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EXECUTIVE SUMMARY

Europe’s transport industry and its related services are an essential part of Europe’s economy. The automotive sector alone generates around 7% of the Union’s Gross Domestic Product (GDP) and employs around 13 million people. It also accounts for one quarter of the EU’s R&D.

Today, the transport sector is challenged by rapidly changing framework conditions and consumer demands. Megatrends, such as the sharing economy; urbanisation; the transition to cleaner energy sources; and consumer demand for increased connectivity will create opportunities for new players and both opportunities and risks for incumbents over the coming decade. In this context, European automotive companies must innovate to remain competitive and to meet increasingly stringent environmental constraints.

New innovative mobility products and services (such as connected, electric and shared vehicles; or personalised on-demand mobility services,) are reaching the European market. For Europe as a whole, these innovations have the potential to translate into economic growth, employment creation, and emissions reductions. These innovations also have the potential to create value for the European economy though lower mobility costs, new jobs, less congestion, improved resource efficiency and potentially improving Europe’s energy trade balance by increasing the deployment of alternative powertrains.

This study focuses on five transport innovation opportunities that are most likely to have direct benefits on jobs and growth in Europe and reduce carbon emissions in Europe in the medium- and long-term. According to a panel of transport experts from industry, academia and the public sector, they also have the potential to enhance the competitiveness of European firms. These innovations are:

1. Electrification of the power train
2. Electric vehicle charging infrastructure
3. Lightweight materials
4. Shared personal mobility and
5. Connected vehicles.

Figure 1 shows the five shortlisted opportunities along the traditional automotive value chain segments – from vehicle manufacture to after market of the vehicle use, - along with other innovation opportunities that will also have significant potential to grow Europe’s industry and reduce carbon emissions.

Today, the deployment of these innovation opportunities is only at the early stages though. In this report we assess the value chains that underlie the five shortlisted innovation opportunities in more detail. For each segment of the value chain, revenue streams, drivers, barriers and most important challenges are identified.

**Key findings of this study**

**The EU is in a strong position to drive the development of the shortlisted innovations.** Europe’s automotive industry can build upon its expertise and reputation in traditional vehicle technologies and benefit from the automotive clusters that have developed over past decades. Europe has also already proven to be an important test place for many innovative solutions, such as shared or connected services. Figure 2 shows examples of Europe’s key strengths and weaknesses relevant to transport innovation opportunities and their underlying value chains.
Yet the complex nature of the innovations and subsequent spill-over effects across other innovation opportunities and the traditional automotive value chain make it difficult to predict the overall net effect of successfully pursuing these innovations in Europe, especially for the future. For example, growth in shared personal mobility services will reduce car ownership in the medium to long term, which could affect jobs in the traditional automotive sector as well as GDP growth.
The direction in which innovation will take place is influenced by megatrends, such as social and behavioural changes, changes in the geopolitical landscape and the increasing importance of emerging economies, both in terms of place of production and consumption of new goods and services. These megatrends are interlinked and also influenced by other macro factors, such as energy prices as well as resource and infrastructure availability.

The growth of each innovation opportunity relies on the concerted effort of all actors along the value chain. For example, investment in component suppliers for electrification is influenced by the original equipment manufacturers’ (OEMs’) business plans and collaboration strategies to develop certain technologies, which in turn is influenced by consumer and regulatory factors. Investment in shared mobility services, connected vehicles and other alternative modes of travel (for example electric bikes) will, for example, also depend on local policies that define urban planning and infrastructure development.

New business and revenue sources for EU players differ across the value chain segments for different innovation opportunities; the largest growth potential is seen in vehicle use-related services.

- Component suppliers in the vehicle manufacturing stage are seen to be a high value adding segment of the electric vehicle value chain. However from a comparative advantage perspective, European players are not well positioned as these suppliers are predominantly non-EU companies.

- Non-traditional players, such as electronic and IT companies (EU and global) are likely to capture greatest value by enhancing vehicle users’ experience and safety, especially when related to the deployment of connected vehicles, electric vehicles and shared personal mobility services.

- For vehicle maintenance and after use service providers, there is the potential for new revenue streams in the recycling and refurbishing of the batteries of electric vehicles. Concerning connected vehicles, advanced vehicle maintenance services such as remote vehicle prognostics and diagnostics as well as vehicle data-based bespoke services are expected to create new business opportunities.

The car share market has seen immense growth across the world in recent years. Between 2006 and 2014 the total number of members in car sharing clubs increased from 0.35 million to 4.94 million.
Opportunities to create new revenue streams will also arise by linking the potential of two or more innovations. For example, shared personal mobility services based on electric-drive vehicles can accelerate the electrification of our transport system, create economies of scale and enhance the uptake rate of electric vehicles across all consumer groups.

New business opportunities are attracting players not traditionally associated with the mobility sector and will continue to do so in the future.

- Electronics, chemical and mobile technology companies will play a key role in the provision of electric and connected mobility innovations.
- IT companies (EU and global) are well positioned to provide app-based subscription services for electric, shared and/or connected vehicles. Also IT hardware companies will derive significant value from the growth of these innovations.
- European utilities, property developers, commercial and retail players will see revenue potential from setting up charging infrastructure.

Traditional automotive component suppliers and Original Equipment Manufacturers (OEMs) can capture value by either providing services in the use and after market segment; or developing strategic partnerships with the new players in the value chain (IT, electronics and utilities).

- OEMs can generate new business by working closely with utility companies and IT companies to provide smart charging technologies for electric vehicles at home, work and retail places.
- OEMs and suppliers can increase their competitive position by establishing strategic partnerships with telecom operators to provide hardware and software for connected vehicle services.
- OEMs can generate additional revenues and offset the costs from declining sales by moving into shared personal mobility services.
Car owners and users also stand to benefit from new innovation opportunities, which arise from lower fuel costs, time savings due to less congestion from transport system efficiencies, lower maintenance costs, improved mobility or driving experience and a green consumer image.

- Electric vehicles combined with connected technologies provide enhanced driving experience; connected vehicles help optimise traffic flows and hence decrease congestion levels.
- Shared personal mobility and electric vehicles incur low mobility costs compared to the ownership of a conventional vehicle in the long run. This can lead to a rise in disposable income and associated economic benefits.
- Greater and improved charging infrastructure would address the range anxiety for consumers and lead to greater uptake.
- Lightweight materials increase the fuel-efficiency of vehicles and thereby reduce the running costs.

Yet the uptake of innovation opportunities and the transition to a low carbon transport sector will not take place at a sufficient scale on its own. While not subject to inherent technology or financing barriers, the potentials of some innovations such as connected and/or shared vehicles remain untapped due to general policy inertia or obstruction from local laws. For example, growth in shared personal mobility services may be affected by the taxi lobby, local planning restrictions and complex legal requirements. The build-up of interoperable electric vehicle charging infrastructure may be hampered by a lack of standardisation efforts and dominant players who deploy unique solutions rather than focus on coordinated efforts. Electric charging facilities in shared residential buildings may face planning constraints and ownership rights. The uptake of connected vehicles may be hampered by a lack of coordinated efforts across the European Union to make deployed systems interoperable across borders.

To reap the benefits of transport innovations, close collaboration between the government, local authorities, industry and civil society is therefore required. This will also help to overcome a set of risks and challenges:

**Policy risks**

- Lack of policy incentives and public funds to drive innovations such as electric vehicles and their infrastructure and connected vehicles
- Lack of industry standards or protocols to ensure interoperability across EU Member States and compatibility between different innovation providers/operators
- Lack of a clear definition in the responsibilities of the deployment of new innovations
- Uncertainty of legal frameworks concerning safety, insurance and data protection or data monopolies (e.g. from automotive industries or telecom service providers) that affects new innovations.

The use of lightweight materials in the automotive industry is forecast to increase significantly over the upcoming decades, from its current level of 30% (total mass of the vehicle) to 70% by 2030.
Market risks

- Skills shortages
- Uncertain demand due to lack of consumer awareness on benefits of innovations
- Risk that innovations might be regarded as threats as opposed to opportunities by the different players in the value chain.

Technological risks

- Uncertainty of life-cycle emissions of different innovations and the dependency on clean energy sources to ensure a clear life-cycle benefit
- Ongoing changes in design and technologies that affect cost and widespread usability.

In brief, the global race for reaping the benefits from the innovation opportunities and opening up the related revenue streams has started. To play a leading role in this race, European stakeholders have to overcome policy, market and technological risks. Overcoming these will require collaborative approaches across all relevant actors. The first step towards encouraging such collaborative approaches is to ensure a common understanding of the vast potential benefits for all implicated parties, including component suppliers, manufacturers, service providers, end-consumers and after-market service providers. In particular, ‘traditional’ players in the value chain will have to rethink and challenge their current product and service offerings to be fit for this race and to help Europe continue to play an important role in transport products and services on a global scale.

Policy makers will play a key role and need to be mindful of all 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. A clear role for policy is therefore on a number of fronts, including

1. Fostering innovation ecosystems in the value chain by providing clear legal frameworks, to encourage disruption and overcome inertia, all while ensuring that end-user demands are met, value is created in and for Europe (e.g., in terms of jobs, growth, exports), and Europe’s strengths (on country and regional level) are leveraged;
2. Encouraging cross-sector and cross-border collaboration; and
3. Tackling skill shortages by ensuring what is taught in universities, and what is pursued in research is relevant for the industry.
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1 INTRODUCTION

1.1 Objectives of the study

Developing a shared vision and pathway for how European industry can foster its competitiveness and help Europe meet its jobs, growth, environmental and societal challenges is urgent and essential. This is in line with Europe’s Strategic Transport Research & Innovation Agenda (STRIA) that will contribute to meeting Europe’s climate obligations.

The objective of this report was to identify and explore innovation opportunities in the automotive sector that contribute to the sector’s decarbonisation and help Europe’s industry to improve the competitiveness of its firms on the international market. Rather than taking a sector approach, i24c sought to understand the trends, drivers and key success factors for innovation in Europe, focusing on the entire value chain – from the vehicle supplier and manufacture stage to the after-market stage, and to identify the barriers preventing full scale commercialisation of the innovations.

The study was split into two stages to deliver these objectives.

1. First stage - Identify five key innovation opportunities from a long list of opportunities

The aim of the first stage of this study was to identify five innovation opportunities that have the potential to meet the dual goal of i) decarbonising Europe’s transport sector and ii) providing opportunities for European industry to gain a competitive advantage.

2. Second stage – Provide a high-level analysis of the five key innovation opportunities

The aim of the second stage of this study was then to further explore the five shortlisted innovation opportunities to gain understanding in the following areas:

- The scope of the innovation opportunity,
- The innovation’s market potential from today’s point of view,
- The innovation’s greenhouse gas (GHG) emission reduction potential,
- The innovation’s job creation potential,
- The innovation’s main revenue potentials,
- The competitive landscape for each segment of the value chain,
- The main challenges and risks that the innovation opportunity faces and brings, and the barriers that have to be overcome to achieve large-scale deployment of the innovation in Europe.
1.2 Structure of the report

The report is structured as follows:

- In **Section 2**, we provide a brief understanding of the transport and automotive sector and its major innovation opportunities that have the potential to contribute to GHG emissions reductions.

- In **Sections 3-7**, we provide the results of Stage 2 of this study for each innovation opportunity; this includes, for example, an analysis of their growth potential, potential revenue streams, their competitive landscape; pertaining risks and barriers etc. These innovation opportunities are:
  - Electrification of the powertrain (Section 3)
  - Electric vehicle charging infrastructure (Section 4)
  - Shared personal mobility services (Section 5)
  - Connected vehicles (Section 6)
  - Lightweight materials (Section 7).

- **Section 8** provides the overall conclusions of this study.

- **Section 9** (annex) presents the study methodology that also shows how the five innovation opportunities were shortlisted for stage 2 of this study and summarises this study’s limitations.
2 UNDERSTANDING THE EU TRANSPORT AND AUTOMOTIVE VALUE CHAINS

2.1 The importance and impact of the value chains

Transport is a key enabler for economic growth, social activity and social integration. It allows the movement of goods and passengers by linking the geographic locations of supply and demand. As such, transport allows the functioning of a whole economy and defines its productivity.

The European Commission’s Transport White Paper (Roadmap to a Single European Transport Area, 2011) highlights the importance of Europe’s transport value chain:

- The transport sector generates around 7% of the Union’s Gross Domestic Product (GDP) and employs around 12 million people (including the automotive industry that employs around 2.2 million people).
- Goods transport including the logistics and storage activities accounts for around 10-15% of the cost of a finished product.
- Around 13% of every household’s budget is spent on transport goods (e.g. costs for vehicle ownership) and services (e.g. costs for the use of public transport).

However, given the size and nature of the transport value chain, transport is also a source of environmental concerns and other negative externalities:

- Congestion costs are about 1% of GDP annually in Europe.
- The transport sector depends on oil and oil products for more than 96% of its energy needs - this has a significant impact on the EU’s trade balance (in 2013 the EU imported around 88% of its crude oil from abroad).
- In 2014, the transport sector (including international aviation) was responsible for around 23% of Europe’s greenhouse gas emissions.
- In the same year, road transport alone accounted for around 72% of transport energy consumption in the EU in 2012 (followed by international aviation with 13%), and was responsible for around one-fifth of the EU’s total CO₂ emissions.

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6Eurostat, GHG emissions, analysis by source sector, EU-28 in 2014
### 2.2 Megatrends affecting the automotive value chain

Innovation in the automotive value chain has been spurred by megatrends that have been increasingly affecting the way people choose to travel. The table below provides a summary of the megatrends and drivers of change that are key to understanding the future of the automotive value chain and its challenges.

<table>
<thead>
<tr>
<th>MEGATREND</th>
<th>DRIVERS OF CHANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SOCIETAL CHANGES</strong></td>
<td>The global population is still expected to increase and the age profile of the population is changing. The proportion of young people is shrinking, while the percentage of older people is on the rise. Such demographic change will have far-reaching effects on the labour (skills), goods and capital markets as well as their geographic distribution.</td>
</tr>
<tr>
<td></td>
<td>Rapid urbanisation and job opportunities are increasing population densities in urban areas and cause land scarcity. This has impact on congestion and availability of space for transport infrastructure and means. It will also alter people’s demand for personal mobility and the transport means they choose.</td>
</tr>
<tr>
<td><strong>BEHAVIOURAL CHANGES</strong></td>
<td>Society is increasingly aware of the environmental impact of their activities. Also transport users in Europe have increased their awareness of the energy efficiency of their vehicles (whether this is due to environmental or cost concerns). The energy efficiency of vehicles is likely to remain very important over the medium to long term. As such, consumers are changing their mobility choices and decisions to reduce the environmental impact and costs of their trips. The climate impact of vehicles will furthermore have important implications for R&amp;D investment and technology deployment.</td>
</tr>
<tr>
<td></td>
<td>Increasing shares of the population use smart mobile phones, communicate via social media platforms and benefit from the use of mobile phone applications. As a result, also ICT-based transport services are increasingly accepted and used (which, in turn, drives overall ICT acceptance and awareness).</td>
</tr>
<tr>
<td></td>
<td>There is a shift to a sharing community (or ‘collaborative consumption’) – especially the younger generation is increasingly comfortable with sharing products and services.</td>
</tr>
<tr>
<td><strong>ECONOMIC/INDUSTRIAL CHANGES</strong></td>
<td>Industrial production and workforce increasingly cut across borders, sectors and markets. Supply chains are becoming increasingly complex and global, including the supply chains in the automotive sector.</td>
</tr>
<tr>
<td></td>
<td>Product support services are increasingly important as part of the marketing effort for industrial products and facilities. In the automotive industry, the vehicle aftermarket is particularly prone to increasing shares of value creation compared to other segments in the automotive value chain.</td>
</tr>
<tr>
<td><strong>(GEO-) POLITICAL CHANGES</strong></td>
<td>The “servisation” of products (the selling of a product’s function rather than the product itself) is becoming a viable business model. This has an impact on how transport modes are used and which transport services and products will increase market share in the future.</td>
</tr>
<tr>
<td></td>
<td>Emerging markets continue to grow, leading to a growth in demand for transport products as well as increasing (low-cost) competition from around the globe. Lower labour costs in developing countries such as China have attracted significant foreign investments. At the same time some regions of Europe are increasingly capable of competing on low-cost labour with the rest of the world.</td>
</tr>
<tr>
<td></td>
<td>Importance of climate policy has increased around the globe and in Europe specifically, putting ever increasingly stringent standards on vehicle manufacturers and suppliers. Environmental and climate protection are key challenges for the transport sector and will remain so in the future.</td>
</tr>
<tr>
<td></td>
<td>Resource and energy scarcity have become a major risk to the transport sector.</td>
</tr>
<tr>
<td></td>
<td>Reduction of trade barriers and the integration of markets continue to drive competition.</td>
</tr>
</tbody>
</table>

Source: Ricardo Energy & Environment
The megatrends and their drivers lead to multiple implications for the automotive value chain, i.e. on the activities and responsibilities of the value chain and their actors. To stay competitive in the changing environment, players in the value chain have to innovate to both meet customers' desires while accommodating increasingly challenging economic/industrial and (geo-)political constraints.

2.3 Innovation in the automotive industry

The European automotive industry has shown to have been responsive to the above-sketched megatrends. New innovative products and services have been launched and have often successfully been taken up on the market. Innovative products contribute significantly to the turnover of the automotive industry, accounting for almost half of the total (JRC, 2011). As a result, the automotive value chain has become a leading innovator in Europe. More than 60% of all companies active in the automotive value chain are considered active in innovation (JRC, 2011).

The main drivers that stimulate innovation in the automotive industry can be summarised as:

- The potential to increase the performance and quality of vehicles and vehicle use services – and with this to ultimately improve image and increase market shares (in 'old' or new markets)
- The opportunity to add greater flexibility and reduce costs in the production processes to remain competitive with low-cost markets
- The need to comply with regulatory and fiscal policies that steer innovation efforts in directions that are aimed at industrial, societal and/or environmental benefits.

These drivers have led to a variety of innovations along the traditional automotive value chain. Traditional actors or new entrants are currently pursuing these to varying degrees.

Figure 2-1 provides an overview of the most relevant innovations that have been identified in the course of this study. These innovation opportunities have been categorised and allocated to the different segments of the traditional automotive value chain. These innovations have been selected on the basis of:

- Their market growth potential
- Their job creation potential in Europe
- Their GHG reduction potential
- The extent to which value added will shift across existing players / to new players
- The level of R&D investment (i.e. funds that have already been made available to drive the innovation).
However, there is some indication that EU-based companies lag behind compared to their competitors (for example with regard to electrification of the powertrain). The **main barriers** that hold back innovations in the automotive value chain include:

- The high capital intensity of (some) innovations (such as electrification of the powertrain),
- The uncertainties in the volume and structure of the future market, caused by,
  - mismatches between consumer demand and innovation supply,
  - lack of information and confidence from consumers,
  - ‘chicken and egg’ situations/ network effects (i.e. many new innovations in the automotive value chain require a certain level of minimum adoption to meet user demands, such as electric vehicle charging infrastructure or shared mobility services),
The complexity of some innovations that require coordinated efforts between several players in the value chain (e.g. vehicle/fuel/infrastructure/consumer),

The lack of qualified or skilled personnel (e.g. in the development and maintenance of low carbon vehicle technologies, such as for plug-in and battery electric vehicles).

Supportive regulatory, fiscal, command and control, collaborative, communication and diffusion instruments are needed to overcome these barriers.

The next sections dive deeper into each of the shortlisted innovation opportunity using the following structure:

- **Key highlights** – overview of the main key findings of the following analysis.
- **Overview of the innovation opportunity**
  - High level description – brief description of the scope and definition of the innovation opportunity in the context of this study,
  - Revenue streams for industry – main activities related to the innovation opportunity that create value (incl. a visual overview of the innovation opportunity that shows where the revenue streams lie in relation to ‘traditional’ value chain segments of the automotive value chain),
  - Key risks and challenges – that can affect the size, timing and potential of the opportunity.
- **Analysis by value chain segment** – high-level analysis of the revenue streams, competitive landscape, key players, drivers and related sectors for each key segment of the innovation’s opportunity value chain. Depending on the innovation opportunity, these can be roughly related to the following three segments of the traditional automotive value chain
  - i. Vehicle manufacturing stage,
  - ii. Vehicle use stage, and
  - iii. Vehicle maintenance and after-market stage.
3 KEY INNOVATION I: ELECTRIFICATION OF THE POWERTRAIN

3.1 Key highlights

- **A transition from traditional internal combustion engine (ICE) vehicles to electric vehicles is one of the most promising ways of decarbonising road transport.** If combined with clean energy sources, carbon emissions from the transport sector can be significantly reduced while tackling other environmental impacts (e.g., local pollution, noise reduction). The total reduction potential will depend on factors such as the uptake of the vehicles, their degree of electrification and the carbon content of the electricity used.

- **Europe is now leading the world EV sales market** (driven largely by Norway, France, the UK, the Netherlands, and Germany). A study by Bloomberg New Energy Finance (BNEF) forecasts that sales of electric vehicles will hit 41 million by 2040, representing 35% of new light duty vehicle sales worldwide (Green Car Congress, 2016).

- **Despite the increasing EU market share in EV sales, the US is leading this industry** in terms of high R&D spend, favourable incentives, better infrastructure and legal environment, more accessible research facilities in universities, lower labour, production and energy costs, and strong cooperation among cities (Ernst, 2012).

- **The EU economy can benefit from this opportunity as a whole** by reducing energy dependency, risk of trade balance deficits and exposure to geopolitical risks.

- **A successful large-scale uptake of electric vehicles comes with the development of a whole new mobility eco-system.** This eco-system will attract new players that are currently not primarily engaged in the mobility sector (such as ICT service providers, electricity and infrastructure providers etc.).

- **The shift to electrification will provide new revenue streams in delivering and integrating the products/services** (such as the integration of electric vehicles and charging infrastructure via IT and GPS services/mobile phone applications) from both the traditional and newly engaged actors. These revenue streams can be pursued by either: i) entirely new actors (e.g., data management service providers), ii) new actors to the automotive value chain (e.g., utilities), or iii) traditional actors in the automotive value chain that are able to increase the scope of their ‘traditional’ business services (e.g., car manufacturers and suppliers).

- **New business models** (such as IT services that manage charging operations) **will be predominately located at the vehicle use stage,** enhancing the smooth and barrier-
free use of the vehicles and its accompanying services. Value-adding services in the vehicle use stage for EVs tend to be more important compared to the traditional car value chain.

- **Electric vehicles drive other innovation opportunities and their value chains** such as shared mobility services (that are already established first ‘niche’ markets of EVs thanks to ‘foreseeable’ trip patterns of users), connected vehicles and autonomous vehicles.

- **The industry is currently facing the challenge of irregular and low consumer demand for these vehicles.** The supply chain is characterised by small job lots and low volumes increasing investment risks for businesses engaging in this innovation opportunity. This risk acts as a **barrier to attract more players to take up the revenue streams from electric vehicles.**

### 3.2 High-level description of the innovation opportunity

Electrification of the powertrain ranges from micro hybrids to full battery electric vehicles. See Figure 3-1 that gives an overview of the different degrees of electrification of different vehicle drive-train concepts.

**Figure 3-1: Overview of different degrees of electrification of the powertrain**

Stop/start, mild and full-hybrids mainly provide revenue streams in the vehicle manufacture stage (including OEMs and suppliers). On the other hand higher degrees of electrification provide the opportunity of the creation of a whole new eco-system attracting many new players (such as electricity providers or data management providers) with their distinct business models to enter the automotive value chain. In addition plug-in electric and battery electric vehicles provide revenue streams in ‘enabling’ value chains (e.g. charging infrastructure provision or telecommunication) that run parallel
to the automotive value chain. These enabling value chains make electric vehicles a viable alternative to ICE (internal combustion engine) vehicles.

Traditional players in the automotive value chain have the possibility to extend their product/service portfolio by both i) engaging in the innovation opportunities that are directly related to their traditional product/service portfolio (i.e. e-vehicle design, build, maintenance and after-market) and/or ii) taking up opportunities in the enabling value chains that lie outside their traditional scope of activity.

Figure 3-2 shows indicators for market growth potential, job creation potential, GHG reduction potential and potential for transitions in the value chain for electrification of the powertrain as currently understood.

**Figure 3-2: Assessment of the innovation opportunity’s potential according to current forecasts**

### Market growth potential
Europe is now leading the world EV sales market (driven largely by Norway, France, the UK, the Netherlands, and Germany), with about 25,000 more electric car sales in the first half of 2015 than North America, and around 34,000 more than China. In the first half of 2015, almost 80,000 new battery electric and plug-in electric vehicles were registered in Europe (EVObsession, 2015). Sales rates are however still considered to be low and not on track to achieve ambitious deployment targets.

### GHG reduction potential
Electric power trains can lead to significant CO₂ emission reductions and air quality benefits. The tank-to-wheel GHG emission of a conventional ICE vehicle is approximately 140 gCO₂/kWh. The equivalent figures for a plug-in hybrid (PHEV) and battery electric vehicle (BEVs) are 92-126 g CO₂/km and 60-76 g CO₂/km respectively when assuming the average EU energy mix (467g CO₂eq/kWh). If the BEVs are solely charged by renewable energy, the emissions can drop to 0 g CO₂/kWh (R Edwards (EC JRC), 2011). Hence, a gradual decarbonisation of the electricity grid will be key to improve well-to-wheel GHG emissions from EVs.

### Job creation potential
Even though job losses can be expected in the oil and conventional vehicle industry, a net increase in job numbers thanks to e-vehicle deployment is foreseen (Todd, 2013). In a scenario where Europe rapidly moves to electrification, EU employment is forecast to increase by 850,000 to 1.1m jobs by 2030 (ECF, 2014). Any growth in market potential might however lead to job parity in the market in the longer run, due to a reduction of jobs in the internal combustion automotive industry. Within the EV value chain, EV components and charging infrastructure industry are expected to create the highest number of jobs.

### Transitions in the value chain
Electrification is driving growth in new business sectors. Large scale deployment of EVs requires a completely different ecosystem of which the functioning still has to be established. Utilities will have a major role to play as the energy source for EVs. Smart grid can help balance and create additional capacity and also enable consumers to manage EV charging costs. New business models will emerge in the areas of charging station manufacturing, installation and operations. Innovative financing solutions such as battery leasing, battery financing and car leasing to businesses have and will play a further contribute to higher sales of EV vehicles (GE Vehicle Innovation Center, n.d.).
3.3 Main new revenue streams for industry

New revenue streams that are closely related to the traditional value chain arise from the design and manufacture of electrified vehicles and their components. Hybrid and especially plug-in and battery electric vehicles require a re-thinking in the whole manufacturing process. The maintenance and after market segments will be confronted with the need for new skills to deal with new vehicle components and their specific requirements.

The following enabling value chains will provide revenue streams outside the scope of the traditional automotive value chains:

1. **Charging infrastructure provision** (e.g. Schneider (FR), ABB (CH)): The charging infrastructure value chain consists of equipment procurement, manufacture, sales, installation and maintenance services. Apart from the players who provide the infrastructure itself, there will be players who are responsible for network management, infrastructure operations and provision of home and public charging station services to end users. Charging infrastructure enables the use of plug-in electric vehicles. Different types of infrastructure are currently available (conventional, fast and rapid charge infrastructure) and there is potential to develop further (in terms of their features and deployment) technologies in the future such as wireless charging in-built in the road or ‘flash-charging’, such as currently developed by ABB (DH) (buses are charged within 15s at bus stations to allow them continue to the next flash charging at the next bus stop).

2. **Provision of electricity services** (e.g. EDF, ChargePoint (US), Ecotricity (UK)): Plug-in electric vehicles can be plugged into the existing electricity grid to recharge the on-board batteries. Electricity providers are increasingly important and engaging players and offer electric vehicle-related services such as metering, billing, etc for powering electric vehicles. Emerging technologies such as smart grid and vehicle-to-grid services by energy suppliers also benefit EV users to manage their energy costs.

3. **Telecommunication** (e.g. Vodafone (UK), AT&T (US)): Telecom providers are new players in the automotive value chain and will be increasingly responsible for data transfer and management from EVs to servers with the rise of electrified powertrains. Other companies will have opportunities to provide services such as bespoke fleet management tools, development of mobile apps to enhance e-mobility experience, charging infrastructure information and booking services.

Figure 3-3 on the following page shows the revenue streams along the traditional automotive value chain. The enabling value chain of charging infrastructure, which is also shown in this Figure is subject to a separate, more detailed analysis provided in Section 4.
Figure 3-3: Revenue streams along the traditional automotive value chain for the innovation opportunity ‘Electrification of powertrain’
3.4 Key risks and challenges affecting the uptake of the innovation

- **Lack of customer acceptance** due to (perceived) concerns on low driving range (“range anxiety”), customer awareness of the vehicle technology and its benefits, technology confidence, high upfront investment costs, and safety concerns.

- **Chicken and egg situation of recharging infrastructure availability** and e-vehicle deployment (customers want to see a broad role out of recharge infrastructure before investing into electric vehicles; infrastructure investors want to see a large uptake of electric vehicles before investing into recharge infrastructure).

- **Potential job losses** in existing automotive value chain.

- **Need for new/adapted skills** to deal with new vehicle components, their integration into the vehicle and their specific requirements (especially in the maintenance/repair and after market segments). There is a strong competing demand for skills (mechatronics, electronics, computer engineering etc.) with other sectors (e.g., aeronautics).

- **Lack of proven profitability of new products and services** – current plug-in EV models are partly sold at losses that are absorbed by the OEMs.

- **Lack of policy initiatives** to help drive demand for EVs, concerning demand-side measures, especially ‘soft’ measures such as access to bus lanes etc. (Norway is a role model, which is reflected in high EV uptake numbers) and supply-side measures (funds for R&D and infrastructure deployment).

3.5 Analysis by value chain segment

Although the following overview is provided by traditional value chain segments, nothing will prevent the actors in these sectors from seizing revenue streams that currently lie outside their traditional scope of activity. For example, component suppliers or OEMs might decide to seize opportunities that will evolve in the vehicle use stage and/or opportunities that are, traditionally, not related to the automotive sector.

The rating of the value creation opportunity (either ‘low’, ‘medium’ or ‘high) is a relative rating of the value creation opportunity of this segment compared to other segments in the value chain.
<table>
<thead>
<tr>
<th>VALUE CHAIN SEGMENT</th>
<th>COMPONENT SUPPLIERS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RATING OF VALUE</strong></td>
<td>Rating: HIGH</td>
</tr>
<tr>
<td><strong>CREATION</strong></td>
<td>• Component suppliers are seen to be a high value adding segment of the value chain because of the high dependency of the whole chain on the suppliers for their design and manufacture for high-value components. (Ernst, 2012)</td>
</tr>
<tr>
<td><strong>OPPORTUNITY</strong></td>
<td>• Suppliers are either technology specialists or process specialists who help in the whole process of component design, testing, and system integration with expertise in engine technology, battery and thermal management solutions as well as battery integration. They play a key role in the delivery of e-vehicles.</td>
</tr>
<tr>
<td><strong>RELEVANT ACTORS</strong></td>
<td>European: Bosch (Germany), Continental (Germany), Valeo (France), Saft (France), ABB (Switzerland)</td>
</tr>
<tr>
<td><strong>EXAMPLES</strong></td>
<td>International: NEC (Japan), A123 Systems (China), LG Chem (Korea)</td>
</tr>
<tr>
<td><strong>RELATED SECTORS</strong></td>
<td>The electronics industry is key to this innovation, as they have knowledge advantage relating to the key components of the electrified drivetrain (electric motors, power electronics and battery cells) (Ernst, 2012).</td>
</tr>
<tr>
<td><strong>COMPETITIVE LANDSCAPE</strong></td>
<td>• Despite the increasing EU market share in EV sales, the US is leading this industry in terms of high R&amp;D spend, favourable incentives, better infrastructure and legal environment, more accessible research facilities in universities, lower labour, production and energy costs, and strong cooperation among cities (Ernst, 2012).</td>
</tr>
<tr>
<td></td>
<td>• Korea and China have a lead in developing battery technologies.</td>
</tr>
<tr>
<td></td>
<td>• Europe is focused on powertrain development and alternative materials (presence of leading automobile technology companies, especially in Germany).</td>
</tr>
<tr>
<td></td>
<td>• Europe developed its own electronics strategy in 2013 to maintain Europe’s leading edge in the design and manufacturing of electronics (EC, 2015).</td>
</tr>
<tr>
<td><strong>RISKS AND CHALLENGES</strong></td>
<td>• Lack of sufficient standards for quality and performance (Ernst, 2012).</td>
</tr>
<tr>
<td></td>
<td>• Constantly evolving technology hinders high volume production.</td>
</tr>
<tr>
<td></td>
<td>• Competing demand for skills (mechatronics, electronics, computer engineering etc.), technologies and services with other sectors.</td>
</tr>
<tr>
<td></td>
<td>• Stress on re Lithium material with growing demand for batteries</td>
</tr>
<tr>
<td><strong>GEOGRAPHIC DIMENSION</strong></td>
<td>GLOBAL</td>
</tr>
</tbody>
</table>
### DRIVING INNOVATION IN THE AUTOMOTIVE VALUE CHAIN

#### VALUE CHAIN SEGMENT

<table>
<thead>
<tr>
<th>RATING OF VALUE CREATION OPPORTUNITY</th>
<th>OEMs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rating:</strong> MEDIUM TO HIGH</td>
<td></td>
</tr>
<tr>
<td>• Majority of OEMs have limited expertise and intellectual property in the main technology components of electric vehicle technologies, especially in electrochemistry and power electronics and thus require a strong strategic alliance with suppliers.</td>
<td></td>
</tr>
<tr>
<td>• However, OEMs are key in developing system level R&amp;D, vehicle integration, efficient manufacturing techniques, targeted sales and service support.</td>
<td></td>
</tr>
<tr>
<td>• High dependency on suppliers reduces the profitability of OEMs.</td>
<td></td>
</tr>
<tr>
<td>• Especially in case of plug-in EVs, revenue streams are higher for OEMs if they increase the scope of their activities and increasingly engage in vehicle use stage to benefit from these later-stage opportunities as well.</td>
<td></td>
</tr>
</tbody>
</table>

#### RELEVANT ACTORS (EXAMPLES)

<table>
<thead>
<tr>
<th>European:</th>
<th>International and Other:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renault-Nissan (France/Japan), BMW (Germany)</td>
<td>Toyota (Japan), Tesla (USA), BYD (China – JV with Daimler)</td>
</tr>
</tbody>
</table>

#### RELATED SECTORS

| Telecom industry to provide OEMs (and maintenance services providers) with real time information on vehicle and battery status to support R&D and design improvements. |

#### COMPETITIVE LANDSCAPE

| • Europe has many premium vehicle manufacturers whose EV platforms may instil consumer faith in the technology. |
| • European OEMs have a competitive advantage due to their competences in vehicle production, engineering and availability of qualified personnel along with a highly competent European chemical industry that is important for ongoing battery development that helps to decrease their cost in the long run (Ernst, 2012). |

#### POTENTIAL BENEFITS / 'INTERNAL' DRIVERS

| • European OEMs can deliver the whole range of EVs but thanks to their highly competitive ICE technologies, they may have more competitive advantage in hybrid models that still rely on an ICEs compared to other technologies in the short to medium term. |
| • OEMs can seize the opportunity to develop a market to build both an internal and export market (rather than ‘allowing’ importing cells or the battery pack) for all electrification types. |
| • Electrification of the powertrain is a high value strategy for OEMs to comply with increasingly stringent CO₂ targets and will potentially become the only means to comply with such standards in the long run. |
| • In the long run, full electric cars have the potential for reduced production costs, potentially leading to greater profit for the OEMs. |
| • OEMs’ strategies are driven by consumer preferences but can also influence consumer choice. This can lead to consumers increasingly recognising the value of EVs (NB: see the following section on vehicle use phase), yielding higher sales. |
| • OEMs are well placed to develop new business models to diversify their business and increase their range of products and services. A key option to deal with decreasing vehicle ownership rates in Europe. |

#### RISKS AND CHALLENGES

| • High investment required and thus a larger economic risk if reasonable sales numbers are not generated (Ernst, 2012), which is currently the case in Europe. |

#### GEOGRAPHIC DIMENSION

| GLOBAL |

---

**Source:** Ernst, 2012.
## Driving Innovation in the Automotive Value Chain

### Value Chain Segments

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
</tr>
</thead>
</table>
| **Rating of Value Creation Opportunity** | Rating: MEDIUM - HIGH
  • Services around the vehicle use stage will become crucial to increase user friendly features, avoid risks and reduce range anxiety for drivers (i.e. the fear to run 'dry' due to the comparatively limited battery capacity). These services are largely inexistent in the traditional automotive value chain and key to scaling up electric vehicles. |
| **Relevant Actors (Examples)**        | Customers: 
  Private EV users; car clubs such as Paris-Autolib, Car2Go; Company fleets (British Gas (UK), FedEx (US), EDF (FR), La Poste (FR) etc.)
  Other Stakeholders: 
  Charging service providers (ChargePoint (US), Ecotricity (UK)), utilities and energy service providers (EDF), Smart grid and vehicle-to-grid integrators (ABB (CH), Cisco (US)), Telecom (Vodafone (UK), AT&T (US)), DSOs (50 Hertz, ENEDIS) |
| **Related Sectors**                   | • Europe is one of the largest plug-in vehicle markets today. Norway and Netherlands have the highest share of EVs in Europe. Other big markets are USA and Japan. China’s market is expected to increase significantly, although increases in vehicle ownership rates have slowed down recently.
  • Europe already has an intelligent transport systems (ITS) action plan and a Directive that supports the engagement of the telecom sector in the mobility space (i.e. development of smart cars, cooperative intelligent transport systems (C-ITS)).
| **Competitive Landscape**             | • Finance and lease industry (e.g. commercial banks or independent finance companies) that provide services such as electric car leasing and battery leasing.
  • Telematics service providers and mobile application developers.
  • Utilities industry: (sustainable) electricity production and distribution, energy subscription services and smart grid management.
  • Diverse mobility integrators who offer innovative mobility solutions with unique business models such as electric car share, carpool, peer-to-peer car rental service, etc. (Frost & Sullivan, 2011) |
| **Potential Benefits / 'Internal' Drivers** | End users (Vehicle users):
  • Reduced total costs of vehicle ownership (reduced fuel costs, potentially reduced maintenance costs of full battery electric vehicles compared to complex ICE cars, potentially reduced other ownership costs (i.e. via subsidies/policy interventions).
  • Time gains through home charging option (no trips to and queues at fuel stations).
  • Value from backup electricity stored in battery (i.e. in case of electricity shortages) sold back to the grid or used to power homes (vehicle-to-grid systems).
  • Value from image creation - environmental/technological awareness / acceptance of new technologies / “smart” choices / “innovator”) - for consumers and fleet operators/owners (companies).
  • Value from enhanced driving experience (fast acceleration, quiet vehicles etc.).
  EU electricity sector:
  • Potential to add value in enabling intermittent energy sources (wind, solar) thanks to increased decentralised electricity storage capabilities (car batteries)
  • Potential to add value in providing new energy-related business models/services such as smart metering, vehicle-to-grid etc. and in driving the uptake of smart grids thanks to using EV batteries as energy storage that can contribute to balancing supply/demand
  • Self-consumption (Vehicles-to-Home) with PVs or small wind turbine (e.g., in Denmark)
  ICT/Telecom sector:
  • Arising opportunities in the automobile market to manage data transfer and management services between EVs, charging stations, fleet managers, vehicle users, OEMs etc.
  • Opportunities to add value in realising bespoke solutions to these stakeholders/entities by making use of available data (e.g. fleet management tools, mobile apps, booking services etc.)
  Charging infrastructure sector (will be discussed in separate value chain). |
| **Risks and Challenges**              | • Lack of customer acceptance due to (perceived) lack of driving range for EVs ("range anxiety"), lack of customer awareness of benefits, high upfront investment costs, lack of technology confidence and safety issues.
  • Costs of connection to the distribution grid to high for home owner |
<p>| <strong>Geographic Dimension</strong>              | Regional |</p>
<table>
<thead>
<tr>
<th>VALUE CHAIN SEGMENT</th>
<th>VEHICLE MAINTENANCE &amp; AFTER USE SERVICE PROVIDERS</th>
</tr>
</thead>
</table>
| RATING OF VALUE CREATION OPPORTUNITY | Rating: MEDIUM  
- There is a potential for high value creation in the recycling and refurbishing industry from the batteries (e.g. the high value metals of cobalt and nickel, also lithium once demand increases and recycling lithium becomes necessary/viable). |
| RELEVANT ACTORS (EXAMPLES) | Aftersales service stations, advertisers and vehicle & battery recyclers (such as Retriev Technologies, 4R, Umicor); battery refurbishers to develop battery second life applications (OEMs such as Nissan and GM). |
| RELATED SECTORS | • Battery recycling industry (i.e. use of batteries in static applications).  
• Telematics industry: Companies that are responsible for data aggregation and management help in vehicle surveillance and maintenance. The data from the vehicle helps service and maintenance providers in diagnosis and prognosis of issues in the vehicle. |
| COMPETITIVE LANDSCAPE | • Currently there are unrealised opportunities in battery refurbishing, recycling, swapping, etc. (McIntire-Strasburg, 2015). |
| POTENTIAL BENEFITS / ‘INTERNAL’ DRIVERS | • Entirely new value-adding market that will evolve to refurbish and recycle batteries and e-vehicle specific components for their reuse or vehicle after-use.  
• If raw materials are properly recycled this can put downward pressure on wholesale prices (e.g. Lithium or Manganese)  
• New opportunities in the vehicle maintenance segment to cope with new components and especially batteries and their management systems (e.g. battery rebalancing, replacements, or upgrades). |
| RISKS AND CHALLENGES | • High risk as economic benefits and business case are not entirely clear.  
• A large-scale take up of full battery-electric vehicles may reduce the overall need for vehicles maintenance services (as battery EVs require less maintenance due to their simpler technology than conventional vehicles). |
| GEOGRAPHIC DIMENSION | REGIONAL |
4 KEY INNOVATION II: EV CHARGING INFRASTRUCTURE

4.1 Key highlights

- **EV charging infrastructure is vital for the adoption of electric vehicles and therefore contributes to the decarbonisation of the sector.** EV charging stations for EVs are equivalent to fuel stations for ICE vehicles. EV charging stations should ideally be powered by wind or solar energy turning electric vehicles into a zero emission transport solution.

- **The total number of private and public EV charging stations in Europe is expected to reach 1.8-2 million in 2017 and 3.6 million by 2020** (with current levels at around 0.7 million), with the fast charging station market showing 100 fold increases through 2020.

- Europe is well known for its strength in engineering innovation which can be used to customise recharge devices for particular specialty niches (such as smart grid technologies, wind-powered charging solutions, etc.). However, the US has already brought forward innovative ideas for new charging solutions (such as FreeWire and their ‘Mobi’ mobile charging unit).

- **Charging infrastructure helps to addresses range anxiety.** Due to the limited range available in most EVs today, a robust public charging infrastructure is required to address the issue of range anxiety (phenomenon where drivers worry that the electric car battery will run out of charge before the destination). However, charging solutions that are currently being deployed still require longer charging times compared to the time taken to refuel a conventional ICE vehicle.

- **The charging industry is currently facing a number of issues affecting deployment at scale.** Decisions on the type of plug/sockets, charging protocols, standards etc. have to be made and enforced - these choices could affect EV uptake for years to come. Viable business models still have to emerge/be proven and legislative framework conditions have to be put in place to allow deployment at public and private premises, including semi-private premises such as collective housing (in France already in 2011 legislation was put in place that ensures that also people in collective housing can gain access to recharge infrastructure thanks to the ‘droit à la prise’ (‘right for a socket’)).
• **Home charging is a dominant method of charging EVs.** It will remain so in the short to medium term, however public charging network is vital to overcome range anxiety. Workplace charging is a promising second option for charging infrastructure.

• **Technical and organisational interoperability across public charging stations and providers is a key driver.** Subscribers to one network should be able to charge at other locations while not experiencing any technical barriers or paying high prices for switching between operators.

• **Charging infrastructure is a potential source of revenue for various stakeholders.** For example, retailers deploying charging infrastructure in front of their premises have the potential to create revenue from both providing parking space (i.e. via parking fees) and the customer being attracted to their store/spending more time at their store. Examples of retailers who have started providing EV charging stations at their facilities are IKEA and Kroger Co.

### 4.2 High-level description of the innovation opportunity

A well-developed electric vehicle charging infrastructure is vital for wide-spread adoption of plug-in electric vehicles. Unlike regular internal combustion engine (ICE) vehicles, plug-in electric vehicles (in the following simply abbreviated as ‘EVs’) require a recharging infrastructure that is built upon the currently existing electricity supply infrastructure – an infrastructure that is new to the automotive sector. Wide-spread EV adoption has to overcome a "chicken-and-egg situation". A situation where investment in an EV charging infrastructure requires a large number of electric cars on the road to become economically viable. At the same time EV users prefer to see a well-developed charging infrastructure in place before deciding to purchase an electric car. To overcome this situation, Governments in Europe (such as in the UK, France, Germany, etc.) are increasingly investing in charging infrastructure. They have subsidised home and public charging stations to kick-start the adoption of EVs (ABB, 2014).

There are different charging solutions available that respond to different charging needs:

• **AC home charging** (110V/220V, 15A-32A) is suitable for domestic use. Nissan uses a home charging solution from AeroVironment (US), which allows recharging of a typical 24 kWh lithium ion battery pack within 8 hours.
• **Fast/rapid (AC or DC) charging** solutions, for example from Ecotricity (UK), are widely used in public areas as they allow recharging such batteries to 80% capacity within 30 mins. Tesla is an example of a vehicle provider that has been rolling out such rapid charging infrastructure in the public space (i.e. its ‘Supercharger’ network) across North America, Europe and China\(^6\). It only caters Tesla vehicle S models (20-30 min charging time for 50% of the battery) that can use these chargers for free of any extra charge.

• **Wireless/inductive charging** which utilises an electromagnetic induction to charge the battery when the electric vehicle is in motion or parked over the charging plate. Wireless charging is a more expensive and less efficient mode of recharging and may thus become a premium charging option for its convenience. Also ‘flash-charging’ solutions, such as currently developed by ABB (DH) can be considered as wireless charging solutions (buses are charged within 15s at bus stations to allow them continue to the next flash charging at the next bus stop).

• **Battery swapping** solutions refer to systems that allow depleted batteries to be exchanged with newly charged batteries at dedicated swapping stations within several minutes. The company Better Place (US) that had started deploying their battery swap systems in demonstration projects around the globe at the beginning of this decade (e.g. in Israel, Denmark, San Francisco, Hawaii etc.), in cooperation with Renault-Nissan. Better place filed for bankruptcy in 2013. Some of the reasons that are said to have contributed to this bankruptcy were i) lower than expected EV uptake numbers, ii) standardisation requirements (necessary for the battery swap process) that were not attractive (i.e. too restrictive on design) for car and battery manufactures, and iii) high investment costs for battery swap stations.

Increasing numbers of start-up companies in the sector show that there is significant scope for innovation: for example, FreeWire (US) has developed a mobile EV charging unit, called Mobi, which avoids high infrastructure costs, can avoid underutilisation and allows a quick scale up of capacity by flexibly adding more Mobi stations.

Other innovative charging solutions are, for example, wind or solar EV charging stations.

Figure 4-1 shows indicators for market growth potential, job creation potential, GHG reduction potential and potential for transitions in the value chain for charging infrastructure as currently understood.

\(^6\)http://www.inautonews.com/tesla-aims-for-europe-wide-charging-infrastructure
Market growth potential

The total number of private and public EV charging stations in Europe is expected to reach 1.8-2 million in 2017 and 3.6 million by 2020 (with current levels at around 0.7 million), with the fast charging station market showing 100 fold increases through 2020. Europe has recently experienced strong EV sales (a growth of 55% in the first half of 2015 when compared to the first half of 2014), which should go in hand with an acceleration of the EV charging station market. Approximately 10% of EV charging stations are expected to be within the public or semi-public domain by 2020 (Hayfield, A., 2013). Such public stations will be required to make sure issues of ‘range anxiety’ are adequately addressed.

GHG reduction potential

EV charging stations should ideally be powered by wind or solar energy turning electric vehicles into a zero emission transport solution. Smart grids can help integrate the system better and can monitor energy flows and adjust to changes in energy demand and supply. In the US, between March 2012 and July 2013, EV charging stations provided 6.1 Megawatt hours of energy via 1,419 charges which is equivalent to 966 gallons of gasoline and 8,054 kg GHG emissions saved. (THV11, 2013)

Job creation potential

EV charging infrastructure can provide job opportunities across its entire value chain. Charging infrastructure is one of the areas expected to produce maximum new jobs in the EV industry to address sector specific issues and risks. The spill over effects on jobs and output are expected to be high due to the long and diversified supply chain. However, in the long run, considering a high uptake scenario, public (typically unmanned) and private electric recharging infrastructure might come at the cost of jobs at conventional petrol/fuel diesel fuel stations. (ECF, 2014)

Transitions in the value chain

Different EV charging business models have emerged - each with its own level of complexity, risks and reward structure. The general value chain consists of the charging infrastructure hardware manufacturer, installation and maintenance service providers, managers of the entire charging infrastructure, agents that integrate smart-grid solutions for utilities, and providers of consumer services including charging station details aggregator, day-to-day operators of infrastructure, etc. (EY, 2011) However, it is still uncertain if charging infrastructure operation will become a viable business model for investors and entrepreneurs in the long run.
4.3 Main new revenue streams for industry

The charging infrastructure value chain is **multi-dimensional** (meaning that there are multiple options of electricity sources, utility providers, service providers, etc.), **highly modular** (meaning that single players such as infrastructure providers or service providers can be easily added or replaced) and has a potential for **mass customisation** (meaning that service offerings can be easily tailored to consumers’ preferences, such as the type of recharging, the type of energy source, etc.).

In a nutshell, the charging infrastructure value chain must: i) enable the transfer of electricity from the producer to the user, ii) have a metering and billing system that allows the user to pay for the service, and iii) follow safety protocols and carmakers’ requirements to guarantee the safety and interoperability of the infrastructure system. Providing these services, and the necessary infrastructure with it, comes with various **revenue streams along the value chain. These can be grouped around the following value chain segments:**

1. **Charging station suppliers** (e.g. Siemens (DE), Bosch (DE), ABB (CH), Schneider Electric (FR), Tesla (US), who also acts as provider and operator) - They are responsible for the designing, procuring of raw materials and manufacturing of the charging stations. The design of the charging stations must comply with safety regulations and be compatible with EV manufactures requirements. The suppliers sell the charging stations to the infrastructure providers.

2. **Charging station infrastructure provider** (e.g. Vinci Energies (FR), Elektromotive (UK) (also an operator)) - These players are responsible for the physical installation of the charging stations and their connection to the grid. The real estate for installation may be provided by home owners, parking lot providers, retail stores, public authorities, private companies, etc. Construction companies support the infrastructure providers by provisioning the groundwork, wiring, etc.

3. **Charging station operator** (e.g. ChargeMaster (UK), Ecotricity (UK)) - The operators are responsible for the day-to-day operations of the station and act as customer interface. They work with utilities who are responsible for the electricity supply (grid or renewables). Together with the utilities, station operators may also enable compatibility with smart energy grid and provide smart charging capabilities. They also work with IT companies who are responsible for data management and development of tools which allow then to provide metering, billing, in-vehicle/mobile-based infrastructure information and customer support services to EV users.

4. **Charging station maintenance & servicing** (e.g. Elektromotive (UK)) - Maintenance service providers are responsible for conducting routine maintenance and servicing charging station network on a regular basis over the contract period. They may work with infrastructure providers or operators.
Revenue streams furthermore arise in the enabling value chains of:

1. **Provision of electricity services** (e.g. EDF (FR), Scottish Power (UK)): Utilities provide electricity required to charge the electric vehicle. The electric utility company also enables compatibility with smart energy grids and smart charging. The smart energy grid will allow dynamic energy sourcing (provide the choice of energy source such as coal, solar wind, etc.), load distribution (manage peak demand or source electricity from areas which are utilising less energy during that time of the day) and remote energy management (support from telecommunication companies). The utilities also enable smart charging capabilities, i.e. enable users to manage their energy consumption, monitor status of charge of the vehicle, schedule charging, etc.

2. **Telecommunication and IT services** (e.g. Zapmaps (UK), Chargemap (FR), Vodafone (DE), etc.): Telecom and IT service providers facilitate the web integration of the charging infrastructure network. Data regarding the usage, availability and functioning of a public charging station is transmitted to the operator who in turn can allow users to access the information as a value-added service. There are a number of companies, such as Zapmaps (UK), who integrate charging station details from various operators into their website and provide smart phone applications for dynamic access of this information to drivers or other stakeholders. IT systems are further also required to identify and authorise users to benefit from the charging network (e.g. via radio-frequency identification technology (RFID) and providing telephone-like roaming services to users not registered to the specific system). Telecom and IT service providers also provide services such as metering, billing and customer support.

3. **Real estate provision** (e.g. Stores like IKEA, services along motorways): Real estate is one of the highest cost factors to install public charging infrastructure. It requires support and possibly investment from private companies, public authorities, private land owners and home owners alike. Revenue streams for real estate providers may come from an increased number of customers/time spent at retail outlets, from the charging of parking and/or charging fees.

4. **Civil engineering services** (e.g. Vinci Energies (FR)): Civil engineering companies facilitate the installation of charging stations at parking lots, work places and residential buildings and might take responsibility for connecting the stations to the electricity network and intelligent energy management systems. (Vinci Energies, n.d.)

Figure 4-2 on the following page shows the above revenue streams along the traditional automotive value chain segments and the enabling value chains.
Figure 4-2: Revenue streams along the traditional automotive value chain for the innovation opportunity ‘EV charging infrastructure’
4.4 Key risks and challenges affecting the uptake of the innovation

- **Interoperability.** Charging service to EV users’ needs to be interoperable between different service providers/operators, across Member States. Interoperability of stations is a key driver for a successful roll out of infrastructure, which will allow subscribers to switch between different charging stations operators while, for example, paying telephone-like ‘roaming’ charges when using charging infrastructure that is not included in their subscription.

- **Charging protocols.** The plug and charging protocols currently still vary between different EV manufacturers and charging station providers. While this is not a concern for home charging stations (manufacturers recommend the plug most suitable for their EV - for example, Nissan has liaised with AeroVironment (US) who provides a home charging unit with a SAE J1772 plug), public charging networks need to be accessible for all EV models. Some examples of different kinds of plugs used in public fast charging stations are CHAdeMo (compatible with EV models from Nissan, Mitsubishi, Citroen, etc.), Mennekes Type 2 (AC connector used in Audi, BMW, Chevrolet and Daimler), Combined charger System-CCS (BMW, Chrysler, Ford, GM, Porsche, and Volkswagen) and Tesla’s supercharger (for Tesla Model S). Stakeholders are currently still disputing over the most favourable standard for charging station plugs and power levels. However, certain industry players also advocate to refrain from any standardisation at this stage of development, taking the view that all standardisation restricts further innovation in the sector.

- **Uncertain market.** The EV charging infrastructure market is still evolving - and constantly upgraded with new designs, technologies and standards. Given the limited uptake of EVs till date and the limited use of charging infrastructure, infrastructure providers currently still experience high and capital-intensive investment risks.

- **Uncertain capacity utilisation.** While many EV user behaviour studies show that the dominant charging method will be home and workplace charging, public charging infrastructure will also be required to solve the ‘chicken-and-egg’ situation and cater for the exceptional circumstances when home and/or work charging does not suffice. While the build-up of such public charging infrastructure is capital intensive, it remains uncertain whether this infrastructure’s utilisation rates will yield viable business models.
### 4.5 Analysis by value chain segment

While the following overview is provided by specific value chain segments, nothing will prevent the actors to seize revenue streams that currently lie outside the scope of their segment. For example, Eletromotive (UK), a charging station infrastructure provider, has also expanded into the operator sector providing charging services to EV users.

The rating of the value creation opportunity (either ‘low’, ‘medium’ or ‘high’) is a relative rating of the value creation opportunity of this segment compared to other segments in the value chain.

<table>
<thead>
<tr>
<th>VALUE CHAIN SEGMENT</th>
<th>CHARGING STATION SUPPLIERS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RATING OF VALUE CREATION OPPORTUNITY</strong></td>
<td><strong>European:</strong> Bosch (DE), Elektrobay (UK), ABB (CH), Schneider (DE), Siemens (DE) <strong>Other/International:</strong> Semaconnect (USA), Eaton (USA), Hitachi (JP)</td>
</tr>
<tr>
<td><strong>RELEVANT ACTORS (EXAMPLES)</strong></td>
<td><strong>RELATED SECTORS</strong></td>
</tr>
<tr>
<td><strong>COMPETITIVE LANDSCAPE</strong></td>
<td><strong>Charging station component suppliers are dependent on key strategic partners to succeed (OEM, city administrations, etc.), which allow them to focus on technology development while the partner assures or creates infrastructure demand. Partnerships with OEMs and infrastructure providers can lead to higher sales.</strong></td>
</tr>
<tr>
<td><strong>POTENTIAL BENEFITS / ‘INTERNAL’ DRIVERS</strong></td>
<td><strong>In the nascent stage of the industry, the charging infrastructure may have to be constantly upgraded with new designs, technologies and standards.</strong></td>
</tr>
<tr>
<td><strong>RISKS AND CHALLENGES</strong></td>
<td><strong>Charging station suppliers and providers – see next table – face the issue of unclear responsibilities in who is responsible for the roll-out of charging infrastructure. As a result, clients and marketing strategies are unclear (e.g. clients can range from retailers to public authorities and private persons).</strong></td>
</tr>
<tr>
<td><strong>GEOGRAPHIC DIMENSION</strong></td>
<td><strong>GLOBAL</strong></td>
</tr>
</tbody>
</table>

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1 HVAC- Heating, Ventilating, and Air Conditioning

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**Example:**

- This sector has many branded and unbranded players. Suppliers will have to constantly revamp their product to stay in the business, which may include technology innovation (such as innovation in modularity of design, increased efficiency of charging, functioning etc.).
- This value chain segment has a very low barrier to entry as the technology is low-tech; players will compete on price and compatibility with electric vehicles.
- As hardware is getting commoditised, the cost of a standard charging station has already dropped by around 50% between 2011 and 2013.
- There are higher-value opportunities for inductive charging as a premium charging option or for public transport like electric buses, etc. and other more innovative charging solutions which might become viable alternatives.
### CHARGING STATION INFRASTRUCTURE PROVIDERS

<table>
<thead>
<tr>
<th>VALUE CHAIN SEGMENT</th>
<th>RATING OF VALUE CREATION OPPORTUNITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rating: MEDIUM</td>
</tr>
<tr>
<td></td>
<td>• It is a low cost and low technology service, which in the short term is a high volume low margin business opportunity.</td>
</tr>
<tr>
<td></td>
<td>• There are limited number of customers (station operators and EV owners) and growth is highly dependent on the uptake of electric mobility.</td>
</tr>
<tr>
<td></td>
<td>• Infrastructure providers can choose to engage in the management of the network, in customer service and maintenance services, to benefit from further revenue streams.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RELEVANT ACTORS (EXAMPLES)</th>
<th>European:</th>
<th>Other/International:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Elektromotive (UK), Vinci Energies (France), Elm (UK), ChargePoint (UK)</td>
<td>CarCharging (USA)</td>
</tr>
</tbody>
</table>

| RELATED SECTORS | Civil engineering: Infrastructure providers will need to liaise with companies providing civil engineering services to deploy the infrastructure. |
|                | Real estate: Land owners need to demand or at least authorise the installation of charging infrastructure. |

| COMPETITIVE LANDSCAPE | Many countries in Europe are providing subsidies to install charging stations. For example, the scheme Chargeplace Scotland provides a 100% subsidy to Scottish organisations who install charging stations provided that the charging facility is free for public use for the first 12 months. |
|                       | In Japan, four automakers (Toyota, Honda, Nissan and Mitsubishi) have jointly established a company, Nippon Charge Service, which compensates set-up costs and operating fees for firms and municipalities looking to build a charging station. |

| POTENTIAL BENEFITS / ‘INTERNAL’ DRIVERS | Infrastructure providers can facilitate on-site renewable energy to power the station to attract environmentally friendly EV users, thereby adding value to the overall charging proposition and attracting more users. Such solutions might also prove to be commercially interesting for the operator. |
|                                       | • Infrastructure providers can actively engage in the market for home charging stations by liaising with EV manufacturers and EV dealers to benefit from both private and public charging infrastructure deployment. |
|                                       | • Infrastructure providers might choose to expand their activities to operator and maintenance services. |

| RISKS AND CHALLENGES | Challenge to expand geographically as infrastructure providers will need to forge new partnerships in different regions and comply with regulations and requirements which may vary from region to region. |
|                     | Set-up of charging infrastructure is capital-intensive, which is a barrier to actively engaging in this value chain segment. |

| GEOGRAPHIC DIMENSION | REGIONAL |

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**Driving Innovation in the Automotive Value Chain**
### Rating of Value Creation Opportunity

**Rating:** HIGH

- Although EV charging station operations are a low technology solution, it can be positioned as a high cost service. (Ernst & Young, 2011)
- Charging station operators have the potential to offer value adding solutions highly beneficial for the user such as ensuring:
  - Compatibility with smart energy grids (which enables dynamic energy sourcing, load distribution and remote energy management) as well as,
  - Smart charging capabilities (energy measurement, monitoring status of charge, management of load on the grid, etc.)
- Operators further have the opportunity to provide (in partnership with IT and Telecom service providers) IT services and supporting tools such as in-vehicle/mobile-based infrastructure information for EV users (for example comprising information on the availability of stations, status & type of stations, energy cost, etc.), one-touch RFID solutions for user recognition, cashless payment plans, to enhance the user’s charging experience.

### Relevant Actors (Examples)

**European:**
- Zero Carbon world (UK), Fullcharger (FR), Clever (DK)

**Other/International:**
- Chargepoint (US), Plugshare (US), NRG eVgo (US)

### Related Sectors

- **ICT and Telecom sector:** responsible for the customer interface, and web connectivity of the charging stations.
- **Utilities:** Responsible for electricity supply, enabling of smart grid services and provision of renewable energy.

### Potential Benefits / ‘Internal’ Drivers

- As of August 2014, Japan (1,978) had the largest network of CHAdeMO fast chargers, followed by Europe (1,181) and then USA (686). Japan is now home to more EV public charging points than fuel stations.
- Strategic alliances between suppliers, providers, operators and EV manufacturers will prevent operators from other countries to easily enter the market.

### Risks and Challenges

**Operators**

- A wide variety of value adding services (such as metering, billing, mobile-based services, station management, etc.) to a large numbers of customers improves profitability as variable cost is low.
- Customers will need to subscribe to a network connection, which provides regular income and higher customer retention.
- This segment is characterised by low variable costs (similar to the telecommunication industry) meaning that every additional customer benefiting from the services of the charging station operator will result in increased profitability (and ROI).
- Data management processor will provide operators with insights into subscribed customers such as consumer details, charging patterns, average energy consumption, etc. These key consumer insights will help operators enhance user experience by providing bespoke subscription options.

**Other enablers**

- EU electricity sector:
  - Potential to benefit from value adding services by providing new energy-related business models/services such as smart metering, vehicle-to-grid connectivity, peak shaving, energy consumption updates, etc.
  - EV charging stations can be made compatible with smart grids to allow dynamic electricity sourcing, providing the best cost solution to the consumers’ preferences.
- ICT/Telecom sector:
  - Potential to benefit from value adding services from in-vehicle/mobile-based infrastructure information services to EV users.

### Geographic Dimension

**Regional-Global**
<table>
<thead>
<tr>
<th>VALUE CHAIN SEGMENT</th>
<th>INFRASTRUCTURE MAINTENANCE &amp; AFTER USE</th>
</tr>
</thead>
</table>
| RATING OF VALUE CREATION OPPORTUNITY | Rating: LOW  
• There is a low value added potential in this industry as the technology to be serviced is low tech.  
• Resolving technical issues will require support from grid management companies and charging station suppliers, as a result there is a high dependency on other players for providing appropriate services, which will require profit sharing.  
• Charging station infrastructure providers or operators may also take on the responsibility of infrastructure servicing and maintenance limiting the business opportunities for players whose primary focus is charging station service & maintenance, resulting in high competition and loss in market share.  
• Resale value and market of the charging station equipment is unknown. |
| RELEVANT ACTORS (EXAMPLES) | Regional players and unbranded service providers such as ABM (UK). |
| COMPETITIVE LANDSCAPE | Due to the low value creation opportunity of this segment, small, regional players should be encouraged to extract value from this segment of the value chain by liaising with infrastructure providers and charging equipment suppliers. |
| POTENTIAL BENEFITS / ‘INTERNAL’ DRIVERS | Value can be created from this segment by providing EV operators (or private persons who have deployed infrastructure at their private premises) a wide array of services such as periodic cleaning services, standardised inspection and testing, continuous monitoring and alert management, repair when needed and providing manufacturer-approved warranty service.  
• Market can be captured by catering to all kinds of charging equipment from different manufacturers and different power levels – potential that can be exploited by strategic partnerships with operators. |
| RISKS AND CHALLENGES | It will be a challenge to expand geographically as service and maintenance providers will need to forge new partnerships in different regions and comply with regulations and requirements which may vary from region to region. |
| GEOGRAPHIC DIMENSION | REGIONAL |
5 KEY INNOVATION III: SHARED MOBILITY SERVICES

5.1 Key highlights

- **Vehicle sharing will reduce emissions** thanks to the more efficient use of the vehicles and to the typically new and fuel-efficient fleet that car clubs offer (such as small and increasingly even electric vehicles). Carplus (UK) estimates that the UK car club fleet saves 2,700 tonnes of carbon per year, each vehicle producing 30% less carbon than the average UK vehicle.

- **Shared Personal Mobility is an increasingly growing market.** Registered car sharers in Germany rose nearly 7-fold between 2010 and 2014 to 1.04 million. The trend for this is to increase across Europe with more car clubs (Zipcar, City Car Club) being created.

- **While not necessarily market leaders in tracking and monitoring devices, European suppliers can leverage on their close relationships with OEMs to capture market share.** These long established relationships and proximity to OEMs gives European in-vehicle monitoring systems (IVMS) suppliers a competitive edge.

- Most shared mobility innovations appear to stem from California, where there is a high share of urban consumers using on-demand ‘e-hailing’ (ordering a means of transport via a computer or mobile device) services (such as Uber). However, this does not limit Europe’s opportunities to engage in the provision of shared mobility services. Many of these services, especially where infrastructure and public space are needed, require the consent of local public authorities, which may be an entry barrier for international companies. **Expansion towards the East** (i.e. China, where car ownership has recently been slowing down) will be a growth opportunity.

- **OEMs can move into the space of vehicle sharing services:** some are already taking the lead, such as Daimler’s “Car2Go” (present in 30 cities in Europe and the US) and Ford’s dynamic car sharing scheme (“GoDrive”), which offers cars and car parks in 20 locations in London.

- **Not only private persons, but also corporations have the opportunity to capitalise on car sharing:** Companies can make use of corporate car-sharing schemes such as AlphaCity (BMW) to reduce parking congestion around their sites, make better use of their land and/or reduce total costs of fleet ownership, all depending on the exact application and scope of the shared vehicles.

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8An IVMS (In Vehicle Monitoring System) combines the installation of an electronic device in a vehicle, or fleet of vehicles, with purpose-designed computer software at least at one operational base to enable the owner or a third party to track the vehicle’s location, collecting data in the process from the field and deliver it to the base of operation.
5.2 High-level description of the innovation opportunity

Several mega trends such as increased urbanisation leading to rising congestion, pressures on individuals’ disposable income and new mobility services and technologies have triggered consumers to seek out more innovative ways to travel. Shared mobility services refers to the common use of modes of transport that were traditionally used as personal or private means of mobility. This includes vehicle sharing (renting cars or bikes for a short period of time) or carpooling (shared use of a car, also known as ‘ride sharing’; e.g. CarPooling (UK), BlaBlaCar (UK, FR), Car2gether (Daimler, DE)). Both types of service can be ‘dynamic’, i.e these operations can happen at very short notice, typically via the use of appropriate computer/telephone software.

Vehicle sharing can be further differentiated into:

- **Peer-to-peer (P2P) vehicle sharing** - A fleet of cars is owned by a private persons. The marketplace matches owners of cars that are available to other drivers to rent for short periods of time (e.g. Relayrides (US), Getaround (US), Buzzcar (FR), Livop (FR), EasyCar (UK), Autopia (BE))
- **Business-to-consumer (B2C) vehicle sharing** - A company owns a fleet of cars and facilitates the sharing amongst members, these companies could, for example, include
  - auto manufacturers (e.g. BMW (“DriveNow”, DE), Renault (“Twizyway”, FR), Daimler (“Car2Go”, DE)),
  - rental brands (e.g. Hertz (“Hertz 24/7”, US)), or
  - specific car sharing brands (e.g. ZipCar (US), Stadtauto (DE), GoGet (AU), Autolib (FR))
- **Not-for-profit (NFP) vehicle sharing** - A local organisation or community that facilitates car sharing with the goal of changing driving habits over making a profit (e.g. CityCar Share (San Francisco Area), Modo (CAN)).

*Uber* has been cited as a car sharing service, although this is not entirely correct. It is better classified as an on-demand transport or an innovation on the traditional taxi model. Many such ‘ridesourcing’ mobility options (the passenger and the driver do not share

- **Users of shared vehicle service schemes will increased their disposable incomes by avoiding the sunk costs of an owned vehicle.** This can be a benefit to the wider European economy.
- **Online services such as comparison and review platforms will be able to capture value through expansion of their services into the shared mobility sector.** In the UK alone, such services are used by 10m people that generate £650m in commission fees (for example, Money Supermarket was recently valued at £560m on FTSE generating £40m in profit annually).
the same destination, as compared to the “traditional” carpooling or ridesharing) rely increasingly on ‘e-hailing’ - the process of ordering a car, taxi, limousine, or any other form of transportation via a computer or mobile device. Companies delivering such online platforms are called **Transport Network Companies (TNCs)** (examples are Lyft, Sidecar, Wingz, Summon, next to Uber (all US) or Haxi (UK)). TNCs are considered under shared mobility services given their increasingly important position in the mobility market. TNCs are a useful example of the disruption and ambiguity the transition to such a mobility innovation can cause.

TNCs are in their infancy and their fortunes depend on how well governments can implement balanced controls to protect consumers without stifling this important innovation. Changes are required to the financing, insurance and legal frameworks that are currently in place. Any state that can tackle these issues quickly, despite resistance from incumbents, will have a significant first mover advantage in a global context. Risks are however significant, both in terms of consumer safety as well as reputational risks for the TNCs.

Shared mobility services increase the resource efficiency of our transport system. Research shows that on average a car is only used one hour per day. Hence sharing such means of transport are a logical step towards more resource-efficient travelling.

As with other innovation opportunities, traditional players in the automotive value chain have the possibility to extend their product/service portfolio by: i) engaging in revenue streams that are directly related to their traditional product/service portfolio (i.e. design, build and maintenance of vehicles specifically adapted for shared use) and/or ii) exploiting opportunities that lie further away from their traditional scope of activity (e.g. engaging in the actual delivery of shared services, entail the set-up of IT systems, system management, appropriate infrastructure provision etc.).

Figure 5-1 shows indicators for market growth potential, job creation potential, GHG reduction potential and potential for transitions in the value chain for shared mobility services as currently understood.
Figure 5-1: Assessment of the innovation opportunity’s potential according to current forecasts

### Market growth potential

The car share market has seen immense growth across the world in recent years. Between 2006 and 2014 the total number of members in car sharing clubs increased from 0.35 million to 4.94 million (ACEA, 2014). The bicycle share market has also seen significant increases in recent years. China was the biggest market in 2014 for bicycle sharing. Worldwide, there were 855 cities that offer bike-sharing schemes (Statista, 2015). In Europe, 1.3 million people carpool on a monthly basis (TECH.EU, 2014). However, legal frameworks need to be revised to ensure consumer safety while also not stifling the innovation. It is expected that new players in the market will increase the demand for such mobility services.

### GHG reduction potential

It is estimated that one shared car replaces around 15 private passenger cars (Frost & Sullivan, 2010). The same study estimated that carsharing members drive 31% less than when they owned a personal vehicle, hereby reducing the overall amount of personal transport. Shared cars frequently have better fuel efficiency than their private counterparts and hence lower emissions. For example, in Munich, CO₂ emission per km of a shared car fleet were estimated to be 12% lower than the one for a private car fleet. In Germany, it was estimated that 104 tonnes of CO₂ were saved by car sharing in 2011 (Stadium, n.d.). Public policies have to ensure that shared individual means of transport are not an alternative to mass public transport, which would jeopardise GHG reductions. The use of electric vehicles combined with the use of alternative energy sources can make shared mobility services a very efficient mobility option.

### Job creation potential

The job creation potential of the car share industry appears to be limited, will however depend on its impact on car ownership rates. Around 60 car sharing companies in Europe have emerged in the last decade creating potential for new employment opportunities. However, reduced car ownership rates that might result from increased uptake of shared vehicle mobility options could possibly lead to less employment potential in the automotive industry. The second order rebound effect is difficult to estimate, especially the number of jobs located in Europe.

### Transitions in the value chain

Growing interest in the car sharing sector has led to innovative business models and solutions. Independent car share business models are expected to work increasingly close with the automotive sector, ICT providers and application developers in the future. Electric car share models will furthermore require additional charging infrastructure, more sophisticated IT support, and hence lead to even more players engaged in the value chain of shared mobility services.
5.3 Main new revenue streams for industry

Revenue streams are mainly in the **vehicle use phase**. This stage is open to new business models providing (dynamic) vehicle sharing and ride sharing services in various forms. The service is differentiated by type of vehicles and new technology and online platforms. Online platforms (accessible via PCs, mobile phones or on-board units) enable the service itself (i.e. they enable the matching of supply and demand), allow comparisons and marketing of the available services, ensure monitoring and tracking of the vehicles, and provide subsidiary services (such as location finders, parking space finders, recharge infrastructure finders, etc.). Insurance companies have the opportunity to provide new insurance models to cover the risks and uncertainties of shared mobility services. Currently the liability of drivers and/or passengers is high with insurance premiums 3-4 times higher than private car insurance. This is likely to fall as the market continues to grow.

The **vehicle manufacturer stage** provides opportunities for the design and marketing of car club and sharing-specific vehicles for OEMs. Shared e-bicycles is another growth area that has become increasingly popular in South-East Asia, particularly China. Also in Europe e-bicycles are increasingly deployed as shared mobility options (e.g. in Madrid⁹, Copenhagen¹⁰, Zurich¹¹ etc.).

It is likely that there will be a greater need for **maintenance** due to the higher utilisation of shared vehicles. However this is will be offset by reduced vehicle ownership and maintenance needs in the private vehicle segment. The shift in maintenance services could be from a B2C to a B2B model with offerings competing to meet the maintenance demands from these new sharing services.

Figure 5.2 on the following page shows the revenue streams along the traditional automotive value chain.

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DRIVING INNOVATION IN THE AUTOMOTIVE VALUE CHAIN

Figure 5.2: Revenue streams along the traditional automotive value chain for the innovation opportunity ‘Shared Personal Mobility Services’
5.4 Key risks and challenges

• **OEMs might see shared services as a threat rather than an opportunity to their traditional business.** If European OEMs do not move into the space there is a chance that other global players will build momentum. BMW and Daimler have already recognised the potential and have launched their Drive Now (BMW) and Car2Go (Daimler) services. Other manufacturers are likely to follow this trend.

• **Legal frameworks are required to protect consumers** without penalising businesses and innovative activities. These legal frameworks will support insurance services to understand the boundaries of liability in the shared environment. In some instances the innovation may require changes to the existing rules and regulations; for example, in the related e-hailing value chain there have been considerable disputes regarding the level of regulatory compliance levied at the innovative solutions versus traditional solutions. These include driver checks, vehicle checks, insurance policies as well as areas concerning safe working hours and “fair” user charges.

• **Uptake will be slow without policy support.** Policy measures such as car sharing lanes on major roads (Leeds, UK; already a standard in the US given their ‘high occupancy vehicle’ lanes, especially at frequently congested highways) or preferential parking zones in cities for shared vehicles can increase uptake.

• **Increase in shared mobility services could increase overall traffic volumes.** This especially concerns urban areas where shared personal mobility could substitute mass public transport. There is a risk that policies could have unintended effects if not well ‘dosed’ to avoid a shift from mass public transport to shared individual transport, such as adding to congestion levels and GHG, noise and pollutant emissions.
5.5 Analysis by value chain segment

The rating of the value creation opportunity (either ‘low’, ‘medium’ or ‘high’) is a relative rating of the value creation opportunity of this segment compared to other segments in the value chain.

<table>
<thead>
<tr>
<th>VALUE CHAIN SEGMENT</th>
<th>SUPPLIERS AND OEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RATING OF VALUE CREATION OPPORTUNITY</strong></td>
<td>Rating: MEDIUM</td>
</tr>
<tr>
<td></td>
<td>• Opportunities in this segment include vehicle customisation suitable for sharing. This includes the design and installation of on-board units, such as on board computers, touch screens, RFID readers (for (un)locking the vehicles), key and card detectors (used for parking and/or re-fuelling/charging the vehicle and (high-definition) telematics devices (GPS systems).</td>
</tr>
<tr>
<td></td>
<td>• The value creation of the design and integration of such technology into vehicles is limited unless combined with further down-stream vehicle use-related revenue streams (see next table).</td>
</tr>
<tr>
<td><strong>RELEVANT ACTORS (EXAMPLES)</strong></td>
<td>European: On-board technology: Pinpointers (UK), My Drive Solutions (UK), Vulog (FR), OpenFleet (FR), Electricfeel (CH; for e-bicycles) Sharing-specific vehicle design Renault (FR – “TwizyWay”), Daimler (US – “Car2Go”)</td>
</tr>
<tr>
<td></td>
<td>Others/International: On-board technology: Eileo (US), NXP (USA), Samsung (Korea), HIKVision (China)</td>
</tr>
<tr>
<td><strong>RELATED SECTORS</strong></td>
<td>• Electronics and telematics industries will drive much of the innovation in the sharing hardware technologies.</td>
</tr>
<tr>
<td><strong>COMPETITIVE LANDSCAPE</strong></td>
<td>• The USA and East Asian markets have a leading edge in both electronics manufacturing and the mobile phone industry, which is most relevant for the customisation of the vehicles. The automotive engineering competences of European OEMs might allow them to bring innovative vehicle (and bicycle) design solutions tailored to the needs of vehicle sharing, such as seats/mirrors that are easily adjustable to the physical conditions of the driver, quicker to the market than their international competitors.</td>
</tr>
<tr>
<td><strong>POTENTIAL BENEFITS / ’INTERNAL’ DRIVERS</strong></td>
<td>Technology suppliers have the opportunity to deploy their systems in a potentially rapidly grow market that will allow them to grow their business.</td>
</tr>
<tr>
<td></td>
<td>• As mentioned above, OEMs increasingly recognise the trends towards ‘sharing’ and decreasing car ownership. They could enjoy first mover advantages by demonstrating their ability to design purpose-built shared vehicles, which can help them engage in downstream revenue streams. Current examples of purpose-built vehicles for shared services include the Renault electric-drive “Twizy”, used in the sharing service “TwizyWay” (Renault).</td>
</tr>
<tr>
<td><strong>RISKS AND CHALLENGES</strong></td>
<td>• Technology for on-board units is fairly uncomplicated. As a consequence the competition may be strong. This could favour cheaper production markets. EU suppliers will need to benefit from their relationships with OEMs and their proximity to the customer to gain market share.</td>
</tr>
<tr>
<td><strong>GEOGRAPHIC DIMENSION</strong></td>
<td>GLOBAL</td>
</tr>
</tbody>
</table>
### Rating of Value Creation Opportunity

**Vehicle Providers / Technology Providers / Service Operators**

**Rating: HIGH**

NB: Depending on the type of shared mobility service, the functions of vehicle providers, technology providers and service operators will be taken on by the same or different actors. For example,

- In P2P (peer-to-peer) sharing models, the private person acts as vehicle provider. The service operator provides online IT infrastructure (a technology provider for on-board units and vehicle tracking etc. is not existent).

- In B2C (business-to-customer) service models, the service operator might be the same entity as the vehicle provider (an OEM), while they revert to an external technology provider.

- The significant revenue streams in this segment is (whether via P2P, B2C or NFP (not for profit) ride or vehicle sharing service models; whether including or excluding a driver that shares the same destination) in the provision of BackEnd and FrontEnd solutions that:
  - enable the service itself (matching of supply and demand by providing subscription and booking platforms; enabling financial transactions for payments),
  - compare and market available services,
  - monitor and track the vehicles (also for the purpose of further optimisation of the service),
  - support the use of the service by providing subsidiary services (such as location finders for parking space, recharge infrastructure etc.),
  - provide service hotlines to deliver technical and roadside assistance for car sharing operations, incident management, etc.

- Revenue streams also lie in innovative insurance services for private users (e.g. hourly charging) and/or insurance services that are based on the data available from vehicle tracking and monitoring.

- Many actors that engage in this value chain segment will also engage in more upstream revenue streams (i.e. in the set-up and design of vehicles adapted for sharing) to benefit from the opportunities across the segments of the chain.

### Relevant Actors (Examples)

**European:**

- **Technology/software providers:** My Drive Solutions (UK), Vulog (FR), OpenFleet (FR), Electricfeel (CH; for (e-)bicycles)
- **Sharing service operators:** Renault (“TwizyWay”, FR), BMW (“DriveNow”, DE), Autolib (FR), BuzzCar (FR), Daimler (“Car2Go”, DE)

**Other/International:**

- **Technology/software providers:** Eileo (US),
- **Sharing service operators:** Hertz (“Hertz 24/7”, US), ZipCar (US)

### Related Sectors

- Insurance services industry for the provision of tailored solutions for shared mobility.
- Parking space providers (private or commercial) that offer land to park shared vehicles and (want to) promote these spaces online (such as ParkCirca (US) and ParkShare (UK/US).

### Competitive Landscape

- 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). In the US, hailing practices go back to the 1970s, where “slugging” (a form of hitchhiking between strangers that is beneficial to both parties) has since allowed the use of HOV (high-occupancy vehicle) lanes allowing for time savings. Today slugging is seen in and around the busiest US cities, such as Washington D.C., Houston, and San Francisco. This shows the high propensity of US citizens to use and benefit from shared mobility services.

- However, this does not limit Europe’s opportunities to engage in the provision of shared mobility services. Many of these services, especially where infrastructure and public space are needed (such as for charging stations), require the consent of local public authorities, which can be an entry barrier for international companies. Local companies are also more likely to understand the travel needs and patterns of the local population and are therefore better suited to enter the market.

- Nevertheless, ZipCar (US) have shown that international companies have the capability to build up significant markets in Europe.

- It appears difficult for European companies to enter the established North American market, but expansion towards the East (i.e. China, where car ownership has recently been slowing down) will be a growth opportunity.
Declining car ownership rates in Europe is forcing OEMs to move into this space. This would allow them to build new markets and become ‘mobility providers’ to benefit not only from the vehicle build phase but also from the vehicle use phase.

The shift to the provision of ‘mobility services’ rather than just the provision of means of transport has nurtured the development of new business models (provision of shared car/bike system, of ridesharing platforms etc.). These models can be adopted by companies that are, thanks to their ‘traditional’ offering, already closely related to sharing services such as car rental companies. Business models of rental companies need to make smaller adjustments compared to OEMs to enter the market. These new business models can also attract entirely new players.

Expansion opportunities for ‘free floating’ sharing services (vehicle can be parked at any parking space in an urban area – it is not necessary to access or leave the vehicle at a pre-defined parking space), for example provided by Car2Go (BMW), as compared to ZipCar (Cars have to be returned to ZipCar station) are also increasing.

There are significant expansion opportunities in South-East Asia where bicycle sharing has increased in many urban areas and car sales have recently started to slow down. These developments combined with increasingly strict air quality targets might give momentum to shared car services.

Companies deploying vehicle monitoring and tracking data can use these data to optimise their services and might be able to use this ‘big data’ to the benefit of public authorities (for optimising the whole transport systems) or other new innovations.

Legal frameworks that define the liability in case of accidents/misuse are not yet fully developed – this especially concerns ‘ride-sourcing (e-hailing)’ services.

Legal issues around data collection and further use need to be clarified for the assurance of the privacy of the systems’ users.

Shared mobility services have a high reliance on IT solutions – required skills to meet all demands (or match the services already provided in North America or optimise services) might not be in short supply.

### POTENTIAL BENEFITS / ‘INTERNAL’ DRIVERS

### RISKS AND CHALLENGES

### GEOGRAPHIC DIMENSION
## DRIVING INNOVATION IN THE AUTOMOTIVE VALUE CHAIN

### VALUE CHAIN SEGMENT

#### RATING OF VALUE CREATION OPPORTUNITY

**Rating: LOW**

- The value that users create per se will be limited. However, users will benefit in a number of ways from the use of shared mobility services mainly due to costs associated with car ownership (see below).
- Users indirectly create value by transferring their travel data to large databases that are created, which will potentially be of use for the whole transport network planning for public authorities and potential other applications.
- The use of shared services creates marketing value for providers (i.e. ‘word of mouth’) and advances the ‘network effect’ – more users will enhance the system coverage and density, which will in turn attract new users.

#### RELEVANT ACTORS (EXAMPLES)

Users are **private consumers** (in P2P, B2C or NFP/community-based business models) or **organisations** (in B2C/B2B business models) that optimise the use of their vehicle(s). Organisations might use such services on their companies’ premises and/or for external trips.

#### POTENTIAL BENEFITS / ‘INTERNAL’ DRIVERS

**End users (private persons):**

- A reduction in or no vehicle ownership costs in case the use of shared vehicle services replaces vehicle ownership.
- Reduction in journey time, effort and cost for the first and last mile of a journey or the total journey, especially in the case of ‘free floating’ shared services where vehicles can be parked anywhere (i.e. walking distance to station is reduced).
- Guaranteed parking spaces if service comes with reserved parking.
- Value from image creation for private consumer (environmental/technological awareness/acceptance of new technologies / "smart" choices / "innovator").
- Revenue generation for unused assets, such as driveway space and spare/unused vehicles (both can be shared via peer-to-peer sharing schemes).
- Option to choose from a range of different vehicles (i.e. choose the most appropriate car for the type and purpose of journey).
- Time savings and less inconveniences from not having to refuel or maintain vehicles.

**End users (companies that deploy their company-wide vehicle sharing scheme):**

- Reduction in total cost of fleet ownership for companies.
- Better utilisation of existing car fleet and opportunity to replace cars earlier (i.e. update quicker to newer, more energy efficient cars).
- Value from image creation for fleet operators (companies) (environmental/technological awareness/acceptance of new technologies / "smart" choices / "innovator").
- Freeing up of parking space in and around company premises.
- Gains in brand reputation for ‘innovator’ and ‘green’ business effects on marketing.
- Opportunity to offer shared vehicles to employees for use in their spare time.

#### RISKS AND CHALLENGES

- No 100% guarantee that the car the individual wants is available when required (especially if booking is done on short notice).
- Adapt to new way of travelling that requires pre-booking – change in habits and travel behaviour.
- Change of attitude from ‘ownership’ to ‘sharing community’ is required.

#### GEOGRAPHIC DIMENSION

LOCAL
The agent problem occurs when one person or entity (the “agent”) is able to make decisions on behalf of, or that impact, another person or entity. The dilemma exists because sometimes the agent is motivated to act in his own best interests rather than those of the other person or entity.

<table>
<thead>
<tr>
<th>VALUE CHAIN SEGMENT</th>
<th>VEHICLE MAINTENANCE &amp; AFTER USE</th>
</tr>
</thead>
</table>
| RATING OF VALUE CREATION OPPORTUNITY | Rating: LOW - MEDIUM  
• Although the ways in which vehicle after use and maintenance services may be accessed could change, the potential for growth in this segment of the value chain appears to be small.  
• Any increases in vehicle maintenance due to increased utilisation will largely be offset by reduced vehicle ownership rates.  
• Value creation lies in the increased need for cleaning and servicing for the next user. This could increasingly rely on mobile valeting services rather than a centralised valeting service. |
| RELEVANT ACTORS (EXAMPLES)   | • Increases in the sales of mobile valeting units can be expected with the growth of this innovation opportunity. |
| POTENTIAL BENEFITS / 'INTERNAL' DRIVERS | • There are many small operators in the mobile valeting services industry (Prideshine, Smart Auto Valet) which is a potential growth area. These operators would be well placed to engage in the value chain and contribute to its growth. |
| RISKS AND CHALLENGES         | • The “agent problem” could lead to poorly maintained and cared for vehicles. Operators will need to ensure users are made aware of the potential penalties for poor care of their vehicles. |
| GEOGRAPHIC DIMENSION         | LOCAL                                                                                           |
6 KEY INNOVATION IV: CONNECTED VEHICLES

6.1 Key highlights

• **Connected vehicles are expected to reduce congestion, and associated emissions.** Furthermore, connected vehicles are increasingly likely to be electrically-powered shared vehicles with optimised driving characteristics; further reducing transport GHG emissions and lowering air pollutants.

• **The global connected car market is likely to grow six-fold:** Global annual industry revenues from connectivity are expected to increase six-fold from approximately EUR 30 billion in 2014 to approximately EUR 170 billion to 180 billion in 2020 (McKinsey, 2014).

• **Demand for connected cars is increasing across the world.** Surveys show that the number of people willing to switch to brands with connected services has almost doubled (20% in 2014 to 37% in 2015) in the last year across the world. At the same time, consumers’ willingness to pay for connectivity is also increasing (McKinsey, 2015).

• **Europe is expected to be the largest market for embedded connectivity, second only to US.** Both regions have developed solutions that are already on the market – for example, BMW’s **ConnectedDrive** in Germany and Apple’s **Carplay** in the USA are examples.

• **Connectivity creates new and promising business models.** Most automotive executives agree that connectivity is likely to enable many new services (such as ADAS, emergency and roadside assistance, etc.) and business models (subscription charges, in-app purchases); offering significant growth potential for the automotive industry.

• **The automotive sector will have to establish new partnerships to capture value from the arising opportunities.** OEMs and suppliers need to reposition themselves to electronics and IT companies. Developing new and innovative connected technologies will require strong partnerships with players in the telecom, electronic device and IT service industry.

• **Car connectivity could shift revenues along the value chain.** There could be a redistribution of revenues from OEMs to connectivity hardware providers, and from insurance companies (decrease due to telematics-based insurance discounts) to maintenance providers (increase due to rising after-sales revenue streams). The overall value generation along the chain is expected to remain similar (as this has been the case since the 1980s) (McKinsey, 2014).

• **There is a strong focus on in-car connectivity and vehicle-to-person services in Europe.** Technologies for cooperative services (vehicle-to-infrastructure, V2I, and vehicle-to-vehicle, V2V) are still maturing (PAC, 2015).
6.2 High-level description of the innovation opportunity

Connected vehicles are vehicles equipped with communication technologies such as internet or wireless local area network access. These technologies allow the vehicle to directly communicate with:

- Other connected vehicles (vehicle-to-vehicle, V2V)
- The surrounding infrastructure (vehicle-to-infrastructure, V2I)
- The ‘Cloud’ (in-car connectivity)
- Users through device systems like smart phones (vehicle-to-person)

Each technology has its own benefit. Connecting to the cloud allows vehicle drivers to use services such as navigation, dynamic routing (based on traffic, weather, or road conditions), automatic parking spot finders, etc. V2V and V2I communication (collectively known as “cooperative services”) enables **data-enhanced driving functionalities and advanced safety features**. An example of data-enhanced driving functionalities is automatic vehicle speed adjustment in accordance with traffic flow, speed limits or traffic signals. Advanced safety features include road works warnings, cooperative collision risk warning, vulnerable road user protection, etc. Other connected vehicle services include emergency and roadside assistance, stolen vehicle recovery, infotainment apps and remote vehicle controls (locking, temperature control, etc.).

Connected vehicles have the potential to improve road safety, optimise transport efficiency, enhance mobility, increase service reliability, and reduce energy use and environmental impacts. This can lead to positive economic impacts on value added and productivity.

Also, connected vehicles and advanced driver assistance systems (ADAS) advance the development of autonomous vehicles – a closely related innovation opportunity for the automotive industry. Most manufacturers will phase in various levels of autonomy until fully autonomous vehicles are widely tested and accepted by the general public\(^\text{13}\).

\(^\text{13}\)In 2014, the Society of Automotive Engineers (SAE), an automotive standardisation body, published a classification system based on six different levels. The classification system is based on the amount of driver intervention and attentiveness required, rather than the vehicle capabilities, although these are very closely related. The SAE automated vehicle classifications are the following:

- **Level 0**: Automated system has no vehicle control, but may issue warnings.
- **Level 1**: Driver must be ready to take control at any time. Automated system may include features such as Adaptive Cruise Control (ACC), Parking Assistance with automated steering, and Lane Keeping Assistance (LKA) Type II in any combination.
- **Level 2**: The driver is obliged to detect objects and events and respond if the automated system fails to respond properly. The automated system executes accelerating, braking, and steering. The automated system can deactivate immediately upon takeover by the driver.
- **Level 3**: Within known, limited environments (such as freeways), the driver can safely turn their attention away from driving tasks.
- **Level 4**: The automated system can control the vehicle in all but a few environments such as severe weather. The driver must enable the automated system only when it is safe to do so. When enabled, driver attention is not required.
- **Level 5**: Other than setting the destination and starting the system, no human intervention is required. The automatic system can drive to any location where it is legal to drive.
By incorporating connected vehicle technology, autonomous vehicles will be safer, faster, and more efficient, since, for example, valuable information about the road ahead can be obtained (e.g. allowing rerouting based on information such as a lane closures or obstacles on the road). Also, as autonomous vehicles rely on knowing the roadway they are traveling on, changes to the roadside, such as new developments or construction, will require the type of real-time information exchange that connected vehicle technology provides.

Figure 6-1 shows indicators for market growth potential, job creation potential, GHG reduction potential and potential for transitions in the value chain for connected vehicles as currently understood.

**Figure 6-1: Assessment of the innovation opportunity's potential according to current forecasts**

**Market growth potential**

The market size of connected vehicle components in Europe is estimated to be EUR 32 billion in 2015, growing to EUR 115 billion in 2020 (EC, 2015). A variety of industries are affected directly or indirectly by trends in the connected vehicle industry. European automotive industry and the telecom industry are expected to be the two main beneficiaries from the growth in connected vehicles.

**GHG reduction potential**

Connected vehicles are expected to reduce congestion, and associated emissions. Furthermore, connected vehicles are increasingly likely to be electrically-powered shared vehicles with optimised driving characteristics; further reducing transport GHG emissions and lowering air quality pollutants. Connected vehicles in urban environment will result in more efficient transport systems in general (KPMG, 2015).

**Job creation potential**

The connected vehicle industry is estimated to create new jobs worldwide. 400,000 new jobs are expected to be created in the United States alone (IBSG, 2011). Estimates for Europe have not been identified, however, the trends show a great potential for highly skilled jobs in the short term (EC, 2015). In the UK alone, connected and autonomous vehicles are estimated to create 25,000 jobs in the automotive manufacturing industry and an additional 320,000 jobs in related industries (KPMG, 2015).

**Transitions in the value chain**

The ecosystem for connected vehicles is growing rapidly making the value chain very complex. The predominant key actors linked to the connected car industry are the automotive industry, the telecom industry (enabling high speed and high bandwidth mobile connectivity) and the ICT industry (providing hardware and software applications that enable connected car features). Other actors are expected to include infrastructure providers and vehicle users (EC, 2015).
Connectivity is becoming an integral part of the automobile industry. Companies and industries with no links to the automotive industry are now becoming key players creating a complex automotive value chain. Connectivity is redistributing revenues across the automotive value chain. It is likely to increase vehicle prices, lower vehicles’ operation costs (through more efficient driving), and will lead to changes in insurance premiums and maintenance costs (thanks to safer and more efficient operations). Increasing connectivity will trigger a shift towards subscription and usage-based revenues from software and services, such as navigation updates or media streaming (McKinsey, 2014).

Business models are still evolving across the whole value chain. Connected vehicles’ revenue streams can be categorised into the following areas:

1. **Suppliers and OEMs - Design and development of connected vehicles and their infrastructures:** Players in this segment of the value chain include automobile manufacturers, hardware and software providers and content developers. Their key activities are the design and development of service delivery infrastructure in the vehicle and on the roadside to enable two-way communication. This includes the integration of hardware and software into the vehicle, such as electronic systems (controllers, Bluetooth module in infotainment systems, etc.), software systems and wireless (user) interfaces. Roadside units may be mounted on traffic signs and key points along roads, informing drivers of potentially dangerous road conditions ahead, speed limits and upcoming junctions.

2. **Service providers:** Revenue streams in the vehicle use stage taken up by service providers may be driving related or non-driving related:
   - **Driving related services** provide functionalities to improve user safety and driving convenience. Such functionalities include connected navigation, parking assistance systems and advanced driver assistance systems (ADAS).
   - **Driving unrelated services** are data-based services and enhance user comfort and driving experience. Examples of driving unrelated services are web browsing, messaging services, provision of on-demand real-time media content, remote vehicle control, etc. Although driving related services are more important to a car user, driving unrelated services can become the prominent source of revenues. Other support services like stolen vehicle tracking, tolls, parking and payment services are also keys sources of revenue.

Given the increased data availability via vehicle tracking systems, **insurance** companies can provide enhanced personalised insurance policies based on driving behaviour/patterns over periods of time.

During the vehicle use stage, **backend support** from IT and telecom companies is vital to enable data processing and transfer, and management of road side units and on-board equipment.
3. **Vehicle maintenance & service providers:** Data transfers between the connected vehicle and vehicle maintenance and service providers enable preventive vehicle diagnostics and maintenance to car users. In this context “eCall-equipped” cars automatically call the nearest emergency centre in case of a crash (in Europe, all new cars from April 2018 have to be eCall-quipped).

Figure 6-2 on the following page shows the revenue streams along the traditional automotive value chain.
Figure 6-2: Revenue streams along the traditional automotive value chain for the innovation opportunity ‘Connected vehicles’.

**TRADITIONAL AUTOMOTIVE VALUE CHAIN - HIGH LEVEL OVERVIEW**

- **Vehicle manufacture** → **Vehicle sales** → **Vehicle use** → **After market**

**INNOVATION OPPORTUNITY: CONNECTED VEHICLES - VALUE CREATION OPPORTUNITIES**

**Design and development of service delivery infrastructure including user interface**

- **Hardware & Content development**
  - Integration of on-board sharing technology
    - Electronic systems enabling connectivity (e.g. CAN controller, Bluetooth module in infotainment system, other embedded devices)
    - Software system
    - Wireless interfaces (telematics; in-car connectivity)
    - V2X cooperative awareness systems with ability to store, analyse and forward received V2X notification messages

**Provision of connectivity-enabling built infrastructure**

- Installation of road side units with the ability to broadcast periodically I2V
- Potential for (I)2V services

**Opportunities related to provision, usage and maintenance of connected vehicles**

- **Driving related services**
  - Connected navigation
  - Networked parking assist
  - Real-time traffic information & smart re-routing
  - Emergency services
  - Hazardous location notification
  - Advanced driver assistance systems

**Driving-unrelated services**

- Connected navigation
- Networked parking assist
- Real-time traffic information & smart re-routing
- Emergency services
- Hazardous location notification
- Advanced driver assistance systems

**Other opportunities**

- Web browsing, email and news services
- Messaging services and social media
- On-demand real-time media content
- Location-based services
- Remote control of vehicle environment/ car features

**Potential further use of “big data”**

- Data processing and data transfer
- App and content development
- Management of road side units and on-board equipment
- Data management and security
- Billing and payment processes
- Helpdesk/Hotline

**Potential for other cooperative services & autonomous driving**
6.4 Key risks and challenges

- **Safety and security concerns:** There are consumer concerns regarding the privacy/the use of collected data, and the safety and reliability of deployed technology. Currently consumers are unaware or lack evidence on the potential benefits and risks of connected vehicles.

- **Lack of customer acceptance:** Limited customer awareness of the technologies and system functionalities is likely to affect the pace of uptake of connected vehicles.

- **Lack of willingness to pay:** Consumers are used to one-off payments for car purchases. Vehicle connected services would incur monthly costs similar to a mobile phones.

- **Industry-wide standards for technologies, software development and service provision:** Communication protocols and parameters for cooperative services are to be finalised. Setting such standards would allow faster deployment of connected vehicle services.

- **Coordination across different stakeholders:** The different stakeholders of the connected vehicle eco-system have different priorities. As a result, there is no consensus on the standards, services that should be provided first, and technologies to be used and developed. This is leading to delays in technology roll out, lack of interoperability of services across borders and disruption in communication links to provide connected services.

- **Paradigm shift in dealership models:** Car salespersons would require training and knowledge of connected technologies and able to communicate benefits to prospective customers. This may increase time and costs involved in the vehicle sales process.

- **Administrative and legal barriers:** Responsibilities in case of software/hardware malfunctioning is still unclear; as a consequence, insurance services are still unclear.

- **Data monopoly:** Single players along the value chain (e.g. data service providers) may collect data and refuse to share it, which may hinder new/other players (e.g. OEMS) making equal use of the data collected to provide similar or advanced services.

6.5 Analysis by value chain segment

While the following overview is provided by specific value chain segment, nothing will prevent the actors to seize revenue streams that currently lie outside the scope of their segment.

The rating of the value creation opportunity (either ‘low’, ‘medium’ or ‘high) is a relative rating of the value creation opportunity of this segment compared to other segments in the value chain.
## Value Chain Segment

<table>
<thead>
<tr>
<th>Rating of Value Creation Opportunity</th>
<th>Suppliers and OEMs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rating: HIGH</td>
<td></td>
</tr>
</tbody>
</table>
| • Opportunities for suppliers and OEMs in this segment refer to the enabling of in-vehicle connectivity solutions. This includes the design, development and integration of on-board units, telematics devices (GPS systems), Dedicated Short Range Communication (DSRC) radio, memory, safety application electronics control unit (ECU), driver-vehicle interface (touch screens), and vehicle internal processing and communication network. Other products include:  
  - Software- Integration of suppliers OS system into vehicle control and other embedded systems.  
  - Set up of wireless interfaces (telematics & in-car connectivity).  
  - Provision for V2X (V2V or V2I) cooperative awareness systems: these systems have the ability to store, analyse and forward received V2X decentralised environmental notification messages.  
  - Suppliers (and OEMs) can increase their competitive position by establishing strategic partnerships with telecom operators. Suppliers are also collaborating with other technology groups to establish their position as leaders in connected car systems (e.g. Continental has liaised with IBM and Cisco\(^\text{14}\)).  
  • Apart from the vehicle-end connectivity, infrastructure-side development is also necessary to allow vehicle-to-infrastructure and vice versa communication.  
  • Vehicle technology is increasingly becoming a key factor for consumer choice. OEMs are thus using connected technologies to differentiate their products and develop a competitive edge. Suppliers are collaborating with other technology groups to establish their position as leaders in connected car systems. For example, Continental has signed contracts with IBM and Cisco\(^\text{15}\).  
| European: NXP (NL), Continental AG, Bosch (DE), TomTom (NL)  
OEMs: BMW (ConnectedDrive, DE), Mercedes (Mercedes me, DE), Audi (DE), Volvo (SE) | Other/International: Apple (CarPlay, US), Google (Android Auto, US), IBM (US)  
OEMs: Honda (Hondalink, Japan), Hyundai (S. Korea), Tesla (US) |

## Relevant Actors (Examples)

**European:** NXP (NL), Continental AG, Bosch (DE), TomTom (NL)  
**OEMs:** BMW (ConnectedDrive, DE), Mercedes (Mercedes me, DE), Audi (DE), Volvo (SE)  

**Other/International:** Apple (CarPlay, US), Google (Android Auto, US), IBM (US)  
**OEMs:** Honda (Hondalink, Japan), Hyundai (S. Korea), Tesla (US)

## Related Sectors

- Electronics, IT and telematics industries will drive the innovation by providing hardware solutions.
- Companies that develop roadside units would also be required to develop the infrastructure that enables V2I/I2V and I2I communication.
- Electronics and telematics industries will drive most of the innovation in the connectivity hardware.

## Competitive Landscape

- Large organisations such as Google and Apple are entering this market providing their operating systems.
- TomTom (NL), HERE (DE), and Google are increasingly forming an oligopoly on a global scale (McKinsey, 2014) to provide dynamic real-time geo-information services. HERE (offering location data services and formerly belonged to Nokia) was bought by Daimler, Audi and BMW in 2015.
- Europe is expected to be the largest market for embedded connectivity, second only to US. Both regions have developed solutions that are already on the market – for example, BMW’s ConnectedDrive in Germany and Apple’s Carplay in the USA are examples.
- Demand for connected vehicle systems is expected to be the strongest in the United States, China and then followed by Western Europe\(^\text{16}\).
- An independent study conducted showed that consumers had more trust in German OEMs compared to US or Chinese OEMs in terms of privacy of data (McKinsey, 2014).

## Potential Benefits / ‘Internal’ Drivers

- Opportunity for suppliers of connected car systems to establish direct relationships with end users and provide their offerings in the vehicle aftermarket. This opens up new markets with strong growth potential.
- Connected cars will redistribute power from dealers to manufacturers as OEMs will have information on car’s performance, drive patterns, maintenance requirements, but most importantly consumer preferences.
- Connectivity allows OEMs to expand the customer relationships and directly connect with car users.

## Risks and Challenges

- Uncertain additional product development costs for hardware and software.
- Cost benefit analysis of embedded connectivity vs smartphone-based connectivity or a hybrid of both. Each has its own advantages and disadvantages.

## Geographic Dimension

GLOBAL

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14http://www.ft.com/cms/s/0/50c272c4-dce9-11e3-ba13-00144feabad0.html#slide0
15ibid
<table>
<thead>
<tr>
<th>VALUE CHAIN SEGMENT</th>
<th>USE-RELATED SERVICE PROVIDERS</th>
</tr>
</thead>
</table>
| **RATING OF VALUE CREATION OPPORTUNITY** | Rating: MEDIUM  
- The revenue streams lie in data-based services which could be a source of periodic and usage-based revenues, including revenues from monthly subscriptions, in-app purchases and media purchases, etc.  
- Revenue streams may be driving related or non-driving related services each with its own service offering and business model. The backend support operations for these services could be a business opportunity.  
- Revenue streams also lie in insurance services that are based on the data available from vehicle tracking and monitoring. |
| **RELEVANT ACTORS (EXAMPLES)** | Global connectivity service providers- Navigation services (Garmin, Google), Social Media (Twitter, Facebook), Media streaming (iTunes, Spotify), etc. |
| **RELATED SECTORS** |  
- Smart phone and telecom industry have similar services and offerings for mobile phones.  
- Insurance companies: value creation opportunity for companies that offer personalised insurance policies based on driving behaviour/pattern over periods of time.  
- Back end support hotlines and call centres. |
| **COMPETITIVE LANDSCAPE** |  
- A majority of the European companies providing connected vehicle services are already offering environmental information, entertainment and navigation services (PAC, 2015). For example, Audible and Spotify provide music for the BMW ConnectedDrive.  
- In Germany, companies focus strongly on the development and integration of back-end systems and infrastructure enablement; British companies are concentrating on the provision of connected car services, such as car-to-driver and in-car connectivity (media, navigation services, etc.) (PAC, 2015). |
| **POTENTIAL BENEFITS / ‘INTERNAL’ DRIVERS** |  
- This segment has a high potential for revenue generation from ‘direct-to-customer’ services. Once established, it allows service providers to expand into other service offerings with relatively little effort.  
- Service offerings in this segment allow providers to collect, analyse and monetise vehicle and driver data.  
- Service providers can upgrade their offerings with value-added services in a business-to-business-to-consumer model that encompasses content owners, aggregators, broadcasters, advertisers, online retailers, and application providers. |
| **RISKS AND CHALLENGES** |  
- Connected vehicle data volume must be managed: over the next decade, due to vehicle connectivity, 400 million GB of data transfer through mobile networks is expected.  
- It is key to ensure that technological and financial resources are in place to build the end-to-end architecture that provides uninterrupted and secured connectivity service to the user. |
| **GEOGRAPHIC DIMENSION** | GLOBAL |
### VALUE CHAIN SEGMENT: USERS

**RATING OF VALUE CREATION OPPORTUNITY**

**Users**

Rating: **MEDIUM**

- Connected vehicles not only increase driving comfort and vehicle safety but also frees up driver’s time for other tasks. Route optimisation, navigation and cooperative services reduce driving time and costs.
- Connectivity helps car sharing companies manage their vehicles as well as track and coordinate their operations.

**FUTURE BENEFITS / ‘INTERNAL’ DRIVERS**

- Improvement of driving comfort and reduction in stress.
- Route optimisation functions saves fuel and thus reductions in vehicle operation costs.
- Remote vehicle diagnostics and prognostics reduce maintenance costs.
- Enhancement of road safety through cooperative safety services, safety systems and automatic emergency calls.
- Reductions in congestion leading to higher productivity and time gains.

**RISKS AND CHALLENGES**

- Consumers’ willingness to pay for services that are partly already available in their smart phones is still unknown.
- Consumers are not yet fully aware of the technology and its benefits - they do not trust the connected vehicle value proposition.
- Consumers are anxious about privacy/ the use of collected data, and the safety and reliability of deployed technology.
- Legal frameworks in case of malfunctioning technology are still unclear.

**GEOGRAPHIC DIMENSION:** **REGIONAL**

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### VALUE CHAIN SEGMENT: VEHICLE MAINTENANCE & SERVICE PROVIDERS

**Rating: MEDIUM**

- This segment has opportunities for value creation from advanced vehicle maintenance services such as remote vehicle preventive prognostics and diagnostics, maintenance schedule and alerts systems, vehicle data-based bespoke service, and breakdown service.
- Value generated in this segment is typically through revenue from aftersales maintenance and service subscriptions, parts repair and replacement.
- OEMs must support their connectivity services through a helpline or other assisted services. Users can avail these services by paying a monthly subscription.

**RELEVANT ACTORS (EXAMPLES)**

- **European:** Bosch Drivelog (DE), Connect (DE)
- **Other/International:** My CarFax (USA), Auto Care free (USA)

**POTENTIAL BENEFITS / ‘INTERNAL’ DRIVERS**

- Remote diagnostics and vehicle prognostics is a mechanism to lower maintenance cost, at the same time increases loyalty for the services. The net revenue from these operations can offset the cost to provide telematics services.
- Strong consumer acceptance: A study showed that around 23% of new car buyers would follow app recommendations for maintenance (McKinsey, 2014).

**RISKS AND CHALLENGES**

- Availability of car condition data is a key requirement for offering maintenance and insurance services. Currently only the OEMs will have privileged access to this data.

**GEOGRAPHIC DIMENSION:** **REGIONAL**

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7 KEY INNOVATION V: LIGHTWEIGHT MATERIALS

7.1 Key highlights

- **Lightweight materials increase the fuel efficiency of cars.** For every 10% reduction in mass using lightweight materials there is a corresponding reduction in fuel consumption and emissions of 6-7%\(^{18}\).

- **Lightweight materials can be used to offset the increased weight of other components,** such as safety technologies or other emission reduction technologies (e.g. hybrid components or batteries).

- **The use of lightweight materials in the automotive industry is forecast to increase significantly over the upcoming decades,** from its current level of 30% (total mass of the vehicle) to 70% by 2030 (McKinsey 2012).

- **Today, the global lightweighting industry is concentrated in the USA and Europe.** Europe already has a number of multinational material suppliers and pre-processors, who have formed strategic partnerships with companies down the value chain. For example BASF and Fisipe have partnered with SGL.

- **Although currently expensive, the continued industrialisation of carbon fibre could reduce its cost by 70% in the long term,** thereby making it a viable alternative to aluminium (which has a lower weight reduction potential). The cost delta between aluminium and carbon fibre would then reduce from 80% to approximately 30% in 2030 (Mckinsey & Co., 2012).

- **The use of lightweight materials will significantly grow across industries.** Apart from the automotive industry, lightweight materials are also used in the aviation industry, in wind turbines, etc. Such applications will increase demand over the next two decades and reduce costs.

7.2 High-level description of the innovation opportunity

Automobile manufacturers have been facing growing pressure to increase fuel efficiency of their vehicles to reduce CO emissions from the transport sector. One of the key methods to improve a vehicle’s fuel efficiency is weight reduction. It takes less energy (or fuel) to accelerate a lighter vehicle when compared to a heavier one. A 10% reduction in vehicle weight can result in a 6%-7% fuel efficiency improvement. Traditionally, automobile

\(^{18}\)Ricardo-AEA (2015)
companies have reduced the size of the vehicle as a whole to achieve fuel efficiency (cutting weight of a typical car from 3,500 pounds to 2,500 pounds over the last 20 years), which has its limitations. In current car models, the vehicle body accounts for around 30% of the vehicle's weight. Reducing body weight along with lighter engines (or batteries in case of electric vehicles) and smaller suspensions can further reduce the overall weight of the vehicle.19

Lightweight materials allow the vehicle to carry additional advanced systems, such as emission control systems, safety devices, and integrated electronic systems without increasing the overall weight of the vehicle. Light weighting is especially important for electric and hybrid vehicles since this will increase the electric driving range of these vehicles, or, alternatively, allow the use of smaller batteries. Smaller batteries reduce the overall costs of the vehicles and contribute to further weight reduction.

Apart from boosting fuel economy, it is important that lightweight materials maintain the integrity of the structure and provide safety. Next to the 'classic' lightweight materials, such as aluminium, magnesium and ultra-high strength steel (HSS), there are also composite materials (e.g. polymer composites, metal composites, ceramic composites) that reduce weight. Some of the lightweight materials used in modern automobiles are provided in Table 7-1.

Table 7-1: Common lightweight materials and their potential for mass reduction compared to heavy steel components20

<table>
<thead>
<tr>
<th>LIGHTWEIGHT MATERIAL</th>
<th>MASS REDUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnesium</td>
<td>30-70%</td>
</tr>
<tr>
<td>Carbon fibre composites</td>
<td>50-70%</td>
</tr>
<tr>
<td>Aluminium and Al matrix composites</td>
<td>30-60%</td>
</tr>
<tr>
<td>Titanium</td>
<td>40-55%</td>
</tr>
<tr>
<td>Glass fibre composites</td>
<td>25-35%</td>
</tr>
<tr>
<td>Advanced high strength steel</td>
<td>15-25%</td>
</tr>
<tr>
<td>High strength steel</td>
<td>10-28%</td>
</tr>
</tbody>
</table>

Figure 7-1 shows indicators for market growth potential, job creation potential, GHG reduction potential and potential for transitions in the value chain for lightweight materials as currently understood.

19http://www.technologyreview.com/featuredstory/400002/a-practical-road-to-lightweight-cars/
Market growth potential

The use of lightweight materials in the automotive industry is forecast to increase significantly over the upcoming decades, from its current level of 30% (total mass of the vehicle) to 70% by 2030 (McKinsey 2012). Persistence Market Research (NY, US) recently forecasted a 8.7% global annual growth for polymer composites for 2015-2022; and a 9.9% global annual growth for metal composites (CW, 2015). Carbon fibre components are expected to find applications in 5 million vehicles per year by 2020, compared to 5,000 vehicles in 2012 (Ricardo-AEA, 2015).

GHG reduction potential

Vehicle mass reduction improves the vehicle’s energy efficiency and reduces emissions. A 10% reduction in mass can reduce fuel consumption and CO₂ emissions by 6-7% (Ricardo-AEA, 2015). 50% of steel mass replaced by carbon fiber reinforced polymer (CFRP) can reduce the GHG emissions by approximately 4,000 kg CO₂e/vehicle (which is equivalent to 2.5 gCO₂e/km).*

Job creation potential

Increasing investment in the development and application of lightweight materials is expected to grow jobs in manufacturing and R&D. In 2013, Jaguar Land Rover announced an investment approaching £1.5 billion to introduce an all-new technically-advanced aluminium vehicle architecture in forthcoming models. To support this, 1,700 new jobs will be created in the UK at their Advanced Manufacturing Facility (Automotive Council UK, 2013). However, the potential that is due to the use of lightweight materials (instead of other materials) is difficult to determine. No specific forecasts could be identified.

Transitions in the value chain

Suppliers, new material suppliers and OEMs would benefit from an increase in demand for, and performance of, lightweight materials. Suppliers might be able to enlarge their product portfolio towards new materials and the machinery industry might benefit from new requirements in production processes. Players in the value chain are pursuing vertical integration to reduce supply disruption, to strengthen the market and accelerate industrialisation of lightweighting material in different sectors. (McKinsey, 2012).

* Assumptions: vehicle mileage - 15,000 kms/year, vehicle life - 10 years

http://pubs.acs.org/doi/abs/10.1021/acs.est.5b03192?journalCode=esthag
7.3 Main new revenue streams for industry

The value creation potential of lightweight materials is largely located at the vehicle manufacture stage. The main players of the new value chain need to work in close proximity to each other to develop the desired composite-based product as per the OEM requirements.

The raw materials used to make lightweight materials are (depending on the lightweight material) typically in the form of fibres, polymers, thermoplastics, or resins. In the next stage, the raw materials are pre-processed into semi-finished products (such as reinforced pellets, sheet/bulk moulding components, etc.) or intermediate products (such as laminates, rods, sandwich panels, etc.) depending on their application. Pre-processing is done through moulding and curing of the raw materials into different forms. There are different types of moulding techniques such as compression moulding, injection moulding, and resin transfer moulding; each suitable for a different application or raw material.

Composite fabricators are responsible for the next stage of processing: designing and post-processing. Composite fabricators may also outsource composite designing to computer graphic companies who use specialised software for complex designs. The semi-finished/intermediate products are converted into complex composite structures through different fabrication techniques. Some of the techniques used are drilling, trimming, cutting, painting and sanding. Fabricators have to work closely with OEMs to understand their needs and meet their stringent requirements in terms of design, dimensions, finish etc. OEMs then typically assemble the finished composite panels into the different automobile structural parts.

At the after-use and recycling phase of the value chain, there are opportunities for companies to (a) provide repair and maintenance services, (b) produce lightweight material components which may be retrofitted into used vehicles and (c) recycle the used lightweight materials.

Figure 7-2 on the following page shows the revenue streams of lightweight materials along the traditional automotive value chain.
DRIVING INNOVATION IN THE AUTOMOTIVE VALUE CHAIN

Figure 7-2: Revenue streams along the traditional automotive value chain for the innovation opportunity "Lightweight materials"
7.4 Key risks and challenges

- **The cost of innovative lightweight materials and production techniques are currently still greater than their traditional alternatives** (compared to steel, aluminium costs 30% more but offers a 40% savings in weight and high strength steel costs 15% more but offers a 20% savings in weight).

- **The energy consumption involved in the light material’s production** (especially concerning carbon fibre) is high. Thus the savings in life cycle CO$_2$ emissions may be small or even negative.

- **Environmental policy (e.g. EU ETS) is perceived to increase compliance costs of producing lightweight materials** (i.e. that of aluminium) in Europe. Costs due to the emissions trading scheme (among others) add to the overall production costs of the materials, making European material suppliers less competitive to suppliers based in countries with less stringent environmental policy.

- **Current EU policy does not incentivise the use of lightweight materials.** Current EU vehicle CO$_2$ emission standards are based on the mass of the vehicles. As a consequence, lighter vehicles are relatively subject to more stringent CO$_2$ emission standards.

- **Upskilling / reskilling is required** to enable the European workforce to work with new materials and new processes.

- **New alternative materials have different impact characteristics in case of an accident.** Regulations around safety may need to be revised to support the introduction of these new materials, especially when used in body panels. New crash simulation programmes on the impacts of these materials need to be developed.

- **Most composite materials with thermosetting resins are not easily recyclable.** This is due to their complex cross-linkages which cannot be remoulded. For example, carbon fibre is only partly recyclable. EU legislation sets a target of 85 percent recyclability for vehicles, so carbon fibre’s recyclability is core to its potential for success (Mckinsey & Co., 2012).

- **Maintenance of carbon fibre parts is difficult** since damage can often not be seen through a visual inspection. Expensive technologies are required which impose high investment costs on dealers and workshops. Aging effects of some lightweight materials (incl. carbon fibre) are still unknown.

- **Cutting waste for carbon fibre (stemming from pre- and part forming) is currently still high,** at around 30%. Production processes still need to be improved to reduce such scrap rates.
The lightweight material value chain has been broken down into four value chain segments, namely the (a) composite raw material supply and pre-process stage, (b) composite post-process and vehicle integration stage, (c) vehicle use stage and (d) composite after use & recycling stage.

The rating of the value creation opportunity (either ‘low’, ‘medium’ or ‘high) is a relative rating of the value creation opportunity of this segment compared to other segments in the value chain.

<table>
<thead>
<tr>
<th>VALUE CHAIN SEGMENT</th>
<th>RAW MATERIAL SUPPLIES AND PRE-PROCESSORS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RATING OF VALUE CREATION OPPORTUNITY</strong></td>
<td>Rating: HIGH</td>
</tr>
<tr>
<td>• Opportunities in this segment lie within the scope of companies that are able to pre-process the raw materials into reinforced components of different shapes and sizes.</td>
<td></td>
</tr>
<tr>
<td>• Traditional steel suppliers will be more profitable if they manage to expand their offering to more specialised materials such as high-strength steel, carbon fibre, etc.</td>
<td></td>
</tr>
<tr>
<td><strong>RELEVANT ACTORS (EXAMPLES)</strong></td>
<td>European:</td>
</tr>
<tr>
<td>Raw materials: Evonik (Germany), GSM (The Netherlands), Fisipe (Portugal), BASF (Germany)</td>
<td></td>
</tr>
<tr>
<td>Pre-processing: Sigmatex (UK), Amber Composites (UK)</td>
<td></td>
</tr>
<tr>
<td><strong>RELATED SECTORS</strong></td>
<td>Other/International:</td>
</tr>
<tr>
<td>Raw Materials: 3M (USA), Zoltek (USA)</td>
<td></td>
</tr>
<tr>
<td>Pre-processing: Hexcel (US)</td>
<td></td>
</tr>
<tr>
<td><strong>COMPETITIVE LANDSCAPE</strong></td>
<td></td>
</tr>
<tr>
<td>• Today, the global lightweighting industry is concentrated in the USA and Europe. Europe already has a number of multinational material suppliers and pre-processors, who have formed strategic partnerships with companies down the value chain. For example BASF and Fisipe have partnered with SGL.</td>
<td></td>
</tr>
<tr>
<td>• The primary aluminium sector is increasingly moving from Europe to China and Russia where aluminium can be produced at lower costs (environmental policy in Europe adds around €200/tonne production costs (which is around 15% of the sales price of aluminium). This might risk further downstream activities to be increasingly dominated by these markets.</td>
<td></td>
</tr>
<tr>
<td>• A shift to green forms of energy is required for carbon-efficient production of lightweight materials over its life cycle. Hence, the energy sector is an important player in the value chain. BMW has established a carbon fibre plant in Moses Lake (USA) that is powered by hydroelectric power.</td>
<td></td>
</tr>
<tr>
<td><strong>POTENTIAL BENEFITS / ‘INTERNAL’ DRIVERS</strong></td>
<td></td>
</tr>
<tr>
<td>• OEMs are willing to pay up to €20/kg saved in vehicle weight, depending on the powertrain and the vehicle segment. This incentivises suppliers to invest in lightweight materials.</td>
<td></td>
</tr>
<tr>
<td>• The automotive glass fibre reinforced polymer (GFRP) raw materials market is expected to grow at 5.5% CAGR between 2015 and 2025, increasing the availability of these materials for further use in lightweight materials.</td>
<td></td>
</tr>
<tr>
<td><strong>RISKS AND CHALLENGES</strong></td>
<td></td>
</tr>
<tr>
<td>• There is currently little experience with working with these new materials; training in new production/process techniques is required to develop the necessary skill sets.</td>
<td></td>
</tr>
<tr>
<td><strong>GEOGRAPHIC DIMENSION</strong></td>
<td>GLOBAL</td>
</tr>
</tbody>
</table>

23Input obtained from interview with representative from European Aluminium
24Lightweight, Heavy Impact (McKinsey 2012)
**DRIVING INNOVATION IN THE AUTOMOTIVE VALUE CHAIN**

<table>
<thead>
<tr>
<th>VALUE CHAIN SEGMENT</th>
<th>MATERIAL POST-PROCESSING AND VEHICLE INTEGRATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RATING OF VALUE CREATION OPPORTUNITY</strong></td>
<td><strong>Rating: MEDIUM - HIGH</strong></td>
</tr>
<tr>
<td></td>
<td>• Revenue streams lie with players who invest in new production technologies and new tools for lightweight materials which allows them to reduce currently high cycle times, energy use and production costs.</td>
</tr>
<tr>
<td></td>
<td>• There are predictions that the automotive carbon fibre composites market will be worth US$ 4 billion by 2016 (Catalyst &amp; Ricardo, 2013).</td>
</tr>
</tbody>
</table>

| **RELEVANT ACTORS (EXAMPLES)** | **European:** |
| | Post-processing: SGL (Germany), Gurit (Switzerland), Tencate (EMEA) |
| | Automobile OEM: BMW, Mercedes (Germany) |
| | **Other/International:** |
| | Post-processing: Toray (Japan), Teijin (Japan) |
| | Automobile OEM: Ford, Chrysler (USA) |

| **RELATED SECTORS** | • There is the opportunity to learn advanced assembly techniques from the aviation industry, such as assembly techniques where strong adhesives attach the lightweight panels onto the body frame. |

| **COMPETITIVE LANDSCAPE** | • The strong OEM base in Europe offers the opportunity to build economies of scale and drive down the cost of innovative technology. Collaboration between OEMs will further enhance this opportunity. For example, BMW has established a joint venture with SGL group (manufacturers of CFRP). Jaguar Land Rover is in partnership with Cytec (composite supplier). |
| | • In the US, General Motors and Teijin have collaborated to produce advanced composite technologies and they forecasts industry sales of carbon fibre cars to reach 3 million units by 2020. |
| | • Europe is a large market for luxury and premium cars and they are the most likely to adopt these materials first to compensate for the weight of other premium vehicle features. This segment is also less price sensitive than smaller vehicles where the technology may be prohibitively expensive to implement significant weight savings. |
| | • The aluminium processing market is well established in Europe and currently there is low risk for complex aluminium automotive components to be supplied by Asian suppliers²⁵. |

| **POTENTIAL BENEFITS / ‘INTERNAL’ DRIVERS** | • As demand increases the opportunity for economies of scale will allow industrialisation of innovative techniques for lightweight materials manufacture. Over the next two decades the cost of carbon fibre is expected to reduce from €42 per kilogram to between €23 and €14 per kilogram by 2030 (Mckinsey & Co., 2012) |
| | • OEMs can adopt lightweighting techniques as one of the methods to increase fuel efficiency of their vehicles. |
| | • Especially electrification of vehicles requires high composite usage to offset battery weight. Increasing electrification of vehicles will therefore drive the use of lightweight materials (Catalyst & Ricardo, 2013). |
| | • Lightweight materials also allow the vehicle to carry other additional advanced systems, such as emission control systems, safety devices, and integrated electronic systems without increasing the overall weight of the vehicle. |
| | • New design opportunities arise from using these different materials, which, with well-designed marketing strategies, could allow OEMs to capture market share. |
| | • Aluminium is a stiffer and easier to assemble than steel. This provides additional benefits for OEMs (and their suppliers) to use the material. |

| **RISKS AND CHALLENGES** | • The cost of the new materials may not be passed onto customers in all cases, and the economies of scale may not arrive quickly enough to prevent these increased costs squeezing OEM margins. |

| **GEOGRAPHIC DIMENSION** | **GLOBAL** |

²⁵Input from interview with representative of European Aluminium
# Driving Innovation in the Automotive Value Chain

## Value Chain Segment: Vehicle Users

<table>
<thead>
<tr>
<th>Rating of Value Creation Opportunities</th>
<th>Rating: Medium</th>
</tr>
</thead>
<tbody>
<tr>
<td>• A growing number of car users are becoming increasingly aware of the cost and environmental benefits of lighter, fuel efficient vehicles.</td>
<td></td>
</tr>
<tr>
<td>• Also motorsport companies are beneficiaries of lightweighting technology.</td>
<td></td>
</tr>
</tbody>
</table>

## Competitive Landscape

- Consumers in Europe are on average more environmentally conscious than their counterparts in USA or China. Fuel efficiency is an increasingly important factor in vehicle purchase.

## Potential Benefits / 'Internal' Drivers

- Lighter vehicles are more fuel-efficient and thus have lower operating costs.
- Some of the composite body panels are dent and scratch proof, which reduces maintenance costs in case of minor accidents.
- Composite body panels mounted onto a steel frame, similar to the techniques used in motorsport vehicles, can make vehicles safer – another potentially selling point of vehicles with lightweight body shells.

## Risks and Challenges

- Lightweighting materials may result in increased vehicle upfront purchase costs, which might be barrier to large-scale penetration of these materials.

## Geographic Dimension

- Global
### Material After Use & Recycling

<table>
<thead>
<tr>
<th>Value Chain Segment</th>
<th>Relevant Actors (Examples)</th>
<th>Competitive Landscape</th>
<th>Potential Benefits / 'Internal' Drivers</th>
<th>Risks and Challenges</th>
<th>Geographic Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rating of Value Creation Opportunities</strong></td>
<td>Rating: MEDIUM</td>
<td>• Market for composite recycling is in its early stages and its potential is yet to be investigated and realised.</td>
<td>• Lightweight heating and cooling elements recycled elements will give industrial companies new opportunities to use these materials for applications such as aerospace.</td>
<td>• Damage to carbon fibre cannot always be seen and requires specialist detection. This requires investment from dealers and maintenance service providers.</td>
<td><strong>GLOBAL</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Traditional materials already have end of life recycling value chains e.g. aluminium, however there have been advances in the recycling of carbon fibre. New techniques to crush and crack the materials have been developed that allow for carbon fibres use in secondary applications where strength and stiffness are not key requirements (Knowledge Transfer Network, 2010).</td>
<td></td>
<td>• The safety compliance of vehicles made with lightweight materials is not fully known and these vehicles could experience higher insurance premiums until the properties of the materials are better understood.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 95% of the aluminium used in the automotive industry can already be recycled and reused multiple times.</td>
<td></td>
<td>• Most composites with thermosetting resins are not easily recyclable.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Market for composite recycling is in its early stages and its potential is yet to be investigated and realised.</td>
<td></td>
<td>• Appropriate standards need to be developed for waste categorisation and segregation to ensure all the composite waste material is collected. This will enable reliable supply of composites for recycling companies.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Traditional materials already have end of life recycling value chains e.g. aluminium, however there have been advances in the recycling of carbon fibre. New techniques to crush and crack the materials have been developed that allow for carbon fibres use in secondary applications where strength and stiffness are not key requirements (Knowledge Transfer Network, 2010).</td>
<td></td>
<td>• Aluminium scrap is increasingly leaving Europe, i.e. to China. In China it is more cost-efficient to recycle aluminium (e.g. many process steps can be done manually). This is problematic to achieve circular economy targets in Europe. Aluminium leakages causes value losses for Europe (much of the scrap is currently illegally leaving Europe). 25</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 95% of the aluminium used in the automotive industry can already be recycled and reused multiple times.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>European: Hambleside Danelaw (UK), Filon (UK), European Composite Recycling Services Company (ECRC)</td>
<td>Other/International: Trex Company (USA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• A few companies in Europe have begun experimenting with the business model involving recycling automobile composite body panels.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• ECRC is a consortium developed by a number of key players in the composite industry to provide cost effective recycling solutions and a platform for future growth.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• In the US, the carbon fibre recycling is a niche market predominantly focusing on recycling of aircraft components.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

25Input from interview carried out with European Aluminium.
8 CONCLUSIONS

The innovations analysed in this report provide a clear opportunity to decarbonise transport while contributing to Europe’s industrial competitiveness. These innovations are driven by the linkages between consumer preference, industrial strategies and policy mechanisms. Constant offering of enhanced (or new) products or services allow growth opportunities for various players in the value chain. The industry needs to keep innovating to meet consumer preferences (in terms of costs, safety, and (environmental) performance). Policy stimulates innovations mainly in the context of environmental and safety policy.

Europe is well placed to adopt and scale up these innovation opportunities. However, traditional players will increasingly have to adapt to pursue new innovations and to avoid losing high revenue streams to players that have not been previously involved in the automotive value chain (or only to a lesser extent). The focus will need to be on the delivery of the many identified data-driven services that have the potential to improve users’ access to transport means as well as their use.

Some risks and challenges have to be addressed to enable European players to capitalise on these innovation opportunities. These risks can be broadly related to policy issues (such as lack of clear and long-term incentives, standards, or responsibilities), market issues (such as demand uncertainties and skills shortages) and technological issues (such as still undefined ‘final’ solutions resulting in high investment risks and uncertainty of life-cycle benefits). Overcoming these risks will require collaborative approaches across all relevant actors.

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. A clear role for policy is therefore on a number of fronts, including encouraging cross-sector and cross-border collaboration and fostering innovation ecosystems in the value chain. Disruption must be encouraged; inertia and silos must be avoided.
9 REFERENCES

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Understanding Transport and the automotive industry


Electrification of powertrain


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**Connected Vehicles**


FT (2014), Age of mega supplier heralds danger for carmakers, http://www.ft.com/cms/s/0/50c272c4-dce9-11e3-ba13-00144feabdc0.html#slide0


**Lightweight materials**


Mckinsey & Co. (2012), Lightweight, heavy impact.


The study was undertaken through desk research based research, internal team brainstorm sessions and external expert interviews. This annex briefly sketches at which stages of this study desk-based research and/or interviews were carried out and what their respective outputs were.

### 10.1 Definition and identification of innovation opportunities and game changers

As part of the first stage of the study, a high-level literature research and internal expert discussions allowed to develop a long list of innovation opportunities in the mobility sector.

**Innovation opportunities** were categorised into the following four groups:

- Energy use and supply
- Advanced materials and production technologies
- Information and communication technology
- New business models / mobility services / enhancing modal shift

The scope of single innovation opportunities within these four categories had to be carefully defined. Many innovation opportunities in the automotive value chain are inter-related and can furthermore be split into more distinct innovation opportunities. This is illustrated by the following example on ‘e-mobility’:

*The innovation opportunity e-mobility, can, when looking at the automotive value chain specifically, be split into electrification of the powertrain (i.e. of the vehicle itself), and vehicle charging infrastructure. Both of these can be looked at in more detail, resulting, for example, in the innovation opportunities of batteries, turbo chargers, wireless charging infrastructure, fast charging infrastructure, etc. E-mobility is furthermore often brought in relation with new mobility services, such as shared vehicle services.*

The above example shows that the definition of single innovation opportunities is not straight-forward. For the purpose of this study, it was therefore agreed that innovation opportunities were defined according to the following criteria:

- They are mutually exclusive, i.e. distinct enough to avoid major overlaps with other innovation opportunities.
They are detailed enough to be able to capture essential differences as to where market and or job creation potential can be expected to take place. For example, the innovation opportunity ‘e-mobility’ was seen to be a too broad definition for an innovation opportunity, as it would not allow to capture differences in job creation potentials (and their geographic location) caused by, e.g. infrastructure development and battery development.

They are collectively exhaustive, i.e. they cover the main (potential) developments in the automotive value chain, while avoiding a list of innovation opportunities that becomes complex to analyse. The aim was to define 10-15 innovation opportunities and assess them using standard assessment criteria (see next section.

The process of identifying these innovation opportunities also helped to understand game changers or megatrends in the automotive value chain and their impact on new developments. Game changers that affect the automotive value chain and consequently the development of innovation opportunities within the value chain were categorised by:

- Societal game changers
- Behavioural game changers
- Economic/Industrial game changers
- Geo-political game changers

The next step was to match innovation opportunities against the game changers in the form of a matrix. This helped setting out a clear definition for both of them, shown below.

Initial discussions with experts and literature review showed that such distinctions were not obvious and the term ‘trend’ is frequently used to describe game changers and innovation opportunities. A distinction between what affects the value chain from outside and what can actually be seen as a resulting development from within the chain is frequently not made. For the purpose of this study this distinction is however essential to ensure only real ‘internal’ trends (or innovation opportunities) are assessed.
Furthermore, matching innovation opportunities and game changes helped to better understand, which innovation opportunities are more relevant and have greater development potential than others: those that could be matched against more game changers (and can therefore be seen as ‘response’ to more of these game changes) will be relatively more relevant. The ultimate rating of innovation opportunities was however mainly based on the input of external experts (see the following section).

10.2 Assessment of long list of innovation opportunities

The identification of innovation opportunities described above provided a long list of 13 innovation opportunities. These opportunities were assessed by external experts using five criteria agreed at the kick-off meeting for this study. The experts were asked to rate each of the opportunities along the five criteria on a scale from 1 to 5. The assessment criteria and the meaning of the rating are provided in Table 10-1.

<table>
<thead>
<tr>
<th>CRITERION</th>
<th>DESCRIPTION</th>
<th>RATING SCALE (1-5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market growth potential</td>
<td>Assesses the extent to which the global market of the innovation opportunity can be expected to grow</td>
<td>1 - no or very limited market growth potential</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 - significant market growth potential</td>
</tr>
<tr>
<td>Job creation potential</td>
<td>Assesses the extent to which a build-up of the innovation opportunity’s industry will create jobs in Europe assuming a large-scale take up of the innovation - these jobs can either be created in the sector itself, in any related sectors and in any segment of the related sector’s value chain</td>
<td>1 - no or negative job creation potential in Europe at large scale take up</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 - significant job creation potential in Europe at large scale take up</td>
</tr>
<tr>
<td>GHG reduction potential</td>
<td>Assesses the extent to which GHG (greenhouse gas) emissions can be reduced assuming a large-scale take up of the innovation</td>
<td>1 - no or very limited GHG reduction potential at large scale take up</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 - significant GHG reduction potential at large scale take up</td>
</tr>
<tr>
<td>Extent of transitions in the value chain</td>
<td>Assesses the extent to which the value chain underlying the production/delivery of the innovation opportunity will change existing value chains in the mobility/transport sector</td>
<td>1 - existing value chains within the mobility / automotive sector will not change (value added will remain with the same players)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 - existing value chains within the mobility / automotive sector will change significantly (value added will shift across existing players / to new players to a large extent)</td>
</tr>
<tr>
<td>R&amp;D investment</td>
<td>Assesses the extent to which funds have already been made available to support R&amp;D activities that drive the innovation opportunity (in the public or private sector)</td>
<td>1 - no or very limited funds have been invested so far</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 - significant funds have already been invested</td>
</tr>
</tbody>
</table>
The assessment matrix distributed among experts in the form of an Excel file contained a high-level description of each of the innovation opportunities and insight for each innovation opportunity - specific information relevant to the 5 assessment criteria. This ensured that experts had a similar understanding of the innovation opportunities to be assessed and their scope.

Altogether 28 experts of 22 different organisations were approached and invited to contribute to the assessment. Out of these, 8 experts were able to return the completed assessment matrix file (from 8 more experts out-of-office responses were received; the other invitations, including follow-up messages remained unaddressed).

Table 10-2 shows the affiliations (by type of organisation) of the respondents. Since respondents were not specifically asked whether they preferred to keep their responses anonymous, we refrain from stating the names of the responding experts in this report. All consulted experts work in the transport sector and engaged in analysing future developments of the sector.

<table>
<thead>
<tr>
<th>TYPE OF ORGANISATION</th>
<th>NUMBER OF RESPONDENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>OEM</td>
<td>2</td>
</tr>
<tr>
<td>NGO</td>
<td>2</td>
</tr>
<tr>
<td>Automotive supplier</td>
<td>1</td>
</tr>
<tr>
<td>Academia</td>
<td>1</td>
</tr>
<tr>
<td>Automotive consulting</td>
<td>1</td>
</tr>
<tr>
<td>International organisation</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 10-3 presents the weighted averages of the rankings received from the 8 experts for each innovation opportunity and assessment criterion. The cells highlighted in blue show the top 3 ranked innovation opportunities for each criterion.
Table 10-3: Average assessment of long list of innovation opportunities (based on the view of 8 experts)

<table>
<thead>
<tr>
<th>Innovation Opportunity</th>
<th>MARKET GROWTH POTENTIAL</th>
<th>JOB CREATION POTENTIAL IN EUROPE</th>
<th>GHG EMISSIONS REDUCTION POTENTIAL</th>
<th>EXTENT OF TRANSITION IN THE VALUE CHAIN</th>
<th>R&amp;D INVESTMENT ALREADY DEDICATED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrification of the powertrain</td>
<td>4.4</td>
<td>3.1</td>
<td>3.2</td>
<td>3.0</td>
<td>3.8</td>
</tr>
<tr>
<td>Charging infrastructure</td>
<td>3.6</td>
<td>2.8</td>
<td>3.3</td>
<td>2.9</td>
<td>2.8</td>
</tr>
<tr>
<td>Fuel cell technologies</td>
<td>2.0</td>
<td>2.1</td>
<td>3.1</td>
<td>2.5</td>
<td>2.8</td>
</tr>
<tr>
<td>Lightweight materials</td>
<td>3.5</td>
<td>2.8</td>
<td>2.9</td>
<td>2.4</td>
<td>3.1</td>
</tr>
<tr>
<td>Alternative manufacturing techniques</td>
<td>3.6</td>
<td>2.9</td>
<td>2.0</td>
<td>3.5</td>
<td>2.3</td>
</tr>
<tr>
<td>Advanced battery systems</td>
<td>3.3</td>
<td>2.9</td>
<td>3.4</td>
<td>3.2</td>
<td>3.4</td>
</tr>
<tr>
<td>Connected vehicles</td>
<td>4.0</td>
<td>3.3</td>
<td>2.3</td>
<td>3.2</td>
<td>2.9</td>
</tr>
<tr>
<td>Autonomous vehicles</td>
<td>3.2</td>
<td>2.3</td>
<td>2.8</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Telecommuting</td>
<td>2.8</td>
<td>1.9</td>
<td>3.0</td>
<td>2.4</td>
<td>2.6</td>
</tr>
<tr>
<td>Shared personal mobility services</td>
<td>3.9</td>
<td>2.3</td>
<td>2.6</td>
<td>3.1</td>
<td>2.6</td>
</tr>
<tr>
<td>Demand-responsive transport</td>
<td>2.5</td>
<td>2.1</td>
<td>2.1</td>
<td>2.8</td>
<td>2.0</td>
</tr>
<tr>
<td>Development of multi-modal hubs</td>
<td>2.1</td>
<td>1.9</td>
<td>2.3</td>
<td>2.1</td>
<td>2.7</td>
</tr>
<tr>
<td>Services promoting ‘integrated’ mobility</td>
<td>3.6</td>
<td>2.8</td>
<td>2.2</td>
<td>2.8</td>
<td>2.3</td>
</tr>
</tbody>
</table>
Based on the above assessment, the team interviewed five experts to discuss the 4-5 innovation opportunities they scored highly. These interviews helped to better understand the experts’ ratings and provided relevant information to shortlist the innovation opportunities. They also provided first elements for stage two of this study (the high-level analysis of the single shortlisted innovation opportunities).
10.3 Shortlisting of five innovation opportunities

The above-described expert assessment was designed in such a way that it would allow for a standard multi-criteria analysis. The objective of the multi-criteria analysis was to identify the five innovation opportunities with the greater potential to achieve the dual goal of i) reducing GHG emissions in transport and ii) increasing competitiveness of European industry.

For this purpose weights were assigned to the five assessment criteria as shown in Table 10-4. The criterion GHG emissions reduction was weighted relatively higher, since it is the only criterion that refers to the goal of decarbonising the transport sector. The goal of industrial competitiveness is reflected by the assessment criterion of market growth potential and job creation potential (in Europe). Also the criterion of ‘extent of transitions in the value chain’ provides an indication of the extent to which further new value creation can be expected in case the innovation opportunity is taken up and developed. The criterion ‘R&D investment’ gives an indication of the current interest that has already been dedicated to the innovation opportunity and therefore gives an indication of the current development stage of the innovation opportunity. This indicator was weighted relatively lower than the other assessment criteria as it does not refer to either the opportunity’s decarbonisation potential or its potential to drive Europe’s industry. Provides the average weighted assessment obtained from the external experts.

<table>
<thead>
<tr>
<th>ASSESSMENT CRITERIA</th>
<th>MARKET GROWTH POTENTIAL</th>
<th>JOB CREATION POTENTIAL IN EUROPE</th>
<th>GHG EMISSIONS REDUCTION POTENTIAL</th>
<th>EXTENT OF TRANSITION IN THE VALUE CHAIN</th>
<th>R&amp;D INVESTMENT ALREADY DEDICATED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weighting</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 10-5 below provide the ranking of the innovation opportunities resulting from the weights per evaluation criterion and the average rankings obtained from the external experts. The top 6 innovation opportunities are highlighted in blue in Table 9-5. Sensitivity analysis was carried out and showed that the ranking of the opportunities was largely insensitive to the weighting (meaning that different weighting of the assessment criteria largely yielded the same or similar ranking of innovation opportunities).
Table 10-5: Ranking of long list of innovation opportunities

<table>
<thead>
<tr>
<th>ASSESSMENT CRITERIA</th>
<th>OVERALL RANKING SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrification of the powertrain</td>
<td>34.6</td>
</tr>
<tr>
<td>Advanced battery systems</td>
<td>32.5</td>
</tr>
<tr>
<td>Connected vehicles</td>
<td>31.0</td>
</tr>
<tr>
<td>Charging infrastructure</td>
<td>31.0</td>
</tr>
<tr>
<td>Lightweight materials</td>
<td>29.2</td>
</tr>
<tr>
<td>Shared personal mobility services</td>
<td>28.9</td>
</tr>
<tr>
<td>Autonomous vehicles</td>
<td>28.4</td>
</tr>
<tr>
<td>Alternative manufacturing techniques</td>
<td>28.3</td>
</tr>
<tr>
<td>Services promoting 'integrated' mobility</td>
<td>27.2</td>
</tr>
<tr>
<td>Telecommuting (Telepresencing)</td>
<td>25.8</td>
</tr>
<tr>
<td>Fuel cell technologies</td>
<td>25.4</td>
</tr>
<tr>
<td>Demand-responsive transport</td>
<td>23.1</td>
</tr>
<tr>
<td>Development of multi-modal hubs</td>
<td>21.8</td>
</tr>
</tbody>
</table>

All three innovation opportunities *electrification of the powertrain, advanced battery systems and charging infrastructure* can be seen as sub-opportunities of the broader opportunity of *e-mobility*. As such any further value chain analysis of only the top 5 ranked opportunities would consequently be very biased towards e-mobility. Hence, it was decided to treat *advanced battery systems* at a very high level within the innovation opportunity of electrification of powertrain. As result, shared mobility services, was included in the top five innovation opportunities. The final shortlisted innovation opportunities for further high-level analysis in this study and proposed for further deep dive analysis in follow-up studies is provided in Table 10-6.

Table 10-6: Shortlisted innovation opportunities for further analysis and deep dives and follow-up studies

<table>
<thead>
<tr>
<th>FINAL LIST OF SHORTLISTED INNOVATION OPPORTUNITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrification of the powertrain</td>
</tr>
<tr>
<td>Connected vehicles</td>
</tr>
<tr>
<td>Charging infrastructure</td>
</tr>
<tr>
<td>Lightweight materials</td>
</tr>
<tr>
<td>Shared personal mobility services</td>
</tr>
</tbody>
</table>
10.4 High level analysis of five innovation opportunities

As already mentioned, the exact definition of the single innovation opportunities and their scope is not evidently clear. Also connected vehicles are likely to be increasingly electric and potentially autonomous in the future (autonomous vehicles is another innovation opportunity not shortlisted). While the high-level analysis of innovation opportunities aims at keeping a clear distinction between the different innovation opportunities, such delineations are ambiguous. As a result the high level analysis frequently refers and points to other innovation opportunities that are inter-related.

The high level analysis of the five shortlisted innovation opportunities was based on an analysis template that covers all agreed topics in the value chain analysis for each innovation opportunity. This template was important for ensuring that the same type of information, in the same format and with similar level of detail are provided coherently across all shortlisted innovation opportunities. The information for the template for the high level analysis was obtained from the available literature. As such, no direct references to literature sources were made (unless specific numbers were cited). Main literature items that were reviewed and contributed to the broad understanding of innovation opportunities are listed at the end of this report for further reference.

After the literature review was finalised and all relevant information was compiled, also expert interviews were carried out to fill data gaps and validate some of the information that was identified.

10.5 Limitations

Ultimately, the five shortlisted innovation opportunities merit to be explored in depth studies. The high-level information provided in this study is therefore 'only' a means to provide i) first insights and justification for why these innovation opportunities deserve further attention, and ii) first guidance for the follow-on studies in terms of which value chain segments deserve most attention for further analysis. This study’s objective was therefore not to find answers to specific questions such as referring to the value of specific opportunities or the actions required to benefit from the opportunities’ potential. Rather, the objective was to provide first understanding that allows raising and addressing the relevant questions in follow-on analysis.
Several EU-level initiatives were launched to support innovations in transport. This section provides a brief overview of the most relevant strategies, initiatives, programmes and funds relevant to ‘green growth’ in the transport sector.

EU policies for specific economic sectors are embedded in the European growth strategy Europe 2020, which defines seven flagship initiatives to guide and support these policies. Of major importance for innovation in transport and the automotive industry are the following:

- The Resource Efficient Europe initiative sets out to create a framework for policies to support the shift towards a resource-efficient and low-carbon economy. Specifically, it supports the Roadmap for moving to a low-carbon economy in 2050, which sets out a cost-efficient pathway to reduce domestic emissions by 80% to 95% by 2050 from 1990 levels. It is recognised that in order to achieve a resource-efficient Europe, technological improvements, a significant transition is required in energy, industrial, agricultural and transport systems, and changes in behaviours for both producers and consumers.

- The Digital Agenda for Europe initiative aims to define the key enabling role that the use of Information and Communication Technologies (ICT) will have in helping to meet Europe’s 2020 goals and includes several objectives for the rollout of Intelligent Transport Systems (ITS).

- The Innovation Union initiative is to create an environment to target R&D most efficiently. An approach to innovation is advocated in which research focuses more on practical issues and on bringing innovations to market entry.

These initiatives are in line with the European transport policy. The 2011 Transport White Paper recognises that innovation is essential to its strategy, and that EU research needs to address the full cycle of research, innovation and deployment in an integrated way. The White Paper on Transport furthermore sets an ambitious objective of reducing greenhouse gas emissions from the transport sector by around 60% compared to its 1990 levels by the year 2050, reducing oil dependency, and limiting the growth in congestion. These objectives are to be achieved through sustainability mobility pathways. Implementing

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27This section does not list the regulatory framework that has been put in place concerning the automotive industry (consisting of around 80 EU Directives and over 70 international UN Regulations) nor the possible policy measures that have already been put in place or could be put in place in order to support the uptake of one or the other specific innovation opportunity.

28http://ec.europa.eu/europe2020/index_en.htm


30http://ec.europa.eu/resource-efficient-europe/index_en.htm

31http://ec.europa.eu/digital-agenda/

32http://ec.europa.eu/innovation-union/index_en.cfm

this vision requires the development of new technologies, the availability of suitable infrastructure and the introduction of organisational innovations. Innovative solutions for transportation includes vehicle technologies (e.g. drive trains, materials and design, energy carriers), infrastructure (e.g. network construction, optimisation of capacity – including the application of information and communication technologies, network safety), and transport services (e.g. marketing and pricing strategies). Innovation also needs to target different transport modes, promote sustainable behaviour through better mobility planning, improve the access to information, and enhance cross-modal transport. Currently, EU-based manufacturers of transport equipment (e.g. manufacturers and suppliers to automobile, airplanes and trains), infrastructures (e.g. construction companies for roads, railways, ports and airports) and service providers (e.g. airlines, container transport services, express package services), are seen to be well-positioned in the global market to gain market share. Acting as first movers to tackle the challenges faced by the transport sector and develop and apply innovative solutions has proven a successful strategy in the growing global market for transport equipment and services. This can strengthen the competitiveness of the European transport industry in the future.

As the ‘R&I pillar’ underpinning the White Paper implementation, the Strategic Transport Technology Plan (STTP)\(^{34}\) is the long term transport innovation policy that will identify, in collaboration with all Research and Innovation actors, the most promising technologies that can contribute to the White Paper’s objectives.

These objectives have been incorporated in Horizon 2020\(^{35}\), the new Framework Programme for Research and Innovation. Replacing the Seventh Framework Programme (FP7), Horizon 2020 aims to combine all EU research and innovation funding in one programme. Funding is linked more closely to specific policy objectives, which is in line with the Innovation Union, the White Paper on Transport and the Strategic Transport Technology Plan.

Horizon 2020 is the biggest EU research and innovation framework programme ever launched in Europe, with funding dedicated to research, industrial leadership and societal challenges (such as sustainable transport and mobility). Not only does Horizon 2020 fund research, but it also mainstreams funding for activities in all stages of the innovation cycle. It emphasises the role of public-private and public-public partnerships, and has committed to invest in Joint Technology Initiatives\(^{36}\) in fields including aeronautics and transport. Eight contractual Public-Private Partnerships have been launched in areas including green cars and cleaner manufacturing processes. Also a key priority set in Horizon 2020 is to support research on practical issues identified in the Europe 2020 strategy. For this purpose, six societal challenges have been specified, one of which is ‘smart, green and integrated transport’. The challenge is to create a resource-efficient and environmentally sustainable transport system that provides safe and seamless transport and benefits citizens, the economy and society.

\(^{34}\text{http://ec.europa.eu/transport/themes/research/sttp/}\)
\(^{35}\text{http://ec.europa.eu/programmes/horizon2020/}\)
\(^{36}\text{http://ec.europa.eu/research/jti/index_en.cfm?pg=individual}\)
One of the “10 priorities” of President Juncker set out in 2014 has resulted in the **Energy Union Package** - a framework strategy for a resilient Energy Union with a forward-looking climate change policy that was put in place in 2015. The Energy Union strategy has five mutually-reinforcing and closely interrelated pillars designed to bring greater energy security, sustainability and competitiveness. The pillars most closely related to transport are the:

- **“Energy efficiency contributing to moderation of demand” pillar:** The Commission will pay special attention to those sectors with a huge energy efficiency potential, in particular the transport and buildings sector. Concerning transport specifically, a set of high-level actions are set out that aim to achieve an energy-efficient, decarbonised transport sector. These actions include:
  - Increasingly stringent CO\(_2\) standards
  - Better traffic management
  - Promotion of the use of road charging schemes based on the polluter-pays and user-pays principles
  - Removal of barriers to less greenhouse gas intensive modes of transport, such as rail, maritime transport and inland waterways
  - Promotion of a swift deployment of the necessary infrastructure to promote low carbon transport modes
  - Acceleration of the electrification of the car fleet and other means of transport
  - Promotion of leadership in electro-mobility and energy storage technologies, requiring a full integration of electric vehicles in urban mobility policies and in the electricity grid.

- **“Research, Innovation and Competitiveness” pillar:** The Commission’s aim is to put the EU at the forefront of smart grid and smart home technology, clean transport, as well as clean fossil fuel and the world’s safest nuclear generation to promote growth, jobs and competitiveness. The following elements feed directly into the strategy:
  - The **Integrated Strategic Energy Technology (SET) Plan.** The recently adopted Communication for an Integrated SET Plan highlights ten priority areas of action which are in line with the new political priorities defined in the research & innovation pillar of the Energy Union. It is foreseen that the Commission services will agree with the Member States and the research and industry stakeholders on the strategic objectives and targets in each technology area and will define implementation plans.
  - A **Strategic Transport Research and Innovation Agenda (STRIA).** In the transport area, a Communication on “Research and innovation for Europe’s future mobility” (Strategic Transport Technology Plan) described in 2012 issues related to transport R&I and presented ideas on how innovation could better serve the transport and mobility needs of European citizens and businesses whilst addressing larger societal challenges such as climate change and dependence on oil. However, there is now a need to determine how the transport system should adapt to the decarbonisation challenge while ensuring that increasing mobility needs are met. To this end, a Strategic Transport Research and Innovation Agenda would need to be developed and agreed.

37http://ec.europa.eu/priorities/energy-union/index_en.htm
- **Global Technology and Innovation Leadership.** Global technology and innovation leadership is crucial for Europe’s future, particularly in terms of competitiveness and hence jobs and growth. First mover advantages will be considered by many countries with a focus on incentivising and developing new technologies and services in the broader climate and energy areas. A new global competition has already commenced to position economies around the world in terms of opportunities for jobs and growth in the forthcoming decades. The EU’s industrial leadership in many areas is at stake and it needs to be determined what public policy action is needed to improve the position of our industry in the global marketplace.

Another priority of major relevance to transport is the Digital Single Market. The Digital Single Market[^38] Strategy sets out 16 key actions. One key action is to define priorities for standards and interoperability, such as e-health, transport planning or energy (smart metering).

Furthermore, many sector-specific policies have been introduced to encourage innovation, either directly or indirectly. For example, in the automotive industry the car and van CO\textsubscript{2} Regulations (respectively Regulations 443/2009 and 510/2011, as amended by Regulations 333/2014 and 253/2014) have as one of their objectives the goal to foster the competitiveness of the European automotive industry and encourage research into fuel efficiency technologies. As part of the Commission’s modern industrial policy, the **CARS 21** (Competitive Automotive Regulatory System for the 21st century) Group was established to structure policy discussions on strategic issues.