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 CO_2 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 CO_2 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 CO_2 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 CO_2 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.