comprehensive portfolio of measures, most already being in effect. These measures include legislative and regulatory aspects, information, incentives, calls for projects, RTD&D and EU funded programs for cross-border coordinated actions and projects. The French NPF includes measures for the following fuels in road transport: electricity, CNG, LNG and hydrogen.

Each department of metropolitan France is equipped with at least one recharging point. The focus is mainly on electric vehicles with estimates of roughly 1.6% EV on the road in 2020, underlining the role that electricity can play in airports for stationary airplane use, shore-side electricity supply for inland waterway vessels and seagoing ships in maritime and inland ports of the TEN-T Core Network and other ports.

The Commission considers the current and targeted number of CNG refuelling points sufficient, although the NPF does not provide for any future estimates for CNG vehicles. The NPF focus for CNG is on the TEN-T Core Network and nine French large urban areas emphasizing the role that natural gas vehicles can play in the public transport sector, cleaning vehicles, garbage trucks and captive fleets of light-duty vehicles. The information provided indicates meeting the distance requirement of at least one CNG refuelling point every 150 km.

France cooperates with neighbouring countries and other Member States to support EU-wide circulation for AFV and cross-border continuity for AFI.

Germany

The German NPF has been planned considering the interests of regional and local authorities and stakeholders and, as well, the initiatives to coordinate German plans on alternative fuel infrastructures with other Member States.

The NPF addresses most of the requirements of the Directive presenting the current state of alternative vehicle uptake and infrastructures and setting targets for future recharging points, LNG refuelling points (road) and H2 refuelling points (road). However, the same NPF does not establish targets for LNG refuelling points in ports beyond the facilities already present.

There is a focus on electric vehicles. The German NPF estimates a share of roughly 2% of electric vehicles on the road in 2020. While the targeted number of recharging points seems adequate to cover the needs of electric vehicles in terms of distance requirements in Germany, the ratio of only one public recharging point per 23 electric vehicles estimated for 2020 could become an obstacle for further electric vehicle market deployment. The NPF does not provide any targets for further electricity supply deployment for stationary airplanes and shore-side electricity, but it does describe pilot projects with a focus on inland ports. Considering that Germany has a relatively dense network of CNG refuelling points, offering a good coverage in most regions and in all urban agglomerations, the NPF does not provide for other CNG infrastructure build-up beyond present levels. The German NPF also defines a network of nine road LNG refuelling points able to guarantee meeting the maximum distance requirements for LNG refuelling points for heavy-duty vehicles along the German TEN-T Core Network.

Concerning LNG refuelling points, the NPF does not set target numbers for ports and does not define a LNG distribution system as required by the Directive, allowing the market to show the needs and support the LNG infrastructure build-up. The German NPF contains a comprehensive list of measures which already exist or have been adopted.

It also identifies measures focused on electric vehicles and road infrastructures, measures for other road AFI/AFV types, as well as for waterborne transport, and also several support measures to promote the deployment of alternative fuel infrastructures in public transport services.

Italy

The Italian NPF, adopted in 2017, fully addresses the Directive requirements describing the current state and future scenarios for alternative fuels in the transport sector. The Italian NPF contains a comprehensive list of measures, partially already in place in the case of CNG. Mostcan be considered as having a medium impact on market actor decisions. Since the Italian NPF is a law, it guarantees long periods of validity which could provide certainty for market actors and hence increase the likelihood of national NPF targets and objectives being reached. However, the NPF does not establish hard targets for all fuels and modes, as the NPF uses scenario dependent projections relying on 'expected trends' or 'evolution' rather than real quantitative targets. For electric vehicles, the Commission defines the Italian NPF as conservative. In fact, for 2020, low shares of new sales (ranging from 1% to 3%) and of electric vehicles on the road (ranging from 0.1% to 0.3%) are estimated, and the NPF does not contain any estimates beyond 2020. The same Commission underlines that the Italian NPF has established sufficient 2020 targets for recharging points accessible to the public consistent with the rather low estimates for EV for the same year, also ensuring an appropriate coverage of the TEN-T Core Network with fast recharging points. Forstationary airplane electricity supply, instead, the Italian NPF does not set any concrete targets.

An important role, in the NPF, is played by CNG, Italy having a dense network of public refuelling points. Considering the positive impact of CNG vehicles in reducing CO2 transport emissions, the NPF aims to increase the share of CNG vehicle parks on the road from 2% to 3.3% by 2020, and 6% by 2025. It has also proposed a number of 5 dual-use LNG refuelling points for heavy-duty trucks along the TEN-T Core Network by 2025 to guarantee that the maximum distance requirement for LNG refuelling points along the road TEN-T Core Network is met on Italian territory. The Commission considers the previsions of the NPF designing storage quantities in all 14 maritime TEN-T Core Network ports and beyond exemplary.

A plan for the deployment of hydrogen technologies (hydrogen production, distribution and fuel cell vehicles) has also been defined, even if fixing targets for hydrogen technologies is impossible due to the lack of financing considered essential for their achievement (the only evolution in the short term concerns the inter-MS corridor linking Italy with Austria). The plan contains evidence of Italy's collaboration with other Member States, mainly regarding European projects, especially of the TEN-T family.

Spain

The Spanish NPF, adopted in 2016, addresses most of the Directive requirements containing an extensive discussion on the current state and future scenarios for alternative fuels in the transport sector and setting, for most fuels and modes, specific targets as required by the Directive.

Even if the Spanish NPF estimates a comparably low share of roughly 0.5% electric vehicles on the road in 2020 with a distribution of recharging points which seems to cover electric vehicle needs for distance requirements, it does not fix a 2020 target for recharging points, thus violating a basic Directive requirement and posing a risk to cross-border continuity and a functioning internal market for electric vehicles. The Spanish NPF also contains modest targets and measures for increasing shore-side electricity in its ports, while it does not foresee any increase in stationary airplane electricity supply, considering that it is already good in major airports.

The Spanish NPF focuses on LPG and natural gas, with substantial infrastructures already being in place. It considers a strong growth in CNG and LPG vehicles and fixes appropriate refuelling infrastructure targets consistent with the vehicle projections. The Spanish NPF strongly emphasizes LNG. There are already 15 publicly accessible LNG refuelling points for heavy-duty vehicles and there is a target of 44 by 2020. Altogether, the planned LNG refuelling points could guarantee that the maximum distance requirement for LNG refuelling points along the road TEN-T Core Network would met onSpanish territory.

LNG refuelling is available in all maritime ports in the TEN-T Core Network and in several ports of the comprehensive network.

Spain has also considered hydrogen in its NPF, foreseeing the deployment of 20 publicly accessible hydrogen refuelling points and 500 hydrogen fuel cell vehicles by 2020.

The Spanish NPF contains an extensive list of measures, most already in place. They include regulatory measures to facilitate infrastructure deployment. Longer validity duration for financial support measures could provide certainty for market actors and hence increase the likelihood that the NPF national targets and objectives can be reached. The NPF also includes several support measures to promote the deployment of alternative fuel infrastructures in public transport services.

The interests of regional and local authorities, as well as stakeholders, have been considered during the drafting of the Spanish NPF, such as in the follow up phase of the NPF. Spain is actively involved in coordinating its plans on alternative fuel infrastructures with other Member States, as well as collaborating with them in this field. This specifically concerns the deployment of alternative fuel infrastructures for electricity, natural gas and LPG. Spain and France presently are collaborating on establishing a hydrogen refuelling point corridor connecting the two countries.

United Kingdom

The UK supports research, development and demonstration activities in the field of alternative fuels and propulsion systems.

The UK NPF, adopted in 2017, also addresses all the Directive's requirements containing a description of the current state and some future estimates for alternative fuel vehicles in the transport sector, establishing specific targets. The focus is on the development of a market for electric vehicles. It contains relatively high estimates for EV future deployment with an estimated 1.1% of electric vehicles on the road in 2020. Even if the distribution of recharging points seems to appropriately cover the needs of electric vehicles in terms of distance requirements in the UK, there is the risk, for the future, that the targeted ratio of less than one public recharging point per 30 electric vehicles estimated for 2020 could become an obstacle for further market deployment of electric vehicles.

As far as the electricity supply for stationary airplanes, the UK government considers that airport owners and operators are the best placed to assess the needs and cost/benefits, including the environmental, for stationary airplane electricity supply. The NPF underlines that shore-side electricity is not currently a commercially attractive proposition so it does not set any target for shore-side electricity, leaving it to the port operators and their customers to implement it on a purely commercial basis. The UK NPF fixes specific targets involving an increase in CNG refuelling points, planning from 8 to 13 by 2020, and inLNG refuelling points (currently 11) from 20-48 by 202, suggesting that the maximum distance requirement of at least one refuelling point every 400 km for LNG refuelling points along the TEN-T Core Network could be achieved by that year.

The UK NPF contains a quite comprehensive list of measures, most being in force and foreseen to stay, only a few being obsolete. Some, especially those aimed at improving the economics of alternative fuels, can be considered as having a medium or high impact on market actor decisions, especially for the electricity for road transport, as well as the private recharging infrastructure and public transport. Most of the measures address financing and early market barriers as obstacles to market development.

It is also worth noting the interest of the British government in supporting companies setting up public transport services and public institutions in acquiring low emission vehicles for their fleets. The measures involve direct incentives for purchasing new electric buses (covering 75%-90% of additional costs for zero-emission vehiclescompared to conventional vehicles) and taxis and grant schemes for retrofitting old vehicles (mainly buses).

The UK did not present any evidence for coordinating its plans on alternative fuel infrastructures with other countries, especially neighbouring Member States.

PART 2

SUSTAINABLE MOBILITY

2. SUSTAINABLE MOBILITY

2.1. ENERGY MIX SCENARIOS IN THE EU TRANSPORT SECTOR

Transport is essential to modern living. It drives economic growth, allowing countries to trade goods and communities to connect with one another. Despite the development of new renewable energy sources, liquid hydrocarbons will continue to play a fundamental role in the future mobility system. According to the European Commission study, *"EU Reference Scenario 2016: Energy, transport and GHG emissions Trends to 2050"*, by 2030, fossil fuels will still hold 70% of the energy share in the transport sector, and 66% by 2050. The most common fuel is and will be diesel; however, petrol will also hold an important share, even if the alternative energy share will increase (Fig.2.1).

The transport sector accounts for almost half of the world's oil demand.[5] Road transport currently holds first place in oil demand in the mobility sector (78%) and, according to forecasts, it should remain so also in 2040 (74%). Interesting to note is that, also in this sector, the demand for oil barrels (mb/d) should continue to grow in the future, reaching an increase of 16% by 2040 (Fig 2.2).

Fig. 2.1 Estimated energy mix in transport in the EU, by fuel type (%)

Source: European Commission "EU Reference Scenario, 2016"

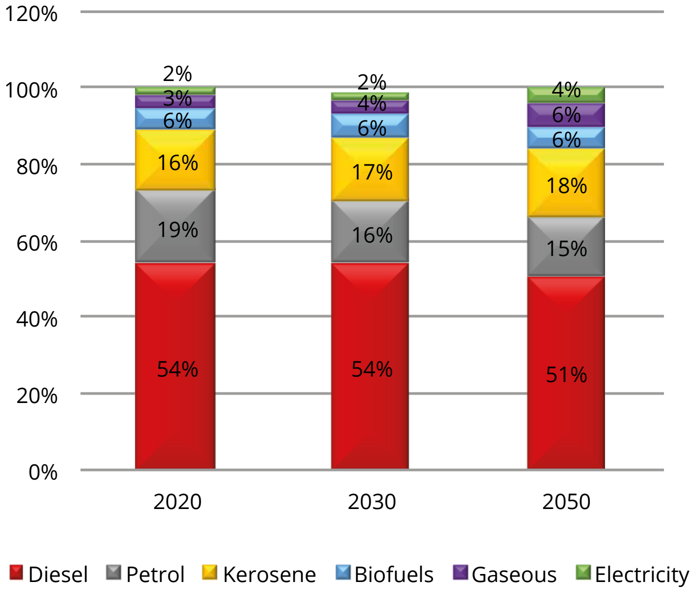
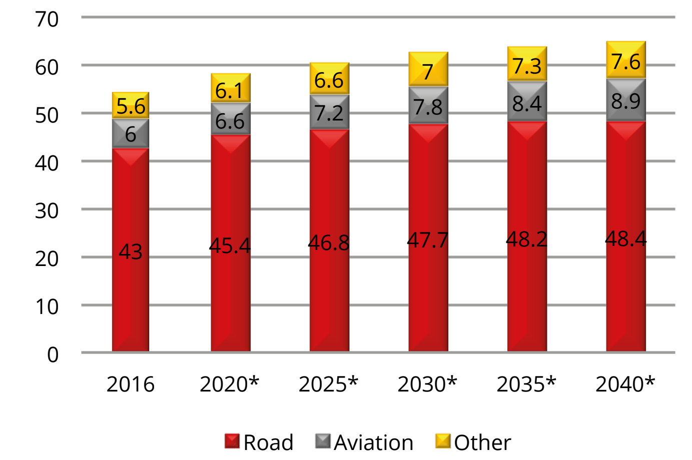


Fig. 2.2 Oil demand in the transport sector (millions of barrels per day)

Source: OPEC



Note: estimates*

5 Organization of the Petroleum Exporting Countries, *World Oil Outlook 2017*

2.2. E-MOBILITY AND ALTERNATIVE FUELS

Transport represents almost a quarter of Europe's greenhouse gas emissions and is the main cause of urban noise and air pollution, often in breach of air pollution limits. Therefore, moving towards a low-emission mobility is essential to the broader shift towards an EU low-carbon economy. Research and innovation activities are fundamental to support the long-term transition towards zero-emission and reduced noise pollution mobility across all transport modes.

Decarbonisation will be one of the main goals of the European Union in the coming years. The use of alternative fuels such as electricity, hydrogen or natural gas, will increase mobility sector energy efficiency and reduce carbon emissions. For this reason, most Member States have introduced incentives for those who buy alternative fuel vehicles and are also investing in infrastructure development (Tab. 2.1).

According to ANFIA data, 567,008 alternative fuel vehicles

Tab 2.1 Incentives & Legislation in the EU

Source: European Alternative Fuels Observatory (2018)

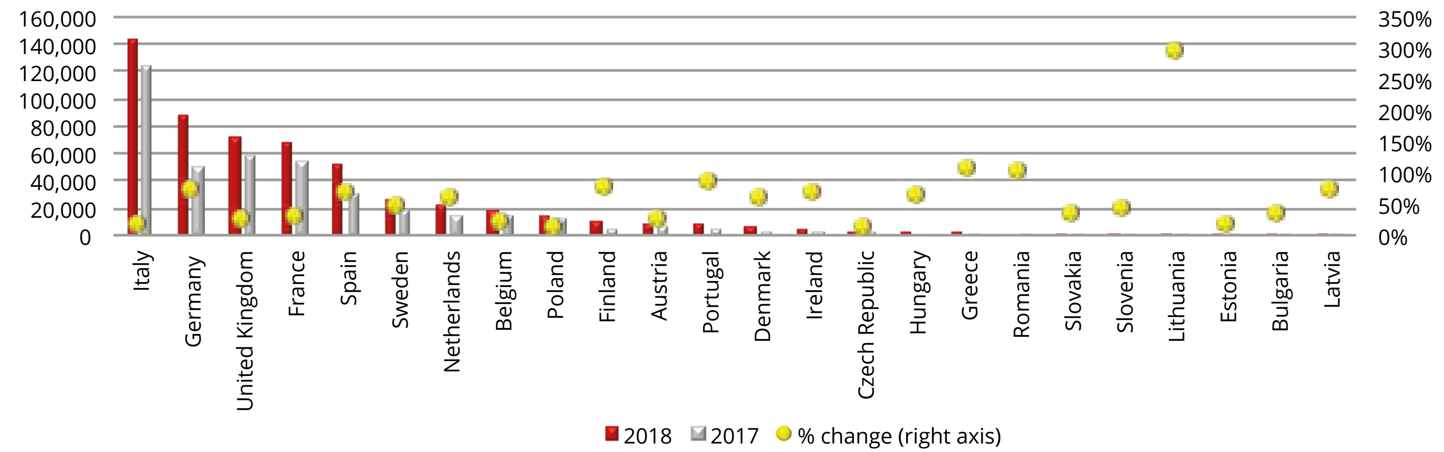
Countries	Purchase Subsidies	Registration Tax Benefits	Ownership Tax Benefits	Company Tax Benefits	VAT Benefits	Other Financial Benefits	Local Incentives	Infrastructure Incentives
Austria	X	X	X	X	X		X	
Belgium	X	X	X	X				
Bulgaria								
Croatia		X						
Cyprus		X	X					
Czech Republic		X	X					
Denmark	X	X		X			X	X
Estonia								
Finland	X	X	X					X
France	X	X	X	X			X	
Germany	X		X	X		X	X	
Greece		X	X			X		
Hungary		X	X	X			X	
Ireland	X	X	X	X			X	X
Italy	X		X					X
Latvia		X	X				X	
Lithuania		X					X	

Countries	Purchase Subsidies	Registration Tax Benefits	Ownership Tax Benefits	Company Tax Benefits	VAT Benefits	Other Financial Benefits	Local Incentives	Infrastructure Incentives
Luxembourg	X		X	X				
Malta	X	X	X	X			X	X
Netherlands		X	X	X				
Poland								
Portugal	X	X	X	X			X	
Romania	X	X	X					X
Slovakia	X	X					X	
Slovenia	X	X	X					
Spain	X	X	X			X	X	X
Sweden								
United Kingdom	X	X	X	X			X	X

were registered in the EU in the first half of 2018 (Fig. 2.3). The best performing countries are Italy and Germany, where 141,000 and 87,000 vehicles, respectively, had been registered. Comparing the 2018 data with those of the previous year, the number of registered vehicles in Europe has risen by 26.2%. In this section, biodiesel, electric, natural gas (CNG and LNG) and hydrogen fuel cell vehicles will be analyzed.

Fig. 2.3 New alternative fuel vehicle registrations (1st semester)

Source: ANFIA



2.2.1. Low carbon liquid fuels

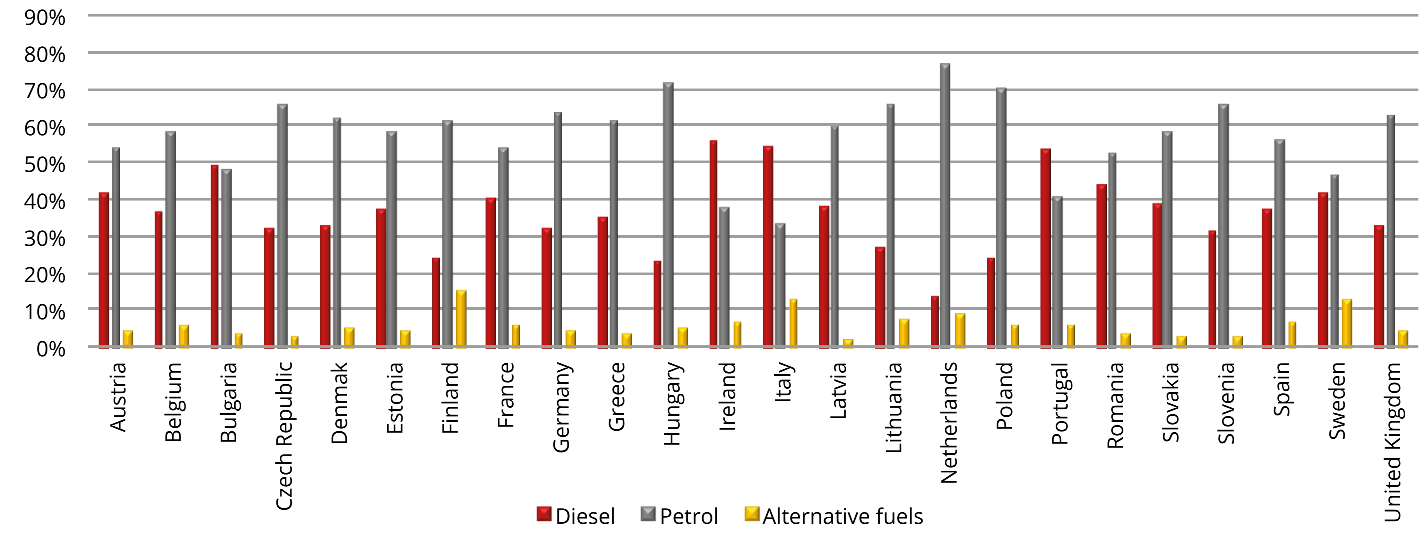
Cars driven by traditional engines (e.g. petrol or diesel) are and will remain the most widespread in the next years. According to the latest report released by the European Automobile Manufacturers Association, in the first semester of 2018, the new vehicles registered in the EU, powered by petrol and diesel, accounted for 93% of the total (Fig. 2.4).

Investing in the research and development of Low Carbon Liquid Fuels is essential to reducing greenhouse gas emissions.

Biofuels can be derived from plants, or from agricultural, commercial, domestic and industrial waste and, today, represent the most concrete response to reduce CO2 emissions from the transport sector. These fuels have a low environmental impact and unlike other alternative fuels do not need new infrastructures to be built. The promotion of biofuels is a political priority of the EU energy-climate policy. Directive 2009/28/EC on the promotion of the use of energy from renewable sources and amending and, subsequently, repealing Directives 2001/77/EC and 2003/30/EC introduces a binding target for 10% share of renewable energy in transport by 2020, with biofuels also making a substantial contribution to this aim. Biofuels are compatible with vehicles already on the market and have a very similar cost and range compared to traditional fuels, making them a sustainable solution, also for aviation, heavy-duty and marine transport.

Fig. 2.4 New car registrations in the EU (1st semester 2018)

Source: European Automobile Manufacturers Association



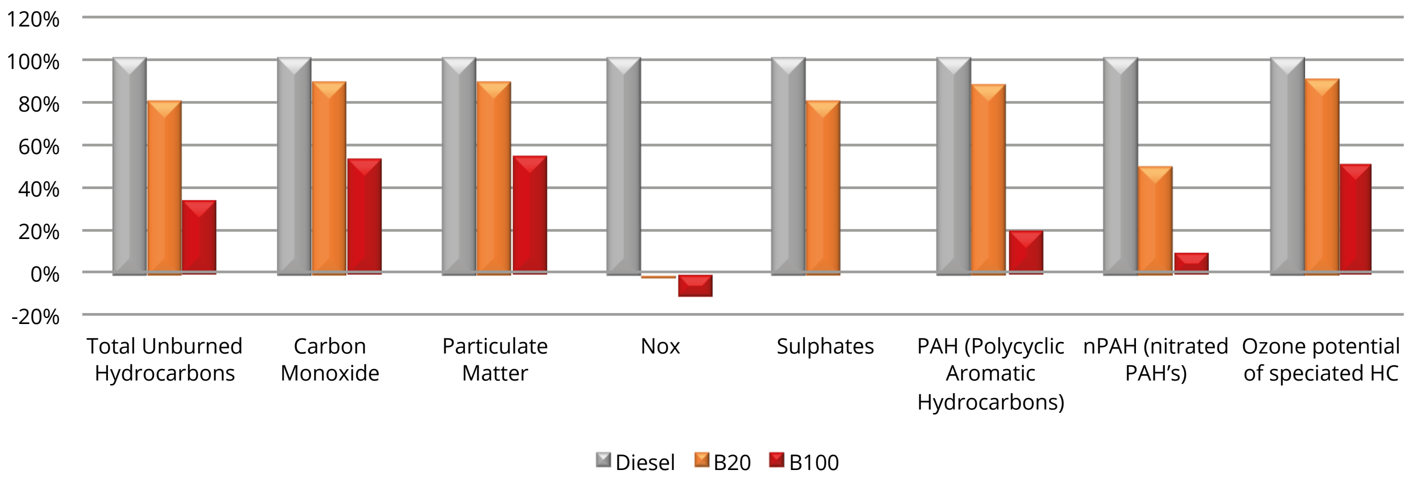
Biodiesel is one of the most common biofuels in Europe. It is produced from oils or fats by transesterification and is a liquid similar in composition to traditional diesel. Biodiesel can be used in diesel engines, alone or blended with diesel oil. Blends with diesel fuel are indicated as "Bx", where "x" is the percentage of biodiesel in the blend (B100 indicates pure biodiesel). According to a test carried out by the United States Environmental Protection Agency, the use of biodiesel in diesel engines results in substantial reductions in unburned hydrocarbons, carbon monoxide and particulate matter. Emissions of nitrogen oxides remain the same or slightly increase. The exhaust emissions of sulphur oxides and sulphates (major components of acid rain) from pure biodiesel are essentially eliminated. The ozone forming potential of the speciated hydrocarbon emissions is 50 % less than that measured for diesel fuel (Fig. 2.5).

2.2.2. Electric vehicles in Europe

Conventional vehicles use fossil fuels (e.g. petrol or diesel) to power an internal combustion engine, emitting CO2, which is one of the main causes of climate change. Instead, new fuels, gasoline-electric hybrid vehicles and even fully electric vehicles have been developed to reduce air pollutants. Above all, electric mobility could make a major contribution to reducing pollution in urban areas. However, "green vehicles" still represent a small part of the car fleet with air pollution still being a

Fig. 2.5 Average biodiesel emission compared to conventional diesel

Source: United States Environmental Protection Agency



Note: B20 (20% Biodiesel); B100 (100% Biodiesel) general concern. Drivers have a choice between several different types of electric vehicles. Following, are listed the EEA's description of each of the main electric vehicle and hybrid technology types, how each works and their associated advantages and disadvantages[6].

Battery Electric Vehicles (BEVs) are powered only by an electric motor, using electricity stored in an onboard battery. The battery must be regularly charged, typically by plugging in the vehicle to a charging point connected to the local electricity grid. BEVs have the highest energy efficiency of all vehicle propulsion systems, typically able to convert around 80% or more of the energy stored in the battery into motion. BEVs, however, still have somewhat limited driving ranges compared to conventional vehicles and typically need a long time to recharge the onboard batteries. BEVs tend to have large batteries to maximize the energy storage capacity and hence allow for longer driving ranges.

Plug-in hybrid electric vehicles (PHEVs) are powered by an electric motor and an internal combustion engine designed to work either together or separately. The on-board battery can be charged from the grid, and the combustion engine supports the electric motor when higher operating power is required or when the battery's charge is low. The electric driving range is less than for BEVs, as the batteries tend to have smaller capacities. The batteries have less energy storage capacity as they rely less on electrical power alone to power the vehicle. The battery capacity in PHEVs is designed more for short trips in the city or commuting, for example, rather than for long-distance journeys. However, as for REEVs, the combustion engine allows for a much longer overall driving range. The environmental impact of PHEVs depends on their operation mode. Moreover, as for BEVs, the overall environmental performance of PHEVs depends greatly on the share of renewables in the electricity generation mix.

Range-extended electric vehicles (REEVs) have a serial hybrid configuration in which their internal combustion engine has no direct link to the wheels. Instead the combustion engine acts as an electricity generator and is used to power the electric motor or recharge the battery when it is low. The onboard battery can also be charged from the grid. Therefore, the electric motor is solely responsible for directly powering the vehicle. One advantage of REEVs is that the conventional engine can be small, as it is needed only when the vehicle exceeds its electric driving range. This helps reduce the vehicle's weight. As for a PHEV, an REEV overcomes the problem of a restricted driving range associated with BEVs because it can be fueled at conventional filling stations.

Fuel cell electric vehicles (FCEVs) are also entirely propelled by electricity. In this case, the electrical energy is not stored in a large battery system but is, instead, provided by a fuel cell 'stack' that uses hydrogen from an onboard tank combined with oxygen from the air. The main advantages of FCEVs over BEVs are their longer driving ranges and faster refueling, similar to those of a conventional vehicle. Because of the current size and weight of fuel cell stacks, FCEVs are better suited for

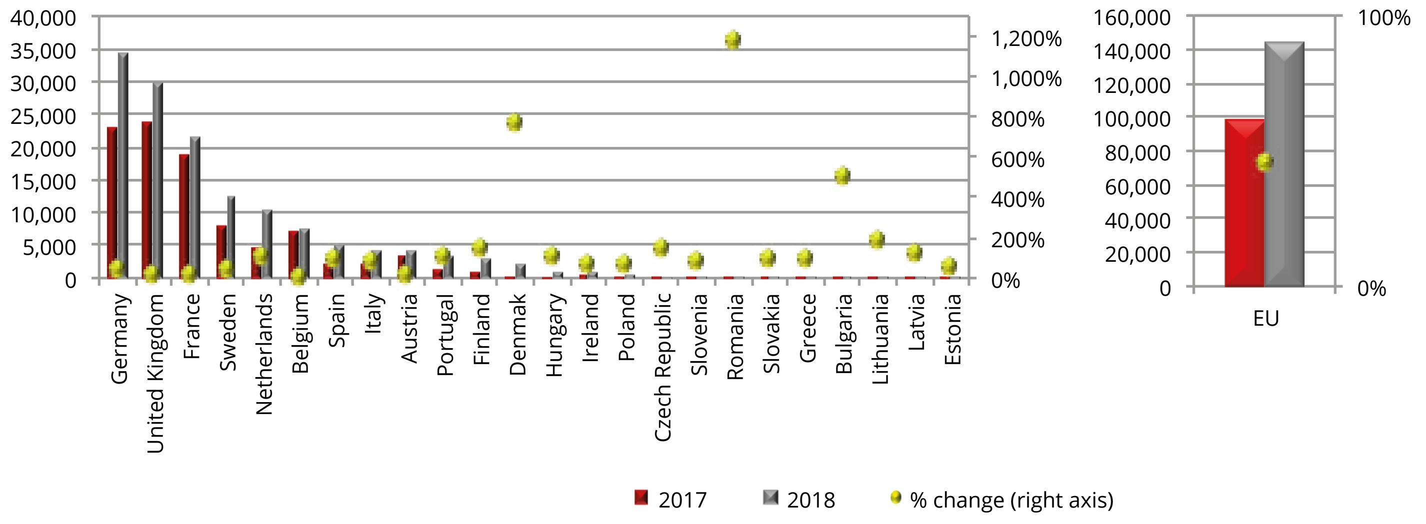
6 EEA, *Electric vehicles in Europe*, 2016

medium-sized to large vehicles and longer distances. Fuel cell stack technology is in at an earlier development stage compared to the technologies described above and few models of FCEVs are currently commercially available. Further technological development is needed for FCEVs to improve their durability, lower the costs and establish a hydrogen fueling infrastructure, including standalone stations or pumps for hydrogen.

Hybrid electric vehicles (HEVs) combine an internal combustion engine and an electric motor that assists the conventional engine during, for example, vehicle acceleration. A HEV battery cannot be charged from the grid but is typically charged during regenerative braking or while the vehicle is coasting. As an HEV is predominantly powered by its conventional engine, hybridization can be regarded as a technology added to conventional vehicles with the aim of increasing fuel efficiency, reducing pollutant and CO2 emissions, rather than being an entirely separate type of vehicle. HEVs typically have lower fuel consumption and exhaust emissions than conventional technologies. The more sophisticated the hybrid system, the greater the potential to lower emissions. Many different types and models of HEVs exist, ranging from 'micro-HEVs', whose only fuel-saving feature is regenerative braking and where the electric engine on its own is not capable of powering the vehicle, through to 'full HEVs', which are able to drive small distances in electric-only mode.

Fig. 2.6 Electrically chargeable vehicles in EU countries (1st semester)

Source: I-Com elaboration on ANFIA data



The ways in which the conventional engine and electric motor are joined can also differ across different HEV models.

In the first half year of 2018, the European market of electric cars – including BEVs, PHEVs, REEVs, FCEVs – amounted to 143,017 registrations, increasing by 46% relative to the first half year of 2017. The leader market is Germany with about 34,000 electric cars registered in the first half year of 2018, followed by the United Kingdom (29,392), France (21,513) and Sweden (12,615). Romania records the highest growth rate in electric vehicle registrations (1,191%) among the EU Member States in the first half of this year, followed by Denmark (781%) (Fig. 2.6).

The growth of the electrically chargeable vehicles in the

Fig. 2.7 Battery electric vehicles and plug-in hybrid vehicles in the EU (1st semester)

Source: I-Com elaboration on ANFIA data

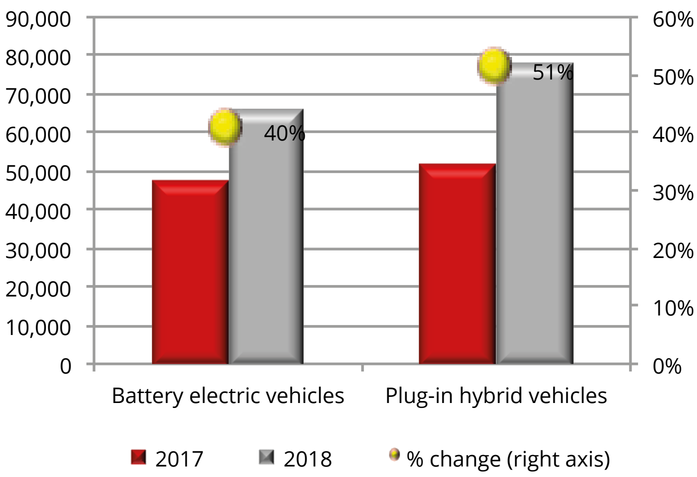
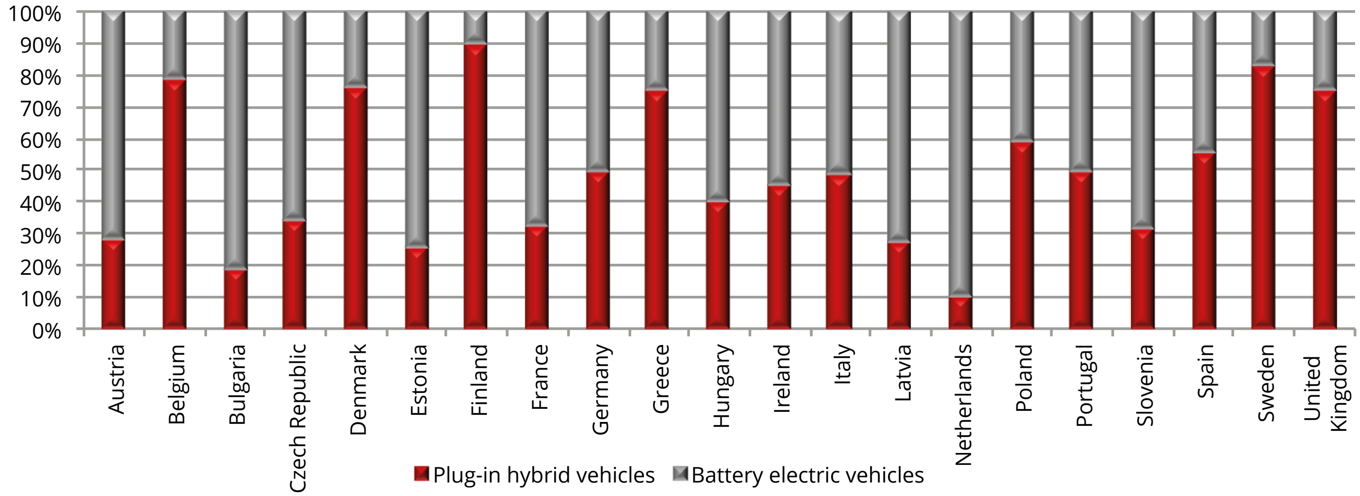


Fig. 2.8 Share of battery electric vehicles and plug-in hybrid vehicles in the EU (%)

Source: I-Com elaboration on ANFIA data



EU is mainly led by plug-in hybrid vehicles[7], growing at higher rate (+51%) than battery electric vehicles[8] (+40%) (Fig. 2.7). In absolute terms, the European market of battery electric vehicles amounts to 65,713 registrations, while for plug-in hybrid vehicles 77,304 cars were registered in the first half of 2018.

Plug-in vehicles are widespread in Belgium, Finland, Sweden and the United Kingdom where the share exceeds 70% of the electric vehicle total (Fig. 2.8). In the United Kingdom, these vehicles amounted to about 22,000 registrations in the first six months of 2018. Instead, battery electric vehicles are very common, for example, in Austria, France and the Netherlands.

In the first half year of 2018, hybrid car sales increased by 37% in the EU and reached 291,584 registrations. France surpassed the United Kingdom and became the leading market, with 45,406 cars registered. Other large markets include Germany, the United Kingdom, Italy and Spain where the number of hybrid cars registered exceeds 37,000 units. The fastest growth is in Lithuania where sales more than quadrupled (however, from a low base).

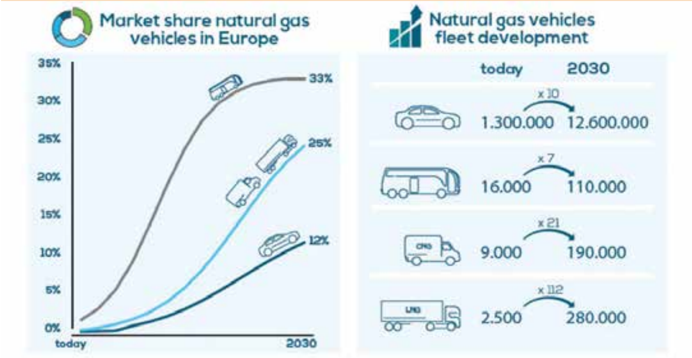
2.2.3. The role for natural gas

Natural gas is seen as an important part of the EU's energy mix and will play a significant role in the mobility of the future. In a vehicle powered by natural gas, energy is released from the combustion of a mixture of methane and other gases that have a lower environmental impact compared to traditional fuels. This type of gas occupies more volume than traditional liquid fuels, thus, it must be compressed (Compressed Natural Gas) or liquefied (Liquefied Natural Gas) to make it practical for transport application. CNG is mainly used for small vehicles (cars and light-duty trucks), while LNG is used for heavy-duty vehicles (trucks, locomotives and vessels). The market for natural gas vehicles is expected to grow enormously by 2030 (Fig. 2.9).

According to a study by NGVA Europe, the number of CNG cars in Europe will increase 10 times, reaching a market share of 12%. CNG and LNG are a real alternative to conventional diesel, even for long distance transport. Gas fuelled urban buses and coaches will see a 33 % market share, whereas the freight transport sector is projected to reach 25 % of the EU market[9]. The average price for CNG in Europe is €0.99/kg, which is 48% lower than petrol and 31% lower than diesel, making it an economical fuel

Fig. 2.9 Prospects for the natural gas market in 2030

Source: www.ngvglobal.org



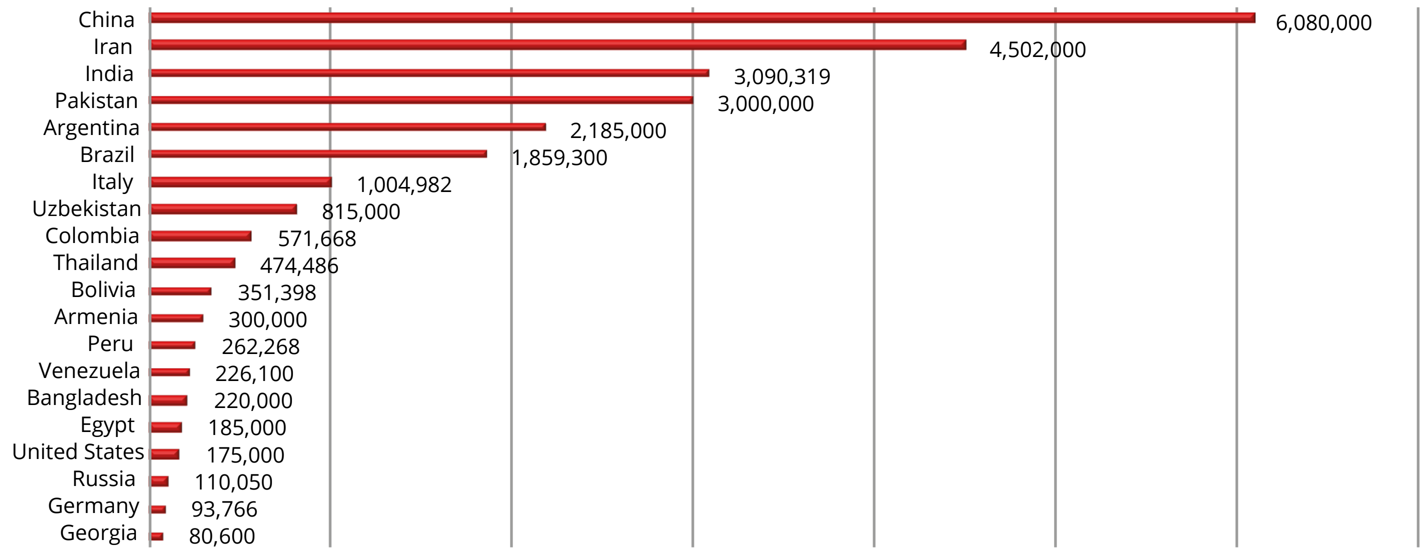
7 Includes extended-range electric vehicle (EREV).
8 Includes fuel cell electric vehicles (FCEV).

9 Estimations on the future development of the European Natural Gas Vehicles by NGVA Europe

for transport. Even though Natural Gas vehicles are, on average, more expensive to buy than conventionally-fuelled vehicles, the initial cost is offset by the lower CNG fuel price. HDV vehicles will see the largest fleet development with numbers expected to increase112 times by 2030, resulting from the spread of LNG refuelling stations (currently, there are only 164 filling stations in the EU[10]). LNG is a natural gas that has been converted to liquid form for ease of transportation. By cooling the gas down to -162 °C, the volume reduces to 1/600 compared to its gaseous state. In this process, heavy hydrocarbons (condensate, LPG), carbon dioxide, water and sulphur are removed. It is nontoxic, colourless, non-flammable and non-corrosive. The energy density is 2.4 times higher than CNG. LNG is also used for waterborne transport both at sea and on inland waterways. The LNG infrastructure for fuelling vessels is, however, at a very early stage, with only Sweden having a small-scale LNG bunkering facility for sea going vessels, though several member States have drawn up development plans. According to the European Commission, a network of refuelling points for LNG maritime should be available at least by the end of 2030[11]. Despite important growth forecasts in Europe, natural gas-powered vehicles are still not widespread. Among the

Fig. 2.10 Top 20 countries, by no. of natural gas vehicles (2017)

Source: www.ngvglobal.org



10 https://www.ngva.eu/stations-map/

11 Directive 2014/94/EU of the European Parliament and Council of 22 October 2014

top 20 countries in the world for the number of LNG and CNG vehicles, there are only 2 European countries (Italy and Germany) (Fig. 2.10).

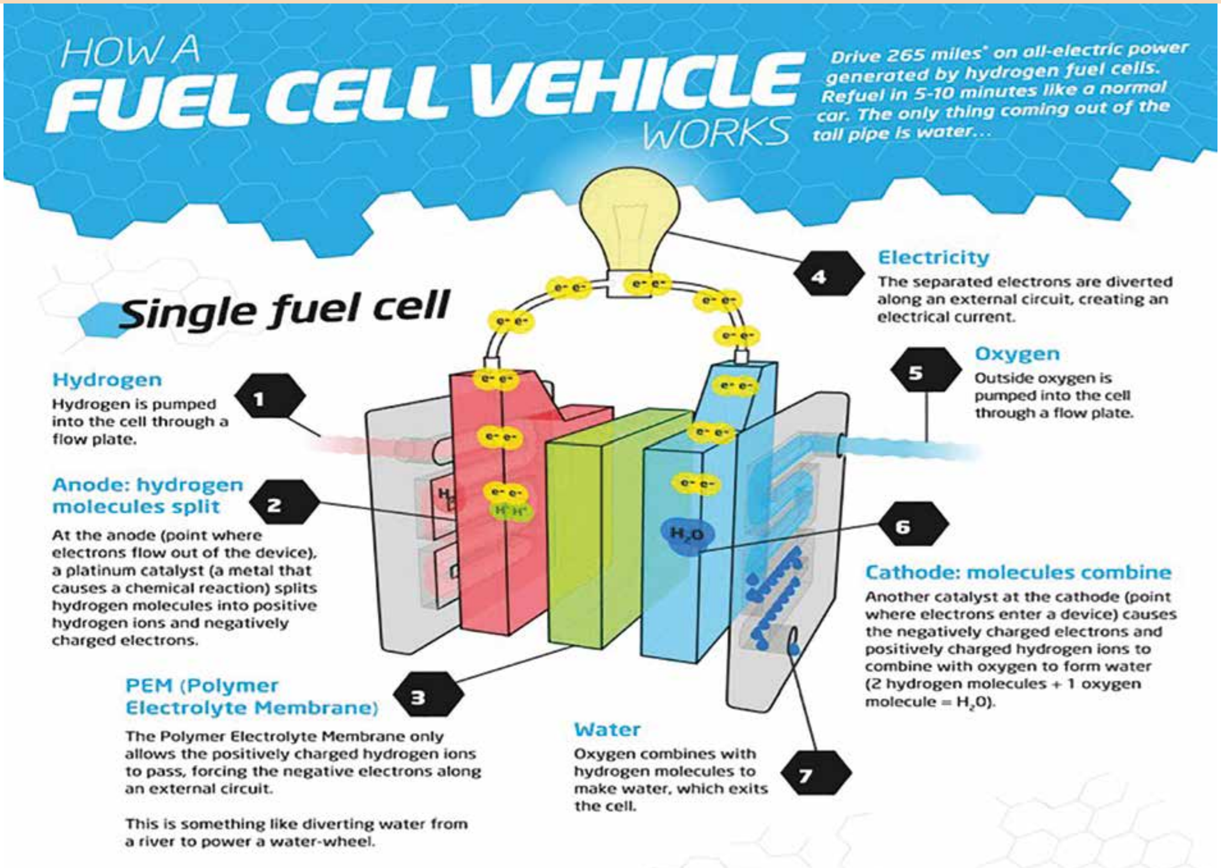
2.2.4. Hydrogen and fuel cell scenarios

A fuel cell is a tool that converts the chemical energy of a fuel into electrical energy and heat without using thermal cycles. Hydrogen is a gas that can be easily ionized due to its molecule consisting of two weakly bonded atoms. Oxygen is the most common oxidizer being freely available in the atmosphere and able to react with hydrogen, producing a non-harmful product such as water (Fig. 2.11).

Fuel cell vehicles use hydrogen to power an electric

Fig. 2.11 How a fuel cell vehicle works

Source: Hyundai



engine and, for this reason, they are considered electric vehicles, even if their range and refuelling make them more similar to traditional fuel vehicles. Fuel cell vehicles offer several important benefits:

- they can drive long distances without needing to refuel (more than 500 km) and refuel quickly (3 to 5 minutes), similar to current gasoline/diesel cars;
- thanks to a much higher energy density of the hydrogen storage system (compared to batteries), fuel cell powertrain cost is low compared to the amount of energy stored (kWh). This makes it more attractive for those vehicles requiring larger energy storage (heavy load capacity and long range vehicles);
- the FCEV infrastructure can build on existing the gasoline distribution and retail infrastructure, creating cost advantages and preserving local jobs and capital assets.

According to an Information Trends study in 2017, 6,475 hydrogen vehicles were sold worldwide. The majority of these were sold in the US and Japan, with only 9% in Europe (Fig. 2.12).

Currently there are only 5 models of Hydrogen Fuel Cell Vehicles available from 3 Asian manufacturers (Honda, Hyundai and Toyota) (Fig. 2.13). In the last few months, however, some of the large European manufacturers have expressed their intention to develop hydrogen vehicles.

Lower sales of hydrogen vehicles are mainly due to their price and the lack of filling stations. The purchase cost of a hydrogen vehicle is currently higher than for internal combustion engine vehicles, while travel costs

Fig. 2.12 Hydrogen fuel cell vehicles sold, by region (2017)

Source: Information Trends

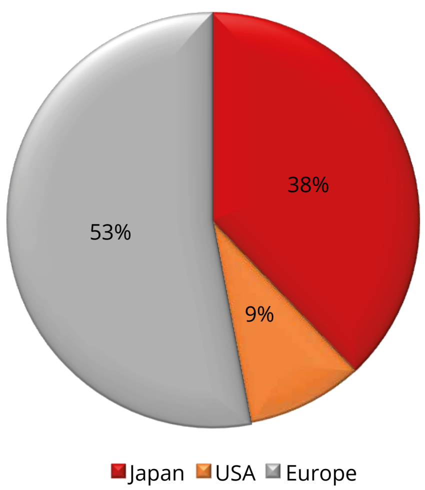


Fig. 2.13 Hydrogen fuel cell vehicles sold, by company (2017)

Source: Information Trends

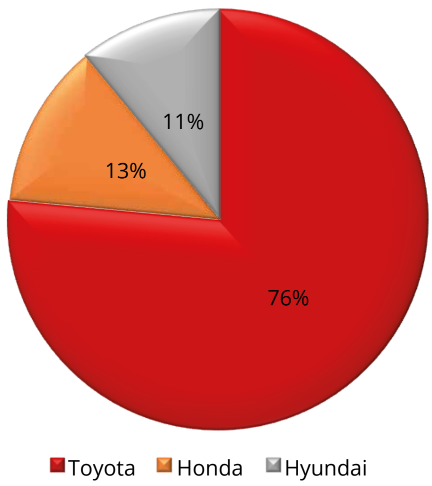
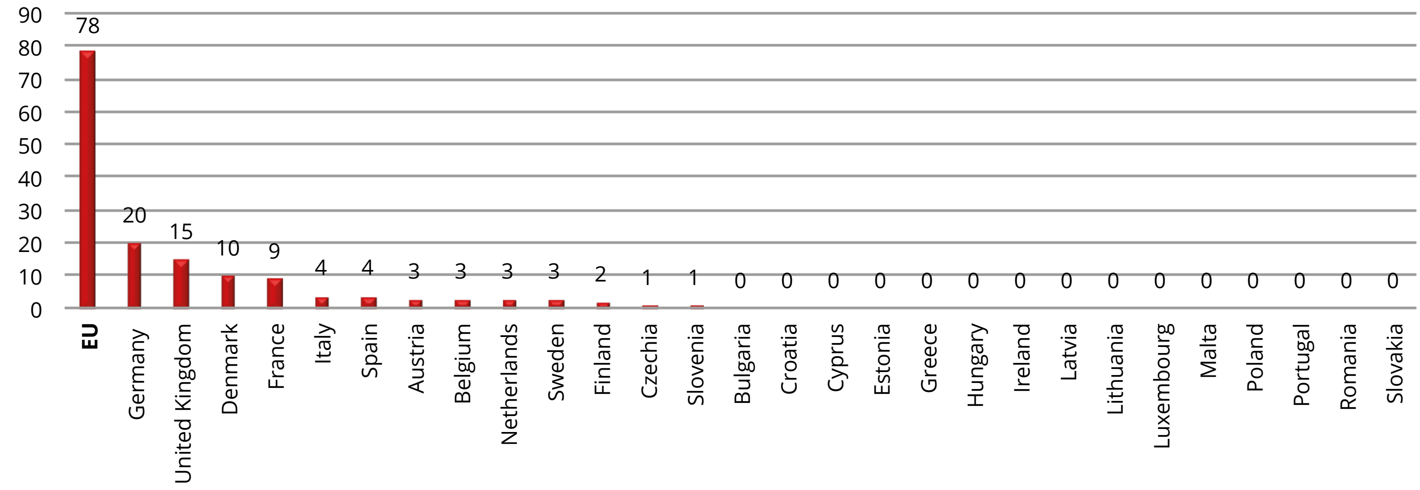


Fig. 2.14 Total number of hydrogen filling stations in the EU (2017)

Source: European Alternative Fuels Observatory



(hydrogen price per kilometre travelled) is already similar to the cost of an electric vehicle. The evolution of the hydrogen vehicle market in the EU is held back by the absence of adequate infrastructures. Currently, there are only 78 filling stations operating in Europe, 69% in only 4 countries (Germany, UK, Denmark and France) (Fig. 2.14).

2.3. NEW INDUSTRIAL SYNERGIES BETWEEN THE ENERGY AND MOBILITY SECTORS

The development of electric mobility is giving rise to interesting synergies between the transport and energy sectors. One of the main common objectives concerns the development of batteries. In the third mobility package drawn up by the European Commission, the Strategic Action Plan on Batteries is included along with its report on raw materials[12]. Among the objectives of the plan is the assurance of access to raw materials, including recycling, support for the production of cells within the Union and support for the development of innovative technologies in partnership with the Member States and the European Investment Bank. It is essential that the European production chain of cells has the lowest environmental impact possible, for example, by using the energy from renewable sources. Creating a skilled workforce is also essential to improving the environmental sustainability of European industry.

12 European Commission, *Europe on the Move: Commission completes its agenda for safe, clean and connected mobility*, 17 May 2018

The Strategic Action Plan on Batteries is part of the EU's efforts to reduce greenhouse gas emissions from transport and to meet the commitments of the Paris Agreement. The production of innovative batteries plays a strategic role both for the global competitiveness of the automotive sector and for the transition to a circular and decarbonised economy. According to some estimates, by 2025, the battery market in the EU could be worth €250 billion a year. Only to meet the European demand, will it take between 10 and 20 "gigafactories" (large-scale battery production facilities). To tackle these future challenges, in 2016, the "Innovation and Networks Executive Agency" launched the first Synergy Call for Proposals in the Transport and Energy Sector, with a total budget of € 40 million. This call is dedicated to areas such as smart energy grids, electric mobility, intelligent and sustainable transport systems and joint rights of infrastructure coupling. Actions selected under this call will support the deployment of sustainable and efficient transport and energy infrastructures by contributing to achieving the following specific objectives:

- **Transport sector**
  - Ensuring sustainable and efficient transport systems, by supporting a transition to innovative low-carbon and energy-efficient transport technologies and systems, while optimizing safety.
- **Energy sector**
  - Increasing competitiveness by promoting the further integration of the internal energy market and the interoperability of electricity and gas networks across borders;
  - Supporting projects promoting the interconnection of networks in the Member States;
  - Removing internal constraints;
  - Decreasing energy isolation;
  - Increasing electric interconnectivity and achieving price convergence between the energy markets.

PART 3

THE DIGITAL TRANSFORMATION IN THE TRANSPORT SECTOR

3. THE DIGITAL TRANSFORMATION IN THE TRANSPORT SECTOR

3.1. SHARED MOBILITY AND ITS IMPACT ON CONSUMERS AND COSTS

The idea of sharing things and using them together has worked perfectly well for hundreds of years. All of a sudden, however, it has begun to spawn disruptive business models with an increasing number of customers, producing high revenues. The shared economy is now an integral part of the global economy. People are opening their homes to others (e.g. Airbnb), sharing their journeys (e.g. BlaBlaCar) and clubbing together to fund films, music albums, games, all sorts of things (e.g. Kickstarter). Shared mobility is one of the most important key segments of the shared economy. According to Roland Berger, in terms of revenue, the mobility sector is one of the fastest-growing segments of the shared economy and, moreover, in no other sector of the shared economy are so many established players entering the market. Finally, the mobility sector is a testing ground for the software and hardware solutions of tomorrow[13].

3.1.1. Shared mobility: services and characteristics

shared mobility is a term used to describe transportation based on the sharing of a vehicle among users and the use of technology to connect users and providers. Among shared forms of transportation, car sharing is very successful.

Specifically, it is possible to identify four shared mobility models, listed below (Fig. 3.1)[14]:

First model – Peer-to-peer car rental: Peer-to-peer provision with a company as a broker. Individuals can rent their cars when not in use. These are not companies, but consumers allowing other people to use their vehicles, and supply and demand meet through a broker, which provides an online platform, such as a website and/or app, and collects the payment, taking a percentage of the total income. An analogous case is Airbnb, where people can rent a flat or house or even a room in a town or city for a short period, instead of booking a hotel or bed and breakfast (B&B).

Second Model – Modern car club: Short-term rental of vehicles managed and owned by a provider. The provider owns a number of vehicles that are strategically parked in a city or in certain areas of a city, either in dedicated parking lots and/or on authorized public roads. Potential users can look for a vehicle near to where they are, go and drive to their destination, then park the car at the end of their trip in another dedicated parking lot or in an authorized public parking space. Locking and unlocking is typically done with a smartphone or smartcard. This is all done via an app (finding the car via a live map, registering details, paying, etc.). This model has also

13 Roland Berger, *Shared Mobility. How new businesses are rewriting the rules of the private transportation game*, 2014

14 MDPI, *Sustainability and Shared Mobility Models*, 2018 – https://www.mdpi.com/2071-1050/10/9/3194/htm

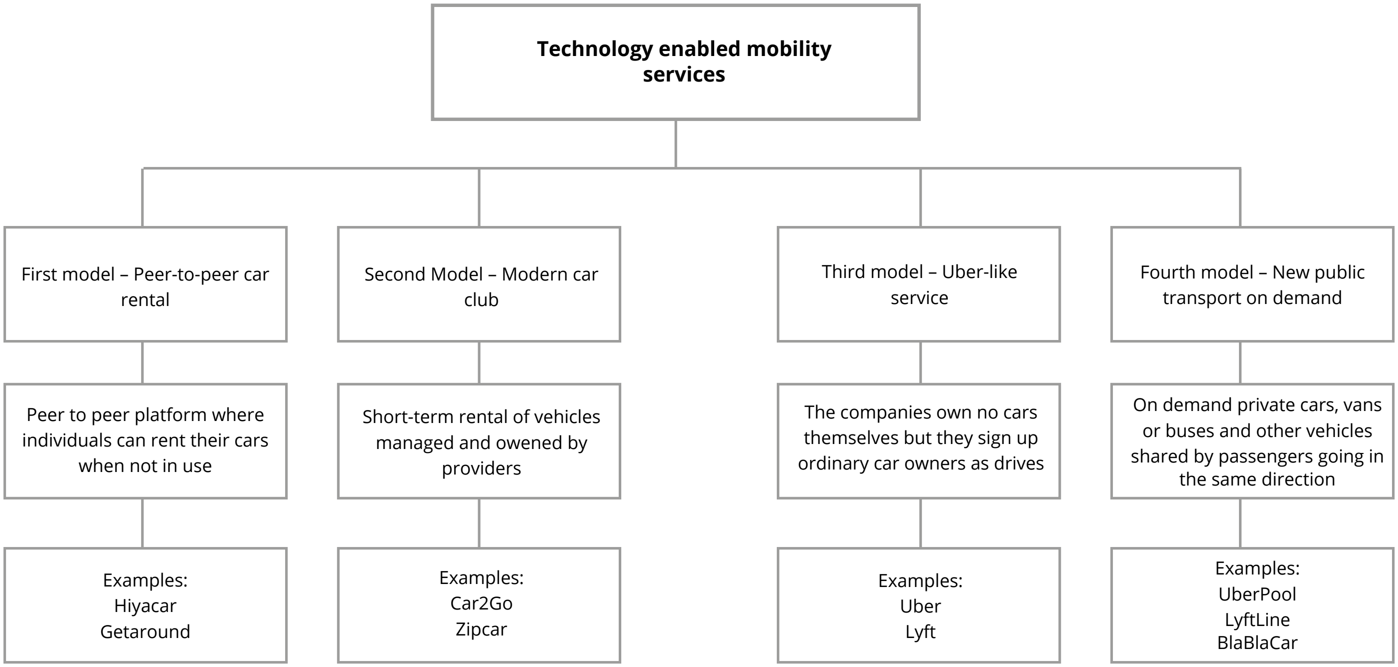
been referred to as flexible car sharing. Many, although not all, of these services require a membership and an annual fee. Customers can then individually access a fleet of cars for short-term usage in return for a fee, typically per minute.

Third model – Uber-like service: Companies own no cars themselves, but they sign up ordinary car owners who act as drivers. The service relies on an app, provided by the company, which also collects payment, taking a percentage of the total income.

Fourth model – New public transport on demand: On demand private cars, vans, or buses and other vehicles, such as large taxis, shared by passengers going in the same direction. It is essentially a user-oriented form of public transport. Options could include users specifying pick-up and drop-off locations and required departure and/or arrival times, which would essentially be shared taxi services, and taxi-bus services using pre-defined stops and requiring a reservation in advance. A variation of this model, used for inter-city travel, is that of drivers offering rides from one city to another, for passengers willing to carpool.

Fig. 3.1 Shared mobility models

Source: MDPI, 2018

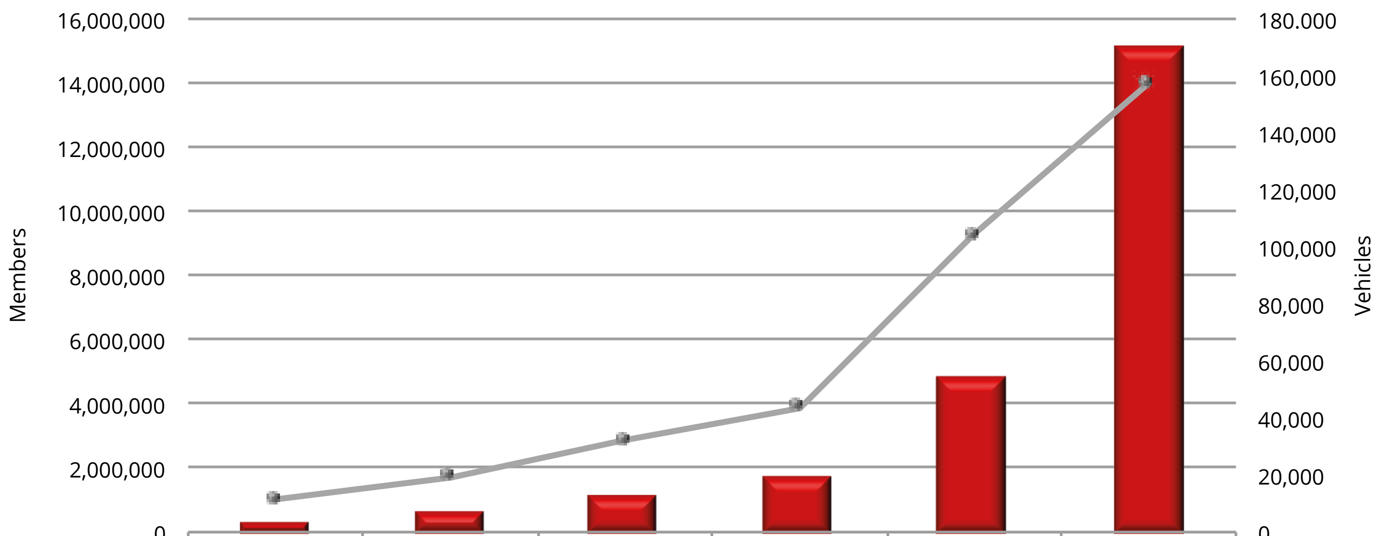


Shared mobility is seen as a promising way to reduce traffic congestion and CO2 emissions, although the extent of these reductions would depend on the type. For example, the first three models can yield profits for private parties, but they do not seem to have a lot of potential to substantially reduce congestion or CO2 emissions. The fourth model, which entails individuals not only sharing a vehicle, but actually travelling together at the same time, is more promising in terms of congestion and CO2 emission reductions. When combined with urban transit, shared mobility also offers the opportunity to reduce parking demand, increasing developable land available for other more productive uses. Consequently, less time spent looking for parking has a positive impact on traffic congestion and emissions.

In 2016, car sharing was operating in 46 countries and six continents, with an estimated 2,095 cities and approximately 15 million members sharing over 157,000 vehicles (Fig. 3.2). Both members and vehicles increased exponentially between 2014 and 2016, with a growth rate of 211% and 51%, respectively.

Fig. 3.2 Global car sharing market

Source: University of California, Berkeley, 2018



	2006	2008	2010	2012	2014	2016
Members	346,610	670,822	1,163,645	1,788,027	4,842,616	15,050,192
Vehicles	11,501	19,403	31,967	43,554	104,125	157,416

Fig. 3.3 Car sharing market, by region (2016)

Source: University of California, Berkeley, 2018

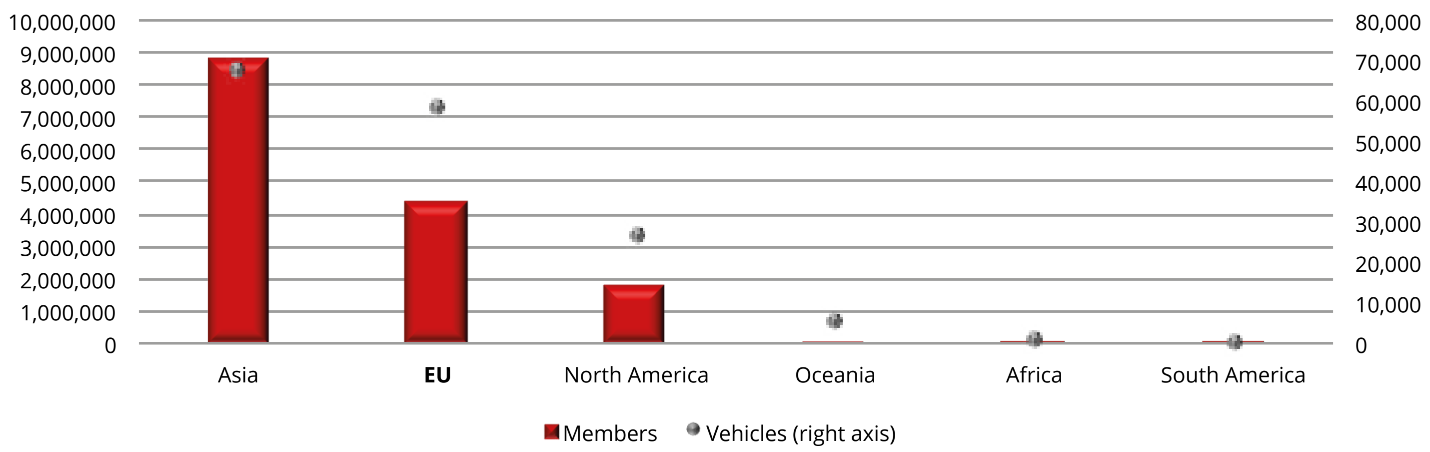
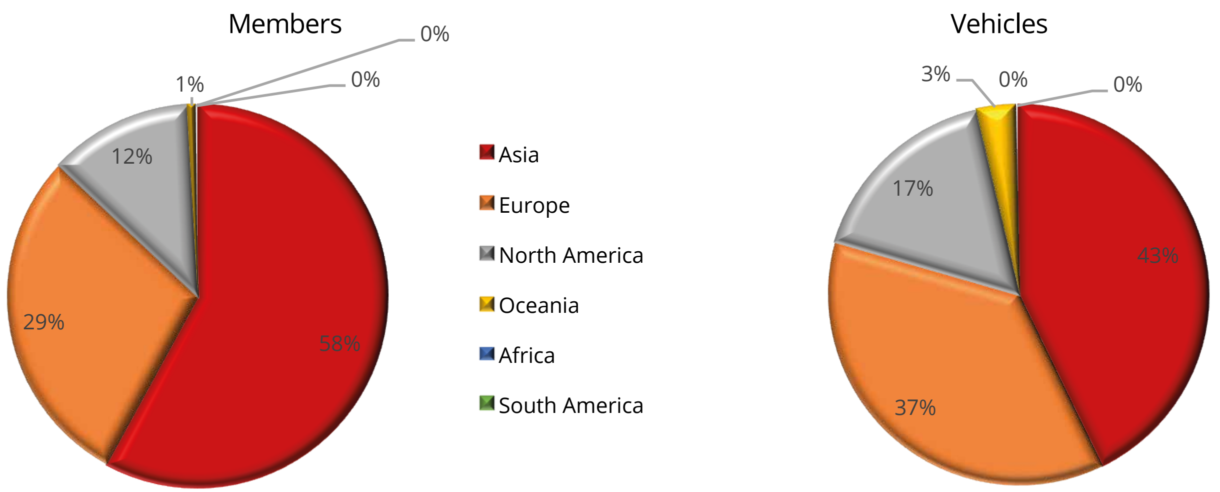


Fig. 3.4 Car sharing market, by region (in % of total, 2016)

Source: University of California, Berkeley, 2018



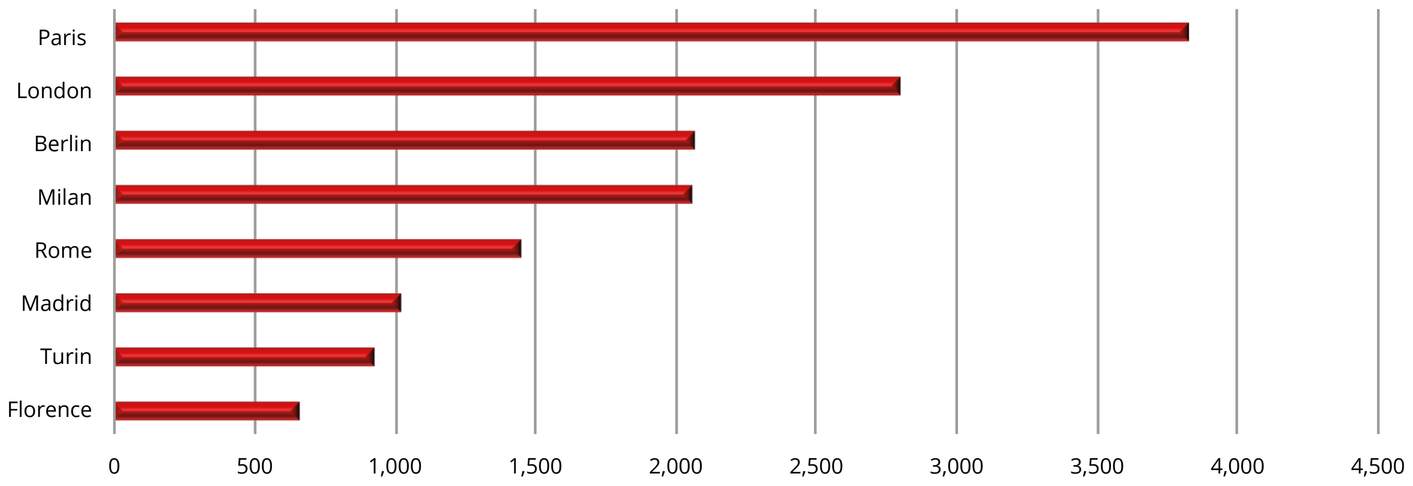
Asia is the largest car sharing region, in terms of members and vehicles, followed by Europe and North America (Fig. 3.3). Asia accounts for 58% of worldwide members and 43% of global fleets deployed. The world's second largest car sharing market, Europe, accounts for 29% of worldwide members and 37% of vehicle fleets (Fig. 3.4).
In Europe, car sharing is widespread especially in Paris, London, Berlin, Milan, Rome, Madrid, Turin and Florence, where a high number of sharing vehicles is available. According to some estimates, Paris ranks at the top with 3,827 car sharing vehicles, followed by London (2,800) and Berlin (2,070) (Fig. 3.5).

3.1.2. Opportunities and challenges of car sharing and user experiences

The impressive growth in shared mobility reveals the relative appeal of these new options to existing choices. Shared mobility services enable a sense of ownership of one's trip, reducing the need for ownership of a personal vehicle. People are increasingly willing to forgo using a private vehicle for the comfort and ease of a shared option that meets their mobility needs.
The market size for shared mobility is still indefinite but it is likely that this trend will continue to grow[15]. According to a survey conducted by ING Bank in October 2018[16],

Fig. 3.5 No. of car sharing vehicles in EU cities (2016)

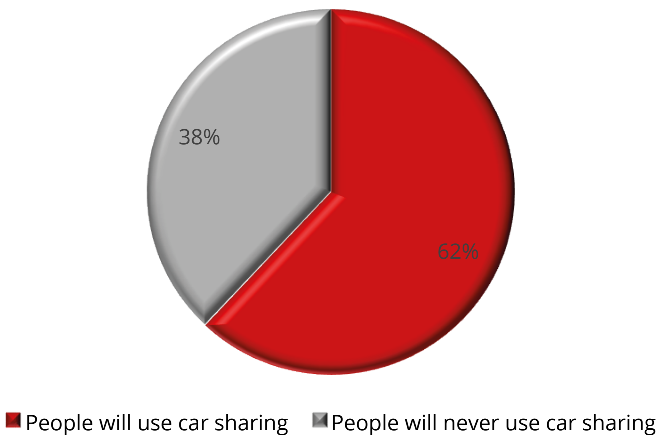
Source: Statista



15 Atlanta's Transportation Plan, *New Mobility and Technology*, 2018
16 ING Bank, *Car sharing unlocked*, 2018

Fig. 3.6 How many people will use car sharing? (sample of EU citizens with a driving licence)

Source: ING Bank, 2018

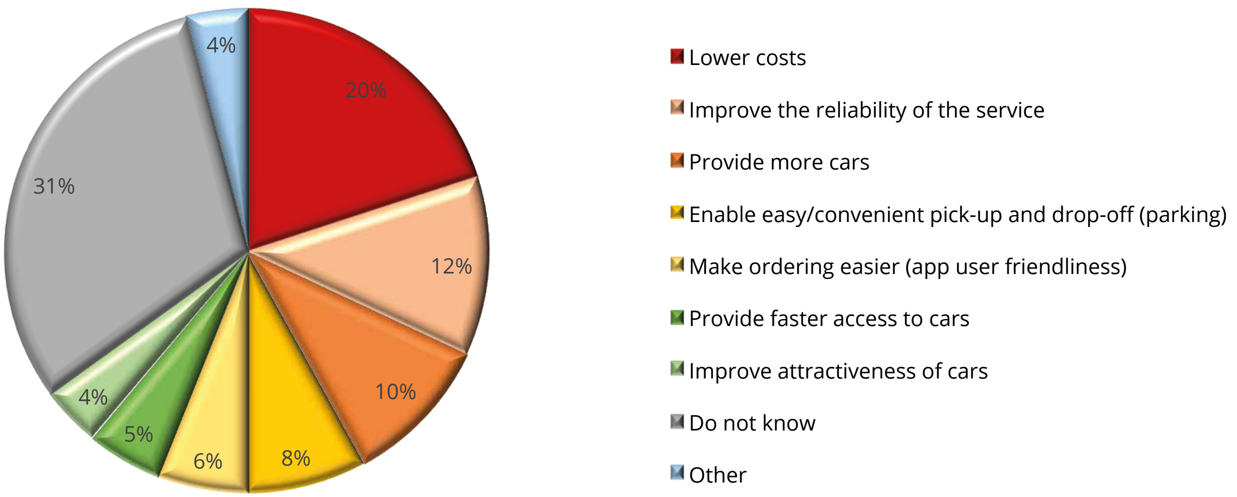


close to 7% of Europeans with a driver's licence state that they use car sharing, while 23.5% would consider using car sharing services over the next year. Interest rises among people who do not own a car and/or use public transport as their main mode of travel. People living in metropolitan areas, where parking spaces are limited, also show high interest. So do young people and those living in countries with relatively lower incomes. 62% of respondents will use car sharing for three main reasons – low cost, more sustainability and flexible alternative to car ownership. Instead, 38% of respondents will never use care sharing (Fig. 3.6).

Interest in car sharing is present amongst many Europeans but there are some barriers that need to be overcome (Fig. 3.7). Although costs were mentioned as a motivation for

Fig. 3.7 What is the main thing car sharing services should improve on? (sample of EU citizens with a driving licence)

Source: ING Bank, 2018



car sharing, a number of people also see this as the main obstacle to using car sharing services. 20% of respondents would lower the cost of car sharing services. Other barriers can be categorized as qualitative aspects that form the user experience. 12% of people would like reliability of services to improve. Users need to believe they can rely on car sharing to fulfil their needs when necessary. Sufficient supply of cars is also related to this. Furthermore, car sharing needs to focus on convenience and ease of use. This is due to the fact that car sharing services currently attract a very specific demography – young, urban and well-educated users with access to smartphones and credit cards. It is still unclear if shared mobility will spread to other segments of the population and this disparity is raising concerns about transportation equity and access. Moreover, a large number of people simply do not consider car sharing as an option. They might have psychological barriers to car sharing or it simply does not match their social norms. Most people in this group prefer their own car and do not plan to use car sharing.

As well as the previously considered issues, we should consider if the supply is sufficient, not just in fleet-owned cars, but also in peer-to-peer car sharing in order to facilitate growth in demand.

According to the ING Bank survey, the majority of people (61%) said ‘yes’ when asked whether they would share their car in return for money (Fig. 3.8).

Willingness to share your own car is especially high in Turkey, Italy and Spain, but low in Belgium and the Netherlands (Fig. 3.9).

Fig. 3.8 Percentage of Europeans willing to share their car for money (sample of EU citizens with a driving licence

Source: ING Bank, 2018

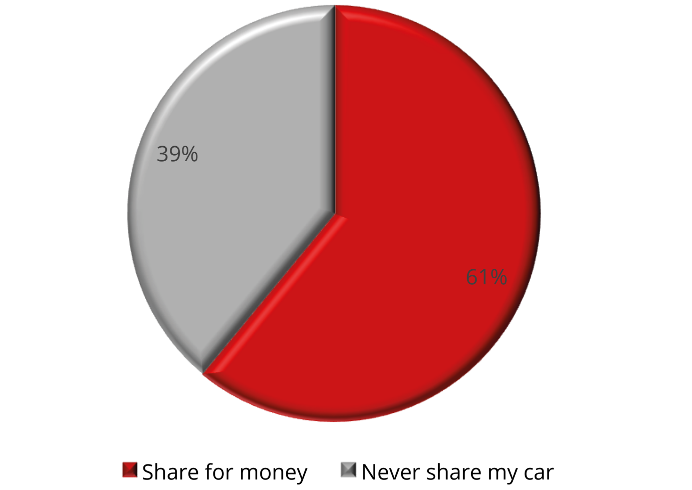
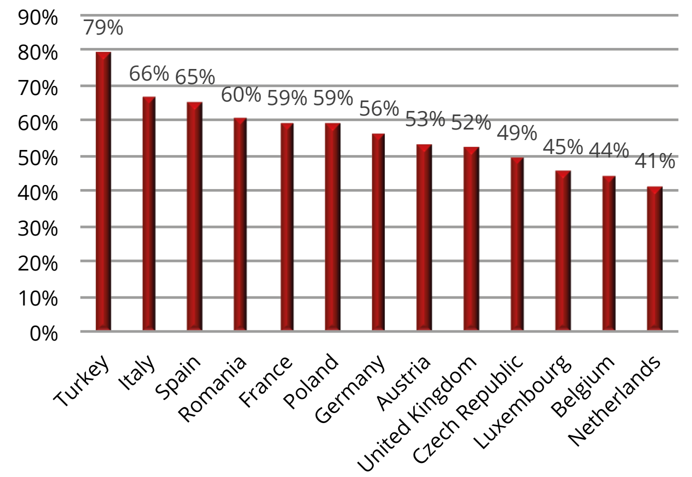


Fig. 3.9 Percentage of respondents willing to share a car for money, by country (sample of EU citizens with a driving licence)

Source: ING Bank, 2018



3.2. THE IMPACT OF IOT AND 5G ON THE TRANSPORT INDUSTRY

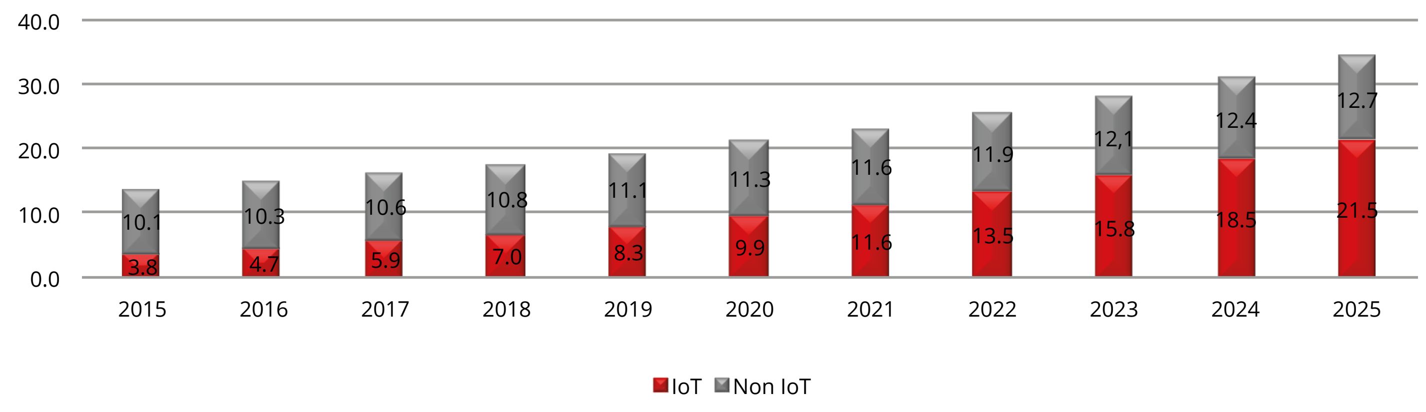
3.2.1. Autonomous and connected cars: current situation and market trends

The first digital revolution successfully integrated the one-to-one communication scheme introduced by the Internet into the transport sector, bringing improvements related to shared mobility (such as the optimization of number of vehicles and routes per passengers), traffic (initially, GPS showing the route, later also showing congestion levels and suggesting the best route), as well as real time information about public transport (people can access routes and timing info about buses, subways, trains, taxis through their smartphone).

Currently, a new digital paradigm, that can be called the “second digital revolution”, is integrating some key features that will have a tremendous impact on people and society, introducing services that will markedly differ from those we are used to today. The dissemination of smart sensors in the surrounding environment and in objects, as well as in wearable and similar devices, is paving the way for the Internet of Things. This definition identifies a new framework in which the Internet is upgrading from its former status (a computer network where information is available for human beings on request) and has become a network connecting objects, robots and most other machines allowing them to mainly act in

Fig. 3.10 Total no. of active device connections worldwide (installed base, in billions)

Source: IoT Analytics Research, 2018



Note: Non-IoT includes all mobile phones, tablets, PCs, laptops and fixed-line telephones. IoT includes all connected consumer and B2B devices. Estimated data from 2018 to 2025 two ways: following a direct human request, that can be communicated to multiple channels and devices, such as voice command, and "autonomously". The latter implies these actions are not directly related to a direct request, but to a large amount of data elaborated by sophisticated algorithms which guide the machine's behavior in relation to the information input and behavior patterns.

The growth of the Internet of Things gives rise to two related phenomena. On the one hand, the increasing number of digital objects and devices connected to the Internet, which exceeded 17 billion by mid-2018, with the number of IoT devices (not including smartphones, tablets, laptops or fixed line phones) reaching 7 billion. The total amount of connected objects is estimated to exceed 34 billion by 2025.

On the other hand, data produced by these devices will significantly increase the total amount of data circulating on the Internet. In the automotive sector, for instance, data generated by connected cars can be listed in several categories that open up different business opportunities but, in order to do so, needs to be managed properly.

Fig. 3.11 Data generated by connected cars and the main use cases

Source: McKinsey & Company, 2016

Perceived privacy sensivity	Macro-category	Car-related use case examples: Today	Car-related use case examples: 2020-2025
Low	**External road and enviromental conditions** (e.g., ice warning on the road from ESP, fog from camera/ sensors' feed	Real-time maps	Preventive safety car adaptation; Live road conditions reports
	Technical status of the vehicle (e.g., oil temperature, airbag, deployment, technical malfunctions report)	Car repair diagnostics; Automatic emergency call (e-call)	Predictive, remote service booking
	Vehicle usage (e.g., speed, location, average load weight in the trunk)	PAYD insurance; Toll/road tax payment	Reduce engineering costs; Trunk delivery
	Personal data and preferences (e.g., driver/passengers' identity, preferred radio station, use patterns of	Vehicle settings "memory" based on key presence at entry	E-commerce in the car; Targeted advertisements
High	**Direct communications from the vehicle** (e.g., calendar, telephone, SMS, e-mail)	Speech control of messaging and e-mail	Proactive navigation and services; Virtual assistant/concierge services

Tab 3.1 A comparison between 5G auctions in EU countries

Source: I-Com elaboration on Mise, Ofcom, CMT, Ficora data.

Country	Total price	Availability (years)	Population (2017)	MHz	Frequency band	Price per MHz (in €, per 100,000 inhab.)
Italy	4,346,820,000 €	18	60,589,445	200	3.6-3.8 GHz	1,993 €
Spain	1,410,700,000 €	20	46,528,024	200	3.6-3.8 GHz	758 €
United Kingdom	1,143,714,909 €	20	65,808,573	150	3.4-3.6 GHz	579 €
Finland	77,000,000 €	14	5,503,297	390	3.4-3.8 GHz	256 €

Data managing applications involve cloud computing services as well as ultra-broadband connections. In the mobility sector, the latter is extremely important in order to constantly manage a proper information flow and reduce latency[17]. In this sense, the new mobile standard, the 5G, is a revolutionary technology. Indeed, compared to previous standards, 5G significantly increases the sustainable bandwidth of both uplink and downlink, and guarantees responsiveness that is under one millisecond, almost equal to real time. These characteristics are extremely important in order to support services such autonomous driving (see below), which requires a very important real-time data flow and needs immediate feedback on possible obstacles or variations on the route. Another important feature is related to the logical separation for different markets and industries allowed by 5G networks. In current networks the same infrastructures are used for different services, while 5G has network separation capability. This means a logical network could be only dedicated to connected and autonomous vehicles, focusing on network performance (bandwidth, latency), business modelling and pricing on vehicle needs.

So far, 5G frequencies have been assigned in the United Kingdom, Italy, Finland and Spain. Tab. 3.1 compares the various 5G competition results related to the bands of 3.4-3.6 GHz and 3.6-3.8 GHz, those that will be (or already are) used for the first 5G trials and services. Given that different countries have different markets and different characteristics (competition levels, catchment areas, digital literacy rates and so on), the comparison shows the price paid by operators for each country standardizing the final results per parameter, such as license duration, number of inhabitants and bandwidth. The breakdown shows that the price paid by operators in Italy is from 3 to 4 times higher than those paid in Spain (€758 million) and the United Kingdom (€589 million) and more than 7 times than Finland (€256 million)[18].

17 Latency is a measure of the time delay required for information to travel across a network. 5G's latency is under one millisecond, which is almost near real-time in sub-milliseconds, while 4G LTE networks provide 10-30 milliseconds elapse for a round-trip communication.

18 It is worth noting that the Spanish results also include €542 million related to interest from payments delayed over 20 years, as well as €868.5 million from the so-called "tasa por reserva", charged by the Spanish Government on Tlc networks.

The distinction between the 1st and 2nd digital revolution is crucial in order to clarify the difference between Connected Vehicles (CV) and Autonomous Vehicles (AV). It is worth noting that they both differ from Electric Vehicles (EV), which do not indicate the electronic technology used to connect vehicles and make them drive autonomously, but the power used by the motors for propulsion. Hence, Connected Vehicles, as well as Autonomous Vehicles, can be powered by fuel, electricity or other kinds of energy.

Connected vehicles are provided with technologies that allow them to communicate with the environment, as well as between each other. The Connected Vehicle concept is related to supplying useful information to a driver (or a vehicle) to help them to make more informed decisions[19]. Hence, this implies that the vehicle only supplies information to the driver, e.g. related to traffic conditions or to potentially dangerous situations to avoid, without making any choices in their place. In most cases, CVs send the information to the driver as well as transportation collecting data agencies, in order to generate historic data to improve real-time conditions and better allocate resources and improve future infrastructure planning, also related to the further deployment of a nationwide (and international) connected vehicle system.

The navigation systems currently used in vehicles already include CV functionalities such as dynamic route guidance, whereas the GPS system receives information on traffic congestion and elaborates and suggests the best route.

Autonomous Vehicles (AV) imply that machines, provided with proper equipment and real time information flows, can take decisions and carry out their own actions, such as self-parking, avoiding collisions autonomously and driving. The Society of Automotive Engineers (SAE) found 6 different levels of automation, from level 0 to level 5 (Tab. 3.2).

Level 0 identifies vehicles without any information support, while level 1 indicates vehicles that analyze part of the environmental conditions and are able to inform the driver, for instance, through acoustic alarms in parking assistance, but who is still required to take control at any time. Therefore, machines belonging to these first two levels cannot be identified as Autonomous Vehicles.

Level 3, also called *Conditional Driving Automation*, includes cars which can monitor the full environment, but still need the driver's decision in particular situations. In other words, the driver has to be ready to intervene on vehicle request.

Level 4 is called *High Driving Automation* and implies that cars are able to drive completely independently, especially environments called "driving modes"[20]. These

19 See Atkinsglobal, *Connected and Autonomous Vehicles*, 2016.

20 The SAE identifies ODD as the specific conditions under which a given driving automation system or feature is designed to function, including, but not limited to, driving modes. An ODD may include geographic, roadway, environmental, traffic, speed and/or temporal limitations. An ODD may include one or more driving modes. For example, a given Automated Driving System may be designed to operate a vehicle only on fully access-controlled freeways and in low-speed traffic, high-speed traffic, or in both of these driving modes. see SAE, "Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles", 2016).

Tab 3.2 Summary of levels of driving automation

Source: I-COM elaboration on SAE International, 2016

Level	Name	Narrative definition	DDT (Dynamic Driving Task)		DDT fallback	ODD Operational Design Domain
			Sustained lateral and longitudinal vehicle motion control	OEDR (Object and Event Detection and Response)		
Driver performs part or all of the DDT						
0	**No Driving Automation**	The performance by the driver of the entire DDT, even when enhanced by active safety systems.	Driver	Driver	Driver	N/A
1	**Driver Assistance**	The sustained and ODD-specific execution by a driving automation system of either the lateral or the longitudinal vehicle motion control subtask of the DDT (but not both simultaneously) with the expectation that the driver performs the remainder of the DDT	Driver and System	Driver	Driver	Limited
2	**Partial Driving Automation**	The sustained and ODD-specific execution by a driving automation system of both the lateral and longitudinal vehicle motion control subtask of the DDT with the expectation that the driver completes the object and event detection and response (OEDR) subtask and supervises the driving automation system.	System	Driver	Driver	Limited
ADS (Automated Driving System) performs the entire DDT (while engaged)						
3	**Conditional Driving Automation**	The sustained and ODD-specific performance by an ADS of the entire DDT with the expectation that the DDT fallback-ready user is receptive to ADS-issued requests to intervene, as well as to DDT performance-relevant system failures in other vehicle systems, and will respond appropriately.	System	System	Fallback-ready user (becomes the driver during fallback)	Limited
4	**High Driving Automation**	The sustained and ODD-specific performance by an ADS of the entire DDT and DDT fallback without any expectation that a user will respond to a request to intervene.	System	System	System	Limited
5	**Full Driving Automation**	The sustained and unconditional (i.e., not ODD-specific) performance by an ADS of the entire DDT and DDT fallback without any expectation that a user will respond to a request to intervene	System	System	System	Unlimited

can be situations such as driving on a highway or parking in a garage. Even if, theoretically, they should be able to cope with all the situations, models belonging to this level may not be capable of self-managing under specific circumstances, due to equipment limitations (e.g. some vehicles may not be suitable for highways as their sensors are not designed to perform at the range needed to travel at high speeds).

Level 5 is identified as *Full Automation*, a system that should be able to handle, unconditionally, all driving tasks just as a human driver. This means the Automated Driving System is ODD independent and can work in all driving modes and under all environmental conditions (rain, fog, snow) without any expectation that the human driver will answer to any request to intervene.

According to PwC estimates (Fig. 3.13), there will not be more non-connected cars sold by 2025. Indeed, out of about 63 million cars sold in the US, the EU and China in 2017, the number of connected cars exceeded 55 million, while the non-connected cars sold were only 7 million. In 2020, the connected cars sold should reach the 65 million threshold, up to 82 million by 2030.

Autonomous car sales projections (Fig 3.14) are related to the different levels explained above. The level 0 cars are those identified in the previous figure, also named as "non-connected". Between the connected cars (almost 56 million in total), more than 50 million belonged to level 1 class, while the autonomous cars sold in 2017 were less than 1 million (level 2). According to PwC projections, level 2 cars should reach 5 million units sold by 2020,

Fig. 3.12 Existing capabilities of car models belonging to level 2 "Partial Driving Automation"

Source: Tesla.com

Fig. 3.13 Estimated no. of cars sold (US, EU and China in millions)

Source: PwC, September 2017

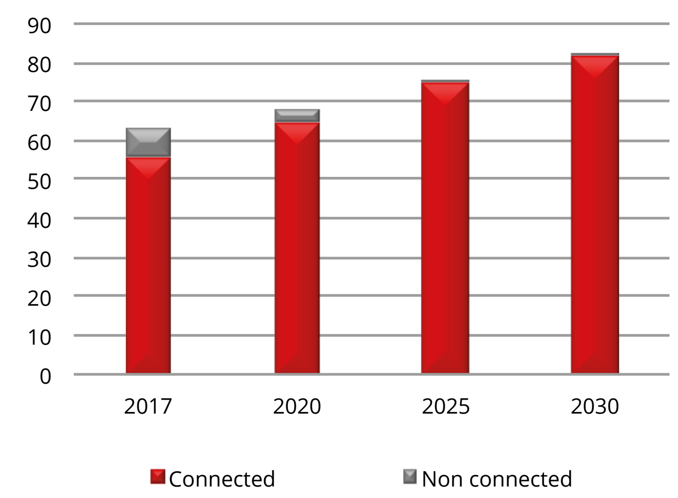
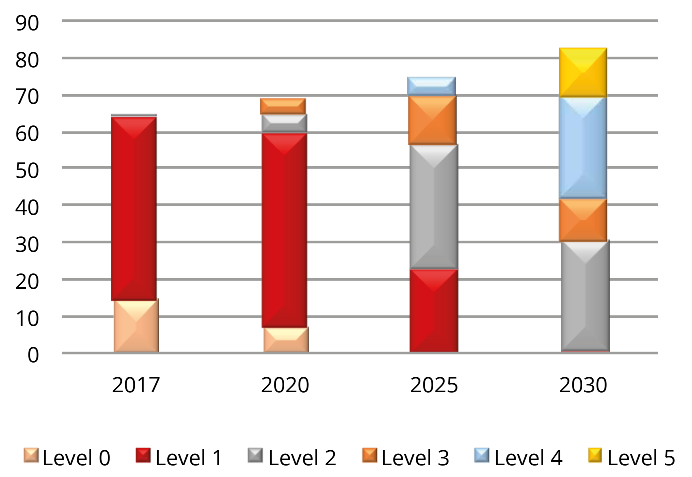


Fig. 3.14 Estimated autonomous cars sold, by type (US, EU and China)

Source: PwC (September 2017)

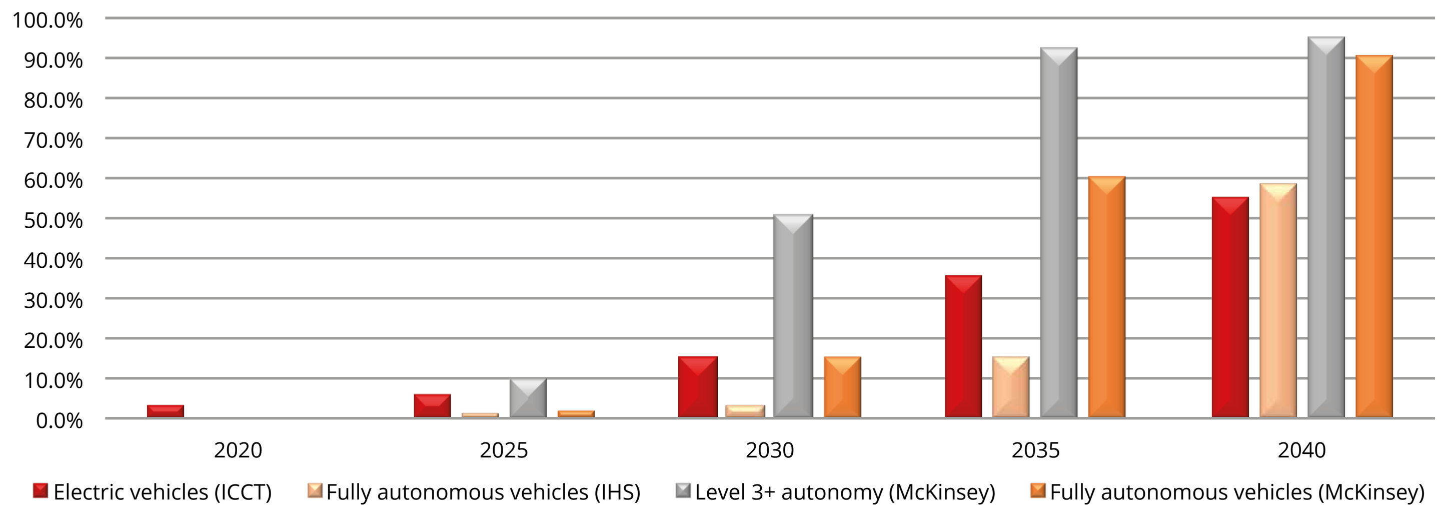


climbing up to 33 million in 2025. Level 3 cars, not yet available on the market, should reach 4 million units by 2020, arriving at the 13 million threshold by 2025. By 2030, level 2 and level 3 car sales should begin to decline, due to the increase in level 4 and level 5 vehicles. For the latter, level 4 cars should reach 5 million units sold by 2025 and up to 28 million by 2030, while the fully autonomous cars (level 5) will be available only after 2025, reaching 12 million units sold per year by 2030.

Projections on the spreading of electric, semi-autonomous (level 3+ autonomy, according to the scale showed in Tab. 3.2) and (fully) Autonomous Vehicles have also been carried out by other consultancy companies, such as McKinsey and IHS Automotive. According to the International Council on Clean Transportation, which

Fig. 3.15 Projection on electric, semi-autonomous and fully autonomous vehicles (in million units installed)

Source: ICCT on ICCT, HIS, McKinsey (2017)



collected and compared this data with its own projections for electric vehicles, projections on future autonomous vehicle sales significantly exceed demand estimates for electric vehicles (Fig. 3.15). Indeed, the latter will account for about 15% of the total of cars by 2030, while level 3+ Autonomous cars should account for more than 50% of the total cars sold. This means that, according to projections, one car in every three connected (or autonomous) cars sold could be electric, while the other 2 could be powered by another type of energy.

McKinsey estimates indicate that vehicles with Level 3 or higher automation could exceed the 50% worldwide cars sold thresholds by 2030, rising to 90% by 2035 (McKinsey & Company, 2016). According to ICCT projections, electric vehicles should reach 30% of total cars sold, maintaining the 1:3 ratio.

IHS Automotive projections, related to fully autonomous vehicles sold on global sales, will be below 5% of total sales by 2030, reaching 15% of sales in 2035 and exceeding the 50% sales threshold by 2040 (IHS Automotive, 2016)[21].

3.2.2. IoT and 5G trials and projects in rail and maritime sectors

the 5G Pan-European Trials Roadmap is coordinated by the 5G Infrastructure Association (5G-IA), in order to develop the work begun by the European Commission within the 5G Manifesto's and 5G Action Plan's framework. The 5G Pan-European Trials Roadmap's goals are supporting the pilots of six vertical industries[22], promoting private 5G trials and creating 5G Pan-European events to spread the new standard potentials among people (namely "5G for Euro2020"), as well as identifying and supporting the 5G Trial Cities. The plan's central part is centered on experimentation, as well as commercial and pre-commercial pilots conducted by network operators and manufacturers in order to involve "vertical" stakeholders. In this respect, according to the 5G-IA monitoring, more than 80 initiatives have been launched amongst the European countries, mainly by network operators (Telco), technological equipment manufacturers and vendors, as well as vertical industries.

Most of the projects that have been carried out focused on tests related to bandwidth, latency, radio interface technologies (frequency waves and bands as well as antennas), network architecture (virtualization, cloud, network slicing, edge computing) and technologies for specific use cases, such as automotive, media and smart manufacturing. Within this framework, 5G private trials involving operators from vertical markets are still few (Fig. 3.16). Most trials are taking place in Spain (16), Germany (12), Italy (11), France (9), the United Kingdom (8) and Finland (7).

A part of these projects concerns the transport industry. Amongst them, the majority are related to connected and autonomous driving, while those belonging to rail and maritime sectors are still a small part of the total.

An interesting project focused on the rail sector is

21 ICCT, *New Mobility: Today's Technology and Policy Landscape*, 2017

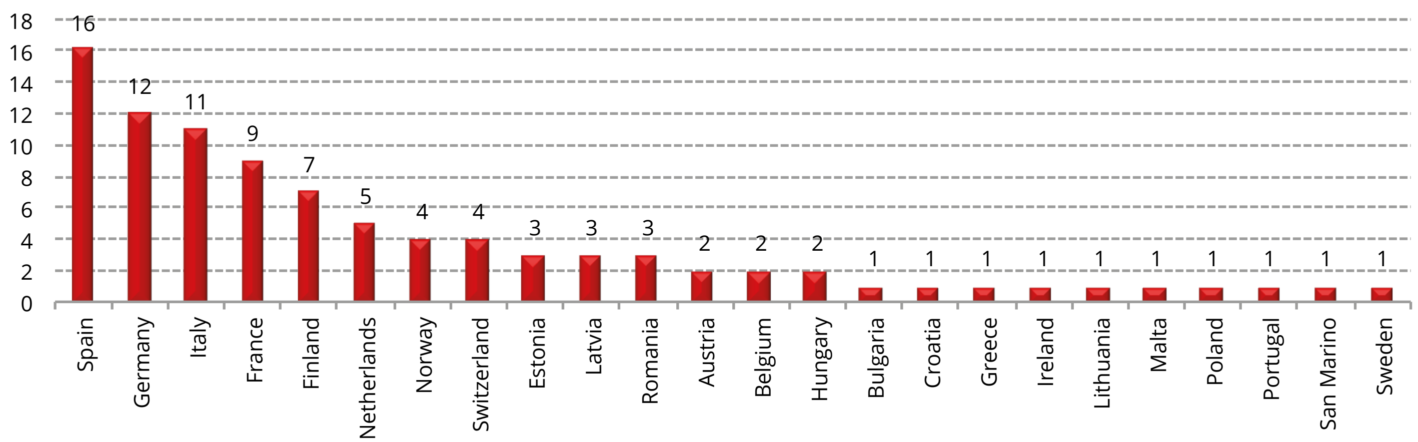
22 The six vertical industries are Consumer and Professional Services, Automotive, Industry, eHealth, Public Safety and Smart City

5G-PICTURE (5G Programmable Infrastructure Converging disaggregated neTwork and compUte REsources). Launched by a 19 member consortium, the project aims at designing and developing an integrated, scalable and open 5G infrastructure supporting operational and end-user services for both ICT and 'vertical' industries. The goal is integrating network and compute/storage resources into a common infrastructure. The project's use cases involve the city of Bristol for smart city test-bed and media services supporting large venues, and the city of Barcelona[23], where 5G seamless service provisioning and mobility management will be tested in high speed railway environments.

This experimentation is important because the railway communication infrastructure has historically evolved using a mixture of different network technologies. This trend led to a series of inefficiencies related to higher costs and complications in deployment, versatility and interoperability, as well as in capacity and other performance parameters. To support a more sustainable development of railway communication infrastructures, new solutions will be developed, aiming at enabling the analysis, monitoring and exploitation of the whole railway system, including power grids, stations and other infrastructures. The new solutions should improve the service characteristics related to delay, reliability and mobility, making the service available even with expected speeds of more than 500

Fig. 3.16 No. of 5G trials and pilots (publicly announced) in EU Member States (as of 20.04.18)

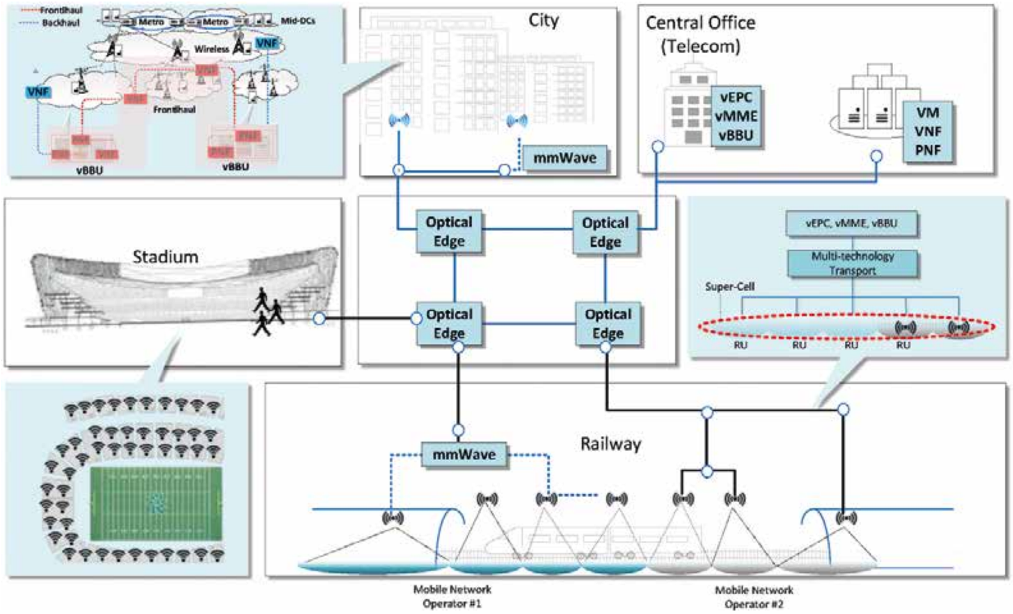
Source: 5G Infrastructure Association (5G-IA)



23 The 5G railway demonstration in the operational rail network will take place in Ferrocarrils de la Generalitat de Catalunya (FGC)

Fig. 3.17 5G-PICTURE Project

Source: www.5g-picture-project.eu



km/h, as well as inside (sub)-stations[24].

At a technical level, the goals are to integrate millimeter wave (mmWave) links with FGC's optical fiber[25] and enabling new railway services or improvements in existing ones, such as the implementation of smart tracks using digital sensors.

A new integrated communications architecture capable of overcoming many of these issues would bring a series of advantages, such as the ability to build a new common infrastructure to support the whole set of communication-based services, serving a large variety of requirements and eliminating the need for today's multiple independent networks, significantly reducing the Total Cost of Ownership (TCO).

Moreover, this approach is in accordance with the European Commission directives, aiming at opening up the rail transport service market to competition[26].

In the maritime sectors, two of the most interesting trials are taking place in Estonia and Italy. In Estonia, the

24 These particular conditions could be reached in transportation systems beyond 2020.

25 mmWave access links will follow the train and the beams will be intelligently steered to the antennas at the train, providing the best connection.

26 See Eurescom, *5G for railway innovation*, 2018, https://www.eurescom.eu/news-and-events/eurescommessage/eurescom-message-summer-2018/5g-for-railway-innovation.html

shipping company Tallink, together with telco operators and manufactures such as Telia, Ericsson and Intel, has launched a trial area in the Tallinn port, creating a digital ecosystem involving partners and consumers. The tested technological solutions allow for delivering superfast and secure connectivity to cruise ships within the port and the surrounding area.

In Italy, the city of Bari was chosen within the *5G for 5 Cities* Italian context for its strategic position as a terminal point along the VIII Pan-European Corridor and crossroads to the Middle East and Balkan countries. The project consortium involves 52 partners, including Tim, Fastweb and Huawei. The first 5G antenna has already been switched on in the cruise terminal, using the 3.7-3.8 GHz frequency band. The trial's goal is to create a Port 4.0, improving security, access control and logistics. 5G technologies will help in automatizing loading or unloading operations thanks to IoT solutions, and will support scanner for face recognition, checking accesses and improving port security operations.

3.2.3. Opportunities and challenges in the age of smart vehicles

The Internet of Things and 5G infrastructures will have a considerable impact on the global economy and will transform various sectors, including the transport one, optimizing the movement of people and goods. By automatizing roadways, railways and airways, smart systems will transform passenger experiences and reshape the way cargo and merchandise are tracked and delivered, creating substantial business opportunities for new players. Automated transport management styles will offer several benefits (Tab. 3.3)[27], such as increasing safety and efficiency, reducing congestion and transport costs and economizing on fuels. Moreover, the incorporation of intelligent systems (ITS), such as communication systems, sensors and smart devices to connect the transportation system in a real-time environment, and IoT solutions in the transportation sector enables vehicles to transfer messages and signals to other vehicles for tracking and monitoring on a real-time basis. The integration of ITS with IoT applications helps to monitor the data from surroundings and increases safety in passenger and commercial vehicles.

One of the main challenges related to the adoption of Autonomous Vehicles is connected to its possible energy impact. Different research has shown how these effects may vary and have a very wide range of outcomes. Caltrans Division of Research, Innovation and System Information made a comparison between several published articles and studies, analyzing the impact of Autonomous Vehicles on the environment and greenhouse gas emissions (Tab. 3.4). It emerges that outcomes are not all going into the same direction. For example, the study of the *Potential Energy Consumption Impacts of Connected and Automated Vehicles* (2017) identifies CAV-enabled factors with the greatest impact on increasing energy consumption (reduced travel costs, higher highway speeds, longer commute distances and inclusion of previously underserved user groups),

27 RED HAT, *Smart transportation applications in the Internet of Things*, 2016

Tab 3.3 Smart transportation system applications and benefits

Source: RED HAT, Smart transportation applications in the Internet of Things, 2016

APPLICATION	BENEFITS FOR END-CUSTOMERS
Fleet telematics and management solutions	
Intelligently monitor vehicle location, movement, status, and behavior	Optimize routes, fuel economy, and driver productivity
Transport logistic applications	
Monitor and track cargo conditions (temperature, motion, light, etc.) and movements	Avoid product spoilage, damage, delays, and theft; optimize routing and logistics
Reservation, toll, and ticketing systems	
Enable automated payment and ticketing	Avoid delays and inconvenience; introduce demand-based fees
Guidance and control systems	
Intelligently monitor and govern transportation network and vehicles	Avoid collisions and derailments, improve public safety, and optimize traffic flows
Inventory and supply chain management solutions	
Intelligently manage the movement goods and materials	Optimize inventories, order processing, shipping, and receiving
Passenger entertainment and commerce	
Offer interactive retail and entertainment services to captive passengers	Generate new revenue streams and improve customer loyalty and passenger experiences
Smart vehicle applications	
Intelligently route vehicles and adapt transportation infrastructure (traffic signals, signage, lanes)	Optimize traffic flows and fuel economy; avoid collisions; improve safety and mobility
Peer-to-peer services	
Introduce smart services like car sharing or parking space finders	Create new business opportunities and revenue streams
Security and surveillance systems	
Intelligently monitor and analyze activities at transportation hubs and networks	Protect against safety hazards, terrorist threats, and other security concerns

while the report *Help or Hindrance? The Travel, Energy and Carbon Impacts of Highly Automated Vehicles* (2016) concludes that AVs might reduce GHG emissions and energy use by nearly half—or nearly double them—depending on which effects will dominate. The study *Estimate of Fuel Consumption and GHG Emission Impact from an Automated Mobility District* (2015) shows that automated mobility districts have the potential to reduce icom institute for competitiveness

Tab 3.4 Environmental Impacts of Connected and Automated Vehicles

Source: Caltrans Division of Research, February 2018

Publication Project (Year)	Vehicle Type	Type of Research/ Result	Description
AV's Impacts on Energy Demand and GHG Emissions (Research in Progress)	AV	Projections and estimates	Expected to develop improved projections of future travel demand and patterns, and an estimate of energy and carbon intensity of vehicle travel. Completion date: February 2018.
Environmental Impacts of Automated Vehicles (Research in Progress)	AV	Meta-analysis of research	Expected to synthesize best research available and highlight research gaps. Completion date: October 2016 (no report available).
Development of Integrated Vehicle and Fuel Scenarios for Low Carbon US Transportation Futures (Research in Progress)	AV	Projections and estimates; modeling	Expected to include model development, assessment of capital and operating costs of vehicle technologies and fuel infrastructure; will also provide estimates of GHG reductions, costs and policy pathways. Completion date: September 2017 (no report available).
Keeping Vehicle Use and Greenhouse Gas Emissions in Check in a Driverless Vehicle World (2017)	CAV	Recommendations	Provides policy recommendations to support VMT and GHG containment goals.
Study of the Potential Energy Consumption Impacts of Connected and Automated Vehicles (2017)	CAV	Potential for impact	Identifies CAV-enabled factors with greatest impact on increasing energy consumption (reduced travel cost, higher highway speeds, longer commute distances and inclusion of previously underserved user groups).
Analysis of the Potential of Autonomous Vehicles in Reducing the Emissions of Greenhouse Gases in Road Transport (2017)	AV	Potential for impact	Analyzes the potential for AV to reduce GHG emissions.
Assessing Autonomous Vehicle Impact on Urban Traffic Emissions and Intersection Performance (2016)	AV	Projections and estimates; modeling	Examines environmental performance of mixed traffic streams (driverless and conventional) using instantaneous vehicle emission modeling.
Fuel Economy Testing of Autonomous Vehicles (2016)	AV	Projections and estimates	Examines fuel economy testing of AV; can degrade fuel economy by up to 3% (no consideration of efficiency).
Help or Hindrance? The Travel, Energy and Carbon Impacts of Highly Automated Vehicles (2016)	AV	Projections and estimates	Concludes that AVs might reduce GHG emissions and energy use by nearly half—or nearly double them—depending on which effects come to dominate. Notes that many potential energy-reduction benefits may be realized through partial automation, while major energy/emission downside risks appear more likely at full automation.
Estimate of Fuel Consumption and GHG Emission Impact from an Automated Mobility District (2015)	AV	Projections and estimates	Provides framework to quantify the fuel consumption and GHG emission impacts of a transit system composed of AVs (an automated mobility district, or AMD). AMD has the potential to reduce total system fuel consumption and GHG emissions; the amount is largely dependent on operating and ridership assumptions.
An Analysis of Possible Energy Impacts of Automated Vehicles (2014)	AV	Projections and estimates	Concludes that widespread AV deployment can lead to dramatic fuel savings but has the potential for unintended consequences.

Publication Project (Year)	Vehicle Type	Type of Research/ Result	Description
The Future of Fully Automated Vehicles: Opportunities for Vehicle- and Ride-Sharing, with Cost and Emissions Savings (2014)	AV	Projections and estimates	Estimates shared AV use leads to 16% less energy use and 48% lower volatile organic compound emissions per person-trip formerly served by a household vehicle.
Environmental and Energy Impacts of Automated Electric Highway Systems (2013)	AV	Projections and estimates; modeling	Uses Motor Vehicle Emission Simulator (MOVES) program to estimate the impacts on emissions and energy use associated with hypothetical implementation of automated electric highway systems on Interstate 70 in Missouri during 2011-2040: • Decreases fossil fuel energy use by more than 25%. • Emissions decrease by up to 27% depending on the pollutant. • 10% reduction in VMT has effect of 5% or less on the criteria of interest.

total system fuel consumption and GHG emissions, while the study on *The Future of Fully Automated Vehicles: Opportunities for Vehicle- and Ride-Sharing, with Cost and Emissions Savings* (2014) estimates that shared AV use leads to 16% less energy use and 48% lower volatile organic compound emissions. On the other hand, the research, *An Analysis of Possible Energy Impacts of Automated Vehicles* (2014), concludes that widespread AV deployment can lead to dramatic fuel savings but may have unintended consequences. This meta-analysis shows that an impact estimate on pollution reduction is still extremely complicated to define, and that final outcomes will strongly depend on how Autonomous Vehicle's will be used and regulated.

In order to analyze both the positive and negative outcomes on Autonomous Vehicles on energy consumption, the National Renewable Energy Laboratory (NREL)[28] identified up to 8 different scenarios depending on the combination of 10 different effects, 4 belonging to a "Private Ownership" framework and 6 to a "Shared Ownership" framework. In detail, the hypothesized effects resulting in a bigger increase in energy consumption could be "travel by underserved population" (+70% use intensity)[29], "faster travel" (+30% energy intensity)[30] and "more travel" (+50% use intensity)[31]. Moreover, the 8 scenarios representing the outcomes of the effects' combination show that the overall impact on fuel demand may vary from -83% up to +217%, confirming that a single and precise estimate of AV impact on energy saving is currently hard to produce.

Other challenges related to connected and autonomous vehicles are correlated to cyber-attacks. By adding several functions common to smartphones, such as

28 NREL is a national laboratory of the U. S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

29 These are youth, disabled and elderly people. The factor is an Author's estimate based on NHTS data.

30 This was supposed to be possible due to safe highway operation. The factor is an Author's estimate based on ORNL 2013.

31 Due to faster travel, reduced traffic, people may live further from destinations or travel more. This factor was analyzed by Author's estimate; Schaefer et al. (2009).

Tab 3.5 Autonomous Vehicles Range of Possible Energy Impacts: positive and negative effects

Source: NREL

Private Ownership (Low Number of AVs)

Effect	Approach	Effect Estimate	Estimate Source
(a) Platooning: close following at high speed to reduce drag	Use estimates of overall savings potential from literature	-10% EI	MIT technology review (2011); Ahn, Rakha, and Park (2013); RITA
(b) Efficient driving: smooth start stop, some stop elimination	Use estimates of eco driving potential	-20% to -30% EI	Gonder, Earlywine, and Sparks (2012)
(c) Efficient routing: traffic avoidance and most efficient route selection	Example case from Buffalo, NY	-20% EI	Sadek and Guo (2011)
(d) Travel by underserved populations: (youth, disabled, and elderly)	Estimate the additional miles if all people over 13 had the VMT of the highest demographic	+70% UI	Author's estimate based on NHTSdata

Shared Ownership (High Number of AVs)

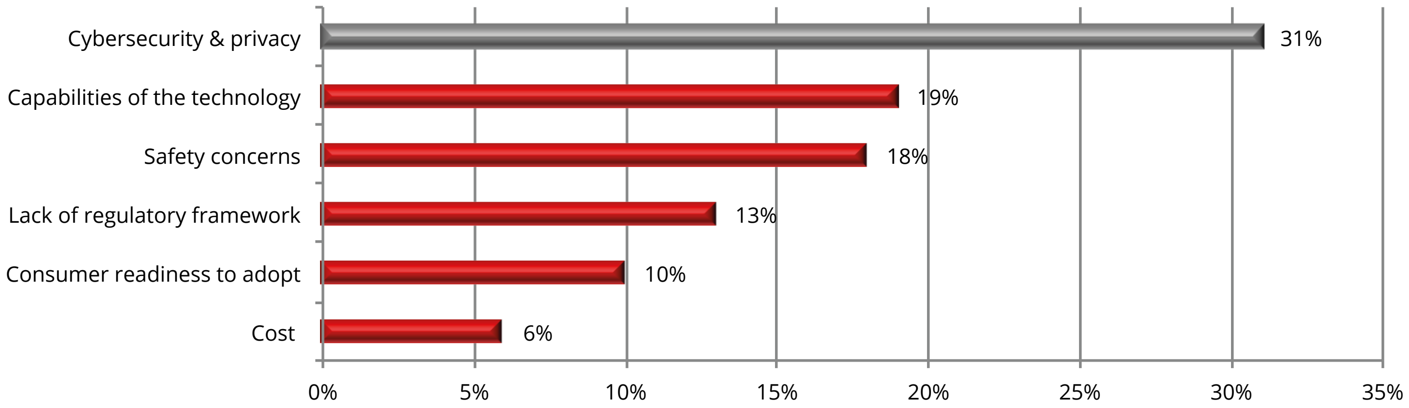
Effect	Approach	Effect Estimate	Estimate Source
(e) Efficient driving: full stop elimination and trip smoothing	Use upper bound of efficiency improvement from smooth travel	-10 to -20% EI (additional to prev. estim.)	Gonder, Earlywine, and Sparks (2012)
(f) Faster travel: possible due to safe highway operation	Estimate impact on fuel economy from aerodynamic drag at 100 MPH	+30% EI	Author's estimate based on ORNL 2013
(g) More travel: due to faster travel, reduced traffic, people may live further from destinations or travel more	Assume the current time spent travelling remains the same (so miles increase with speed)	+50% UI	Author's estimate; Schaefer et al. (2009)
(h) Lighter vehicles: Very few crashes could enable very light vehicles for many duty cycles	Assume weight could be reduced ~75% and each 10% reduction = 6% EI reduction	-45% EI	Author's estimate; Burns (2012)
(i) Less time looking for parking: from fewer vehicles and self-parking	Assume it cuts the wasted fuel in half	-4% UI	Author's estimate; TTI Urban Mobility Report
(j) Higher occupancy: facilitated by IT, automated carpooling	Use the upper bound estimates for "dynamic ridesharing"	-12-20% UI	Transportation Energy Futures (2013)

Notes: UI states for Use Intensity; UE states for Energy Intensity

cellular data and voice functionality, web browsers, online games and entertainment, the increase in use of shared information and in-vehicle connectivity have made cars vulnerable to hackers. Each electronic control unit (ECU), as well as the increasing array of sensors they work with, must be secured in some shape or form, whether it is via cooperating or co-processors, code verification, protection of data at rest and in transit, or

Fig. 3.18 Main obstacles to the growth of connected cars, according to a survey of US and Asia automotive and technology executives (% of respondents)

Source: Foley, 2017



other capabilities that have become common in Internet security[32].

There are several potential vulnerabilities. Experts showed how hackers could remotely access and control vehicle components, as well as tap into private customer data collected by the on-board system. In particular, hackers could access the internal network of the car and control the safety critical ECUs such as braking and engine start/stop operations, making the hacked vehicles extremely dangerous[33]. Cybersecurity threats to connected cars could undermine the industry's roadmap towards autonomous and connected vehicles[34].

According to a survey conducted in 2017 on 83 automotive and technology executives between America and Asia[35], IT security and privacy – selected by 31% of respondents – are an important concern for connected cars and the main obstacle to their development (Fig. 3.18). In addition, cybersecurity attacks emerged as the top legal issue for 63% of respondents (Fig. 3.19).

Consumers are also worried about cybersecurity in connected and autonomous cars, being aware that connected vehicles have the potential to be targeted by a cyberattack.

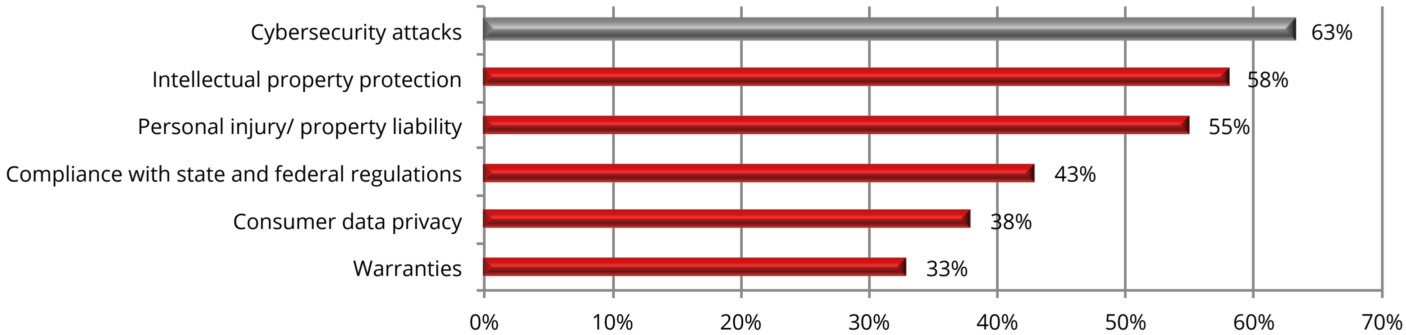
The Irdeto Global Consumer Connected Car Survey examined consumer awareness of cyberattacks targeting connected cars and autonomous vehicles

32 McAfee, *Automotive Security Best Practices* (White Paper), June 2016.
33 Frost & Sullivan and Irdeto White Paper, *Cybersecurity for the Automotive Sector*, 2017
34 McKinsey & Company, *Shifting gears in cyber security for connected cars*, 2017

35 Foley, *Connected Cars & Autonomous Vehicles Survey*, 2017

Fig. 3.19 Main legal issues to be addressed before the development of connected and autonomous cars, according to a survey of US and Asia automotive and technology executives (% of respondents)

Source: Foley, 2017



in six countries – Canada, China, Germany, Japan, the UK and the US. According to this survey, 85% of global consumers indicated that they believe any connected car has the potential to be targeted by a cyberattack (Fig. 3.20).

In addition, the survey found that 59% of connected

Fig. 3.20 Share of consumers who think any connected car has the potential to be targeted by a cyberattack

Source: Irdeto, 2017

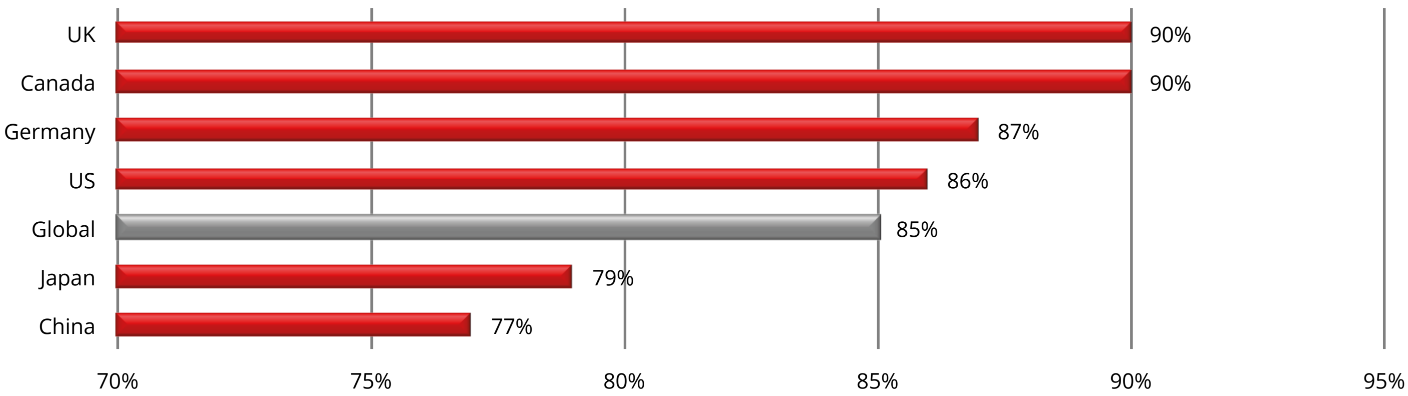
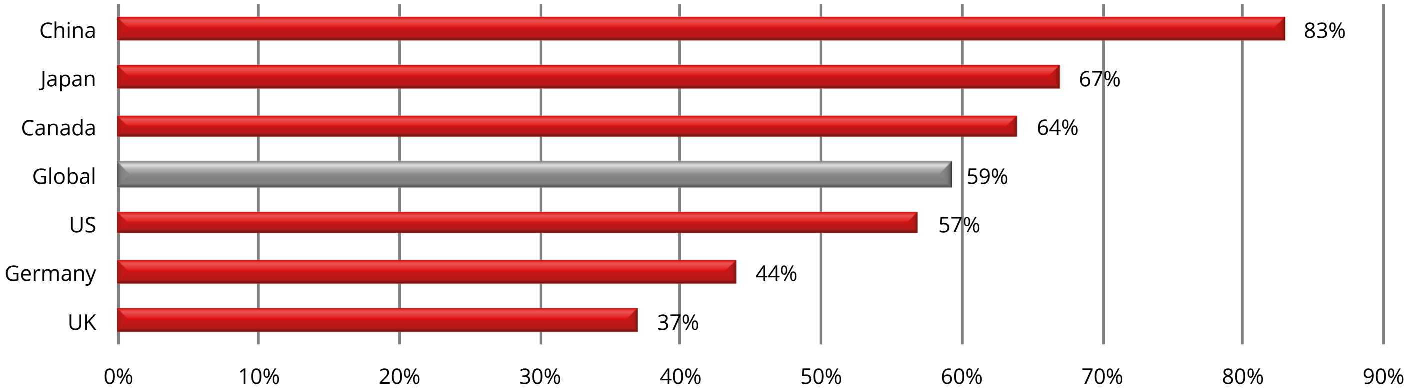


Fig. 3.21 Share of connected car owners who are concerned that their vehicle could targeted by a cyberattack

Source: Irdeto, 2017



car owners are concerned that their vehicle could be targeted by a cyberattack (Fig. 3.21).

Moreover, the rising number of connected cars has increased the risk, resulting in two core future challenges – establishing and maintaining trust and consumer confidence, as well as vehicle safety. Concerning these important topics, companies have an important role in promoting and guaranteeing cyber security in the automotive sector.

3.3. BLOCKCHAIN: APPLICATIONS IN THE MOBILITY INDUSTRY

Investments in research and development have always been fundamental in the automotive sector. As we have observed so far in this chapter, new technologies will rapidly change the industry and vehicles will be increasingly autonomous and connected. In this scenario, blockchain could play an important role. The blockchain is a distributed ledger that allows the users to manage transactions without the need for a central authority. In this system there is no hierarchical order among users but any transaction is based on trust. Each user can modify the ledger but only with the authorization of the majority of users (Fig. 3.22).

The automotive industry is a complex ecosystem with multiple parties involved in the production, distribution, marketing, selling, financing and maintenance of vehicles and the blockchain can be used in all these steps. The main characteristic of the blockchain is to store and share data in a transparent and secure way. Connected cars will generate a huge amount of data and blockchain could be the simplest and safest way to share them. A database that collects all vehicle history can be a valuable source of information for all stakeholders in the industry. Vehicle usage data such as kilometres travelled, maintenance, accidents and driving habits of the owner can be used, for example, by insurance companies to create a personalized insurance policy for each user. The same data could be useful for owners and buyers of used vehicles. Having reliable data on a vehicle can avoid odometer fraud and allow for a more precise evaluation. Another possible application powered by the blockchain in this sector is linked to the automotive leasing market. Visa and DocuSign have developed a proof-of-concept for leasing a car without an agent's brokerage. The leasing is transformed into a fast-automatic process in which the customer chooses the desired car, digitally signs a lease and an insurance policy and obtains the car. Some of the leading manufacturers in the industry (including BMW, Ford, General Motors and Renault) joined the "Mobility Open Blockchain Initiative". MOBI is a non-profit organization working to make mobility services more efficient, affordable, greener, safer and less congested by promoting standards and accelerating adoption of blockchain, distributed ledger and related technologies. The project involves the creation of a standard language that allows the new "smart" systems to communicate automatically.

The future integration between artificial intelligence and blockchain will allow self-driving cars, thanks to the use of smart contracts, to manage all the transactions carried out every day by a road user, such as paying a toll or a refuelling. A smart contract is a computer program stored on blockchain that directly controls the transfer of digital currencies or assets between parties under certain conditions. A smart contract not only defines the rules and penalties related to an agreement in the same way that a traditional contract does, but it can also automatically enforce those obligations. Smart contracts are complex, and their potential goes beyond the simple transfer of assets, executing transactions in a wide range of fields, from rent processes to insurance premiums. Companies participating in the MOBI project see the future of mobility in the blockchain thanks to an increase in transaction speed and the implementation of a reputation management system.

CONCLUSIONS AND POLICY RECOMMENDATIONS

During the next decades the **mobility sector** will undergo marked changes because of several factors, such as the growing number of people moving to (and within) urban areas, the shift toward an even more individual and personalized mobility and the growth of tourism flows. This will all be accompanied by the necessity to contain and reduce greenhouse gas emissions and local pollution to reduce climate change and the increase in non-communicable diseases such as cancers, diabetes and cardiovascular pathologies.

Considering that the EU has set an **economy-wide domestic target of at least 40% greenhouse gas emission reduction for 2030**, implementing policies able to facilitate and accelFeuerate the transition to a cleaner economy is crucial. To achieve this goal, policies at European and Member State levels should ensure **fair and efficient pricing in transport**, promote **multi-modality** – such as inland waterways, short-sea shipping and rail – and encourage the **deployment of a more efficient transport system, based on a technology-neutral approach guaranteeing several tools to reach the set targets**. To support the long-term transition towards a lower-emission mobility, **research and innovation** should be encouraged, including the acquisition of new skills.

Given that road transport employs 5 million Europeans and contributes to almost a fifth of the EU's greenhouse gas emissions, **Europe must play a leading role in promoting a clean, competitive and connected mobility, fostering the adoption of the best low-emission mobility solutions, equipment and vehicles and the development of modern infrastructures supporting them**. In this context, the EU and Member States must guarantee compliance with the rules, facilitating consumer access to affordable, new and cleaner forms of mobility, with the benefits of these new mobility services available to all.

In this respect, the development of digital technologies must contribute to achieving sustainability, revolutionizing the transport sector. Digital connectivity is expected to significantly improve **road safety**, **traffic efficiency** and **comfort of driving**, by allowing users to take the right decisions and adapt to traffic conditions. **Communication between vehicles, infrastructures and with other road users** is also important for increasing the safety of automated vehicles and their full integration into the overall transport system. Considering that several countries around the world (e.g. US, Australia, Japan, Korea and China) are moving rapidly towards deploying digital technologies and, in some countries, vehicles and C-ITS services are already available on the market, **accelerating technological development and ensuring a clear regulatory framework in Europe is essential**. Facilitating the convergence of investments and regulatory frameworks across the EU is a priority to encourage the deployment of Cooperative Intelligent Transport Systems (C-ITS), as well as assuring **continuity of service, data protection, interoperability and international standardization at all levels, a clear regulation of liability,** protecting **the privacy of individuals and their personal data and cybersecurity**, addressing legal aspects and promoting the **coordination of research**.

The availability of a high performing TLC infrastructure is essential to guarantee technological progress in the transport sector. Thus, the role of fiber and the **deployment of 5G** will become very important for the development of digital services in the mobility sector. Encouraging investments and creating a clear, simple and investment- friendly regulatory framework is a priority for EU competitiveness.

This developing revolutionary scenario requires and will require a **stronger social dialogue**, as well as support mechanisms to help people make the best of the new opportunities, for example, taking advantage of those created by digital technologies.

Sustainable mobility

Ambitious goals for sustainability need to be met by investments in a **wide array of low-emission technologies**, taking into account the starting point and the main barriers for the adoption of new solutions:

A. Cars driven by traditional engines (e.g. petrol or diesel) are and will be the most widespread in the next few years and liquid hydrocarbons will continue to play an important role in the future mobility system. Therefore, investing in **Low Carbon Liquid Fuel** R&D is essential to reducing greenhouse gas emissions. The development of low-emission hydrocarbon liquid fuels offers an important opportunity to effectively meet market demand while also contributing to addressing the risks of climate change. Collaboration across industries and sectors will be key to bringing innovative technologies for low-carbon liquid fuels and other products to market. Therefore, establishing an EU industrial symbiosis across the chemical and fuel production sectors, as well as the transport sector, will become essential to accelerating the market readiness of low-carbon technologies. Finally, public policies to support the transition to low carbon fuel technologies should promote:

- a market-based approach allowing the market to pick the best opportunities
- increased market demand for low carbon fuels
- investment and support for innovation and R&D
- clear standards for sustainability criteria based on emission reduction performance.

B. **Electric mobility** provides an important potential to reducing pollution in urban areas. However, “green vehicles” still represent a small part of the car fleet, especially in certain countries. Consumers will not move automatically to electric vehicles if their costs remain high, if the network of charging stations is l not ready, or if new technologies are not easily usable. Therefore, car producers, battery manufacturers, energy suppliers and distributors and, of course, decision-makers will have to work together to promote the electric mobility take-up. Effective public policies need to tax negative environmental practices and favor low-emission technologies. Moreover, EV investment in the generating and recharging infrastructures and battery R&D is urgent in order to reduce costs, improve performance in terms of autonomy and capacity and decrease the long-term environmental impacts resulting from the use and processing of raw materials.

C. **Natural gas** is seen as an important part of the EU's energy mix and will play an important role in the mobility of the future. Compressed Natural Gas and Liquefied Natural Gas offer a real alternative to conventional fuels for light and heavy vehicles over long distances, as well as for maritime transport. Member States need to encourage this shift adopting adequate regulations.

D. **Hydrogen fuel** is also considered an important part of the EU energy mix, contributing to the decarbonization of the transport sector. The main advantages of fuel cell electric vehicles are the zero emission of CO2 and pollutants (tailpipe emission is only water) and the higher fuel cell efficiency compared to internal combustion engines. However, the higher car prices, safety concerns and the absence of an adequate infrastructure limit the potential for this technology. Government policies need to foster consumer acceptance and encourage more private investments from companies seeking to establish a global network of fuel cell refilling stations.

ICT-based mobility

A. **Shared mobility** is characterized by the sharing of a vehicle instead of owning it, and the use of technology to connect users and providers. As shown, there are four main models: the **peer-to-peer platform**, where individuals can rent their cars when not in use (Model 1); the **short-term rental of vehicles** managed and owned by a provider (Model 2); companies owning no cars themselves, but signing up ordinary car owners to act as drivers offering a **taxi-like service** (Model 3); and **on-demand private cars, vans or buses and other vehicles**, such as big taxis, **shared by passengers** going in the same direction (Model 4). Models 1, 2 and 3 can yield profits for private parties, but from the evidence available, do not seem to have the potential to substantially reduce congestion or CO2 emissions, though this needs further research. Moreover, these models (especially1 and 2) will never replace the modes currently used for commuting. As for Model 2 (e.g. Car2Go), although apps are clearly helping boost this model, evidence shows that households may be inclined to give up a second or third car rather than become car-less and completely rely on these services. Model 4, which entails individuals not only sharing a vehicle, but actually travelling together at the same time, is promising in terms of congestion and CO2 emission reduction. However, it is also the most challenging, given the disadvantages in terms of waiting and travel time, comfort and convenience, compared to private car use[36]. **EU local governments** need to work together to exchange best practices and offer a similar regulatory framework to players in order to minimize costs for both companies and consumers but also ensure that

36 MDPI, Sustainability and Shared Mobility Models, 2018

shared mobility works towards reducing congestion and pollution.

B. Currently, the dissemination of smart sensors in the surrounding environment and in objects, as well as in wearable and similar devices, are paving the way for the **Internet of Things**. Internet is upgrading from its former status of a computer network where information is available for individuals on request, becoming a network connecting objects, robots and other devices allowing them to mainly act in two ways: following a direct human request, that can be communicated to multiple channels and devices, such as voice command or "autonomously". For example, **autonomous vehicles (AV)** are machines, provided with proper equipment and real time information flows, that can decide on and carry out their own actions – self-parking, avoiding collisions and driving. However, crucial issues such as liability, interoperability and cybersecurity need to be urgently addressed before autonomous vehicles can begin to operate on EU roads.

C. With the spreading of **5G**, communication amongst objects will markedly improve in capacity and latency reduction, making interaction possible in real time. EU investments in 5G networks need to be supported by an appropriate regulation able to encourage a fast roll-up and allow for a realistic return on private investments, maintaining a competitive framework.

D. **Further research** must be carried out to support the EU legislators in correctly assessing the future of mobility and drawing up the appropriate measures for a development which balances the benefits and challenges for this transformation.

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