ACCELERATING INNOVATION AND INTEGRATION IN THE MOBILITY SECTOR - WINNING THE LOW CARBON RACE

INTRODUCTION

A major transition is anticipated in the transport sector over the coming decade, strongly influenced by trends such as the sharing economy, autonomy, urbanisation, the transition to cleaner energy sources, and consumer demand for increased connectivity. Meeting users and citizens' demand will be key for the uptake of innovations in this sector. Disruptive innovation will create opportunities for new entrants and risks for incumbents. For Europe as a whole, these opportunities – if properly managed and leveraged -- could also translate into economic growth and employment creation, and advance Europe's transition to a low carbon economy.

Both investors and policymakers will need to remain alert to these rapidly shifting forces if Europe's industry is to capture a share of these newly emerging markets and value streams and deliver the most innovative low carbon products and services, which it can sell globally. This demands a new vision of even more targeted policymaking to enable the take off and diffusion of innovation in its many forms – technologies, services, business models, processes and societal innovation. It also requires wider innovation, not only of the transport system, but also of connected mobility, energy, housing and agricultural systems.

CONTEXT

With new impetus and direction given by the Paris Agreement on Climate Change, one of the biggest changes will be the way we use, produce, transform and distribute energy. Under the Paris Agreement, world leaders have resolved to radically reduce carbon emissions by the middle of this century. Countries will now need to implement their commitments under this accord, and in the EU this will be achieved via the 2030 climate and energy framework. Policymakers will need to put in place policies that rein in emissions while remaining mindful of Europe's priorities for economic and industrial competitiveness.

Transport is Europe's biggest source of CO_2, and it is also a significant source of health-damaging air pollutants. While CO_2 from most other sectors is declining, strong growth in demand for mobility has ensured that EU transport emissions still remain above 1990 levels (+ 8%). At the same time, transport plays an important role in Europe's economy, generating around 7% of EU GDP and employs around 12 million people[1] (including manufacturing of transport equipment).

The sector is predominantly powered by oil, 88% of which is imported from overseas[2]. For each €100 spent on fuelling the average vehicle, €43 leaves the European economy to pay petroleum suppliers[3]. Europe spent around €302 bln in 2013 on petroleum products[4], 3,5 times higher than the bill for natural gas. Given this high level of import dependency, the imperative to tackle climate change can go hand-in-hand with capturing economic co-benefits due to reduced oil consumption.

A UNIQUE OPPORTUNITY FOR RESHAPING POLICY

In July 2016, the European Commission launched its "European Strategy on Low Emission Mobility", which will serve as a work-plan for initiatives to reduce pollution and climate impacts from mobility. Similarly, the forthcoming Accelerating Clean-Energy Innovation strategy (ACEI), and in particular the Strategic Transport Research and Innovation Agenda (STRIA), is expected to provide a stable and favourable regulatory framework and conditions for low carbon technologies in the transport sector. As these strategies are converted into legislation and enabling frameworks or funds for R&I, a unique opportunity arises to shape both the greenhouse gas intensity and the competitiveness of the sector over the coming decades. Lessons should be learned from both the successes and the failures of the 2020 climate and energy package, and doing so requires an understanding of the markets for mobility and logistics.

The most important thing to recognize is that many actors in the transport sector do not behave in an economically rational manner. For instance, buyers of new cars undervalue both depreciation and future fuel savings. At the same time, car-buyers are also faced with a myriad of competing priorities in their purchasing decision, such as safety, status, style and utility, to name a few. As a result, in the absence of regulation, buyers of new cars make choices that are far from the economic optimum, and this slows the rate at which efficient technologies are pulled into the pool of vehicles, and it worsens Europe's energy trade deficit. This dilemma is likely to prove challenging for the transition to low-carbon vehicles, which have higher upfront capital costs but lower operating costs than conventional vehicles. Understanding these market dynamics, as well as many others throughout the transport system, is fundamental to good policy-making.

THE MOBILITY VALUE CHAIN IS UNDERGOING RAPID AND DRASTIC CHANGES

The transition to a competitive European low-carbon transport system, must also take place against a backdrop of rapidly changing and interconnected fundamentals, so-called megatrends:

- **Social changes** include demographic changes, such as Europe's aging population, with far-reaching impacts on the availability of skills and capital. At the same time, urbanisation could increase congestion; decrease the available space for transport infrastructure; and alter preferences for personal mobility.
- **Behavioural changes** include increased awareness of the environmental impact of vehicle use; increased consumer interest in ICT-based mobility services; and a new willingness to engage in the sharing economy.
- **Structural changes** in the value chain include the growing importance of emerging economies in both production and consumption of mobility solutions; a shift towards trading the functions of products rather than the products themselves.
- **Geopolitical changes** involve issues around resource scarcity; political instability in oil-producing regions; integration of global markets; and rising global resolve to tackle the climate threat.

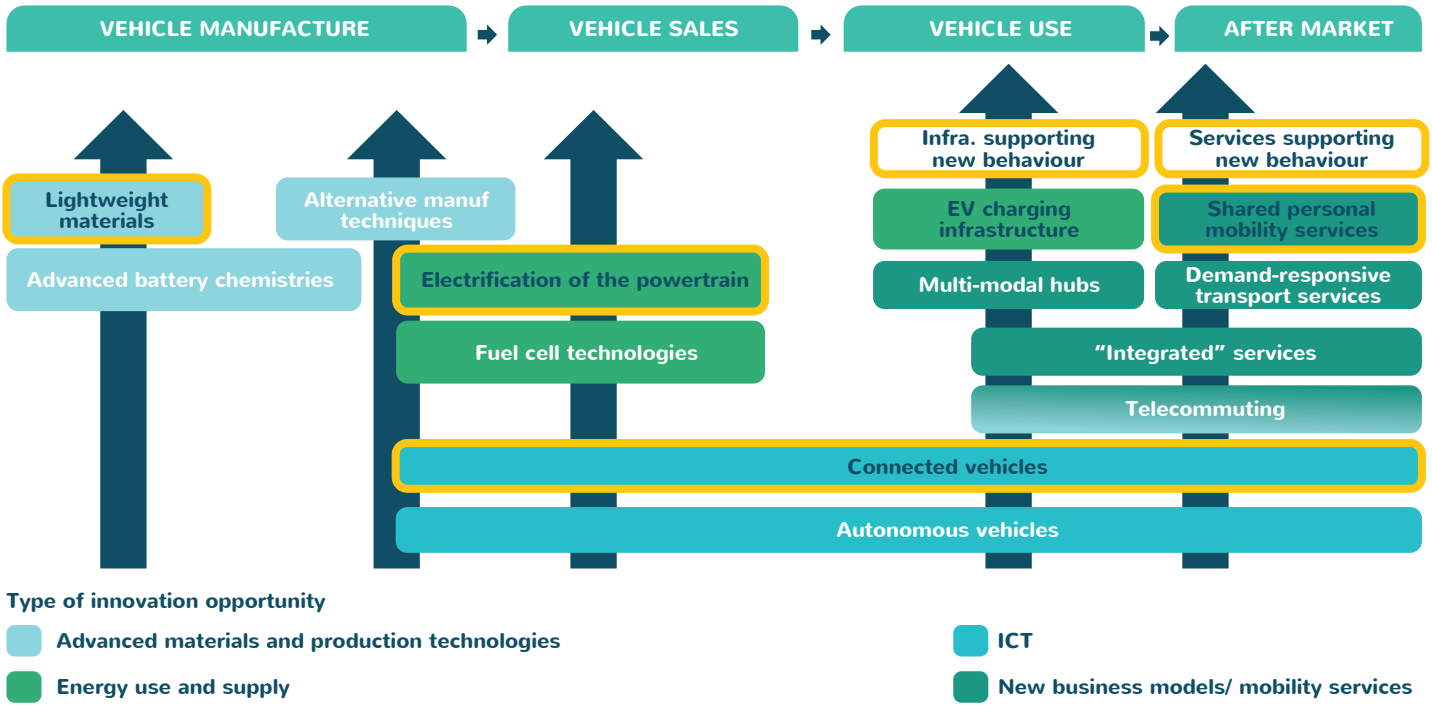
All these game-changing trends demand fast deployment into the market of new technologies and services. They are putting unprecedented pressure on European industry to adapt, and this means that innovation has become the common thread for industry to remain competitive. This innovation can either be supported or hampered through policy choices.

COMPARATIVE ADVANTAGES OF EUROPEAN INDUSTRY TODAY

Ricardo Energy and Environment has conducted an analysis of the transport sector or the i24c - focusing on the passenger transport value chain, to identify where European companies hold a comparative advantage or disadvantage versus overseas rivals, and where are the growth and new markets potentials[5]. The value chain stretches from the supply of raw materials to vehicle use and maintenance. A value-chain focus offers a full picture of an economic sector, and how it might shift as part of the forthcoming industrial transition.

A multi-stakeholder perspective is adopted, whereby we consider all the actors in the mobility value chain ecosystems, each of which have an essential role in enabling innovation and its diffusion. Cooperation models involving different sectors, businesses and cities in delivering innovation are also discussed.

Figure 1: Innovation opportunities within the traditional automotive value chain (High-level representation)



Source; i24c/Ricardo study: Driving Innovation in the automotive value chain (October 2016)

Five innovation opportunities are likely to have the highest direct benefits on jobs and growth in Europe, while drive emission reductions. These are:

Electrification of vehicle powertrains

If combined with clean energy sources, this can be one of the most significant contributors to lowering transport CO_2, air pollution and noise. By helping Europe shift from imported oil to domestically produced electricity, the EU's energy trade balance and economic resilience would be improved. However, the transition is not simple: it requires a shift to an entirely new mobility ecosystem, creating risks for incumbents and opportunities for new entrants. In particular, new openings are created for companies that are outside the automotive sector and specialise in integration with related sectors, such as electricity; the infrastructure to distribute it; and the ICT to ensure it is smartly managed. The electronics industry is key to this opportunity.

European car manufacturers are well placed to profit from this transition due to their competences in vehicle production, engineering and their skilled workforce. BMW and the Renault-Nissan alliance are currently at the forefront, although VW has announced future investments in electrification on a massive scale[6,7]. It is also worth noting that more than 90% of the vehicles sold in Europe are manufactured close to market[8], and it is the location of manufacturing rather than the nationality of the brand that determines where most of the economic benefits are captured. It is also the automotive component suppliers that generate most of the value in a car, around 75% on average in Europe[9]. Companies such as Valeo, Bosch and Continental are already competing strongly on hybrid systems. The 48V mild-hybrid system is one such product that has been placed on the market to meet EU future fuels economy norms and look set to provide one of the most cost-effective and competitive solutions, likely offering negative costs for vehicle owners across the average ownership period.

While traditionally, component suppliers have been located close to the vehicle assembly plants, at present the majority of EV battery cells are manufactured in Asia or the US, which could potentially lead to a shift in where value is generated along the automotive value chain. Asia is currently characterised by higher R&D spend, a better legal environment, and more accessible research facilities in universities. EU manufacturers are currently falling behind Japanese and Korean competitors in obtaining patents for advanced technologies, partly due to the EU's focus on conventional diesel technology not replicated in other major vehicle markets.

If Europe is to benefit economically from this transition, it will be vital to capture value within the value chains for batteries and electronic components, as well as to manage the transitional difficulties from combustion technologies. Changes in battery chemistry could provide an opening for European companies to make competitive investments. There are already signs of a shift in these regional dynamics, with recent announcements of battery manufacturing planned in Germany and Poland. (see Case Study: Vehicle Batteries).

Case Study: Vehicle Batteries

The production of Lithium-ion (Li-ion) batteries for vehicles can be divided into five distinct stages: cell components, cell production, module production, battery pack production, and finally integration into the vehicle. Presently, the production of modules, their assembly into packs and the subsequent integration into vehicles is taking place in Europe (e.g. Renault-Nissan, BMW), while the production of cells and their components (50-60% of the value) is entirely dominated by Asian companies such as Panasonic and LG Chem. These Asian companies have achieved a significant advantage in terms of scale economies.

However, technological development is moving fast, and 3rd or 4th generation cells are on the horizon. Shifting from current cathode technology to more advanced cathodes with less manganese and cobalt will reduce costs by around 40% within 2 years. This explains why car companies are able to announce new battery electric vehicle models for 2016-2018 at around €25k - €35k, with a dramatic range increase to around 300 km. This abrupt change in cell chemistry somewhat levels the playing field.

Going forward, incumbent cell manufacturers, mostly in Asia, will need to consider the risk of stranding their own existing assets when moving to the next generation of technology. This is a problem that potential new European entrants would not face. In other words, second-movers might soon be able to gain the advantage over incumbent leaders in cell manufacturing. In addition, European companies might be able to develop new expertise in use of batteries for "second-life" applications in the power sector, or for recycling batteries when they are no longer commercially viable.

Infrastructure for e-mobility

Different EV charging business models have emerged - each with its own level of complexity, risks and reward structure. There are a number of European players in the market for EV chargers, such as Siemens, Bosch and ABB, some of which are investing heavily in innovation. For example, ABB in 2013 invested 4% of its revenues ($42 billion) in R&D. There are also opportunities for European companies with expertise in installing these charging stations; metering; billing; and maintenance.

Shared personal mobility

Most shared mobility innovations appear to stem from California, where there is a high share of urban consumers using

on-demand 'e-hailing' services (such as Uber). However, this does not limit Europe's opportunities to engage in the provision of shared mobility services. Declining car ownership rates in Europe are forcing car manufacturers to move into this space, which allows them to build new markets and become 'mobility providers', benefiting not only from the vehicle build phase but also from the vehicle use phase. The number of registered car sharers in Germany rose nearly seven-fold between 2010 and 2014 to over 1 million. Some European companies are already taking the lead, such as Daimler's "Car2Go", which is present in 30 cities in Europe and the US.

Connected vehicles

Most automotive executives agree that connectivity is likely to enable many new services, such as collision avoidance and emergency roadside assistance, as well as new business models. The market is expected to grow strongly, with one estimate suggesting a six-fold increase in market value to €180 billion by 2020[10]. Increased connectivity in cars is expected to shift revenues along the value chain, with greater value created by hardware and maintenance providers. Google, TomTom of the Netherlands, and HERE, owned by Daimler, Audi and BMW, are increasingly forming a global oligopoly to provide dynamic real-time geo-information services.

There are various levels of autonomous driving, with the highest levels (4 & 5) creating the potential for major disruption of traditional business models. NuTonomy launched the first major trials of autonomous taxis in Singapore in August 2016[11], which when summoned with the company's ride-hailing app have the potential to massively cut mobility costs by eliminating the need for a driver[12].

Innovative materials

In today's cars, around one tank of fuel in five on average is consumed due to drag, which can be reduced by making greater use of lightweight materials, such as high-strength steel, aluminium, magnesium and plastic composites. A 10% reduction in vehicle weight can result in a 6%-7% fuel efficiency improvement, and therefore manufacturers are willing to pay up to €20/kg saved in vehicle weight[13]. Aluminium offers weight reduction of around 30%, for a cost increase of around 30%. Carbon Fibre materials offer much greater weight reductions (of around 50%), but with a fivefold increase in costs. This high cost is partly offset by delivering high value characteristics of performance, safety and comfort. While primary production of some materials, such as steel and aluminium, is increasingly relocating outside Europe, much of the value from lightweight materials is captured during the processing and manufacturing phases within Europe.

OVERCOMING RISKS TO INNOVATION

In this rapidly shifting landscape, companies face numerous risks:

Technology risks can slow deployment. At the same time, learning effects and changes in design can make it difficult for companies to decide whether first-movers will be rewarded by markets, as has happened in some markets with the Toyota Prius, or punished for moving too early, as happened with Better Place, an EV services provider that filed for bankruptcy in 2013.

There are several **market risks** associated with deploying new products. In the transition to low-carbon mobility, concerns have been raised about the shortage of skilled labour in Europe, such as mechatronics engineers to handle increasing electrification of vehicles. There is also uncertainty about the speed with which consumers will adopt unfamiliar new products (as happened with the roll-out of E10 fuel in Germany), balanced against the risk of falling behind fast-moving competitors, such as Tesla.

Thirdly, there are **policy risks** such as a lack of industry standards or protocols to ensure interoperability across EU member states, as has occurred with EV charging plugs; or sudden swings in policy priorities, such as the Commission's abrupt decision in 2014 to scrap EU low-carbon fuels policy (the Fuel Quality Directive).

As such, policy makers need to be mindful of these risks, which today hamper innovation. Failure to address some of the challenges will undermine the achievement of the outcomes required in terms of value and employment creation, and reductions in emissions and resource use.

LEVERS OF CHANGE - ACTIVELY SUPPORTING, SCALING AND MANAGING

To make a break from incrementalism and to enable the take off of radical innovation in mobility value chains, policymakers need to take a proactive approach by designing policies in a manner that acknowledges the risks and opportunities. Implementing the *"European Strategy on Low Emission Mobility"* and the forthcoming *Accelerated Clean Energy Innovation strategy* provides such an opportunity.

Regulations – The CO2 standards for cars and vans have given automotive component suppliers the certainty they need to invest in new capacity for production of low-carbon technologies, such as mild hybrid systems. However, a culture of lax enforcement of these standards has been allowed to develop in Europe, illustrated by the Volkswagen scandal. Unless tackled properly, this risks damaging the reputation of Europe's automotive sector, and it puts at risk the investments

that already have been made in producing low-carbon automotive components.

The standards will also need to be designed in such a way as to create an incentive for investment in the next generation of technologies beyond the combustion engine, for example via a flexible-mandate or tradable credits for zero-emissions vehicles. This would help drive change beyond incremental improvements to the level that is needed and if the credits were tradable, they could provide car manufacturers with flexibility over and underachievement.

Finally, the existing regulation has so far been designed in such a manner that it penalises the use of lightweight materials, which are an important opportunity for European plastics companies. This opportunity has been overlooked, partly because it accrues to companies that are outside the traditional circle of stakeholders, and it needs to be rectified.

Innovation support – Given the strong international competition for technology dominance in this area, it will be important to ensure that the EU's Horizon 2020 funding is channelled towards the most relevant innovation challenges in transport and builds upon Europe's current strengths. Priority setting is a complex matter and has multiple dimensions (e.g. targeting of actors, goal definition and type of governance approaches, etc.). What is clear though is that the basis for such a prioritization in Europe should first and foremost be on the expectation that innovations will meet end-user demand (e.g., more connected and autonomous urban transport and/or mobility services), create value for and in Europe (e.g., in terms of jobs, growth, exports) and take into account European countries/regions' existing strength[14].

One area that will need more research and investments is battery technologies across the entire battery value chain, from "powder-to-power". For example, funds could finance smart-charging and vehicle-to-grid (V2G) projects to assess impacts on the electricity grid. Financing research projects to examine the role of different battery technologies for ancillary services and the impact on vehicle life cycles could stimulate the adoption of battery second-life and second-use (e.g. V2G, self-consumption) applications.

Innovation support is not only important for producing new technologies but also for facilitating its widespread use. Using Horizon 2020 funds for research, but also mainstreaming funding for activities in all stages of the innovation cycle will be critical to transform investment in R&D into competitiveness gains. Combining H2020 innovation funds with investment support, such the European Fund for Strategic Investments, and risk mitigation instruments such as the EIB's InnovFin instrument, for the development of charging infrastructure or other innovative sustainable transport solutions, will be key in this respect.

Infrastructure developement and support - The construction of EU-wide targeted interoperable recharging infrastructure remains critical to ensure the market roll-out of electric vehicles. Across Europe, the deployment of high power charging station (150 kW) is needed to enable full electric long and transnational journeys. EU-funded and national funded mobility corridors should for example focus on high power charging points, which have proven to be the most efficient along highways.

Furthermore, EV charging services should enable seamless access and payment for publically accessible stations. They should also provide transparency for consumers with regard to pricing, origin of the electricity and ability to choose between services and providers.

Smart Incentives – While CO_2 standards have played an important role in forcing manufacturers to put low-carbon vehicles on the market, policies are also needed to create a "market pull". Tax exemptions and subsidies are playing a key role in spurring electric vehicle markets. Norway and the Netherlands, in particular, are conspicuous examples of the relationship between fiscal incentives and electric vehicle sales. By contrast, where fiscal incentives have not been used, electric vehicles are not taking off. At the same time, a number of factors in addition to fiscal incentives are influencing development of the market for electric vehicles. California, especially, exemplifies a comprehensive electricdrive strategy that goes beyond fiscal incentives and includes a ZEV mandate on manufacturers.

Skills and training – While most of the workforce skills required for the new transport paradigm are well represented in the EU automotive sector, there are some that are in short supply, such as chemical engineers to develop batteries and lightweight materials and electrical engineers to manage the increasing electrical content of vehicles. Tackling skill shortages is a joint responsibility between governments and companies, though ultimately it falls to companies to respond to the prevailing situation. Efforts are also needed to ensure that what is taught in universities, as well as the research areas pursued, are relevant for the industry.

Collaboration – Collaboration between government, industry and civil society can play an important role in defining smart policy. One good example is the role that the UK's Auto Council Technology Roadmap played in reviving the British automotive industry. This was helped by Britain's focus on tackling climate change, which spurred a wave of investment in low-carbon vehicle technologies. Against a backdrop of rising overall investment in UK automotive, annual investments in this area rose from less than 1 billion in 2007 to over £5 billion in 2013[15]. R&D spending more than doubled over the same period to nearly £1.7 billion in 2013.

Smart integration – Vehicles making increasing use of electricity will need to be carefully integrated into the distribution network in order to minimise risks and maximise benefits. Poorly managed, the integration of electric vehicles can lead to significant costs for reinforcing power distribution networks. But smart-charging can minimise these costs, at the same time as enabling vehicles to provide important services to grid operators, delivering a net benefit overall[16]. Policymakers have an important role in delivering the standards and network codes necessary to support such smart integration and reduce the risks of market fragmentation. For example, cars sold in Europe should converge towards a single fast-charging mode, and moves should be made towards a single market for vehicle charging.

By 2030, it should be expected that market design reforms are implemented such that flexibility and storage, also from

plug-in vehicles are "fairly" compensated and consumers have access to a wide range of service energy products and service offerings. In order to maximise smart customer's response potential, it is important to ensure market prices reflect as closely as possible the full real-time value of energy and balancing services.

Massive investment in the distribution system is also required to replace ageing infrastructure, integrate distributed energy resources, and smarten the grid. It is estimated that European electricity networks will require $600 billion in investment by 2020, two-thirds of that in distribution grids[16]. The clearer the need for the investments and their necessary timing, the more likely it will be that governments and authorities commit to modernise the grid and the more likely that private investors will be willing to invest.

CONCLUSION

By promoting and harnessing innovation, Europe's industrial economy can secure long-term competitive advantage in the race to win the most from the global transition to a radically new economy, whose pace as well as shape is made so much clearer by the Paris climate agreement.

There is a clear role for policy on a number of fronts, including by encouraging cross-sector and cross-border collaboration and fostering innovation ecosystems in the value chain, with the aim of encouraging disruption and breaking inertia and silos. The key to unlocking many of the bottlenecks that exist today will be collaboration between governments, local authorities, industry and civil society.

[1]European Commission Transport White Paper

[2]European Comission, EU Energy, Statistical Pocketbook 2015

[3]Fuelling Europe's Future: How auto innovation leads to EU jobs – Cambridge Econometrics 2013

[4]Eurostat, Comext, Imports Extra-EU of Trade Energy, EU-28 in 2013

[5]In investigating the passenger transport value chain, we focus on end-use functions delivered by an industrial value chain – in this case, mobility – rather than on traditional industrial sectors.

[6]Reuters, Volkswagen says needs massive investments for transformation, June 16

[7]South Korea's Samsung SDI announced plans in September 2016 to invest about $358 million to build a plant to make electric vehicle batteries in Hungary, joining the race to build capacity and tap European demand.

[8]Capacity needs in the automotive industry in the short to medium run – OECD 2013

[9]Website of EU automotive parts suppliers CLEPA

[10]McKinsey (2014), Connected car, automotive value chain unbound

[11]http://nutonomy.com/press.html

[12]Shared, autonomous vehicles have the potential to massively reduce mobility costs, but their environmental impact is highly uncertain. Autonomy can enable various improvements to energy efficiency, for example via platooning, eco-driving and reduced congestion. But this could be offset via increased weight of onboard technology; increased usage as mobility costs fall and by making cars available to new user groups. Less vehicles will be needed, but those in use will need to be more durable, with more technology content.

[13]Lightweight, Heavy Impact (McKinsey 2012)

[14]This might be direct spill-overs from existing strength (e.g., using an existing customer base, logistics or knowledge) but also very indirect spill-overs from specialisation-cycles of regions or entire countries (see Brugel-i24c, 2016).

[15]Investing in the low carbon journey – E4tech 2014

[16]En Route Pour un Transport Durable – Cambridge Econometrics 2015