



Towards Low-Emission Mobility

Driving the Modernisation of the EU Economy

European Political
Strategy Centre

Climate action and the modernisation of the economy are two sides of the same coin. The Paris Climate Agreement concluded in 2015 provides more than a comprehensive framework for global climate resilience: it incentivises investment in and deployment of innovations that can spearhead sustainable and job-creating growth. Reaping the economic and social gains of the low-carbon transition hinges on modernising our notion of 'mobility'. In the digital age, underpinned by data and new technologies, mobility means more than getting from point A to point B: it is about a more global, open and competitive space that comprises not just transport, but also connectivity. It is in the transport sector that the European Union has a global competitive advantage and where millions of Europeans find jobs. It is also the sector responsible for a large share of greenhouse gas emissions and for taxing air quality which has a large impact on citizens' health and wellbeing.

"I have a vision of a (...) commuter being able to charge his electric car along the motorway in the same way we fill up on petrol today" *President Juncker, European Parliament, 26 November 2014*

Modernisation of the Economy Leads to Climate Resilience

The EU needs to achieve a strong reduction of CO₂ emissions and deliver on sustainable and job-creating growth. Modernising the mobility system in general and the transport sector in particular can achieve both. Today Europe is a world leader in the sector. Yet, mobility is being profoundly modified. To maintain its leadership, the EU needs to take comprehensive action first and foremost on a more efficient and competitive transport system.

Shaping Mobility in the Age of Connectivity

EU leadership in the mobility sector is not for granted: the digitalisation of the economy and a more competitive global market call European policymakers and businesses to re-think the way they regulate, invest and operate. This implies a more comprehensive approach to mobility that encompasses maximising efficiency and creating synergies across sectors – from transport to energy and digital.

Innovation as a Driver of Competitiveness

The EU is world-renowned for the quality of its production in the transport sector and opportunities are plentiful to improve existing vehicles, components and systems. At the same time, staying ahead of competition calls for bold investments to develop the car of the future, which includes batteries and digital appliances and comes with sizeable potential for exports. Innovation also entails incentivising collaboration among established and incoming players.

Low-Emission Means Systemic Change

Modernising mobility goes beyond addressing technological challenges: it is about creating room for emerging business models and designing solutions that encourage sustainable choices by economic actors and citizens. Such a transition needs to be accompanied by the development of the skills required by a low-emission and knowledge-intensive economy.

EPSC Strategic Notes are analytical papers on topics chosen by the President of the European Commission. They are produced by the European Political Strategy Centre (EPSC), the European Commission's in-house think tank.

Disclaimer

The views expressed in the EPSC Strategic Notes series are those of the authors and do not necessarily correspond to those of the European Commission.

1. The Transport Sector at a Crossroads

Curse and Blessing of Economic Modernisation

The transport sector is at the heart of the European Union's pursuit of job-creating growth. It is indeed home to some of Europe's industrial pillars. **The transport industry alone provides employment to 15 million workers**, more than 7% of total EU employment. This includes 2.3 million jobs in automotive manufacturing¹. The industry has also been a driver of the EU's increasing trade surplus, which amounted to 95 billion euro in 2014, and has become a trademark of Europe's world-renowned quality of production, both in terms of innovation and safety (see Figure 1).

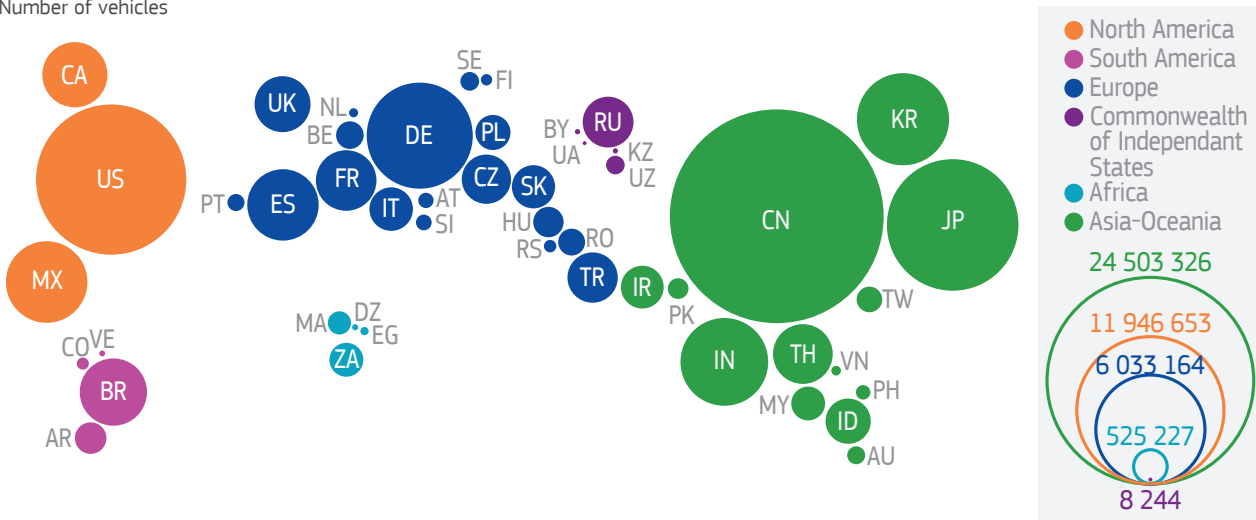
In recent years, the European automotive sector has been gaining renewed momentum with the growth of demand for passenger cars, shifting the issue of

overcapacity to emerging countries. Incentives for a low-carbon transition have, in fact, favoured European production and its higher quality standards. Indeed, EU car manufacturers have specialised in diesel engines, which used to perform at 20% higher 'inherent efficiency' and emit less greenhouse gases (GHG), supported by friendly tax schemes². This is how EU automotive manufacturers have established themselves as global leaders in green technologies.

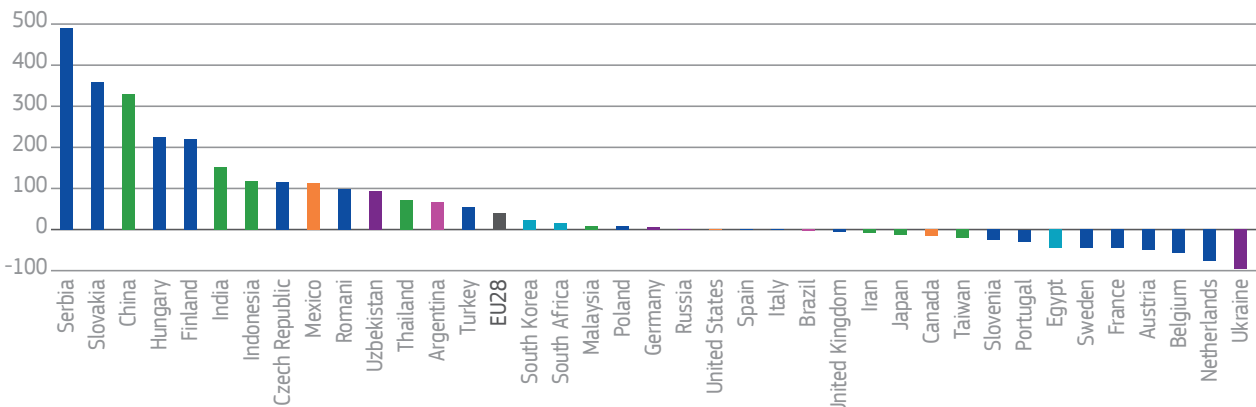
The above model, however, is now being disputed, since **the sustainability challenge is far from being solved**. Indeed, the efficiency gap is narrowing between diesel and petrol automobiles, questioning the game-changing role previously attributed to diesel in terms of emission-reduction³. Moreover, the transport sector continues to be one of the largest emitters of CO₂ (see Figures 2 and 3)⁴ and a considerable source of air pollution, which is a tax on the quality of the air that Europeans breathe and therefore on their health, especially in urban areas. This is not just a drag on efficiency but also a cost that burdens public spending and service provision – from health to

Figure 1: World Motor Vehicle Production, 2015

Number of vehicles



Percentage change 2005-2015



Note: France and Germany include only cars and LCV as of 2011. Netherlands includes only Terberg reported for HCV as of 2013. Sweden includes only cars.

Source: OICA.

cleaning. Overall, mobility captures 13% of an average European household budget⁵ and is also very inefficient: a car is parked 92% of the time and, when the car is used, fewer than two of its five seats are occupied⁶. Furthermore, even though a car sold in 2014 was 25% more efficient in terms of CO₂ emissions than one sold in 2000, growth in travelled distance and car ownership, due to a lack of alternative solutions, and the increased average weight of vehicles, have excessively offset efficiency gains. Finally, the recent car emission scandal highlighted the need to target efforts towards reducing carbon emissions and air pollutants altogether, since CO₂ is only part of the problem.

Transport is also still responsible for half of the EU's 400 billion euro annual energy import bill. This is due to transport's reliance on oil-derived products, which supply 94% of energy demand in the sector of which road transport represents 75%. Addressing the low-carbon challenge will thus not only contribute to achieving the EU's climate objectives, but it will also shift spending to more labour-productive sectors and increase Europe's energy security.

The transport sector today is, therefore, both a curse and a blessing for the EU's economy and society. On the one hand, it provides its economic lifeblood. On the other hand, it hampers the very economic gains it helps accrue by being less sustainable than desired. Transport needs to be at the core of a policy nexus between the modernisation of the economy and its low-carbon transition.

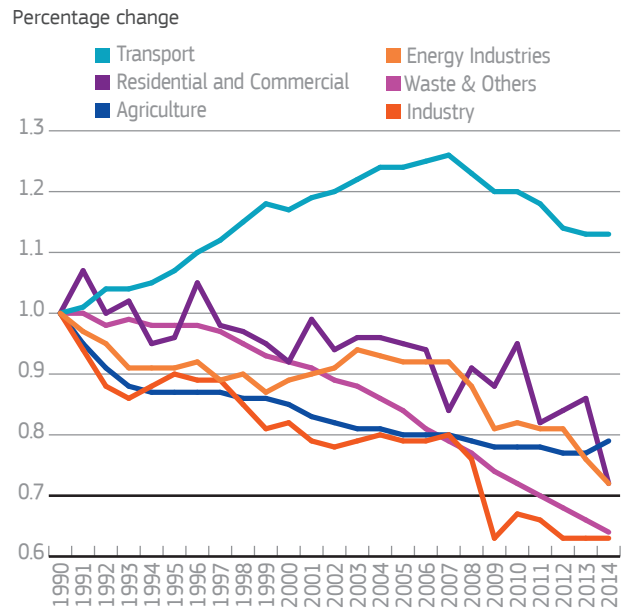
An Evolving Sector at the Heart of Global Transformations

The leading position of the EU transport sector in the world is not cast in stone. Mobility systems in general and transportation in particular are, in fact, undergoing profound – and inevitable – transformations. They are expected to evolve more in the next 10 years than they have in the past 50.

A **more competitive global market** is emerging, especially in the car industry, as innovation is diffused. New players, including China, are putting pressure on established car manufacturers of which Europeans are leaders and the largest exporters of the world.

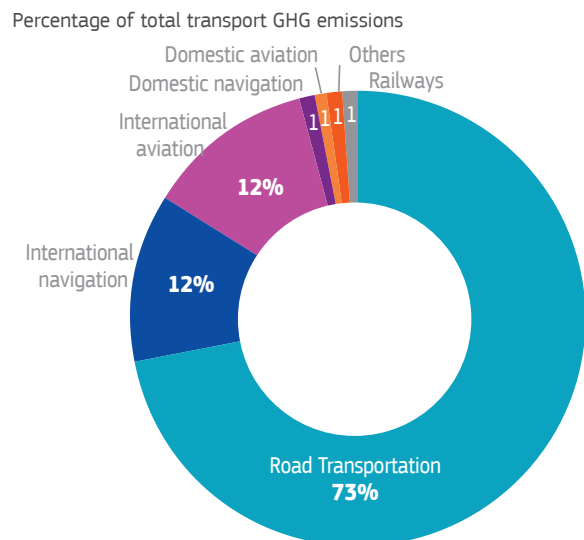
Competition has also extended to producers of **new and lightweight materials** – aluminium, composites and more performant steel – that are increasingly in demand to make cars more fuel-efficient: for every 10% reduction in mass, a car diminishes fuel consumption by a corresponding amount, and emissions by 6–7%.⁷ For instance, BMW's i3 car is mainly made of carbon fibre and the factory that produces it uses 50% less energy and 70% less water than a conventional facility – in line with the principles of the circular economy which the EU spearheads as a model.

Figure 2: Greenhouse Gas Emissions (GHG) in the EU



Source: EEA, GHG data viewer.

Figure 3: Greenhouse Gas Emissions (GHG) from Transport in the EU, 2014



Source: EEA, GHG data viewer.

The transport market is not only becoming more open but it is being fundamentally reshaped by **digital technologies**. Data-driven innovation that runs on ever more interoperable infrastructure is **turning transport into a mobility service**. Leading car manufacturers are now becoming mobility providers for which data analysis is the key ingredient to make vehicles more efficient and user-centric. Not coincidentally, the highest valued added of products, including cars, comes from the integration of services and the optimisation of the user experience.⁸ In other words, **transportation is leaving the age of standardisation to enter that of customisation**.

Box 1: Addressing Road Freight Transport Requires Tailor-Made Approaches

Although **fuel amounts to approximately one third of the operational cost** of driving a truck, the fuel efficiency of trucks and emissions have remained relatively constant in the EU since the early 2000s, raising doubts on the industry's willingness to innovate⁹.

Improved engine efficiency would decrease the fuel bill for transport companies and would benefit the climate alike. It could also have a wider economic impact as these benefits could be passed on to consumers through lower priced goods. Trucks represent only 4% of the on-road fleet, but are responsible for almost 30% of CO₂ emissions from road transport¹⁰. There are currently no EU standards for CO₂ emissions of trucks unlike in other key markets such as Japan, China, Canada and the United States where they are being implemented. Enhanced monitoring and reporting of CO₂ emissions in the EU could contribute to labelling trucks in the future, which can help to create competition between manufacturers and therefore lower prices.

However, to **promote industrial innovation and increase the EU's competitiveness at the global level**, there might be a need for new legislation to introduce CO₂ emission standards. Connected vehicles technology (trucks driving close behind one another, thereby saving fuel and emissions) also has an important potential for long-distance transport. Electrification is not easy for road transport over long distances, even if experiments are ongoing to electrify hybrid trucks via an overhead catenary system (similar to those used for trams and trains). Liquefied natural gas could be another alternative to diesel. Considering that the average truck load factor is only about 50%, the broader system also needs to become more effective. Rationalising transport pricing, intermodal transport, innovative city-logistics business models as well as a smarter use of big data requires combined efforts from research, industry and public authorities and can help make the transport of goods much more efficient. Innovation and fuel efficiency measures might entail higher initial investments costs, which should be addressed in different ways to limit financial obstacles to the pursuit of sustainable projects, notably for small hauliers.

New business models thrive in this data-rich and hyper-connected environment. Mobility is increasingly becoming an **on-demand service** that dynamically responds to needs and wants. Indeed, Toyota recently announced investments in Uber's ride-sharing services, and Volkswagen responded by buying shares in Gett, one of Uber's key competitors. At the same time, not only are users ever more fond of **ride-sharing**, but connectivity is also paving the ground for innovative public-private partnerships, particularly in urban settings: the BMW Group is proposing **intermodal mobility solutions** that combine private and city-run services. Uber users in Amsterdam will soon be able to order rides from cars with bike racks. Changing business models and the shift towards a service-oriented economy are also influencing consumers' preferences in the shift **from owning to sharing**: in Germany alone, car-sharing membership has grown 30% in the last 5 years.¹¹ It is estimated that one in 10 cars sold worldwide in 2030 will be shared.¹² This does not mean that vehicles will no longer be sold, but that private-vehicle sales may drop by as much as 2% annually in developed economies rich in urban centres, such as Europe and North America.¹³

If in the short-term more and more transport services are being shared, soon a growing number of them will be automated: **driverless cars** are not a distant future, since they even escorted world leaders at the latest G7

meeting in Japan. The **electrification of vehicles** is an ever more immediate reality – and a critical juncture between modernisation and sustainability. Battery prices have dramatically fallen already, and in 5-10 years they are likely to be made sufficiently small and cost-effective for electric vehicles to become affordable for the average consumer.

The shift towards a service economy also means that future job growth is expected to be concentrated in such sectors, with a likely contraction in those occupations that rely heavily on routine tasks, such as low-skill manufacturing jobs, but also some craft and clerical occupations. **Where tasks are routine, automation is likely.**¹⁴ The transition towards a low-carbon and connected mobility will therefore have to be managed. This involves anticipating the potential labour reallocation that will likely occur in certain sectors and mitigating potential social costs, while maximising economic gains.

A more competitive and complex mobility system is thus on the rise. The choices that the EU will make today will determine whether it will lead or lag behind in the race towards the modernisation of the economy, and stay ahead of future developments in this area of strategic importance for Europe and its citizens.

2. Anticipating Disruption, Shaping Mobility

The competitiveness and sustainability of the EU's economy lie in the decisions that policymakers and business leaders will make today in the face of the trends that will mark future mobility systems. For example, if EU manufacturers are not fast and flexible enough to adapt their production models to changing consumers' expectations, the risk of losing market share to emerging economies becomes more severe. Similarly, European producers face a challenge of integrating the supply of raw materials to guarantee security of supply, in view of the wider application of electronic systems and the growing popularity of battery-based energy storage solutions which will require larger quantities of rare earth elements¹⁵.

European policymakers must look at transport as a systemic issue. They should not focus merely on regulation but on establishing the conditions for innovations to proliferate and drive Europe into a modernised, low-carbon economy. For instance, the electrification of the fleet should coincide with the gradual decarbonisation of the electricity system as it would be counterproductive to fuel them with fossil fuel electricity sources. In parallel, the electricity grid will need to be able to cope with extra demand, and to become more flexible in shifting electric vehicle charging demand from peak periods to low system demand.

'Let's shift gears early to be ready for the future. (...) A European industry that develops new green technologies faster will win. A European industry that quickly moves from low emission vehicles to zero emission vehicles will win.'

Commissioner Bieńkowska, Fédération Internationale de l'Automobile, 29 June 2016

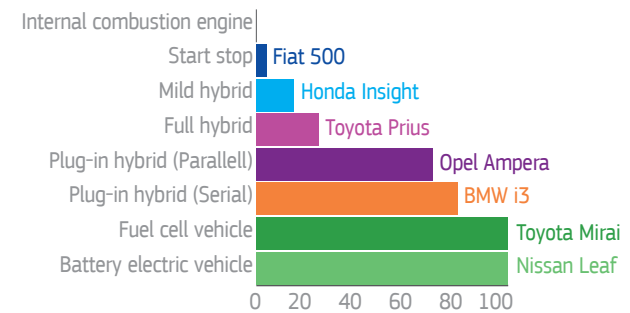
At this stage, there is not one right policy answer to the questions posed by the transformation of the transport sector and, more generally, of mobility. There are, for instance, **different degrees of vehicle electrification with different impacts on CO₂ emissions** and therefore different solutions available (see Figure 4): investing in 'transitional' technologies such as hybrid cars, directly into fully electrical solutions or even a diversified strategy. Again, one could invest in designing the car of the future from scratch with substantial potential efficiency gains but high initial costs or build further on existing features for shorter-term gains. The EU has a range of instruments to steer the modernisation of the economy. What is required is a commitment to take or deliver on actions in the following areas.

Strategic Investments and Innovation

The transition towards a low-carbon mobility system requires an important amount of private and public investments to **improve access to alternative fuel infrastructures and increasingly to telecom and electricity system capacities**. Investing in such infrastructures is a building block for the modernisation of the economy, since these would connect to new businesses that could increase competition for the provision of innovative and cost-effective services. New funding instruments should be made available to stimulate such competition and address the high capital intensity which often acts as an obstacle to newcomers to markets. The European Fund for Strategic Investment can be instrumental for scouting emerging demands for innovative ventures thanks to its demand-driven approach. At the same time, the investment endeavour needs to be coupled with greater transparency to be

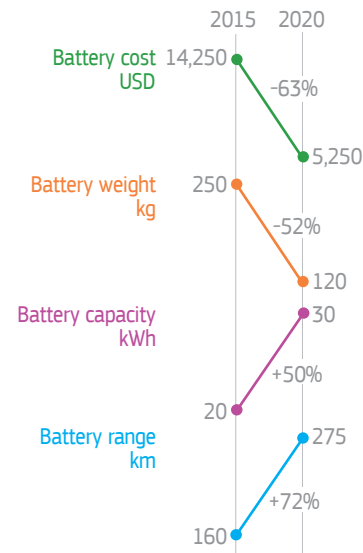
Figure 4: Overview of the Different Degrees of Electrification

Percentage of electrification



Source: Industrial Innovation for Competitiveness; JRC.

Figure 5: Battery Cost Reduction/ Performance Improvements



Source: Goldman Sachs.

enforced to remove hidden subsidies and perverse incentives for fossil fuel consumption in order to create a more predictable investment ecosystem and accelerate the low-carbon transition.

There are clear strategic areas where the European Commission can be entrepreneurial, for example in the development and production of the next generation of batteries. Today, the market is dominated by Japanese, Korean and Chinese manufacturers. Yet batteries will be a crucial piece of the low-emission transition of the European economy: better batteries guarantee efficiency and less energy dependence. Creating the **batteries of the future** is instrumental to making electric vehicles more competitive, efficient and customer-friendly. Reduced battery costs, weight and charging time, increased capacity, range and storage capabilities, and smart grids are all dimensions that matter (see Figure 5).

At the same time, there are **ample opportunities for incremental improvements**, necessary to allow time for the deployment of infrastructure and more performing components of electric cars that will be able to address 'range anxiety': the perception that electric cars will not be able to run for desirable distances, without needing re-charging. For instance, it is expected that hybrid cars, using a mixture of fuel consumption and electricity to different degrees, will become increasingly popular during a transitional phase¹⁶.

Targets to Accompany Modernisation

CO₂ targets for vehicles play an important role in the low-carbon transition: they represent commitment mechanisms for car manufacturers to embrace new technologies and follow sustainable trends. New car emissions are now significantly below the 2015 targets and the car manufacturing industry is on track to achieve the 2021 targets as foreseen by EU regulation¹⁷. The European Commission should now begin to **define the next generation of targets**, bearing in mind the role that digitalisation and innovation will have for the modernisation of the economy in the low-carbon transition, and the fact that none of the trends shaping mobility can be assessed in isolation.

The right regulatory framework and its implementation are needed to accompany the modernisation of the transport system. For instance, the **car-emission scandal**, affecting Volkswagen and to a lesser extent an increasing number of other manufacturers, casts a shadow over the integrity of the whole sector. It affects EU manufacturers' competitiveness in the global market and led to the downgrading by credit rating agencies. This increases difficulties to access finance, thereby threatening the possibility to invest in innovation and future growth¹⁸.

Box 2: Norway Leads the Way Towards Zero Emissions

Norway is leading the way for the transition to zero emission electric cars. In 2015, electric vehicles had a 17% market share of new vehicle sales. The sales of electric vehicles have been bolstered by wide-ranging incentives for low emission vehicles, including generous tax exemptions. Electric cars are also exempt from road tolls, are allowed free public parking, free public charging, reduced highway ferry rates and are permitted to drive in most bus lanes. As part of a broader package of measures on Norway's long-term energy policy, the governing parties are even considering banning the sale of petrol and diesel cars from 2025 onwards. In parallel, the city of Oslo has decided to double the congestion charge for cars entering the city. For the first time, this will also apply to drivers of electric vehicles albeit at a lower fare. 93% of the generated revenues will be earmarked for investments in public transport. Moreover, nearly all of Norway's electricity is derived from hydropower, resulting in an ample supply of virtually carbon-free electricity.

Skills and Resilience

The low-emission transition, characterised by a growing role of services in the economy, will require new skills and offer opportunities for growth and job creation. Emerging mobility systems will require engineers to work in multidisciplinary teams, as transportation becomes more and more a connectivity issue. Workers in maintenance will have to learn how to **manage new vehicle components, technologies and their specific requirements**. This implies bridging the existing gap between the automotive, information- and communication sectors, and other 'newcomers' such as

electricity providers. The New Skills Agenda for Europe¹⁹ aims to make the workforce of the future resilient to ongoing trends by equipping it with the skills that address mismatches at sectoral level and the needs of the evolving transport sector.

A Modern Way to Measure and Assess

To achieve the right results it is important to evaluate and address the CO₂ efficiency of a vehicle in a holistic way, **integrating lifecycle analyses from 'well to wheel'**. Firstly, this should include well-to-tank emissions, produced to turn a resource into a fuel

and bring it to a vehicle, with links to the EU's broader energy policies. Secondly, these should also include the embedded emissions created during vehicle production, including the materials used and their disposal, with links to the circular economy. Finally, the 'tank-to-wheel' emissions (combustion of fuel in vehicle operation) linked to the EU's research, innovation and deployment policies should be addressed. This integrated assessment being closely related to the availability of data to monitor the progress made, can only be done gradually. The **measurement of 'real world' emissions** is in this regard a matter of credibility. It will help consumers and economic actors support the changes that go hand in hand with the transition as they will enjoy a reduced energy bill, while contributing to the achievement of climate targets and a healthier environment. It is also about effectiveness of vehicle tax schemes, as most Member States use type-approval CO₂-emissions as a basic reference. Likewise, improving the test-cycle will enable the EU to remain a world leader in setting technical standards, which can create a competitive advantage to European industries in third-country markets.

Demand Management

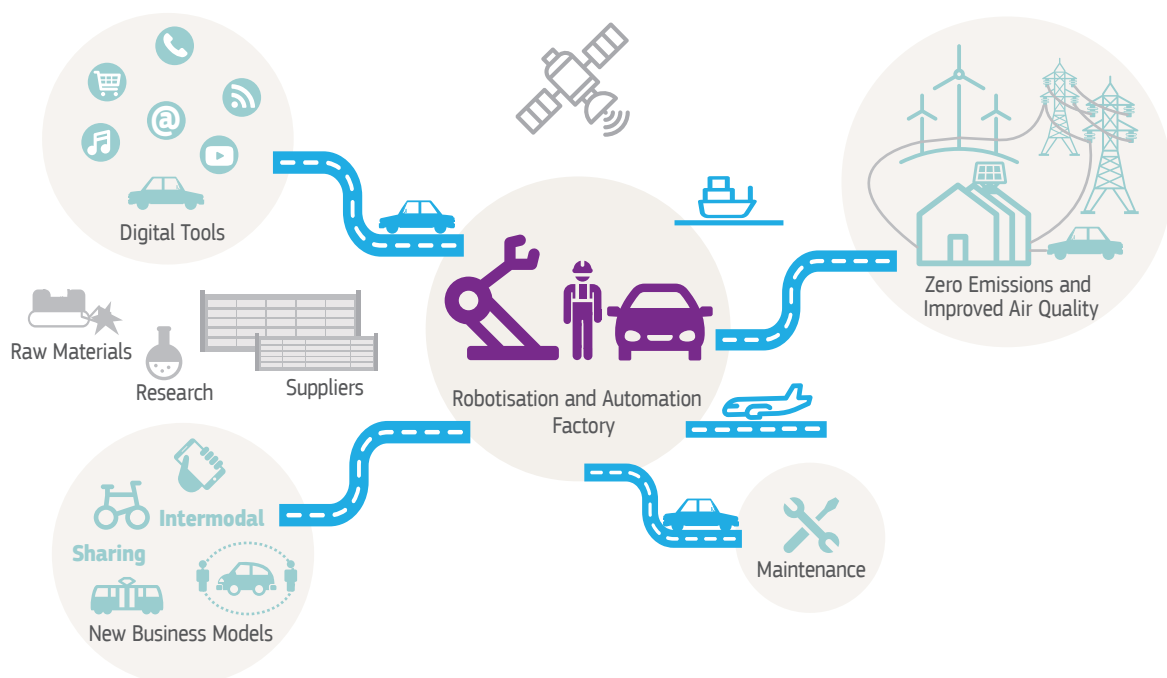
For passenger transport, it will be important to enable people to shift from individual, privately owned cars to public and shared transport as well as inter-modal solutions. These will have **multiplying effects with positive impact for air quality, congestion in cities**, etc. Support schemes and subsidies for shared e-mobility concepts could therefore be a better

way of accelerating the transition than the current mainstream subsidy model for the purchase of electric cars. Technology, combined with innovative business models, can be an important enabler. For instance, e-mobility and digitalisation are critical for multi-modal transport solutions. The role of smart cities and bottom-up solutions will be crucial in this regard. It will be important to ensure that these disruptive changes benefit all citizens and do not create new disparities in terms of access to mobility.

Citizen-Centred Policymaking

A successful design and deployment of low-emission and economically effective policies requires testing policy pilots against **user behaviour, the key driver of consumers' mobility choices**. These are influenced by the decisions of other market participants, cost factors, availability but also attractiveness of options, as well as accessibility and acceptance of new mobility solutions. The situation is very different throughout the EU because of varying fuel and electricity prices and large differences in tax structure and other incentives. A successful deployment strategy requires testing and adapting based on the responses provided by household and individual behaviour. For example, having charging or refuelling stations near one's house, workplace, local business, or parking spaces incentivises the uptake of new business models such as multi-modal car-sharing. In turn, this behavioural change would increase the demand for electrified cars, making them more affordable for more people, particularly in urban areas.

Figure 6: The Mobility Ecosystem Involves New Players



Box 3: A Wide Variety of Incentives With Different Results Across the EU

Sales of plug-in hybrids and battery-electric vehicles are increasing fast, spurred by different incentives at different levels, but remain a small fraction of total sales in the EU and account for just 1.3 % of all new EU cars sold. Regions and Member States can decide about aid schemes for the purchase of low-carbon cars, tax exemptions and reductions or other incentives, and choose to invest in the deployment of infrastructure.

- As a result, the relative share of plug-in hybrids and battery-electric vehicle sales is highest in the **Netherlands** and **Denmark**, reaching 12% and 8 % respectively of national car sales in 2015.
- **France** has introduced an ecological bonus-malus tax scheme which provides electric car buyers with up to 10.000 euro in benefits when the purchase is accompanied by the scrapping of a diesel car older than ten years.
- Recently, **Germany** announced it would provide 1.2 billion euro in subsidies to spur sales of electric vehicles.

Other Member States are taking similar measures. Increasingly cities are introducing urban access restrictions for certain vehicles, phasing out diesel vehicles in particular and therefore favouring electrified vehicles. The **EU** could help streamline incentives to make them compatible with its climate and energy policy objectives, also ensuring these initiatives remain general so as to avoid favouring specific car producers. It will be important, however, to find the right balance between subsidiarity and uniformity.

Innovation in Governance

Change also comes in the way society is organised and how various **public and private stakeholders cooperate with each other to make the transition happen**. Flexible and innovative instruments of governance are crucial to success. These are necessary to overcome the chicken-and-egg-problem of, for example, investing in charging infrastructures before developing and deploying zero-emission cars, or *vice versa*. It involves 'smart' cities and local authorities, aggregators or other third parties that can facilitate the deployment of electric vehicle infrastructure, utilities that deliver the energy source and make smart charging available. The automotive industry can, in parallel, increase availability of models and partnerships,

including with local businesses – with a new approach towards company cars – Non-Governmental Organisations and civil society. The European Commission can facilitate bottom-up initiatives by offering its know-how and by acting as an orchestrator and testing pilots. For instance, the 'innovation deals', currently being developed for circular economy projects, are an important example of public private sector entrepreneurship opening new avenues for future mobility. Simultaneously, GEAR 2030, the structural dialogue on the automotive industry steered by the European Commission, should gradually include the new players entering the automotive value chain, including disruptors from other sectors, to anticipate game-changing trends and better accompany the transition.

Box 4: Global Action on Aviation and Maritime Shipping

For aviation and shipping, a comprehensive set of measures needs to be developed both at the international and EU level. Aviation is one of the fastest-growing sources of greenhouse gas emissions, accounting for about 3% of the EU's total. **In 2014, approximately 21,600 airplanes were in service worldwide, a number that is expected to double over the next 20 years.** In February 2016 the first CO₂ emissions standards for aircraft were agreed upon. In parallel, negotiations are ongoing within the International Civil Aviation Organisation (ICAO) to achieve an agreement on market-based measures.

International maritime shipping is not covered by the EU's emissions targets and emits about 2.5 % of global greenhouse gas emissions with **a large potential of efficiency improvements** to be steered by the International Maritime Organisation (IMO).

Sustainable growth of the aviation and maritime sectors are an economic opportunity, as they directly allow for reducing operational costs of airlines and shipping in terms of fuel consumption. It is mainly through innovative technologies that these sectors can find decisive answers to these challenges.

3. Conclusion

The mobility system in general and the transport sector in particular are drivers and drags for the European Union as it faces a combination of challenges. Transport will fuel the modernisation of the economy and is a key source of European employment, but it also tops the ranking of polluters. Yet, mobility is undergoing great transformations as a result of a complex set of trends. The automotive industry is especially affected. **The EU can show that modernising the economy and addressing climate change go hand in hand.** It should start with incentivising the low-emission transition in the transport sector. A successful sustainable mobility strategy requires a systemic approach which acts at the intersection between

technology, infrastructure financing, multi-modal mobility, and public-private partnerships. This is why the European Commission is spearheading the **Energy Union** as a key component of the comprehensive strategy to ensure the transition towards a more modern and sustainable economy, which includes the Capital Markets Union, the Digital Single Market and the European Pillar of Social Rights. This implies coherence between mutually reinforcing policies such as climate, energy, transport, circular economy, industrial competitiveness, and research and innovation. The strategy aims to enable Member States and local communities scout new, sustainable opportunities in a world of change. It is a novel approach to spur job creation while improving the quality of the air that Europeans breathe, as well as making cities less congested and more liveable.

Notes

1. Eurostat
2. Joint Research Centre (2009), '2009 Technology Map of the European Strategic Energy Technology Plan (SET-Plan)' https://setis.ec.europa.eu/system/files/EUR%20report%20Technology%20Map%20Part%20I_FINAL.pdf
3. European Environment Agency (2016) 'Reported CO2 emissions from new cars continue to fall' <http://www.eea.europa.eu/downloads/f5659c658f4f44c09170758e3960bc27/1468246747/reported-co2-emissions-from-new.pdf>
4. The transport emissions have increased by 33% between 1990 and 2007, since then fallen but they increased slightly again in 2014.
5. EU Transport in Figures (2015), '[Statistical Pocketbook](#)'
6. Ellen MacArthur Foundation, '[Growth Within: A Circular Economy Vision for a Competitive Europe](#)'
7. Ricardo-AEA (2015), '[The Potential for Mass Reduction of Passenger Cars and Light Commercial Vehicles in Relation to Future CO2 Regulatory Requirements](#)', Report for the European Commission, Directorate-General for Climate Action
8. See also EPSC Strategic Note 7 '[Integration of Products and Services](#)'
9. On 19 July 2016, the European Commission imposed record fines of EURO 2.93 billion to MAN, Volvo/Renault, Iveco and DAF, which together account for 9 out of 10 trucks produced in Europe, for serious infringement of antitrust rules. The companies involved had engaged in a cartel relating to coordinating prices, the timing for the introduction of emission technologies and the passing on to customers of the costs for the emission technologies.
10. Muncrief, R., Sharpe, B. (2015), '[Overview of the Heavy-Duty Vehicle Market and CO2 Emissions in the European Union](#)', International Council on Clean Transportation Working Paper
11. Gao, P., Kaas, H.-W., Wee, D. (January 2016), 'Disruptive Trends that Will Transform the Auto Industry', McKinsey&Company
12. Ibid.
13. Ibid.
14. See also EPSC Strategic Note 13 '[The Future of Work](#)'
15. Financial Times, Sanderson, H. (May 2016), '[China Plays Long Game on Cobalt and Electric Batteries](#)'
16. Biofuels could also be part of the fuel mixture whilst electrifying further, but these are faced with concerns about the environmental performance. It's therefore crucial that strict sustainability criteria would apply to avoid potentially negative impacts for biodiversity and, directly or indirectly, for carbon sinks. Hence, its future lies in the first place in transport modes for which fuel will likely remain for a long time the main source of energy, such as in aviation.
17. The switch towards low emissions fuels is also being promoted by the target for each Member State to have a 10% share of renewable energy in transport by 2020 and the obligation for fuel suppliers to reduce GHG intensity of fuels supplied by 6% in 2020 compared to 2010.
18. Shareholders also become more and more nervous. For example, Norway's sovereign wealth fund, the largest in the world and the fourth shareholder of Volkswagen, announced on 15 May 2016 that it will join the class-action lawsuits filed against the German carmaker.
19. European Commission (2016) A New Skills Agenda for Europe - Working together to strengthen human capital, employability and competitiveness. COM(2016) 381/2 <https://ec.europa.eu/transparency/regdoc/rep/1/2016/EN/1-2016-381-EN-F1-1.PDF>