RACE2050 *- Responsible innovation Agenda for Competitive European transport industries up to 2050*

D4.1- Report on existing Equipment and Services Transport Strategies

Dissemination level:

PUBLIC

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1. Executive summary

This *Report on Existing Equipment and Services Transport Strategies Trends* has two targets. First, to offer an overview of the EU transport industry current and future trends; secondly to feed the next stages of RACE2050 action, in order to achieve the broader goal of the project.

All the scenarios available forecast a constant development of the transport market, both in passengers and freight volumes, to a ratio bigger than the global GDP expected growth, although this trend is challenged by new social behaviours. The industries landscape is changing in all the sub-sectors: vertical and horizontal integrations and creation of European big players are the main current trends, a tendency which is not ended yet.

Service industry
Although benefiting from growing volumes, the whole European transport service industry nevertheless presents poor financial results and difficult market conditions. Thus, the need for a radical new shape of the business (as proposed for the shipping industry), a different approach to customers' behaviours (as for the private land mobility) and, more generally, an end-to-end offer needs to be addressed. Environmental awareness has spread more and more, and is considered not a burden but a potential selling point; higher energy prices are affecting rather strongly the sectors' economic sustainability, thus pushing to energy saving strategies.

About the EU-27, it is, all together, a mature market. However, the present scenarios forecast increasing freight volumes for the next decades, although lower than the emerging economies. The European inland logistic and freight industry is largely based on road transport, with minor share for the rail and inland waterborne modes. The logistic services have experienced poor financial results and – in some branches – low performance. For this and other reasons, the sector has experienced relevant changes in the past decades, still on-going, namely vertical integration and the great development of continental big players, not only in the rail sector.
The industry – in its new shape – is taking its first step towards new business models, which must consider the relevant challenges of the logistic system, well beyond the container revolution.

EU passenger transport is dominated by private mass motorisation (more than 70% of the total market), followed by aviation, coaches and rail services. As with freight service, the passenger transport industry's financial results remain feeble, while the performances can be increased. Airlines and railway industries, both very capital-intensive, are dominated by large companies, while road sectors (taxis, coaches and buses) present a more fragmented situation. However, a trend towards big international alliances and/or European players, combined with a stronger vertical integration is already running. All the stakeholders are aware of the industry challenges, above all a wider customer satisfaction and tighter multi-modal integration.

Manufacturing industry
As for services, growth of the global market is also expected in the manufacturing industry. Although truly internationalised, the transport manufacturing industry is usually close to the markets served, which has pushed many EU companies to open plants and assembly sites in emerging economies. Considering the role of those new markets, the leadership position of the European industry is challenged by new entrants, which enjoy a fast growing home market, lower

technological gaps and lower final costs.
The automobile and the railway sectors are the most exposed to international competition, in which emerging economies' companies are playing a more relevant role. The high-tech segment and – for the car industry – the premium sub-market are less vulnerable to this trend.
The aviation sector is still a duopoly dominated by Boeing and Airbus, but four non-EU companies will be stepping into the market in the next years, thus giving a new configuration to the industry.
The current studies and the industry stakeholders suggest focusing on top-end segments, R&D development and cutting edge technologies as winning strategies for the EU players.

While mature economies are saturated markets and seem to have experienced their peak in car ownership, emerging economies have increasingly skyrocketing growth, mainly fed by local plants. In this vein, the European car industry is witnessing a turning point in its history. The decline of its traditional market and, abroad, the growing pressure of ´local´ producers create an immense stress on the EU OEMs and on their suppliers. As happened for the EU shipping industry, a shift towards the ´premium´ segment, cutting-edge technologies, technical and non-technical innovations are often envisioned as the next stage for the EU car producers.

The shipbuilding industry is a globalized marketplace dominated by Asian yards: China, South Korea and Japan together hold over 80% of global completions between 2005 and 2012.
European shipyards still hold a strong position in some high-tech and high-value added niche markets, like Cruise vessels, Dredgers, some offshore support vessels and yachting. Furthermore, the European marine equipment industry is home to some of the most successful players globally, and a main driver for innovation in the industry.
The research and innovation capabilities of the European industry places it in a good position to take advantage of the opportunities that lie ahead, like the greening of the fleet, deep-sea exploitation and offshore renewable energies – like wind or waves – where European players are in the forefront in technological terms. But its current competitive position is threatened by the lack of financing, ageing workforce and shortage of skills. Increased competition from dominant and emerging markets alike – as oversupply in some markets are pulling capacity between market sectors and innovation is quickly taken by others, and as intellectual property rights are complicated to enforce at a global level – requiring a steady pace of R&D just to keep a step ahead of competition.

The rail equipment industry not only 'successfully' navigated through the downturn of the past years, but the scenarios available describe a sound development for this sector. Additionally, the EU rail industry appears to be conscious of the challenges to be tackled. The role of the European industry is indeed challenged by fast growing Asian firms which can harm the European leading position. Besides R&D, innovative business models and original (and even extreme) new strategies are claimed as essential. In terms of markets trends, Asia will experience a slowdown of its astonishing expansion (unless a new wave of investment is unleashed in China and India), but other markets could become attractive (Africa, next-11, Americas, Russia). Urbanisation will be another driving force.

The Aerospace Industry is expected to thrive during the next thirty years supported by increasing levels of air travel demand, mainly from emergent economies, and improved air traffic management operability. Main drivers for future technological development should continue to be energy efficiency and environmental sustainability. With a global leading role in Large Commercial

aircrafts' and helicopters' final assembly and marketing (mainly due to successful consolidation efforts in the past), the European Aerospace Industry holds a strong competitive position in the global market place for major components and subsystems supply, second to North American counterparts. The main threats to the European Aerospace Industry's future competitiveness lie in its ability to further consolidate into innovation-driven conglomerates, capable of establishing risk-sharing partnerships with main OEMs for product development, and on new commercial product assembly competitors arising from countries like BRIIC, Canada, and Japan, whose impact on future market distribution can already be noticed.

Technology innovation and market challenges

A competitive transportation sector provides the basis for sustainable socio-economic development in Europe. Global market trends are challenging the system by structural changes, such as on-going internationalization, especially in services, privatization in the transport sector and investments in infrastructure, as well as a global shift of demand towards upcoming economies. Beside this, the global market development is also driven by policy and regulation influencing the openness of markets. This is especially important in transportation, which is characterized by a history of state owned infrastructure and providers.

On the regulation side different strategies in export, restrictions of resources, tax policy for imports and requirements of locating the companies production, to name only a few, may transform frame conditions, as economic and political power is also shifting towards east and south. In this complex system with global linked policies and economics, the European transportation industry has a competitive advantage in its strong base of innovative R&D, production and global exports. The challenge will be to improve adaptability skills meeting the needs of a new world of transportation, which will be formed by needs and demand from emerging countries more than in previous decades. This need for adaption and transformation includes the opportunity for innovation. The key issue for ensuring competitiveness will be to understand different perspectives and follow new approaches.

Energy issues will become more and more central in the future. The transportation sector is still heavily dependent on fossil fuels and its price development. It is highly possible that there will be a rise in the real price of energy in the coming decades. In the near future the use of fossil fuels in transportation will increase, despite programs and guidelines for energy efficiency and a reduction of emissions. There are challenges and opportunities concerning this topic. A lot of countries deal with the challenge of energy security and develop strategies to become more independent of the fluctuating energy price. This also affects future developments in the transportation sector and is therefore a topic of global interest.

Novel materials with improved properties are a prerequisite for more sustainable, efficient and environmentally friendly transportation means. The transportation industries have already begun to utilize advanced materials such as nano-materials, for specific applications. Advancements in materials science and especially in nano-technology offer new possibilities for a wide range of structural and (multi)functional nano-materials with unprecedented properties. For example, certain nano-composites as well as nano-engineered metals have the potential to significantly reduce the weight of aerospace, automotive and naval structures. In this sub-chapter several interesting and important application areas are reviewed, such as high-strength light-weight materials for vehicle structures and engines, self-healing materials and sophisticated coatings, materials enabling high performance power sources, smart materials for adaptive structures, and materials for improved transportation infrastructures.

ICT products are crucial to the transportation industry. For example, in today's cars there are up to

100 microcomputer-based systems called Electronic Control Units (ECUs).
In this sub-chapter we cover existing and emerging technologies that could re-shape the transport industry. We briefly discuss automotive embedded systems, telematics and intelligent transport systems, the connected car and Internet of Things, autonomous vehicle technology and multi-modal transport systems.
The advancement of ICTs is also related to the effective exploitation of alternative engines. Gas and diesel engines will improve mostly due to electronics advances. ICTs will also impact driver assistance systems, including warning systems, error correction, and collision mitigation. The EU has competitive advantages in some areas, such as core Auto ECUs, and Advanced Driver Assist Systems (ADAS). In the area of Electric Vehicle ECUs, the EU is less competitive and needs to do more to stay in the game.
There is no doubt that energy is one of the key issues humanity will have to deal with in the next few decades. An increasingly large fraction of the world use of energy is consumed by transportation. It is supplied mostly by the use of fossil fuels, which are found in limited amounts and are exposed to many various factors (geographical, geopolitical, etc.) limiting their distribution worldwide.
The transportation sector needs to find alternatives, preferably renewable ones, to fossil fuel consumption. In this sub-chapter we briefly review the various alternatives, including hydrogen fuel cells, electric batteries, hybrid engines and bio-diesel. Each is described in some detail, and the sub-chapter ends with a review of various reports concerning the future of usage of the above renewable fuels.

New trends
Globally, concerning integration, customisation and internationalisation the transport industry is facing three trends.
1. While out-sourcing and de-localisation of the supply chain will receive further development, some EU production clusters are showing a strong resilience, and they are truly competitive in the global market. This can lead to more internationalised production system, in which some EU segments can offer first-class products with cutting-edge technological innovations. Vertical and horizontal integration, alliance and joint ventures are expected to remain one way to face a more internationalised market.
2. The traditional borders among transport sub-sectors are crumbling, and more and more companies are developing new initiatives well beyond their core business. The race to offer end-to-end travel service is already open and many companies are stepping in. This is pushing, for instance, Deutsche Bahn to have in its portfolio car and bike-sharing, Daimler is involved in car pooling and car sharing, while Bombardier produces electric buses.
3. In mature economies motor-vehicles ownership is declining, especially among young generation. In such a new market landscape, the industries are already developing new offers and new ideas to meet customers' requests. The ability to cope to this rising trend can be useful also in emerging (and urbanised) economies, where space, energy and pollution issues can force to a limited access to car ownership (as currently in several Chinese cities).

While traditional vertical and horizontal integration are still on the agenda of the transport industry, new forms of competition and integration have been detected. Globally, the whole transport demand will grow, and further international alliances (or consolidations) will be required in order to cope with the economies of scale and scope requested by this new market outline. Still, relevant differences occur between mature and emerging economies: generally speaking, the

latter are showing a growing demand for motorized mobility and vehicle ownership, while the first are declining markets.
Transport companies (both manufacturing and services ones) are not just developing their core business, but are offering a wider range of services, implementing innovating forms of collaboration, and breaking the traditional bounders among sub-sectors. Infrastructural constraints, environmental concerns and energy costs are (and, presumably, will be) the driving factors of this process.

In mature economies, the younger generations display a greater interest in shared-economy, while new attitudes induce decreasing ownership of private vehicles. Time-budget and/or money-budget constraints are leading the new mobility behaviours, and forcing the industry to implement new partnership, joint ventures and other form of collaboration able to match those changed demands. Generally speaking, the transport industry landscape keeps its traditional core business, but it is quickly shifting to new concepts, from vehicle ownership to integrated mobility services.
This new approach could have relevant outcomes also in emerging countries, where the urbanisation process and the density of city (plus energy and pollution factors) could discourage mass motorisation and develop post-ownership attitudes.

2. Introduction

RACE2050 is a research project granted by the FP7 scheme and this report is part of RACE2050 deliverables as submitted in summer 2013. Particularly this is deliverable 4.1, which is linked to Work-package 4 of the project, and it is titled *Report on existing Equipment and Services Transport Strategies Trends*.
In this report, RACE2050 has the goal to compare and integrate existing studies committed to foresight of the transport industry, with the main aim to identify its upcoming trends. In this vein, RACE2050 focused its activities on identifying the ground-breaking issues of production, service and internationalisation, considering technological innovations as well as inventive business models.
WP4 is central for RACE2050 because it assesses the European transport industry's current strengths, weaknesses and potentials. WP4 shall compare and integrate the current industry, technology and foresight studies and collect additional data on factors that may shape and structure the future of European transport equipment and service provision in the medium and long terms (2030 and 2050). WP4 aims thus at i) assessing, mapping and ii) forecasting market activities and trends by paying attention to the role of service companies, industrial management, manufacturing innovation, but foremost, the features of national and international competitiveness .

Concerning this report, there have been four investigation paths:

1. Service companies: that is, collecting, comparing and integrating recent studies of European transport service providers for passengers and freight. More in detail, the report has compared studies on the most prominent European freight transport and logistics service providers, value chains, the relative market shares and customisation profiles with regards to geographical markets, distribution channels and business models. Further, reports on medium-and-long-term business expansion strategies of these players have been collected to identify the most promising service strategies, markets, clients and regions to be targeted.

2. Equipment production companies: that is, assessing the present and emergent structures in European transport equipment and component producers, including sub-systems and ancillary components. This report has collected and compared reports on manufacturing industries, and through its investigation has reported the debate on new market expectation, distribution channels and business models.

3. Technology innovations: that is, reviewing studies on the most promising existent, experimental, emerging and potential technologies for powering and construction of transport equipment and supporting systems in the European passenger and freight transport industries, including innovations on new power units and fuels, new materials and ICT solutions, and specifically
o New fuels and fuel combinations;
o New environmentally friendly powering technologies;
o New materials (with eco-design and/or recycled) in construction of vehicles;
o New energy infrastructures and generating sources.

4. Integration, customisation and internationalisation: that is, addressing the question of further integrations and internationalisation for the EU industry. Moving from there, RACE2050 also enquired into industry inclinations, including a strong attention to after-market packages, intermodal operations and the shift from selling products to offering facilities and services.

3. European Transport Service Industry. International outlook and expected trends

Abstract of the chapter
All the scenarios available forecast a constant development of the transport market, both in passengers and freight volumes, to a ratio bigger than the global GDP expected growth, although this trend is challenged by new social behaviours. The industries landscape is changing in all the sub-sectors: vertical and horizontal integrations and creation of European big players are the main current trends, a tendency which is not ended yet.
Although benefiting from growing volumes, the whole European transport service industry nevertheless presents poor financial results and difficult market conditions. Thus, the need for a radical new shape of the business (as proposed for the shipping industry), a different approach to customers' behaviours (as for the private land mobility) and, more generally, an end-to-end offer needs to be addressed. Environmental awareness has spread more and more, and is considered not a burden but a potential selling point; higher energy prices are affecting rather strongly the sectors' economic sustainability, thus pushing to energy saving strategies.

3.1 Logistics services for Freights

Abstract
About the EU-27, it is, all together, a mature market. However, the present scenarios forecast increasing freight volumes for the next decades, although lower than the emerging economies. The European inland logistic and freight industry is largely based on road transport, with minor share for the rail and inland waterborne modes. The logistic services have experienced poor financial results and – in some branches – low performance. For this and other reasons, the sector has experienced relevant changes in the past decades, still on-going, namely vertical integration and the great development of continental big players, not only in the rail sector.
The industry – in its new shape – is taking its first step towards new business models, which must consider the relevant challenges of the logistic system, well beyond the container revolution.

3.1.1 Overview and forecasts

According to 2008 Seals´ study, "logistics, covering the planning, organization, management, control and execution of freight transport and warehousing operations in the supply chain, generated an estimated potential market volume (total costs) of nearly 900 billion EUR in the 27 European Union member states in 2007, of which around half was outsourced" (Progtrans et alii 2008, 1). Seals analysis counted "about 7 million employments in freight logistics […] for 2005 and at a value added of roughly 300 billion EUR, or approximately 3 % of GDP" (Progtrans et alii 2008, 1).

Mode of transport	NR. of enterprises	TURNOVER M €	Employment (In 1000)
Road freight	600000	269 535	2951.8
Road pass.	331722	98 483	2110.5
Railways	800	70 281	712.4
Pipelines	200	11 839	22.9
Inland waterways	8990	6 117	41.1
Sea transport	8000	89 366	179.7
Air transport	4000	111 662	379.5
Warehousing and support activities	121600	282 701	2379.3
Postal and courier	50000	97 307	1803.1
TOTAL	**1125312**	**1137291**	**10580.3**

Figure 1 - 2009 EU transport operators Enterprises, Turnover and Workforce - (ESC 2012, 82)

The logistic and transport of freight has experienced a relevant growth in the past decade, usually higher the GDP. The above mainly due to the new industrial and economic landscape. Indeed, "the production of manufactured goods is organized increasingly through global value or supply chains, with goods being processed (value being added) in multiple countries that are part of the chain. […] One implication is that more than half of world trade today comprises intermediate inputs. For the world as a whole, the import content of exports has been estimated to be about 30%" (WEF 2012, 8).
Generally speaking, worldwide, many of the major logistic firms (including thus shipping firms) are European, mainly based in Germany, Netherlands, Switzerland and Denmark. The world leadership is in the hands of Deutsche Post-DHL, followed by other European and non-European players, often positioned in the rail sub-market. As reported by EC, the European industry presents some strong factors. "Updated logistics techniques and best practices are swiftly implemented across the Union", an increasingly integrated and concentrated global market in which "several European companies have established themselves as world leaders", and big rising opportunities once ICT will be applied in the freight transport logistics (EC 2007b, 2-3).

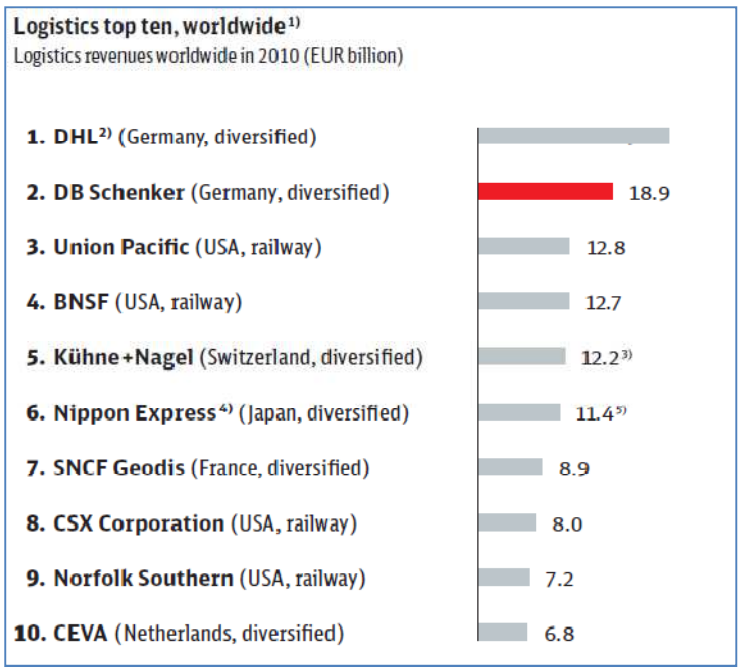


Figure 2 – Logistic Top Ten Worldwide - (Deutsche Bahn 2012, 21)

The freight and logistics market showed, however, a significant volatility compared to the passengers realm. This especially in the turndown of 2008 crisis, although already in 2010 "the European land transport market recovered, albeit with obstacles" (Deutsche Bahn 2012, 20). The crisis, generally speaking, pushed the revenues and the health of the industry down, showing overcapacity in many (if not all) sub-sectors. In this vein, the long-term forecasts have no doubts in positioning Europe as a mature market, which will have a significant growth, although lower then emerging economies. For instance, TransVision forecasts in its EU-27 meta-model baseline scenarios an annual growth 2005-2050 of the freight transport between 1.5 to 2.5% according the different modal choice and period (TransVisions 2009). Focusing on freight, Freightvision estimated a growth of the volume from 2,180 billion tkm in 2005 to 3,139.2 billion tkm in 2050 (Freightvision 2010).
Summarising several findings, Neaa claimed about the waterborne industry the following:

- *Maritime transport is expected to grow substantially, with tonne kilometres increasing within and between [EU] Member States by about 90% between 2005 and 2050.*
- *Maritime transport between [EU] Member States and the rest of the world is projected to increase by 150% between 2005 and 2050.*
- *Worldwide, maritime transport is projected to grow by 150% to 300% by 2050, particularly due to container shipping, which is projected to grow by 425% to 800% by 2050* (NEAA et alii 2009, 69).

On the inland side, Neaa suggested that road "freight in the EU is forecast to increase by about 60% between 2005 and 2050, and long-distance road freight (trips longer than 150 km) to more than double. […] Growth in rail freight ranges from 25% to treble current levels" (NEAA et alii 2009, 70).

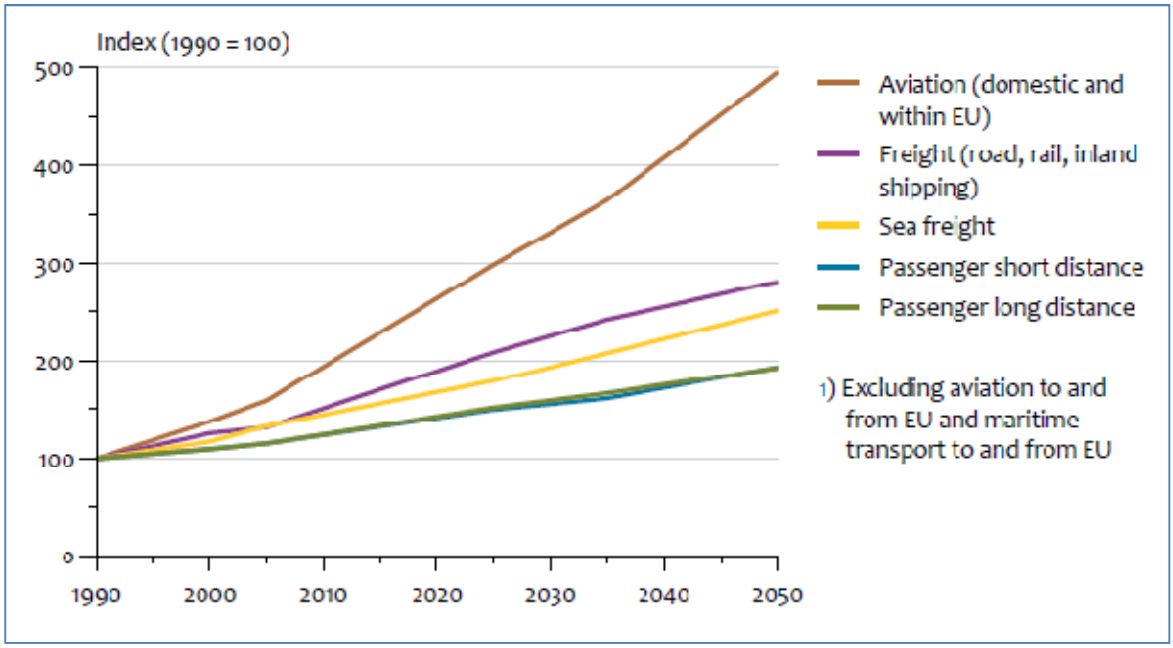


Figure 3 – Transport trends up to 2050 - (NEAA et alii 2009, 70)

So, regardless to the source, freight transport is assumed for the future as a growing entity, even in the mature economic environment of Europe. Although supported by increasing volume, the European freight industry is nevertheless affected by several challenges, which can harm its chances.

First, we are experiencing a constant shift of the core business areas, definitely moving to East, and namely to Asia. "The establishment of the relevant trade corridors is already well underway in some cases; in other cases initial investments in infrastructure are just beginning. As a result of these developments, new trade corridors between Asia and Africa, Asia and South America and within Asia will re-chart global supply chains. Trade volumes will shift towards emerging markets and least developed countries will take their first steps into the global market place" (PWC 2012c, 7). While Chinese and Asian shipping firms are strongly present in the market, there are not – so far – Asian logistic competitors on a more global scale. It is true that Asian firms have not stepped yet into the European market and, rather interestingly, "while China is already making serious inroads into the Fortune Global 500, only one transport company, China Railways, makes the list. Emerging market players do not yet represent major players on the world stage in the T&L

industry, unlike in other sectors such as consumer goods or electronics" (PWC 2012c, 9).

A.04 Trade volumes: compound annual growth rate 2011 to 2012

%

Exports \ Imports	Africa	Asia Pacific	Europe	Latin America	Middle East	North America
Africa	9.4	8.6	12.9	0.6	1.2	−11.5
Asia Pacific	6.1	4.7	1.6	1.2	5.6	3.5
Europe	8.0	4.5	−0.4	8.1	−0.8	−1.5
Latin America	1.8	3.2	−1.9	−0.4	4.1	−4.5
Middle East	11.6	5.3	0.7	3.3	1.8	12.0
North America	−6.5	1.0	2.8	2.1	1.6	−3.6

Figure 4 – Trade Volumes: compound annual growth rate 2011 to 2012- (Deutsche Post DHL 2012, 27)

So, rather confidently, PWC research argues that "there is good reason to argue that [emerging economies] logistics companies need to look no further than their own domestic markets and those of their emerging neighbours to find growth. After all, their markets are generally very far from saturated and growing at double-digit rates – a major contrast from the mature markets of the developed nations, where growth expectations generally hover around a much more modest 5%. Companies in emerging markets which focus on their home markets and actively search for opportunities to enlarge their logistics capabilities will maintain and improve their competitiveness, providing ample room for highly attractive growth" (PWC 2012c, 9).
However, the main challenge for the EU logistic and freight industry is more intrinsic to the customer request. Demand for end-to-end transport, reliable service and full care for the goods are pushing for vertical integration or alliance. For the intra-EU-27 market, this "is one of the main reasons why rail freight operators decide to enter foreign markets. The railways either work in cooperation with partner companies in the country concerned or assume overall management of the transports themselves, thus eliminating frequently time-consuming and expensive interfaces" (Deutsche Bahn 2013, 16).
The internationalisation of the markets and of the industry is shown by Deutsche Post-DHL. Despite it is present all around the world, the firm has kept its core business in Europe, which counted for about 60% of its employees (totalling 428,129 units).

Figure 5 – Deutsche Post DHL employees by region 2012 - (Deutsche Post DHL 2012, 71)

3.1.2 Aviation

Aviation freight transport plays, in absolute number, a marginal role in the freight sector. For EU-27 it is merely a one-thousandth of the total volume, e.g. about 3 billion tkm (Eurostat 2012), and worldwide we can count about "1,600 freighter aircraft in service with a cargo hold of at least 10 tons […]. This is performed by around 200 airlines, some of which handle both passengers and freight" (Airbus 2012, 127).

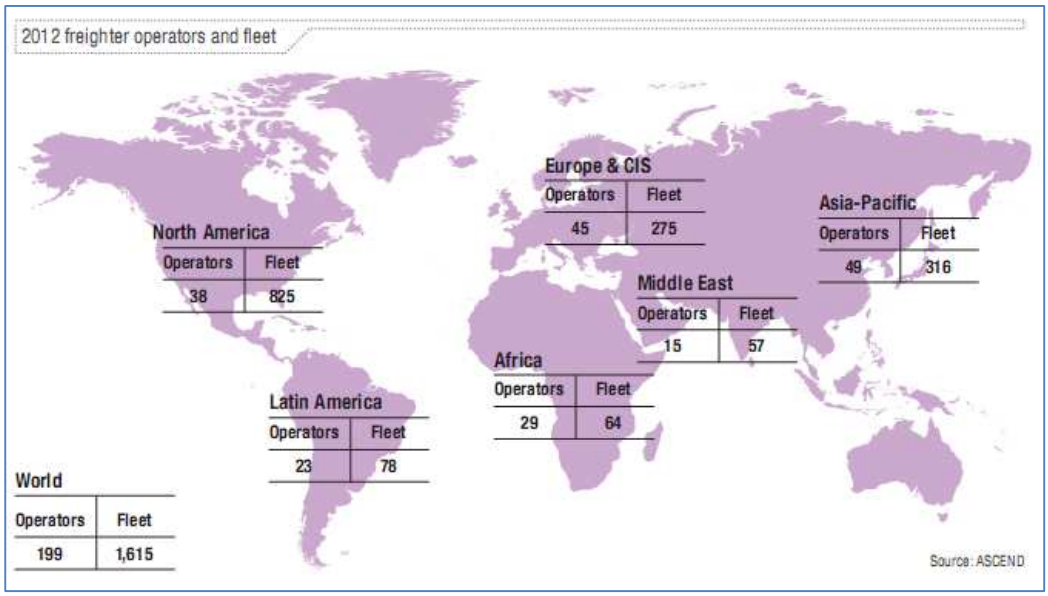


Figure 6 – 2012 Freighter Operators and Fleet - (Airbus 2012, 127)

The industry shows a great volatility connected to mega economic trends, and it is also strongly affected by energy prices. This has been experienced very clear during the past five years, which witnessed both the phenomena, putting the airfreight operators under pressure. As reported by Airbus, "the inter-dependence between the economy/trade and the air cargo industry means that

any volatility or difficulty in the global economy or regional economies has a direct effect on the air cargo market. The most recent economic crisis starting in 2008, and the increasing cost of jet fuel have led to a period of difficulty in the cargo market" (Airbus 2012, 129).
All together, the air cargo industry shows the same trends of the shipping industry, namely over-capacity, increasing costs (usually related to higher fuel price) and lack of coordination among the players (IATA 2011). This lead to bad results in the past years, which are rooted to a wider weakness: "Over the course of the year, decreasing demand owing to the sluggish economy and the increasingly uncertain situation coincided with substantial surplus capacities. Not only did new freight space come onto the market, but capacities also increased as space became available when customers shifted their transports to container shipping which, although slower, was less expensive. As a result of these surplus capacities, freight rates in the air freight market also went under pressure" (Deutsche Bahn 2013, 19).
But, also rail operators, which are more integrating in the logistics market, put under pressure the air cargo: "The railroad network is continuously improving, and multi-modal means of transport are gaining in importance in order to cut the energy bill" (Airbus 2012, 134). However the main scenarios available, although expressing some doubts, are positive in the long terms. Airbus, *pro domo sua*, forecasts that "air transport will still have an important role, especially for on-time deliveries. Therefore, the traffic within Europe is expected to grow at 4 % per annum over the next two decades" (Airbus 2012, 134).

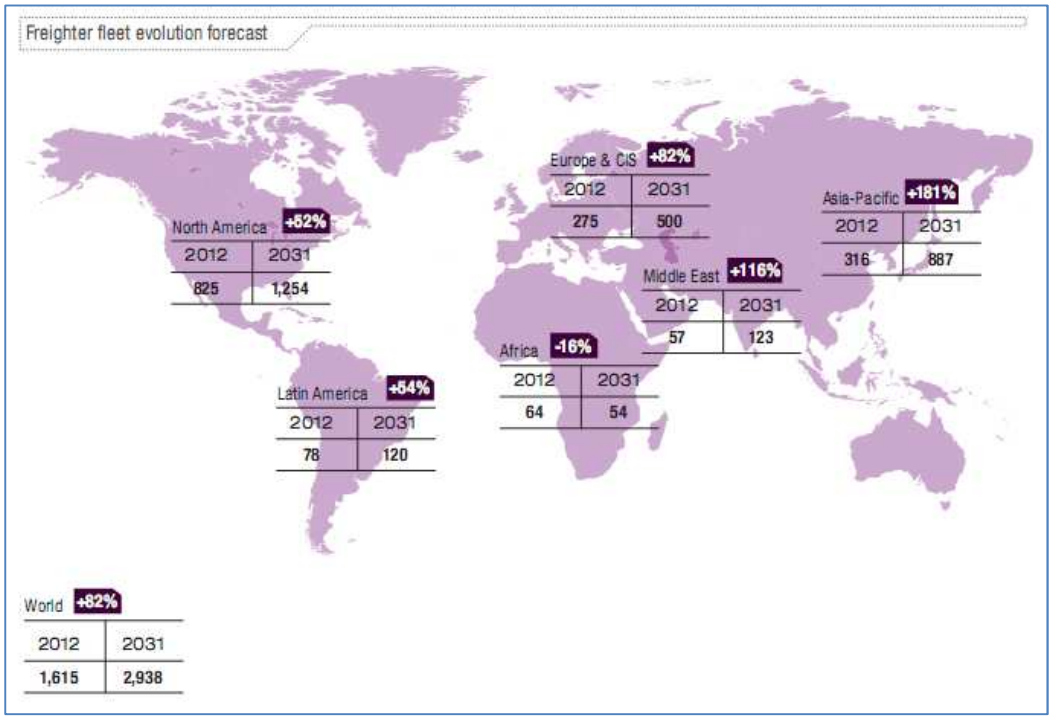


Figure 7 – Freighter Fleet Evolution Forecast - (Airbus 2012, 149)

Boeing claims a positive trend too, with a growing role of the Asian market: "Air cargo traffic growth, measured in revenue tonne-kilometres (RTK), is projected to average 5.2 percent over the next 20 years" (Boeing 2012, 18). However, the current situation is really open to the most different outcomes. The air freight industry can suffer more and more from increasing operational costs, to the point to move back to (small) hyper-specialized niches; or, due to a more integrated logistic market and a more collaborative and internationalised production chains, its role can improve. In other words, "it remains to be seen whether this shift to shipping is merely a temporary pattern or the first sign of a trend reversal" (Deutsche Bahn 2013, 19).

3.1.3 Shipping industry

> *In many ways, shipping comes closest to being an analogy with the airline industry. […] Shipping companies provide a perishable good with low marginal cost in serving an additional customer. Like airlines, they have significant stepwise cost increases when adding a new ship but only limited operational economies of scale in fleet size. Costs per tonne are falling with ship size for a given type of cargo, creating incentives to operate larger ships. Shipbuilders are heavily subsidized and push capacity into the market. […] Demand for shipping is highly volatile, driven by the business cycle. The main substitute is using other modes of transport, or avoiding the need for transport* (IATA 2011, 49).

The international shipping market can be split in inland navigation and international shipping. The market is organized around some big players, based mainly in Europe, China, Japan and Taiwan, as well as North America. Those companies, more frequently in the past years, joined alliances. The biggest player is the Denmark-based firm Maersk.
As reported by Alphaliner, "the global cellular containership fleet capacity has reached 16.34 Mteu as at 1 January 2013, for an annual growth of 6.0%, according to Alphaliner's annual fleet survey. 207 cellular ships for 1.25 Mteu were delivered in 2012, while deletions (comprising scrapped, lost and de-celled ships) reached 201 units for 351,000 teu. In addition, there were 18,000 teu added from capacity upgrades of existing ships, arising mainly from the capacity augmentations of Maersk's 8,200-8,600 teu 'S'-class ships, boosted to around 9,600 teu" (Alphaliner 2012, 3).

"A liner shipping company (LSC) consists of a fleet of ships, with a common ownership or management, which provides a fixed liner shipping service at regular intervals between seaports, and offers transport services to any containerized cargoes that are ready for transport by their sailing dates in the catchment areas served by those ports. In general, LSCs accept cargo from all potential shippers to sail on the dates specified in a published schedule. The primary functions of LSCs are to:
- offer a regular shipping service for cargo consignments and process the associated shipping documentation;
- load containers onto ships and discharge containers from ships;
- provide shipping services on fixed schedules; and
- plan the tonnage availability to serve trade activities and determine whether to build new vessels or charter additional vessels to meet the shipping demand." (Lun, Lai und Cheng 2009, 439)

The shipping market shows evidence of over-capacity, low economic result and low customer satisfaction. Additionally, piracy, extreme weather events and potential cyber-attacks further harm the sector. The study carried by the World Economic Forum on the issue has been particularly meticulous in listing the industry weaknesses, reporting that "the global container shipping industry is arguably one of the most critical links in the expansion of trade and global supply chains. […] If growth and profit are the key measures of health, the global container shipping industry is in a very distressed state. With volatility at an all-time high, evidence points to one conclusion: perhaps it is time for the global container shipping industry to revisit its strategy and consider a new approach." (WEF 2012, 16)

Alphaliner Top 25 as at 1st January 2013							
		Total existing			Orderbook			
#	Operator	teu	ships	% Chart	teu	ships	% existing	Share
1	APM-Maersk	2,584,922	605	49.7%	448,874	33	17.4%	15.4%
2	Mediterranean Shg Co	2,225,011	454	53.5%	254,774	23	11.5%	13.2%
3	CMA CGM Group	1,384,428	408	63.7%	130,144	15	9.4%	8.2%
4	Evergreen Line	723,378	182	47.1%	376,876	38	52.1%	4.3%
5	COSCO Container L.	716,868	162	46.4%	149,330	18	20.8%	4.3%
6	Hapag-Lloyd	632,049	139	48.7%	92,183	7	14.6%	3.8%
7	APL	576,163	126	58.0%	196,600	19	34.1%	3.4%
8	Hanjin Shipping	573,977	110	52.7%	178,444	25	31.1%	3.4%
9	CSCL	549,192	140	25.6%	98,952	12	18.0%	3.3%
10	MOL	506,239	110	51.6%	87,200	7	17.2%	3.0%
11	OOCL	449,905	98	38.7%	132,576	12	29.5%	2.7%
12	Hamburg Süd Group	421,159	103	49.1%	167,040	26	39.7%	2.5%
13	NYK Line	400,669	94	25.0%	52,832	4	13.2%	2.4%
14	Yang Ming Marine Transport Corp.	358,132	83	35.8%	49,750	9	13.9%	2.1%
15	K Line	352,754	71	65.3%	9,592	1	2.7%	2.1%
16	Hyundai M.M.	347,325	59	71.0%	90,615	10	26.1%	2.1%
17	Zim	318,180	84	53.5%	148,168	13	46.6%	1.9%
18	PIL (Pacific Int. Line)	297,312	144	32.9%	89,612	24	30.1%	1.8%
19	UASC	271,034	46	22.1%				1.6%
20	CSAV Group	258,754	56	81.4%	34,400	4	13.3%	1.5%
21	Wan Hai Lines	159,238	70	14.0%	13,596	3	8.5%	0.9%
22	HDS Lines	86,320	21	94.7%				0.5%
23	X-Press Feeders Group	78,695	61	93.5%	3,960	2	5.0%	0.5%
24	TS Lines	75,946	37	95.8%				0.5%
25	NileDutch	65,565	31	98.0%	14,000	4	21.4%	0.4%

Figure 8 – Top 25 shipping companies - (Alphaliner 2012, 3)

Such a comment went further, claiming how the sector had no strategy at all, focusing on short-term results, swinging between rich and poor phases. “At present, the global container shipping industry relies heavily on a spot market pricing model, inducing periods of ´feast or famine´. When demand is high, so are prices and the resulting profits are invested in new ships. When the demand is low, prices drop rapidly, coinciding with new vessels entering the market. This results in a volatile and unpredictable cycle, causing instability in the freight market and dampening global trade growth.” (WEF 2012, 16) Such a market style not only discourages a less instable pricing, but does not achieve appropriate performance. As Maersk CEO – Mr. Eivind Kolding - pointed out, “as an industry we only deliver one out of two containers on time. Name a supplier to your business that only delivers half the time, but is still able to count on your loyalty as a customer” (Maersk 2011, 10).

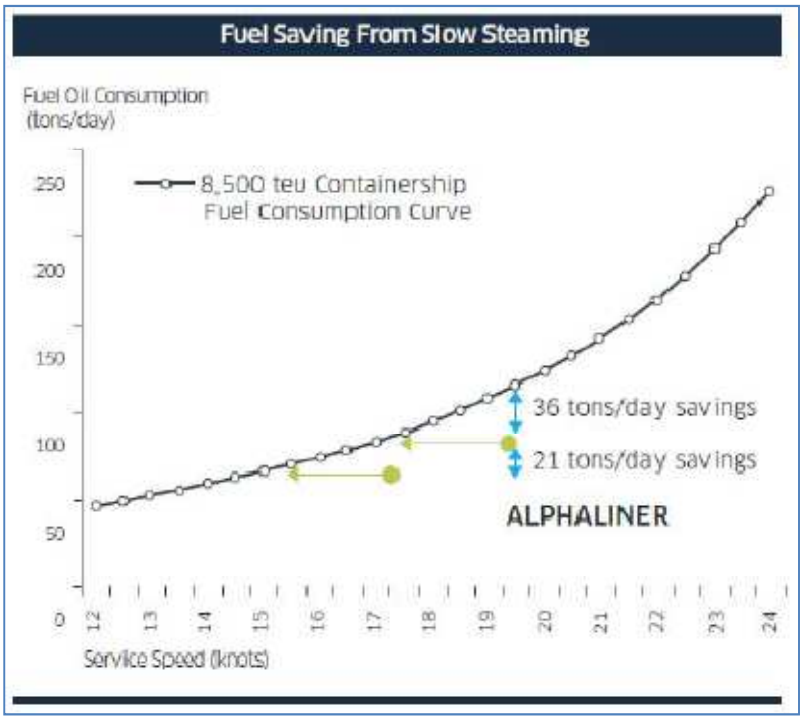


Figure 9 – Fuel Saving from Slow Steaming- (Alphaliner 2012, 4)

Additionally, the vessels ordered during the previous cycle were delivered at the ´wrong´ moment, exacerbating the over-capacity of the industry. Those new vessels – and particularly the new 14.000 and 18,000 TEU vessels – had the ambition to create economies of scale and to address the world-wide growing freight volumes, but so far the industry is experiencing different feedbacks. First at all, the market shows an embarrassing excess of facility, which "continued to plague the container shipping markets all through 2012. The container freight market saw its most volatile year while charter rates remained moribund" (Alphaliner 2012, 1). And the main cause of this distortion – according to WEF – can be traced back in the industry itself – a situation which is giving (un-expected) positive feedback for the environment.

> *Since very big ships are only practical on very high volume lanes, the carriers faced a combination of excess capacity and limited flexibility regarding where the ships can be assigned. As excess capacity tends to lower prices, the carriers looked for ways to reduce their capacity. Being reluctant to render the big ships out of service, many lines resorted to "slow steaming". Modern container ships are designed to run at top speeds of about 25 knots. Slow steaming reduces their speed to about 20 knots and fuel consumed per mile is reduced accordingly. A 20% reduction in speed decreases fuel consumption by about 40%. Slow steaming thus reduces carbon emissions per mile. Given the current period of overcapacity, slow steaming is beneficial to the container shipping lines. It reduces cost and capacity and is better for the environment. In many cases, reduction in carbon emissions is provided as the motivation for slow steaming.* (WEF 2012, 18)

Thus, the economic crisis in mature economies simply pushed forward the intrinsic contradictions of the industry, as said above namely overcapacity, lack of long-term vision and poor performance. Despite some timid attempt to change the market condition, the final result has been a price struggle, which has further weakened the industry. Stressed by "changes in itineraries, delays, additional expenses for human resources, fuels and ultimately insurance premiums all led to significantly higher burdens for the shipping lines" (Deutsche Bahn 2013, 20), no wonder to

observe how, involved in such a spiral, and following a trend familiar to the aviation operators, the companies try to achieve economies of scale and scope through alliances.
The driving forces of those agreements have been i) strategic initiative for performance gain, ii) market coverage, iii) additional business, iv) reduction in waste and v) technology development. (Lun, Lai und Cheng 2009, 443)
The formation of today's global alliances is not a new phenomenon but "dates back to the end of 1995" (Panayides und Wiedmer 2011, 25), with the open agreement of the national governments or over-national agency. "The demotion of the conference system primarily through the US OSRA (1998) and the abolition of the exemption from anti-trust rules by the EU in 2008 have led companies to seek other forms of collaboration in the effort to gain advantages" (Panayides und Wiedmer 2011, 26). However, those "strategic alliances do not aim for price fixing but instead for full integration of the service capabilities of the parties into one whole. Marketing is undertaken on an individual firm basis and can differentiate between the parties to the alliance in terms of client relationship management from the moment the first encounter is made until final delivery of the cargoes to the destination" (Panayides und Wiedmer 2011, 26).

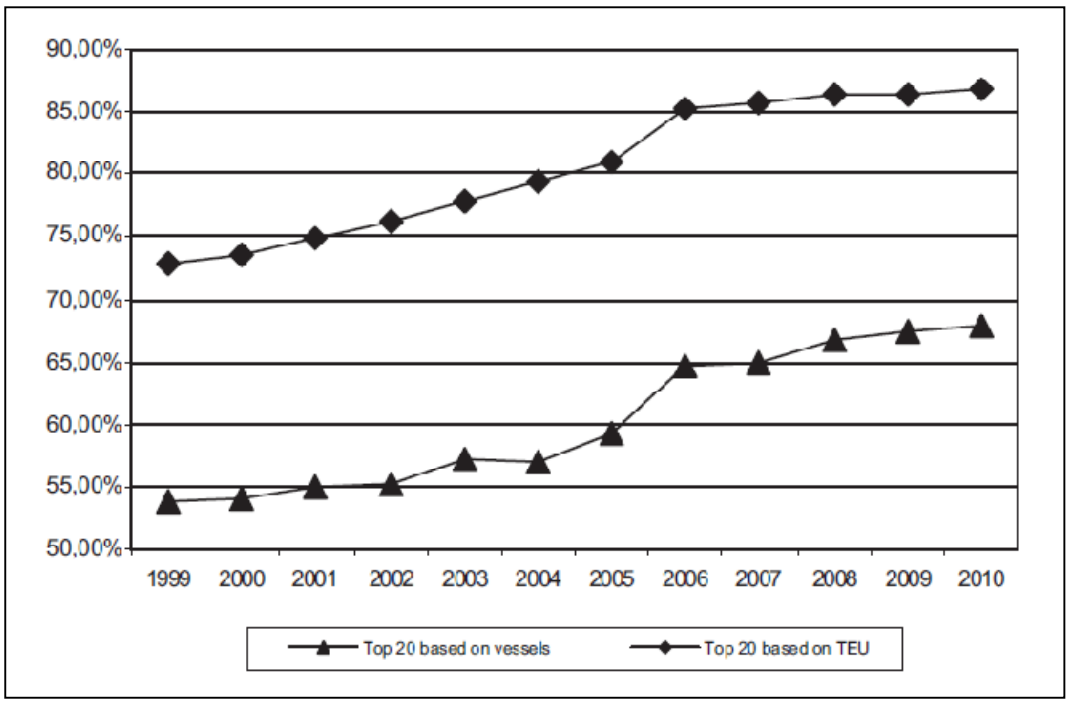


Figure 10 – Share of the top 20 ocean liner shipping companies - (Panayides und Wiedmer 2011, 29)

The situation of European local shipping does not differ so much. As DB reported last year, "inland shipping companies from the Netherlands successfully expanded their market position. According to the [German] Federal Office for Freight Transport, these companies have invested substantially in new capacities in recent years and are now competing extremely aggressively for new contracts. This partly explains why surplus cargo capacities have arisen, especially for the large vessels working the River Rhine, impeding recovery of the prices, which had dropped noticeably during the economic crisis. In contrast to the dynamic growth in transport quantities, there was virtually no improvement in the level of freight rates, despite the economic upturn" (Deutsche Bahn 2012, 15).
Moving back to the shipping industry as a whole, the situation of the world is depicted in such dark colour, that WEF, in its "Key Council Insights and Recommendations" listed three main supply chain

risk, e.g. i) Piracy, ii) Cyber attack and iii) “Bankruptcy of one or more major carriers: although the freight market would adjust, the removal of significant amounts of maritime or air freight capacity at short notice could dislocate time-sensitive global supply chains” (WEF 2012, 6).
Indeed the situation is risky, with weak economic results, depressing tones, and lack of coherent action, all ingredients that can lead to a worst situation. Maersk, the major company of the sector – which is currently not involved in any industry alliance – presented in 2011 a “manifesto”, claiming a different prospective and stressing how “The discourse in shipping has barely changed for half a century” (Maersk 2011, 3). Meagre performance, lack of customer satisfaction and a short term view were the main critics of Maersk´s manifesto, calling for a better quality service, which – in the long run – should avoid bottom-rock price battle and enhance the quality of the service. “For so long, the key driver of industry discussions has been price levels. Customers of course care about cost, but what they really care about is the total cost and not the price on a single box. They can accept rate rises; what they cannot accept is a delivery promise that isn’t trustworthy. Often customers value their ability to trust delivery promises more than they need a rock-bottom price – because the cost implications of late deliveries are far greater”. (Maersk 2011, 11)
Naturally, “as with any change, this will take time. There is no quick-fix solution. Carriers and shippers alike must agree that the industry should no longer continue down a path of instability and volatility. Over time and with discipline, the stability of an efficiency-based model has the potential to ensure the long-term health of the global container shipping industry. With increased communications between the shipper and carrier and a shift to a more customer-centred model, a more stable industry could emerge to support the future growth of global trade” (WEF 2012, 17).

3.1.4 Freight transport on rail

As more diffusely reported in RACE2050 deliverable D6.1, the EU-27 freight rail market is still a quasi-monopoly of national incumbent operators. The role of national, state-owned, de facto only-players is however challenged by new entrants and by more open markets. Generally speaking, with a few exceptions, also worldwide the dominant figure in rail freight is a “national champion”, e.g. incumbent and state-owned operator, although cooperation and more open market are experienced also out of Europe.
Beside this market trends, due to energy and environment considerations, the EU policies have given a great attention to the role of the rail in freight transport, aiming – in the long run – to obtain a shift from road to track. In other words, “by 2050 rail should substantially expand its modal share over medium and long distances for both passenger and freight, based on a dense network connected to all core airports and sea ports, a major expansion of the high speed network, and the deployment of ERTMS and of a European multimodal information, management and payment system” (CER, EIM and UIC 2013a, 3).

EC Transport White Paper goals and the role of rail

To implement this ambition the EC white paper presents 10 Goals for a transformation in Europe's current transport system towards a competitive and resource efficient transport system, and six of these directly concern rail transport, highlighting the importance of this transport mode in Europe for the future,

1. *30% of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050, facilitated by efficient and green freight corridors. To meet this goal will also require appropriate infrastructure to be developed.*
2. *By 2050, complete a European high-speed rail network. Triple the length of the existing high-speed rail network by 2030 and maintain a dense railway network in all Member States. By 2050 the majority of medium-distance passenger transport should go by rail.*
3. *A fully functional and EU-wide multimodal TEN-T 'core network' by 2030, with a high quality and capacity network by 2050 and a corresponding set of information services.*
4. *By 2050, connect all core network airports to the rail network, preferably high-speed; ensure that all core seaports are sufficiently connected to the rail freight and, where possible, inland waterway system.*
5. *Deployment of the modernised air traffic management infrastructure in Europe by 2020 and completion of the European Common Aviation Area. Deployment of equivalent land and waterborne transport management systems (ERTMS). Deployment of the European Global Navigation Satellite System (Galileo).*
6. *By 2020, establish the framework for a European multimodal transport information, management and payment system.* (ERRAC 2012, 12-13)

Given this condition, and a wider worldwide track renaissance, the European freight rail sector is expected to play a significant role in the next decades. The potentialities of this sector are indeed under development, even when applied to globalized and inter-continental trade routes. The daily Deutsche Bahn´s train (run on behalf of BMW) connecting Germany to China through Russia (Deutsche Bahn 2013) is part of wider discussion on the Asian ´Silk´ route.
Given high expectations and potential higher performances of the rail sector, the European market show four major trends:

1. Poor economic results for the rail sector;
2. The vertical integration of freight and logistics services, usually led by rail operators, which encompasses rail transport and other activities;
3. The progress of (a few) European big players;
4. New market landscape and an innovative debate about the EU policies.

Poor economic results for the rail sector
As merciless pointed out by Deutsche Bahn 2012 *Competitiveness report*, “the European rail market has not succeeded in attracting private capital on a long-term basis” (Deutsche Bahn 2013, 36). The question raised by such a statement is about the reason behind such a capital desertion, if we witness a lack of positive economic feedback, or if the (former) incumbent players were so dominant to discourage new entrants (ITS and CER 2009).
The sector has – generally speaking – rather poor financial performances, aggravated by the economic crisis of after 2008, not to mention still needed state subsidies, mainly focused on the infrastructural maintenance and development. The low financial results were rather poor also before 2008 crisis, and usually the main culprit has been indicated to be the ´social privilege´ of railway workers. A closer look shows how the EU railways companies’ workers number declined, also dramatically, in the past twenty-years (Eurofound 2004, see also D6.1), and surely some niche

of un-efficiency are still existing, leaving room for improvement. However, due to political and social conditions, further cuts are not so easy to be achieved, and, all together, the employees cost is just one of the problems. Even Deutsche Bahn claims that “many former state-owned railways are still not effectively organised as private-economy enterprises” (Deutsche Bahn 2013, 36), a consideration that goes further than just a legal framework. The rail sector, also in its freight side, shows a scarce attention to economic results. The rail freight transport in the European context is even more difficult, considering the priority given to the passengers’ convoys, which naturally slow down the speed and the overall efficiency (Thompson 2010).
This and other factors can explain the low performance, like EBIT, of the European firms, among the worst of the all freight sector.

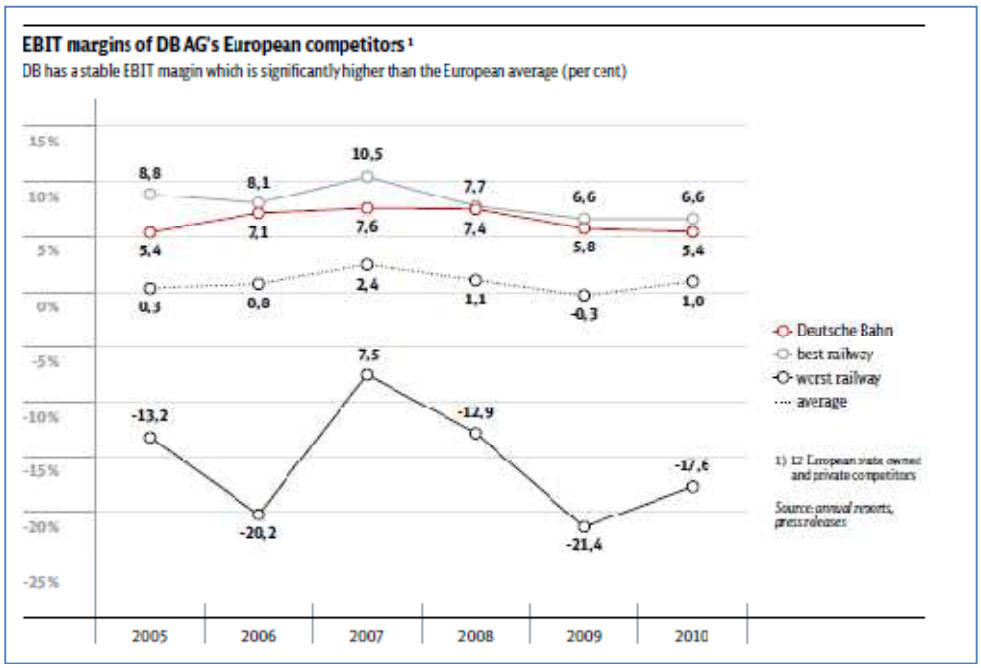
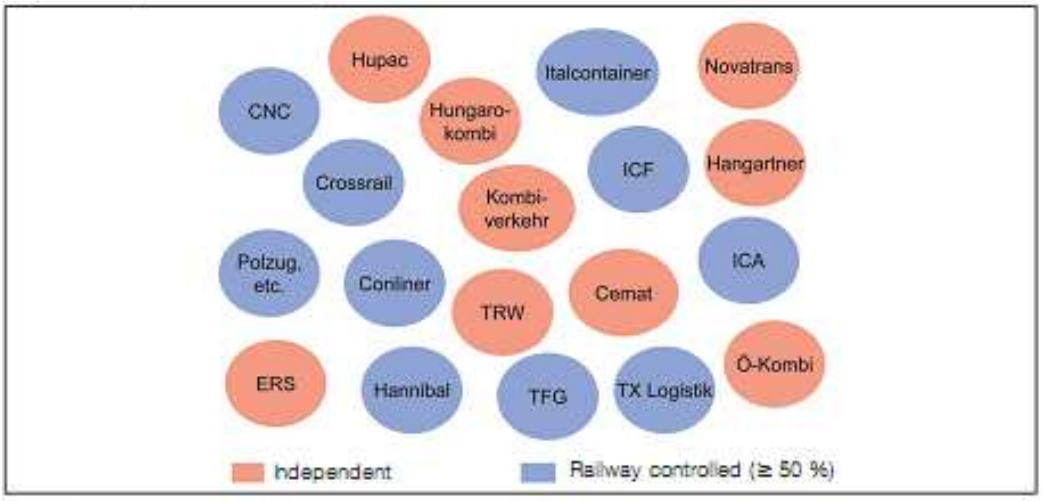


Figure 11 – EBIT margins of DB and European railways companies- (Deutsche Bahn 2013, 37)

The vertical integration of freight and logistics services, usually led by rail operators, encompasses rail and other activities.
There are several reasons behind the vertical integration in the freight and logistics markets. Classical economies of scale and scope can be ´easily´ achieved integrating the different level and activities of the logistic chain. Another pushing factor is the customer requests of end-to-end care of the service, which can be better performed with strong alliance or integrations. “Furthermore, moving upstream in the value chain puts rail freight companies in a position to develop strategies and negotiate directly with customers, which could generate and secure more transport business.” (A.T.Kearny 2009, 8). But it is also true that through those integrations, some players “will add new, more profitable activities. Deutsche Bahn, SNCF and several others have added general logistic businesses to their portfolios, which are already more profitable than other rail freight businesses” (A.T.Kearny 2009, 8). This explains Figure 12. Many logistic operators out of the rail sector have been more and more incorporated in railway companies, generating a strong vertical integration, and also reducing the numbers of the players on the market. Due to their financial leverage, only big railway operators have been able to obtain those results, which were, in their perception, vital to differentiate their portfolio and to react to the new landscape created by an increased liberalisation. So, in the medium run, the former incumbent operators, often still owned by the

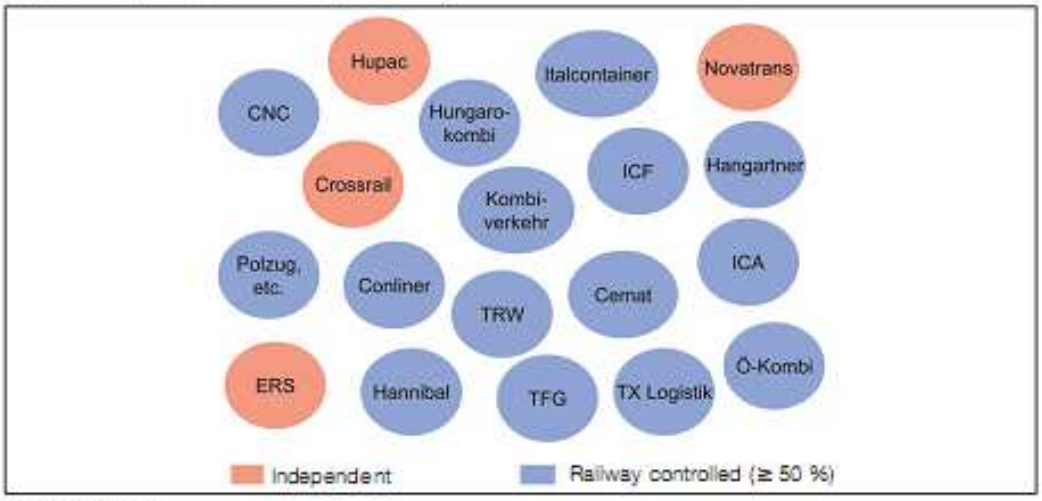
State, are harvesting the benefit of the new business situation, due to their large economies of scale, adequate knowledge of the market, as well as financial strength.

Figure 1: Operators in Europe – 2003



Source: HUPAC

Figure 2: Operators in Europe – today



Source: HUPAC

Figure 12 – European Freight Operators Trends 2003-2008 - (CER 2008, 103 (from Hupac))

In other words, "several railways have become involved in combined transport, either directly or by setting up subsidiaries. Former state railways now participate in combined transport companies to the tune of 50 % or more, a vertical integration which signals a somewhat defensive marketing strategy. Hence the delay in the opening up of the railways, a situation which is not conducive to the development of combined traffic" (CER 2008, 103).

The progress of (a few) European big players

The above can also explain the (rather quick) creation of a few big players in the European arena. Mainly, those players are (former) incumbents, which moved towards vertical integration, or bought other (small and big) railways companies out of their domestic market or, also, transport firms, operating across Europe inside and outside the rail sector. "The incumbents began losing market share at the beginning of the 2000s in many European countries. Today they are witnessing

a reverse trend as incumbent are regaining market share. The gains are not because of their operational superiority but because of market consolidation (A.T.Kearny 2009, 5).
This trend has been fastened in the very last years: “in 2010, SNCF acquired the majority stake in the former private provider Keolis. DB acquired Arriva, one of the leading private providers, the same year and Trenitalia took over Arriva’s German business” (Deutsche Bahn 2013, 36). Therefore we can count nowadays two main operators, e.g. the mentioned DB and SNCF, with a third potential big player, that is RCA-Rail Cargo Austria (A.T.Kearny 2009, 8). Naturally, “in an industry where up to 75 percent of traffic is cross-border, industry experts think only a large network can generate sufficient synergies to run the business profitably” (A.T.Kearny 2009, 9). As reported by the debate, “it remains the case that it is generally easier to compete in international markets by forming alliances with operators in each country, or by setting up or buying subsidiaries in those countries. Therefore cooperation as well as competition must be expected to remain part of the pattern, and this is particularly important where there are strong network effects, as with wagonload freight services and connecting passenger services” (ITS and CER 2009, 68).
However, those merging activities can increase the efficiency of the European freight and logistics industry, enhancing its services, but it is also an unexpected feedback of the liberalisation process, which did not weaken the previous (defined as inefficient) national incumbent operators, but actually enhanced their position. It has been also claimed that inevitably, due to the situation of the European market, only operators dominating a big national network are able to act efficiently through vertical integration, thus shrinking the number of the players (CER 2008).

New market landscape and an innovative debate about the EU policies.
The EU freight rail market has not yet found the magic business-wise silver-bullet (if it exists) to fix its problems, and it seems stuck in its (low) volume. From a North-American perspective (and actually from a Chinese one, too), European markets lack of big distance associated to big volumes, the ones giving to the rail the most comparative advantages. Additionally, despite some first attempts to reverse the situation, especially in the so-called EU green-corridors, in Europe the passengers’ service has priority to the freight transport, harming the performance of the latter. Some stakeholders already wonder if a separation of freight and passengers rail networks cannot be a solution, in order to enhance the volume of both (Thompson 2010, 17), although this inevitably has impressive costs. Those comments underpin what already in 2007 the EC reported, e.g. that “several options have been studied for creating the European rail network giving priority to freight, allowing the players in the sector and the Member States to act without any new Community input; embarking on a series of new measures to create a freight-oriented network made up of sections dedicated to freight and others receiving mixed passenger and freight traffic; and launching a specific programme leading to a European freight-dedicated network” (EC 2007a, 6).
While the EU debate on the transport policy is assuming a new shape, also the industry landscape has changed.
EU policies have strongly supported the rail liberalisation process, co-financed infrastructural projects and envisioned a greater role for the rail sector, generating dramatically changes in the market and developing relevant outcomes in terms of growing opportunities. No need to say, this large array of policies has also received critical comments, which are now developing in the railways stakeholders milieu too.
More generally, the downturn of 2008 crisis has fuelled an already running discussion about the core concept of EU liberalisation policies, focusing particularly on the different speeds of its implementation, as well as on the actual need of vertical separation between (former incumbent)

operators and rail infrastructure manager. A second point of discussion is some industrial practises, like the single wagonload lack of interest by railway operators, something which are against EU policies. Finally, another issue largely debated is the TEN-T programs, as discussed in the next chapter of this deliverable.
About the vertical separation of operators and infrastructure manager, the debate is – generally speaking – more cautious about its absolute needs. While there are no voices against a more open market with an (desirable) wider array of services, the latest research based on the past decade experiences, show a less compact point of view. Mainly, in a nut-shell, "existing studies draw different conclusions concerning the desirability of vertical separation, but seem to agree that there does not seem to be a 'one-size-fits-all' solution in term of unbundling" (Van de Velde, et al. 2012, 4).
Actually, "the effects of vertical separation in terms of induced cost increases resulting from misalignment of incentives are likely to be larger than the increased transaction costs. The efficient setting of track access charges is very important, but cannot by itself lead to the correct alignment of incentives regarding both efficient use and efficient development of the rail network. Whilst past studies generally find that increased competition reduces costs, they show no consistent pattern on the impact of vertical separation on costs" (Van de Velde, et al. 2012, 4). The great expectation of UK rail operators' liberalisation has been not completely fulfilled by adequate results, driving to a general dissatisfaction concerning the performance and the efficiency of the service, not to mention the condition of the companies involved. So, to put in polite way, "U.K. and Australian experiences with franchises have not always encouraged other countries to adopt the practice" (Thompson 2010, 7).
Among others, we can here point out two interesting contradictions of the rail sector, which can have both medium and long-term feedbacks.
The first comment is about the single wagonload transport, (in)famously a loss for the railway operators due to the huge operational cost associated to such a service. Despite the political, environmental and energy-saving pressure to move from road to rail service, moved by a strict financial point of view, some rail (incumbent) operators suddenly realized how onerous the service was, and found easier to cancel the offer at all (ESC 2010). Such a diminished offer will have a first effect in diminishing the role of rail for this sub-sector, although some carriers have no choice more than rail transport, due to the nature of their product. This can thus also lead to new business solution, as – for instance – represented by Rail4Chem, devoted to the chemical industry (A.T.Kearny 2009, 5).
Another open question is the process of wider acquisitions by former incumbent. DB and SNCF have already entered the coach and road freight market through some of their controlled firms. This will have a relevant impact to the market landscape: on the one hand, offering a wider portfolio of solutions should lead to more integrated and holistic transport solutions, closer to the customer need. But, on the other hand, considering the poor results of the rail sector, this can also push to a greater attention to a more remunerative sector out of the (former) core business, therefore impoverishing the attention devoted to the rail sector and to its market share.

3.1.5 Road Freight transport

No doubt that, in Europe, the road freight is the backbone of the sector with more than 70% of the EU-27 inland market share, producing a turnover of 300 billion Euro, employing nearly 3,000,000 people in about 600,000 enterprises.
In the European arena, road freight transport does now enjoy a good reputation. Being completely

dependent, so far, by fossil fuel, and having the burden of the main freight duties in EU-27, the industry is responsible for an impressive share of the energy use and for pollutant emissions. Claimed as i) less energy efficient than other transport systems, especially for long distance transports, ii) polluting, iii) less safe and iv) congestion maker, EU policies aimed to shift to the rail mode (EC 2013a), although with minor or none results (ITS and CER 2009). Although easy to be criticised, road freight industry remains dominant in the EU panorama and to some extend not replaceable.

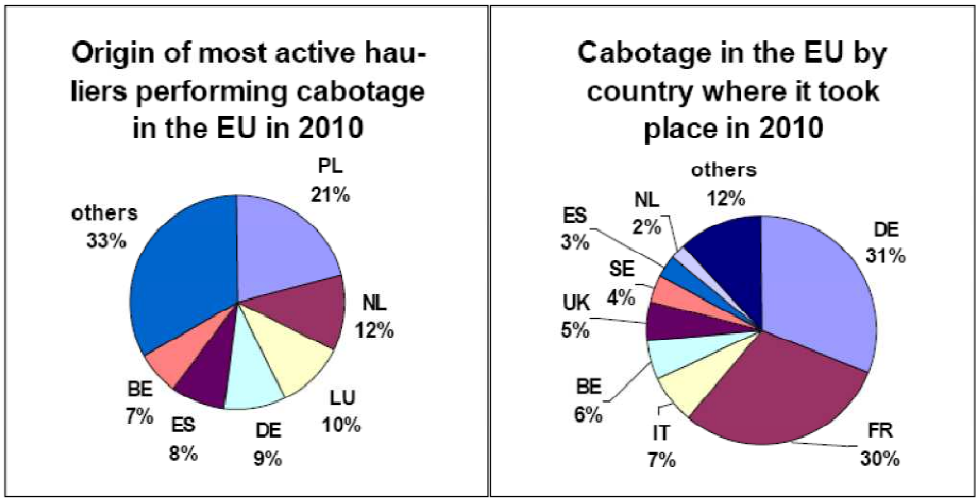


Figure 13 – Road freight transport basic statistics- (DG-Move 2012, 13)

Especially in the short range transport, the road industry has no rivals, considering its flexibility and its tailored approach to the customer needs. The low performance of the rail system and the difficulties met by using some of its service, alike the rail single wagon load service mentioned above, makes road transport very appealing, or even simply indispensable also for long distance. So, the industry landscape is quite contradictory. The road freight market is de facto irreplaceable, but it has reputed to have lower efficiency and meagre business results. Additionally, despite put under pressure by energy and environmental issues, the industry had trouble to develop a consistent strategy to address those questions and to achieve more vital economic results. This is due to "the lack of available funding in undertakings where margins are traditionally low, as well as some lack of awareness of the importance of innovation in the sector" (DG-Move 2012, 6). Indeed, "action is required in a number of areas in order to achieve high quality, sustainable and energy efficient road freight transport. Innovation can be a critical driver in attaining these objectives in that it can lead to significant efficiency improvements in the sector through both technical and process-related change" (DG-Move 2012, 6).

While full electric-powered heavy vehicles are under test, several paths have been researched to deal with the main issues of the industry, including longer and heavier vehicles (ITF 2010), reducing empty journeys and enhancing the quality of the operational factors (ACEA 2010). In order to reduce avoidable and inefficient last-mile operations with large vehicles, "cities in Europe are beginning to develop the concept of Urban Consolidation Centres which constitute links between long distance and urban transport. Cargo arriving by large lorries designed for highway movements is transferred onto smaller trucks and vans more adapted for urban deliveries" (DG-Move 2012, 33).

On top of those questions, we should also mention that within EU-27 national barriers still exist, *de jure* and *de facto*, and DG-Move high level group "identified and researched four key obstacles to the creation of a Single European Transport Area, namely:

- Driver Shortage
- Enforcement Practices
- Cabotage Practices
- Lack of Innovations and Applications of Good Practice" (DG-Move 2012, 3).

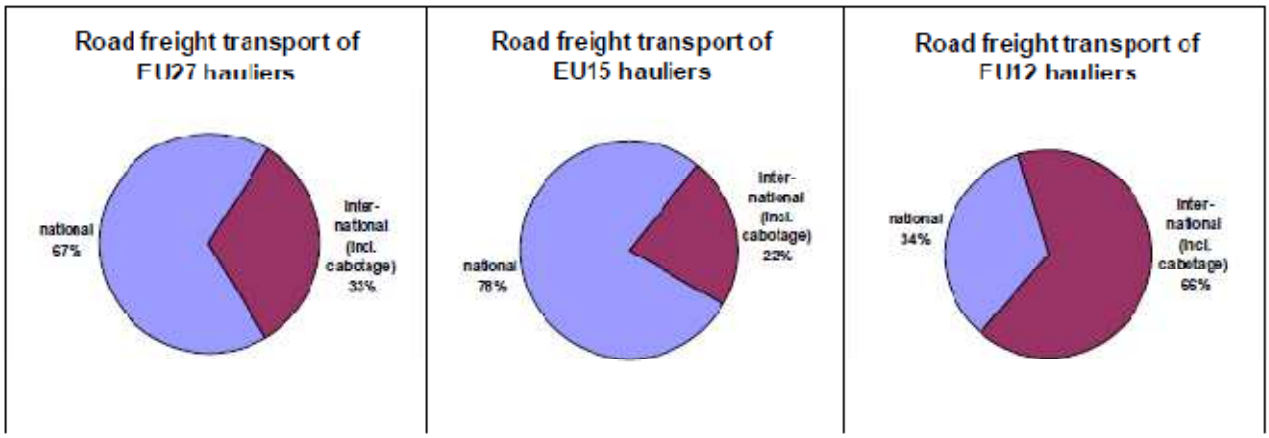


Figure 14 – Share of national and international road freight transport in EU- (DG-Move 2012, 10)

It is well known that the industry has high fragmentations, although "there has been a continuing trend over many years for freight forwarding and sub-contracting to play an increasingly dominant role. […] The rise in the size and importance of pan-European logistics 'integrators' have led to a current position where the top ten land transport (road and rail) integrators alone are responsible for some 13% of total road freight turnover across the EU" (DG-Move 2012, 13). As in all the other freight sectors, also the road freight industry has suffered the 2008 crisis, which has hastened the trends towards a concentration of the sector and its integration with other branches of the logistic chain (IRU 2011). As a result, "a number of providers disappeared entirely from the market", while the over-capacity forced other ones to react "with measures such as taking vehicles out of service and thus significantly reducing the freight space on offer" (Deutsche Bahn 2012, 20).
Additionally, rising operational costs were putting the industry in an unpleasant situation, in which those players with bigger economies of scale and scope had greater chances to keep their market positions (Clecat 2011). All together, the industry suffered "a substantial increase in costs, not only for personnel, financing, repairs and spare parts, but above all a sharp increase in the cost of diesel fuel, which rose by an average of just under 13 per cent. Especially in the case of contract freight rates, these cost increases could only be passed on to the customers with a time lag, and even then not always in full" (Deutsche Bahn 2012, 14).
This new wave of competition among the freight sub-sectors and inside the road freight industry can easily lead to a new business landscape, with reduced fragmentation of the enterprises operating. The smaller players presumably have less room of manoeuvre to resist the current situation and the low prices currently achievable.
Another growing trend is the development of companies operating in the road sector that are part of a larger group. This process takes place in form of concentration *and* horizontal integration. It is expected that the role already played by some big operators (with their core business in the rail sector or in other segment of the logistic chain) will be bigger. This trend will be supported by push and pull factors. On the one hand, a road freight branch in a big logistic company will create an added value and can increase the market opportunity. On the other hand, considering the need of differentiating the portfolio, railway companies have additional reason to step in.

3.2 Passenger Transport

Abstract
EU passenger transport is dominated by private mass motorisation (more than 70% of the total market), followed by aviation, coaches and rail services. As with freight service, the passenger transport industry's financial results remain feeble, while the performances can be increased. Airlines and railway industries, both very capital-intensive, are dominated by large companies, while road sectors (taxis, coaches and buses) present a more fragmented situation. However, a trend towards big international alliances and/or European players, combined with a stronger vertical integration is already running. All the stakeholders are aware of the industry challenges, above all a wider customer satisfaction and tighter multi-modal integration.

3.2.1 Trends and numbers

> *Between 1990 and 2010, passenger transport in the EU27 increased 35% to 6.4 billion passenger kilometres, which is on average almost 13,000 km per person. Of the total passenger kilometres, passenger cars accounted for 73.7%; buses and coaches 7.9%; railways 6.3%; powered two-wheelers 1.9%; and tram and metro 1.4%. Intra-EU air and intra-EU maritime transport contributed 8.2% and 0.6%, respectively. In 2010, € 904 billion or roughly 13.0% of the total household consumption was spent on transport-related items"* (Transport-research.info 2013, 9).

The growth of passenger mobility is a constant of the modern times. Although this issue is better developed in RACE2050 deliverable 5.1, here we can assess passengers' mobility has been constant in its time-budget (about 1 hour/day), although it has covered increasingly longer distances. Industrialisation and higher incomes are two factors, which can push to higher request of personal mobility, which is usually satisfied in Europe by private ownership and use of motor vehicles. Although being part of mature economies, it is expected that European passengers' mobility will increase in the next decades.
Summarising the findings, Neaa suggested that, in absolute numbers, according to the different sources, "air passenger kilometres are forecast to double or triple between 2005 and 2050", while "car travel is forecast to increase up to 2050, by about 40% to 70%"; the growth for "rail passenger transport differ significantly, ranging from 30% to double, between 2005 and 2050" (NEAA et alii 2009, 69-70). TransVision study forecasts that EU-27 will move from 5,619 Pkm million in 2005 to 8,129 Pkm million in 2050.
Other research pointed out how the growing trends that have accompanied Europe in the past century are gone, stating "the forecasts of continued growth in the passenger travel need to be re-assessed. The concept of peak travel is gaining traction with evidence in a number of countries suggesting that rates of growth are declining or, in some cases, being reversed. This may reflect for some Member States saturated car ownership, congestion, and substitution of transport by information technology. Changing demographics, including an ageing population, may also be contributing, whilst the evidence is confounded by the current economic downturn and rising fuel prices" (Transport-research.info 2013).
EU Passengers transport is dominated by private mass motorisation (more than 70% of the total

market), followed by aviation, coaches and rail services. As for the freight service, the passengers transport industry performances can be improved, whereas the financial results remain feeble. Airlines and railways industries, very capital-intensive, are hold by large companies, while road segment (taxis, coaches and buses) presented a more fragmented situation. A trend towards big international alliances and/or European players, combined with a stronger vertical integration is however already running, while the all the stakeholders are aware of the industry challenges, above all a wider customer satisfaction and a tighter multi-modal integration.

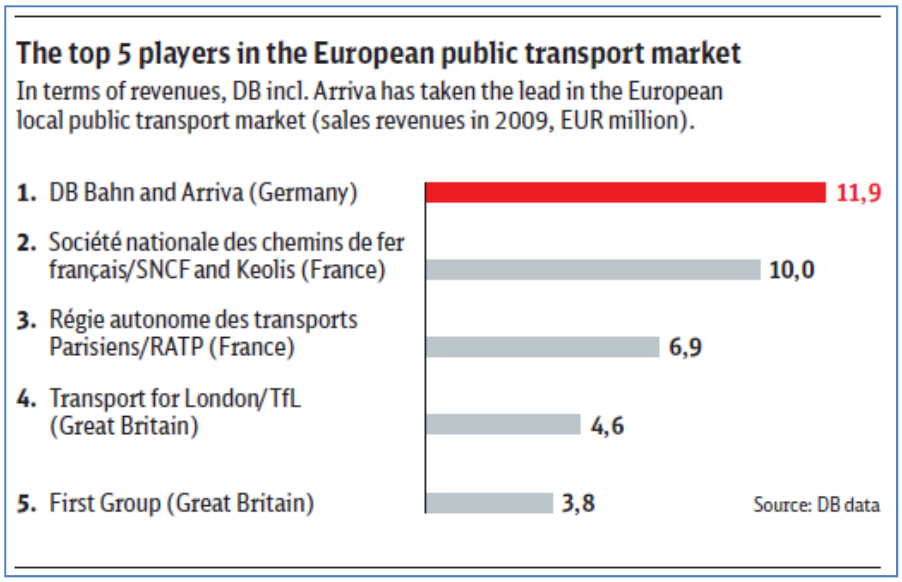


Figure 15 – The Top 5 Players in the European public transport market - (Deutsche Bahn 2012, 12)

3.2.2 Passengers' service industry: motor-car

Car ownership and use of motor-vehicles are personal businesses, which are run on private bases, although require public facilities, as for instance a road network, parking lots, traffic regulation and so on, which usually, if not always, are offered by public bodies and agency, and/or by local and national governments. Additionally, any car user needs a technical system which permits the exploitation of the motor-vehicle, like petrol stations, and naturally repairing mechanics, that is a maintenance, service and overhaul system. Finally, any car owner is involved in many fiscal and bureaucratic burdens, like drive-licences, compulsory insurance and governmental ownership tax, fuel tax excise etc.

All those factors and the related industries do not enter directly the field under investigation by RACE2050. However, in chapter 6 of this report and in deliverable 5.1 we analyse how those costs and those duties can influence travellers´ choices and behaviours. It is true that the car ownership and its everyday exploitation have shown a very low volatility despite fuel increasing coasts and soaring traffic burdens (Litman 2012). But new generations display a shift to innovative attitudes, a situation which is influencing the transport industry as a whole.

Motor-car mobility is not always run on private bases, but also through third parties. Taxi, car rental services and, last but not least, car sharing are forms of individual use of car, which involves an industry. The numbers of such a sub-market do not hit the headline, nor are its statistics reported in any general survey on the transport realm.

However, umbrella organisations and lobby associations, like IRU, claim for EU-27 one million taxi drivers, serving circa 20 customers for each day of service. IRU reports that taxis "account for 5% of

the European local public transport", counting 8% of the all employment in the European transport sector, while numbers of the annual turnover are not easily available for European as a whole, although the German market alone counted in 2008 for 3.5 billion (IRU 2009). The taxi market is highly fragmented (sometimes even run by illegal operators) and perennially under pressure in its financial performance.

The car rental industry is definitely capital-intensive and it is held by several inter-European (or even international) players. As in many other transport service sectors, the 2008 crisis has exacerbated the industry long-period trends, opening what seems to be a new phase of the industry. Two main elements should be underlined. First, not only on the USA, the car rental industry is undergoing a radical transformation. "Four years ago, almost all of the major US car rental companies were owned by car manufacturers. Today only Hertz (80% owned by Ford) remains in auto manufacturer control: Enterprise Rent-A-Car, National Car Rental and Alamo Rent A Car, are owned by the Taylor family of St. Louis; Henry Silverman – whose Cendant – owns Avis; and Sandy Miller, the former franchisee, owns Budget, Ryder, and a variety of other transport-related companies. These, along with a few others, now control over 90 percent of the [USA] market" (Institute of Transport Management n.a.).

The same trend hit Europe, which witnessed – for instance – Volkswagen´s withdraw from Europcar in 2007, while the process of "concentration among the car rental companies that has been evident for years also continued in the year under review. Examples of this concentration were the Hertz' takeover of Dollar Thrifty on the US American market and the merger of Avis and Avis Europe. Especially smaller and regional providers are suffering from competitive disadvantages as they do not operate a nationwide network of rental offices, but have a high fixed cost base, are unable to offer innovative services such as online and mobile reservations, and can only offer limited numbers of modern engine concepts in their fleets, or can only offer these belatedly. In the important segments of tourism and business travel it is above all the large international service providers that have good prospects in the international rental market" (Sixt 2013, 33).[1]

In a broader horizon, the car rental sector does not stand on its own, and it influences (and it is influenced) by the development of the car sharing. The transport industry is already experiencing an overlap among the two fields, which brushes, actually, also the taxi drivers" (Arbideas 2013). Car sharing is a developing phenomenon, counting currently about 700,000 subscribers for EU-27 sharing a fleet of 20,000 vehicles (Momo 2010). There are high expectations about the development of the sector, especially considering a mega-trend towards share-economy and a lower appeal of car ownership in mature economies, especially among the youth. Frost & Sullivan (2012) forecasts for 2020 a strong development in EU, envisioning 15 million users, with a fleet of 250,000 vehicles, one third electric powered. Additionally, beside the ´traditional´ car sharing industry, a peer-to-peer system is also quickly developing, with an expectation of 740,000 users and 310,000 vehicles in 2020 for EU alone.

Considering those numbers, not surprisingly, the car sharing sector witnesses many flourishing initiatives, led by a combination of players. Vehicles manufacturers, which left *en masse* the rental market not longer than 5 years ago or even less, are now stepping in the car-sharing industry, often

[1] "In Western Europe, Germany is the most important single market for car rental, followed by Spain, France and Great Britain. According to data provided by Euromonitor the German market had a volume of around EUR 2.0 billion in 2012, slightly up on the level the year before. The Spanish and French market carried a volume of EUR 1.3 billion in the year under review, and while the market volume in Spain was slightly up, the volume in France contracted a little. The British market recorded a volume of EUR 1.1 billion, which was also marginally down on the previous year's level" (Sixt 2013, 33).

associated with car rental colossi (Daimler with EuropCar, BMW with Sixt) or with public transport operators (like Fiat in the Italian market). Some train incumbents, like Deutsche Bahn, offer a car sharing service too, and so do other local transport suppliers. Finally car rental companies and also the car leasing industry entered the market, directly or indirectly.
All together, the distinction between the two sectors is evanishing, and every day more blurry, at least from the users' point of view, forging all the actors involved in the field to act quickly and effectually to broader their offer (Sixt 2013).

3.2.3 Coach

"The global bus and coach industry finds itself in a state of flux. The global economic downturn is affecting operators in all countries, bringing with it challenges and opportunities for the industry" (KPMG 2012b, 4). In the past twenty years, the "bus and coach" sector has moved from circa 497 million Pkm in 1995 to 510 Pkm million, which represents, for the same period a reduction from 9.4% to 7.9% of the passengers market. Some studies claim how bus and coach have "the highest share of any surface mode of public transport. In particular, enlargement of the European Union has increased the relative importance of scheduled coach travel. Coach transport has a number of advantages over other modes of transport, particularly in terms of safety, environmental impact, and its flexibility and ability to respond to changing demand" (Steer Davies Gleave 2009, 3-4).

Coaches only	**EU States**	**All 40 States**
Passenger-kilometres (millions)	262,983	540,512
Vehicle-kilometres (millions)	10,134	19,899
Passenger journeys (millions)	6,621	7,584
Fleet size	248,897	445,715
Employees (bus & coach)	1,546,955	2,255,445
Annual turnover (€m)	15,425	23,560

Figure 16 – Summary of indicative European Coach Market statistics - (Steer Davies Gleave 2009, 6)

However it is true that the national and EU statistics have to deal with blurry definitions of coach service, mixing it with bus services, and often misrepresenting tourist service run by coach.[2] A main distinction can be done between ´bus´ and coach, the first representing (roughly) short-distance or urban routed journeys, while the latter is operating in longer distance, usual inter-city route, often not on scheduled basis. Such a distinction has some material evidences in the vehicles layout and seat distribution, as well as in legal constraints (alike standing passengers permitted or

[2] "Common difficulties we encountered included the absence of any formal definition of a coach, as distinct from a bus. Many transport statistics (and languages) do not make such a distinction, and no set of rules consistently applies to all Member States. For example, although in most western European Member States standing passengers are not permitted on inter-urban bus/coach services and therefore this was one possible way of distinguishing these services, this is not the case in all Member States. Similarly, vehicles with a separate luggage compartment which might usually be considered 'coaches' are used on urban and rural bus services in some Member States." (Steer Davies Gleave 2009, 4).

not). The coach market itself can be differentiated in several layers.

	Type	Explanation
Services considered as coach services	Regular services	Regular services operate at specified times on defined routes, with specific boarding and alighting points, and are open to all, subject where appropriate to advance reservation. We consider as coach services those services which operate between different urban areas within the same region making limited stops, plus services which operate between different regions
	International regular services	All regular services crossing national boundaries are considered coaches, except where these are within cross-border urban areas (eg. Basel)
	Special regular services	Special regular services operate on defined routes and at defined times, but provide for the carriage of specific types of passengers to the exclusion of others. The main categories of special regular services are school and employee transport services. All special regular services are considered coach services, regardless of the nature of the route operated or vehicle used
	Occasional services	Occasional services are services which do not meet the definition of regular or special regular services, and which are characterized above all by the fact that they carry groups of passengers assembled on the initiative of the customer or the carrier itself. These include privately hired services such as tourist services. All occasional services are considered coach services, regardless of the nature of the route

Figure 17 – Definition of Coach Service - (Steer Davies Gleave 2009, 20)

The differentiation of services – as defined above – represents also diverse industrial micro-cosmoses, which usually have anyway a low prestige. Bus and coach "are not the most glamorous part of Europe's long distance passenger transport system. High-speed rail or airlines attract much more political and media attention. Rail and air are much more visible and require much more (public) investment in highly visible infrastructures. Coaches on the contrary disappear in general traffic and do not require public investments, except perhaps in suitable coach stations at attractive places in urban centres. Yet, long-distance ´express´ coaches cater for a substantial part of the mobility of Europe's less-wealthy citizens, at least in those countries that have appropriately (de)regulated this branch of activity" (ITF 2009, 3).

Services not considered as coach services	Urban regular services	Regular services operating mostly or entirely within the same city or other urban area are not considered to be coach services
	Local/rural services	Regular services in rural areas, or between rural areas and towns/cities, which make frequent stops, are not considered to be coach services

Figure 18 – Definition of no-coach service, e.g. regular bus service (Steer Davies Gleave 2009, 21)

The analyses available are consistent in depicting the industry as appealing for the bottom-end transport clientele and how "the very image of group tourism by coach is outdated and subject sometimes to a clichés-treatment by the media and, as a result, in some cases by authorities

themselves" (Busandcoach.travel 2013b, 4).
International Transport Forum enquires claimed how, indeed, "providers of long-distance coach services focus rather clearly on specific target groups: students, elderly, people with no access to cars, and poorer people in general. Swedish and British studies have shown the advantage of deregulation for these groups, while showing at the same time the limited impact on the rail system in terms of passengers captured. Rail and coach seem to cater for people with different values of time in terms of long-distance travelling (Steer Davies Gleave 2009). Some studies even show that direct competition between both modes in one corridor tends to result in a growing market for both at the expense of the car" (ITF 2009, 16).
Such low profile is also reflected in the lack of statistics, data and even in the "extremely fragmented in terms of the authorities in charge of its regulation. […] As a result, although some statistics are available for the total European bus and coach market, the overall availability and reliability of statistics is poor, and there are few statistics available for sub-sections of the market, such as long distance coach services" (Steer Davies Gleave 2009, 3-4).
This has also cascade effects on the regulation of the service: "In comparison to the rail and air transport sectors, there is little European legislation applying to the bus or coach sectors and as a result, there are significant differences in the regulatory environment within which the bus and coach sector operates in different Member States. One recent change to European legislation is Regulation 561/2006 –- setting out certain rules on driving times, breaks and rest periods – which removed a derogation allowing drivers of international tourist coaches to work up to 12 consecutive days" (Steer Davies Gleave 2009, 3-4).
The occasional tourist coach sub-segment is a tailored market, with high personalized need, which gives encourage to services that "often operated through numerous local, small, family operators" (ITF 2009, 18). Moving up in the scale, coach special regular services can be easily operated by local small firms, while (national) regular service and international regular services are more prone to be included in bigger companies or in multi-national firms. The trend towards the concentration of the industry has received further impulse in the past ten years:

> *One can also observe the continuous expansion of a few main European-wide operators. While the traditional model of small operators as sub-contractors of larger brand-holder or member of market association does not yet seem to be threatened, it will also be interesting to see whether this model will lose in importance and be gradually replaced by larger operators. The expansion of Veolia, as main French group, is currently very visible all across Europe. The British National Express is a second example, although less prominent. Earlier expansions of international groups, such as Stagecoach, have been witnessed in Sweden, but the events showed that these expansions could be very volatile. The future will tell, but a point for further study, in terms of regulatory preoccupations, is whether expanding large conglomerates pose a larger competitive threat to the coaching market rather than the co-operations per se* (ITF 2009, 18).

Such bigger players, like Veolia, Arriva and Keolis, in the past three years have been often incorporated by even bigger players (namely DB and SNFC), pushing further the industry concentration and opening questions about the exact business focus and main interests of those big holdings. On the other side, the sector has also experienced new innovative business models, often mirrored from the low cost airlines example, enhancing the ability of the industry to attract customers. The liberalisation of the service is still under implementation, although the proponents of deregulation claim "that in countries that have removed railway protection and deregulated the

coach sector, coaches tend to capture more passengers from the car than from rail, to conclude that coach deregulation would be beneficial from an overall transport policy point of view" (ITF 2009, 16).
One of the operators umbrella association also claims how association coach routes cover longer distance than train and shorter than aviation, thus being perfectly optimal to integrate the transport chain (Busandcoach.travel 2013b). However, despite a renewed interest by customers, innovative services, and routes offered by European operators on European routes, the coach industry needs to update its visibility and its performance, working on a better and wider level of information concerning the routes available, as well as on its public (mis-)representation.

> *Coach operators and travel companies should take initiatives to ensure that appropriate information on accessible group tourism by coach services is widely available, including via active promotion through modern communication tools and social media to people with reduced mobility and senior citizens. EU and national websites should be created with information on companies offering accessible coach services. Coach operators and travel companies should take further initiatives to support safety, vehicle quality and comfort, and quality of services (via quality and comfort classification systems, labelling etc.), and to better communicate these initiatives to the public"* (Busandcoach.travel 2013b, 8).

3.2.4 Rail

The situation of railway operators has been already discussed above concerning freight transport, as well as in RACE2050 deliverable 6.1. The aim of this paragraph is to underline the main characteristics of the passengers sub-market and its industry trends.
The most interesting element of the passengers sectors is the contradiction between high expectation of growth and (so far) not exciting performance. To use the words of the Forth European Rail package, "passenger rail in intra-EU transport has remained fairly constant at around 6%. The development of domestic rail market segments has been uneven among MS, ranging from a decline of more than 10% in Hungary to a greater than 20% increase in Sweden from 2005 to 2007. This is despite the introduction of circa 6,000 track km of high-speed line over the period" (EC 2013a, 2-3).
Theoretically, the train is well fitted for mass transit in dense areas, like cities, offering high efficiency, lower use of public space, less congestion, minor emission and higher energy efficiency. Considering the percentage of European population living in the cities, and their daily need of commuting, the high cost of motor-car ownership and ride, the inevitable traffic jams, train should be the dominant transport mode. "Against this background and the fact that the EU27 has a 75% urbanisation rate, there is a huge market development potential for suburban and regional passenger rail transport, especially given the rising congestion on roads" (EC 2013, 3). However, historically, the rail operators, usually, have been product-driven and not customer-driven, experiencing a low degree of satisfaction by the users. A long-term lack of coordination with other modes and other operators, and a tunnel vision of the service offered hampered the passenger rail volumes, while

> *since the mid-1990's, in parts of the EU (relatively newer MS in particular) underinvestment has created a vicious cycle of decline, with the decay of infrastructure and rolling stock rendering rail unattractive, especially given the wealth-driven high growth of car ownership.*

> *Cars have a large share of urban transport and 59% of Europeans never use suburban trains* (EC 2013a, 3).

Moreover, the (former) incumbents followed a different rationale than competitiveness, developing more struggle than coordination with other transport modes. The EU envisioned an array of actions to enhance the quality of the rail sector performances and its competitiveness, aiming to achieve those goals mainly through the liberalisation of the operational side. Other actions included a brand new EU high-speed network, trying to re-gain the market obtained by air operators (EC 2013a).
However, "in contrast to the limited intra-modal competition, long-distance rail passenger transport has to cope with strong intermodal competitive pressure from coach operators and airlines as well as private motorised traffic" (Deutsche Bahn 2013, 9-10). The results of the high-speed train has not been negative, on the contrary, although the network integrated more than substituted the aviation offers, catalysing more than shifting mobility. Additionally, even an incumbent as Deutsche Bahn complains that "with the exception of Great Britain, the European long-distance sector is handled almost exclusively by the incumbents in each country" (Deutsche Bahn 2012, 12), not to mention that high speed train are *de facto* in the hands of national operators only. So, all together, "although some parts of the world (notably North America) have competing rail infrastructures, most of the EU's network was designed at country level to be a single network" (EC 2013a, 4), and "under the current system, there are no incentives for European and intermodal cooperation" (EC 2013a, 5, Freightvision 2010).
Those discouraging considerations should leave room for an analysis of the business models to experience that environment and to evaluate the intrinsic limits (and potentiality) of the industry trends.
As seen in the previous section of this chapter, the railway sector experiences weak economic results. Additionally its infrastructures and a large part of its passengers markets are (worldwide) heavily subsided (EEA 2007). With the exception of UK, and unquestionably with different willingness and speed in the different EU countries, the previous incumbents and their political patrons gave (or not) access to new entrants, creating an embryo of competition. Some of those traditional companies reacted moving towards more appealing markets, alike high-speed trains; or they move to the acquisition of abroad companies operating within and out of the rail sector; or they moved towards a more comprehensive mobility offers, ranging from bike-sharing to hotel reservation. In this vein, the railway services have become a part of a wider picture, and the industry benefited both from the competition (however experienced in everyday life) and from different business cultures as performed in other transport services. The rise of a few big European players is still too recent to permit medium term analysis, and it can lead to the most different outcomes in the long run.
While the concentration process is under development, innovative business models are also under implementation. All together, given the megatrends favouring rail as reported previously (and above urbanisation and fuel costs), the rail passengers industry is nowadays better aware of its chance and of its weak points, particularly about a customer-driven offer.

3.2.5 Aviation

The airline industry had experienced in the past two decades a dramatic change, mainly due to the liberalisation of the sector – starting from the late 1980s – in North-America and EU. The following

growing role played by Low Cost Companies (LCC) re-shaped both the market and the industry. Introducing innovative business models, with a more efficient fleet, and thanks to customers´ self-tailored booking process, those LCCs were able to challenge the so-called ´legacy´ company, at least in the short-haul segment. The extraordinary development of LCCs not only altered the landscape of the industry, but stimulated "larger local passenger flows through low fares" (IATA 2012a, 4), increasing the role of aviation in transport.
The traditional airlines companies – based on the *hub-and-spoke* structure – were thus pushed to achieve a more flexible network, a choice that crashes with the long-haul services they have in their portfolio, and thus putting a strong constrain to their range of opportunities. In order to address the mounting problems, in the mid 1990s some alliances among major operators were formed. "Today there are three major alliances: the biggest is Star Alliance, followed by SkyTeam and oneworld. By the middle of 2011 these three alliances were providing over 80% of capacity across the Atlantic and Pacific and just under 80% between Europe and Asia. Traditional interline trips on nonaligned airlines have become much less important" (IATA 2012a, 1).

Low	All 26 members – Adria, Aegean, Air Canada, Air China, Air New Zealand, ANA, Asiana, Austrian, Blue 1, bmi, Brussels, Croatia, Egypt Air, LOT, Lufthansa, SAS, Singapore, South African, Spanair, Swiss, TAM, TAP, Thai, Turkish, United-Continental, and US Airways.	All 11 members – American, British, Cathay Pacific, Finnair, Iberia, JAL, LAN, Malev, Mexicana, Qantas, and Royal Jordanian.	All 12 members – Aeroflot, Aeromexico, Air Europa, Air France-KLM, Alitalia, China Southern, Czech, Delta, Kenya, Korean, Tarom, and Vietnam.
Medium	9 members – Air Canada, Austrian, bmi, LOT, Lufthansa, SAS, Swiss, TAP, and United-Continental (obtained ATI from DOT)	5 members – American, British, Iberia, Finnair, and Royal Jordanian (obtained ATI from DOT)	5 members – Air France-KLM, Alitalia, Czech, Delta, and Korean (obtained ATI from DOT)
High	3 members – Air Canada, Lufthansa, and United-Continental (integrated JV in North Atlantic markets)*	3 members – American, British, and Iberia (integrated JV in North Atlantic markets)	3 members – Air France-KLM, Alitalia, and Delta (integrated JV in North Atlantic markets)

Figure 19 – Level of cooperation among existing Alliance members - (EC US DoT 2010, 7)

The rationales of airlines alliances are "rooted in the fundamentals of network economics and a global economy. […] The legacy carrier business model on both sides of the Atlantic is predicated on a ´from anywhere to everywhere´ consumer proposition. However, no airline is able to efficiently serve every destination its customers require with its own aircraft. Additionally, few city-

pairs can generate sufficient demand on a daily basis to sustain non-stop service. To meet the demands of customers, carriers must seek commercial partners that can help them provide greater network coverage and increased service options" (EC US DoT 2010, 3). The depth of those alliances can thus vary dramatically, according to the single participant needs and strength, from a simple limited cooperation on specific route, to joint venture, to a *de facto* consolidation.

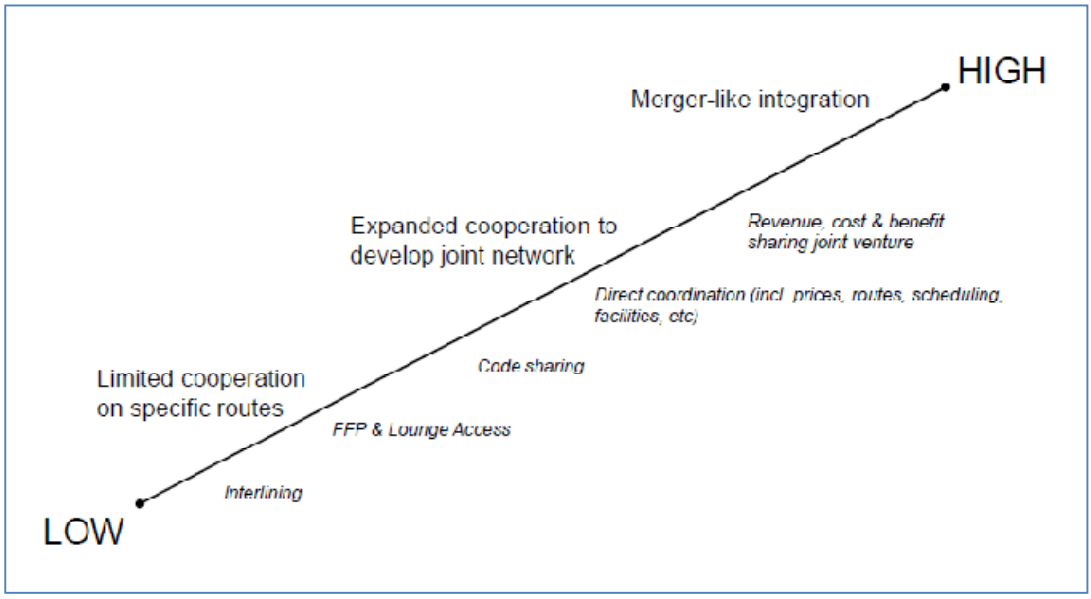


Figure 20 – Degrees of Coordination inside Airlines Alliances - (EC US DoT 2010, 5)

Naturally, network "breadth is important for the global network reach of an alliance. Alliances recruit new members to fill so-called ´white spots´ in their networks, where an alliance does not yet have coverage. Such white spots remain inter alia in Russia (for Star), India (for SkyTeam) and Brazil (for oneworld and SkyTeam). On the downside, while growing in size is important for the network, a large alliance unavoidably increases the complexity of governance, and risks rendering it less efficient in decision making and more difficult to integrate. Alliances, therefore, balance the trade-off between, on the one hand, an increment in global network and increased revenue synergies, and, on the other hand, the risk of inefficiencies due to increased size of the alliance" (EC US DoT 2010, 9). This addresses the question of how efficient are alliances, mainly because "this arms-length cooperation did not allow the integration and efficiencies that were possible", keeping in mind that "cross border mergers, which would be typical in other industries, are prohibited for airlines by anachronistic restrictions on foreign ownership" (IATA 2012a, 1).

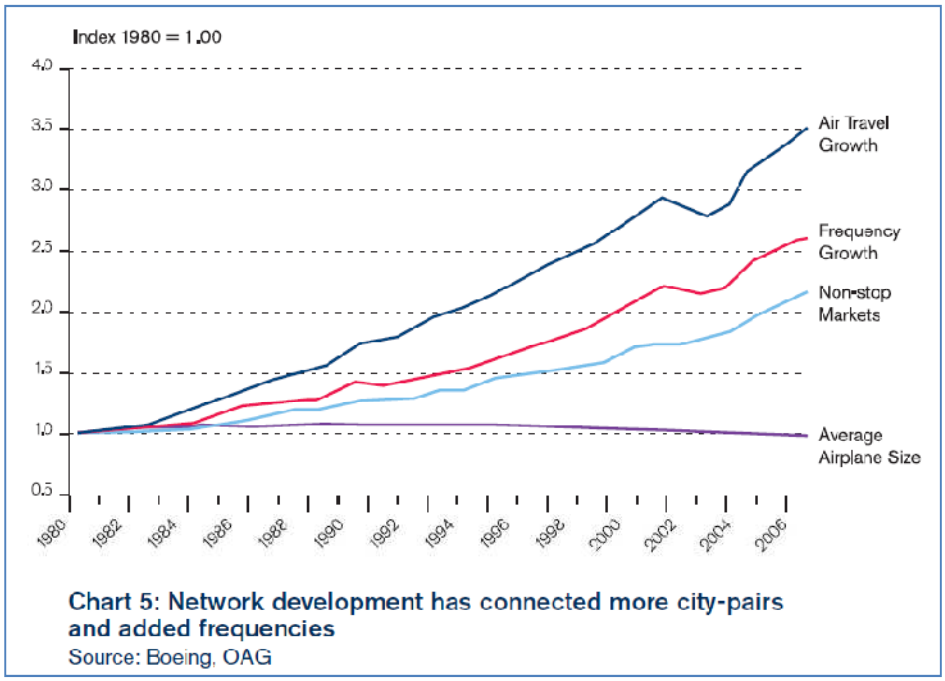


Figure 21 – Civil aviation Network development - (IATA 2011, 6)

If it is true that "international alliances have become a permanent fixture in the airline industry" (IATA 2010b, 1), to give answers to the current difficulties some big EU "national champions" accelerated the merging process, a worldwide trend: "In October 2008, Delta Air Lines and Northwest Airlines merged to form the world's largest airline, a title previously held by Air France/KLM (itself the result of a merger in 2004). Likewise, over the past years, Lufthansa Group has acquired several carriers, including SWISS, Austrian, BMI and German Wings and also has acquired significant ownership stakes in several other carriers including Brussels Airlines and US low cost carrier jetBlue" (IATA 2010a, 1). Beside KLM and Air France integration, British Airways and Iberia are now part of IAGroup, and other smaller airlines entered the orbit of those groups (like Alitalia Wing) through different legal and operational forms.

But, if LCCs have opened a new stage of competition, in the long run the industry has shown two major characteristics, well before LCCs´ arrival on the stage:

1. The number of passengers simply skyrocketed past decades, and such a growth is expected for continued study in the future;
2. The aviation carriers have suffered low profitability, e.g. "over the past 40 years the net post-tax profit of the airline industry worldwide has averaged a paltry 0.1% of revenues" (IATA 2011, 2).

Airlines alliances, as happened for the shipping industry, were therefore an attempt to reverse insufficient profit and poor financial results, gaining economies of scale and scope and sharing profit and risk.

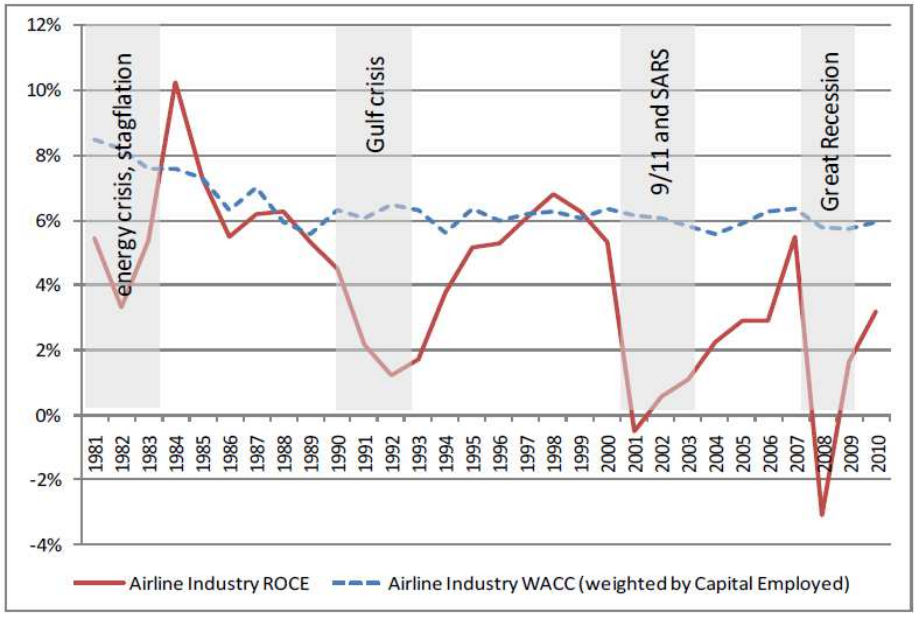


Figure 22 – Financial Trends of Airline Companies - (IATA 2012b, 1)

However, the merging and alliance process has not given an answer to the industry problems, somewhat exacerbating the competition, price wars, and thus poor results. As IATA bitterly pointed out,

> *one of the most vexing questions plaguing the global airline industry is why it remains consistently unprofitable over an entire business cycle. Between 2000 and 2009, for example, it is estimated that the global airline industry incurred net losses in excess of $52 billion dollars and over a much longer period (i.e., 1980-2009), industry wide net losses are estimated to be approximately [US]$16 billion. One commonly posited explanation for the airline industry's inability to earn positive economic returns over the business cycle is that it remains too fragmented, is characterized by excess capacity, and thus is particularly susceptible to exogenous shocks (e.g., September 11th, SARS, spike in oil prices, etc.) which have become all too frequent. Numerous industry executives and analysts have therefore argued that consolidation is necessary in order for the industry to evolve to the point where it can achieve long run economic stability* (IATA 2010a, 1).

However, again in parallel with the shipping industry, the airline companies are far from having achieved better results through their past years strategies. The alliances can appear a good strategy, although in the medium run "a number of airline strategy choices appear individually rational but in aggregate contribute to a market environment that is worse for everyone" (IATA 2011, 3).

New challenges and industry geographies and "niche"

The barycentre of the worldwide air traffic is clearly moving South and East, and this will last for the next decades.

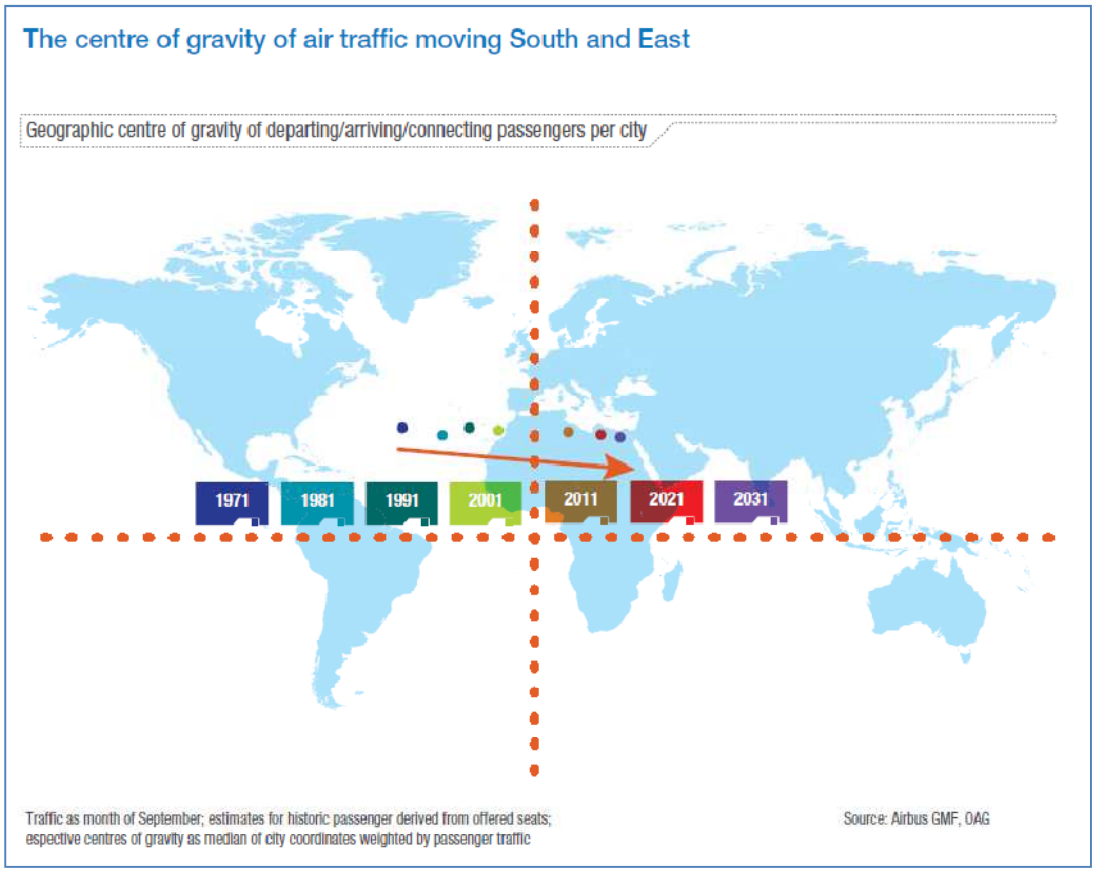


Figure 23 – Civil Aviation centre of gravity - (Airbus 2012, 41)

Additionally, from an EU perspective, "international competition in the airline industry is increasing rapidly due to fast-growing companies from the Middle East, such as Emirates, Qatar Airways and Etihad Airways, as well as Turkish Airlines in South East Europe. Alongside the European competitors Air France-KLM and British Airways/Iberia, plus US carriers like Delta Airlines and American Airlines, the Gulf carriers pose an additional challenge for the Passenger Airline Group in intercontinental traffic" (Lufthansa 2013, 61).

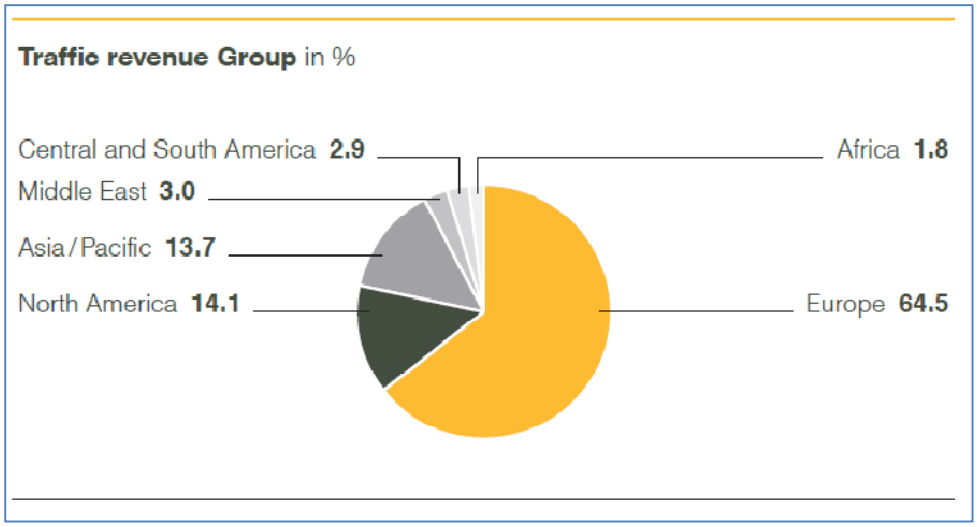


Figure 24 – Lufthansa Traffic Revenue by Region - (Lufthansa 2013, 47)

The internationalisation of the EU main legacy operators is limited, due to the dominant hub-and-spoke model, which necessarily roots geographically the market. British Airways had a stronger

international projection, which is still kept, at least when compared to Lufthansa, although, the major companies are well aware of the competition on the Asian routes as well as of the mounting opportunities rising in the South-American and African markets (International Airlines Group 2012).

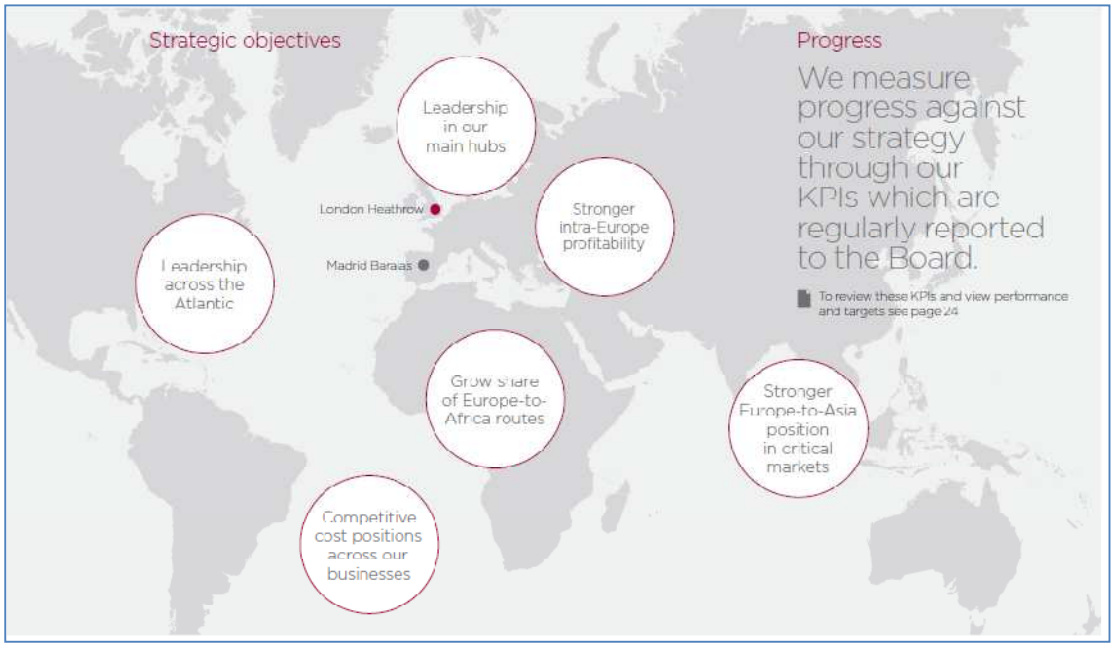


Figure 25 – *International Airlines Group* Aims- (International Airlines Group 2012, 17)

Pushed by new competitors from emerging economies and by LCCs, the legacy airlines (beside the alliance strategy) developed a greater care of operational costs, and today "over the past six years, the difference between the cost base of low cost carriers (LCC's) and legacy airlines has narrowed dramatically. In many geographies, from a passenger viewpoint, the distinction between the two business models (particularly in short-haul) is also becoming increasingly blurred" (KPMG 2013, 16).

In addition, not only LCCs have high revenue from so-called ancillary sales (even 25% of the total). Lufthansa, the biggest EU player, can count first-class results from its MRO branch, and its LSG Sky Chefs Group is world leader in aviation catering.[3]

Wrapping up the path towards better results, there is not a clear indication of which can be a winning model. IATA analyses of the most 2000s successful companies enlighten how "there are no easy size, business model or geographical pointers as to why they were profitable. These profitable airlines represented a number of different business models, small and large, and several profitable airlines can be found in most major regions of the world" (IATA 2011, 14). Some of those profitable

[3] With a revenue of 4.0 €bn and an Operating result of 318 €m, "Lufthansa Technik is the world's leading independent provider of maintenance, repair and overhaul services (MRO) for civil commercial aircraft. The Lufthansa Technik Group includes 33 technical maintenance operations around the world with a total of more than 20,000 employees. The company also holds direct and indirect stakes in 55 companies." (Lufthansa 2013, 78). With a revenue totalling 2.5 €bn, an Operating result of 97 €m, and a global market share of 27 per cent, "the LSG Sky Chefs Group maintains its leading position in the market for airline catering. In addition, the company has added considerably to its product and sector portfolio over recent years, in order to use the skills acquired in its core business to enter adjacent markets and to make up for the cyclical fluctuations in the airline business. Its diversification has focused on expanding the equipment management business and entering new markets such as railway catering or supplying retail chains" (Lufthansa 2013, 84).

enterprises were LCCs carriers; other ones were mainly long-haul operators, and other ones were regional; some were from Latin America, other from Europe or Asia.
The same role of LCCs is nowadays under scrutiny. Airberlin, for instance, positioned itself between LCC and legacy operators. Other companies, however, will not step out of their ´niche´ and will face too many challenges entering long-haul market: “The current LCC model, targeting primarily cost minimisation, appears inconsistent with the complexity (and associated costs of implementation) of a global alliance. LCCs would be more likely to form an alliance if their business models evolve to include long-haul flights for which they will need improved access to feeder traffic. At the moment, however, LCCs appear more likely to continue developing simplified forms of cooperation, which are less integrated and thus less costly than the current global alliance model” (EC US DoT 2010, 10).
But also keeping such a profitable niche, as intra-EU short-haul market, can be sooner or later problematic. The legacy companies are already moving to a LCCs business model for such a service, the barriers to entry are less problematic than expected, and bigger budget constraints, especially for the bottom-end, are expected. High-speed trains and, cheaper intercity bus services can also modify the request.

4. European Transport Manufacturing Industry. International outlook and expected trends

Abstract of the chapter
As for services, growth of the global market is also expected in the manufacturing industry. Although truly internationalised, the transport manufacturing industry is usually close to the markets served, which has pushed many EU companies to open plants and assembly sites in emerging economies. Considering the role of those new markets, the leadership position of the European industry is challenged by new entrants, which enjoy a fast growing home market, lower technological gaps and lower final costs.
The automobile and the railway sectors are the most exposed to international competition, in which emerging economies' companies are playing a more relevant role. The high-tech segment and – for the car industry – the premium sub-market are less vulnerable to this trend.
The aviation sector is still a duopoly dominated by Boeing and Airbus, but four non-EU companies will be stepping into the market in the next years, thus giving a new configuration to the industry.
The current studies and the industry stakeholders suggest focusing on top-end segments, R&D development and cutting edge technologies as winning strategies for the EU players.

4.1 Automotive

Abstract
Generally speaking, the supply chain has become worldwide more and more internationally integrated: components and subsystems are increasingly sourced from other parts of the world. Final car assembly, however, remains in general relatively close to the market. While mature economies are saturated markets and seem to have experienced their peak in car ownership, emerging economies have increasingly skyrocketing growth, mainly fed by local plants.
In this vein, the European car industry is witnessing a turning point in its history. The decline of its traditional market and, abroad, the growing pressure of ´local´ producers create an immense stress on the EU OEMs and on their suppliers. As happened for the EU shipping industry, a shift towards the ´premium´ segment, cutting-edge technologies, technical and non-technical innovations are often envisioned as the next stage for the EU car producers.

4.1.1 Industry structure

In 2009, the European Commission document "Responding to the crisis in the European automotive industry" could still state, correctly at that moment, that “EU is the world's largest producer of motor vehicles”. However, testifying the brisk changes of the sector, in 2012 China has been the largest motor-vehicle producers, overtaking Europe, even when merging together EU+Russia+Turkey productions (KPGM 2012a).
Said so, it is still true that

> *the automotive industry is central to Europe's prosperity. […] It is a huge employer of skilled workforce, directly employing over 2 million people but responsible for some 12 million jobs. It is a key driver of knowledge and innovation, investing more than € 20 billion a year in R&D, making it Europe's largest private investor in R&D. With an annual turnover of € 780 billion and a value added of over € 140 billion, it makes a major contribution to the EU's GDP. It exports far more than it imports, with a surplus of over € 60 billion on overall exports of € 125 billion. In addition, the sector plays a central part in tackling many of the key economic, social and environmental challenges faced by Europe today, such as sustainable mobility and safety.* (EC 2009, 3)

The EU car producers industry landscape is notable simpler than 20-30 years ago, and today we can count six major EU OEM groups, with a grip on the international market, e.g.

- Volkswagen Group (branding among other Volkswagen, Audi, Bentley, Bugatti, Lamborghini, Porsche, SEAT, Škoda, Ducati, MAN and Scania),
- PSA Peugeot Citroën,
- Renault Group (Renault, Dacia, Renault-Samsung, not to mention the alliance with Nissan),
- FIAT (Fiat, Ferrari, Maserati, Lancia, Alfa Romeo, IVECO, Piaggio, and owning Chrysler, Jeep and Dodge),
- BMW Group (BMW, Mini and Rolls-Royce),

- Daimler group (Mercedes and Smart).

Other not-European OEMs but with plants in Europe include Ford of Europe, General Motors Europe, Hyundai Motor Europe, Jaguar Land Rover (owned by Indian Tata), Toyota Motor Europe, Volvo Cars (owned by Chinese Geely) and Volvo Group (ACEA 2012a).

Motor Vehicle Production in the EU by country | **2011**

					TOTAL
	AUSTRIA	130,343		22,162	152,505
	BELGIUM	562,386			562,386
	CZECH REPUBLIC	1,191,968	3,013	4,853	1,199,834
	FINLAND	2,540			2,540
	FRANCE	1,931,030	311,898	51,961	2,294,889
	GERMANY	5,871,918	275,035	164,150	6,311,103
	HUNGARY	200,000		2,800	202,800
	ITALY	485,606	270,342	34,400	790,348
	NETHERLANDS	40,772		32,379	73,151
	POLAND	740,000	85,225	11,907	837,132
	PORTUGAL	141,779	46,385	4,078	192,242
	ROMANIA	310,243	24,924	65	335,232
	SLOVAKIA	639,763			639,763
	SLOVENIA	168,955	5,164		174,119
	SPAIN	1,819,453	480,316	53,913	2,353,682
	SWEDEN	188,969			188,969
	UNITED KINGDOM	1,343,810	103,014	17,175	1,463,999
	EUROPEAN UNION *	15,701,685	1,600,542	395,770	17,697,997

* Double countings are deducted from the totals

Figure 26 - EU Motor Vehicles Production 2011 - (ACEA 2012a, 40)

The EU production is spread in “250 production lines”, which are “split between 16 Member States, and every single Member State is involved in the supply chain for manufacturing and the downstream chain for sales. Typically, there are around 50 upstream component suppliers for a car, spread all over Europe and around 75% of the value-added of a new car is generated by these suppliers” (EC 2009, 3)

Some specific features of the automobile industry
The industry is capital intensive, with a relatively high capital-to-labour ratio, and in many countries a large share of the production is exported.
In recent years, production has been increasingly shifted towards non-OECD regions, in particular Asia. Between 2000 and 2007, the share of the United States and Japan in global production fell from 40 to 30%, while the share of the non-OECD areas increased from producing of one car in ten to one car in five. The economic crisis may serve to reinforce and accelerate this trend.
Market saturation in OECD countries, high shipping costs and efforts by automakers to gain market share by locating production where they sell have encouraged these trends. Outsourcing the manufacturing of small automobiles and parts has also been increasing among main car producers. At the same time, the minimum efficient scale of production has increased over time, spurring mergers and acquisitions in order to gain economies of scale.
The resulting economic geography of the industry is complex, with only some segments being fully global. Automakers and part suppliers form buyer-supplier relationships on a global scale. Inter-regional vehicle and parts trade is substantial, but capped by political and operational considerations. Intra-regional trade of finished vehicle and parts is the dominant operational pattern. Domestic production is still very strong in many national markets. Activities such as design or assembly tend to be geographically concentrated in clusters of specialised activity within countries" (OECD 2009, 92)

As for any other complex industry, beside the OEMs, several tiers of suppliers are involved in the car manufacturing process, although the number of those suppliers and of those tiers has been reduced in the past decades. While spread geographically around the world and, within Europe, in many countries, and despite the outsourcing process, all together the car industry is still organized around production clusters, the markets are definitely "in close geographic proximity to the OEMs' plants" (Bailey, et al. 2010, 314). Which is to say that if the supply chain has become more and more internationally integrated, and "components and subsystems are increasingly sourced from other parts of the world", final car assembly remains in general relatively close to the market. Around 85% of cars sold in the EU are also assembled there" (EC 2012, 15). This is not true only for Europe, but it is a worldwide trend, with a somewhat different pattern for USA market (Bailey, et al. 2010).
Political and market reasons stand behind the above, explaining also the trend, as old as the car industry is, of internationalisation, acquisition of aboard local manufactures and/or implementation of national plans by abroad firms. This has received further speed in the past decades, although as soon as 1920s major American and European firms already acted in such a way (Laux 1992).
Generally speaking, EU car industry positions itself "between the East Asian [Japan and South Korea] experience (characterized by large net exports and outgoing FDI) and the North American pattern (characterized by large net imports and mostly incoming FDI)". In other words, European-based OEMs control about to two-thirds of the EU new vehicle market, while they are exporters "to North America and other world markets. This has allowed Europe to retain a largely balanced position in global trade in vehicles, with these exports broadly offsetting Europe's imports of finished vehicles (mostly from East Asia)" (Stanford 2010, 389).
If compared to its heydays, e.g. 1960s, the core of EU production has shifted toward Spain and south Europe; more recently, facilitated by EU enlargement, "Central and Eastern Europe have become attractive as a low-cost location for new export-oriented automotive investments."

(Stanford 2010, 389). Globally, an even bigger shift has been experienced, that is a strong decline of USA manufactures: Latin American plants were developed. In very recent years, China and India (and other South Asia counties as Thailand) emerged as “major players in the industry. These markets will join Western Europe, Japan, Korea, and the United States as the centres of design and manufacturing for original equipment manufacturers and their suppliers” (Deloitte 2009, 1)
A similar shift occurred also in the market development. Europe and North America are definitely saturated markets, and furthermore they show some signs of decline in the car density. “This situation contrasts strongly with the state of the global market. Worldwide car sales are reaching record levels, due to the development of emerging economies, and will grow further in the coming years. Total sales are expected to reach 78 million in 2012 and are likely to exceed 100 million by 2020. The share of the European market in worldwide sales will therefore decrease significantly, from 29% in 2004 to 20% in 2020” (EC 2012, 14)
Considering the relevant position of the EU market for the EU OEMs and suppliers, the role of the “domestic” is thus a key factor of financial success, which can exacerbate the long term contradictions of the industry. The 2008 crisis and the dramatic drop of the EU market have indeed made more evident the “structural problems pre-dating the crisis. […] Recent falls in demand and production have made the situation worse and average overcapacity in Europe is estimated to be at least 20%” (EC 2009, 4). Thus, as the EU automotive industry lobby states, there is a “critical juncture”. While car manufactures have benefited (at different depth and intensity) “from the strong current and projected growth in motor vehicle sales globally, particularly in the BRIC countries and other emerging markets”, the main troubles are at ´home´. The decline in absolute numbers of the EU market – beside its amplification after 2008 crisis – can be understood as a sort of turning point, and such an outline threatens Europe and “its future global competitiveness. These include a strained market, significant pressure on sales, overcapacity for some manufacturers and markets, a high cost base, increasingly stringent and costly legislation, growing competition from imports and, ultimately, low profitability.” (ACEA 2012b, 1)
The situation seems even worst in the commercial vehicles and powered two-wheelers sub-markets. The first had a bigger decline after the crisis; the latter is “declining in recent years and the registrations in 2011 (1.6 million vehicles) represent a decrease of around 40% compared to 2007. The markets in southern Europe, traditionally important for this sector, are heavily impacted by the debt crisis.” (EC 2012, 15)
So, generally speaking, while facing overcapacity, the industry witnessed a decline in its biggest markets and thus it is under particular pressure. “This has an impact on the profitability on the European market, particularly for the volume segment, where most of the manufacturers reported losses on their European operations in recent years, although the aftermarket (repair services and spare parts) provides them a more profitable activity” (EC 2012, 15). On the contrary, those EU companies which experienced successful operation aboard, and especially in emerging economies, can claim better results, although the “majority of vehicles sold in these markets however is assembled locally”, a situation which “nevertheless contributes to investments in R&D and high added-value jobs in EU” (EC 2012, 15). That success, especially concerning Asian emerging countries, affects primarily the premium car segment, favouring those EU companies able to serve that niche.

Main Destinations of EU Passenger Car **Exports** (in € million)

	2006	2007	2008	2009	2010	2011	% CHG 11/10	% SHARE IN 2011
World	**68,068**	**71,025**	**69,562**	**48,220**	**76,358**	**93,819**	**22.9%**	**100.0%**
United States	27,074	24,754	20,546	12,812	19,156	19,543	2.0%	20.8%
China	2,252	3,345	4,610	5,477	12,181	17,348	42.4%	18.5%
Russia	4,319	6,659	8,786	2,577	4,098	7,050	72.1%	7.5%
Switzerland	4,004	4,324	4,363	3,943	5,277	6,653	26.1%	7.1%
Turkey	2,908	2,835	2,808	2,067	4,260	5,215	22.4%	5.6%
Japan	4,224	4,121	3,254	2,716	3,843	5,094	32.5%	5.4%
Australia	1,831	2,101	2,187	1,614	2,767	3,180	14.9%	3.4%
Norway	2,275	2,703	2,192	1,867	2,733	3,056	11.8%	3.3%
Canada	2,104	2,094	2,085	1,818	2,442	2,512	2.9%	2.7%
South Korea	1,018	975	912	806	1,681	1,955	16.3%	2.1%

Figure 27 – EU Car Export 2006-2011- (ACEA 2012a, 81)

In this landscape, indubitably there are different speeds and different achievements by the individual OEMs. The ability to cope and cover an internationalised market is not just an extra value, but becomes a vital element considering the decline of the domestic market (see also RACE2050 D2.1). The buyers "patriotism" in the European market is still a component of the customers' behaviour, but it is not adequate in the new industrial landscape. The export of the EU car industry is therefore a crucial part to assess its competitiveness worldwide. Although the statistics are not always consistent, the EU-27 sector has an turnover of about 650 million euro, an export of about 105 million and an import of about 30 million. (ACEA 2012a). This means that, as an average for EU-27, circa 15-20 % of the revenues are generated by export.

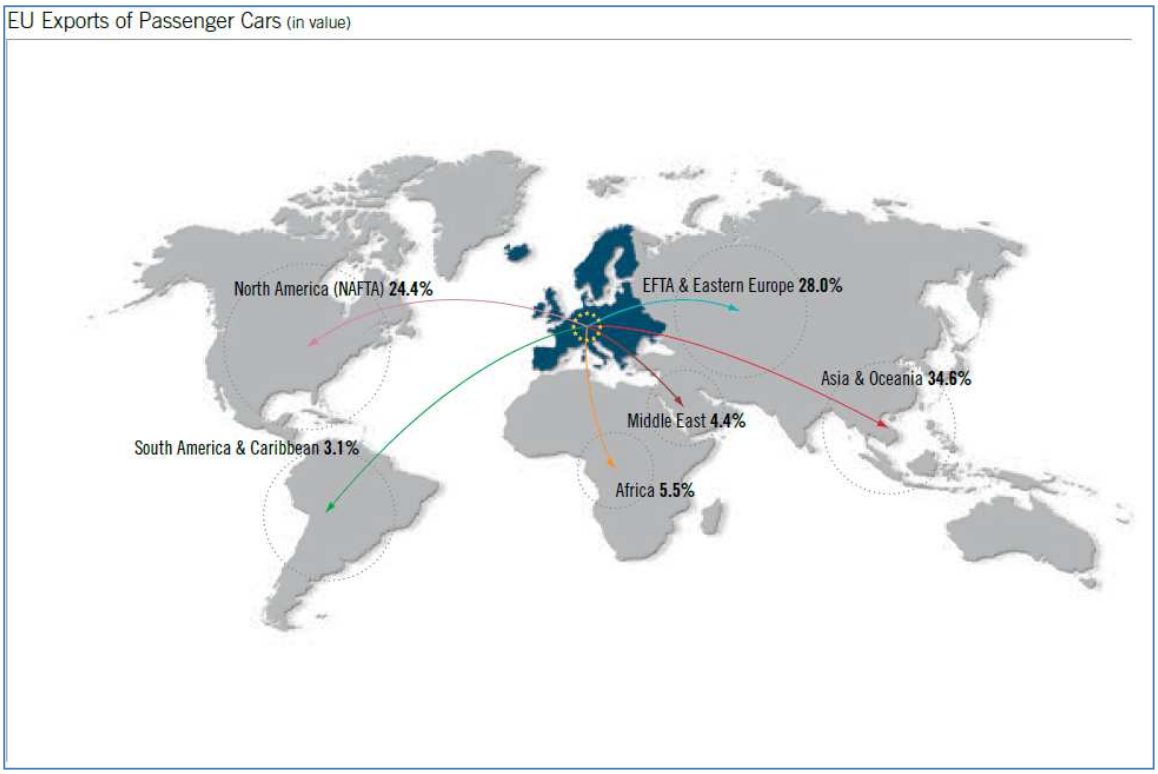


Figure 28 – EU Car Export Map - (ACEA 2012a, 77)

As shown in Figure 28, Asia & Pacific is the biggest market, while USA, China and Russia are the top three countries for the EU car export. China and Russia had an increase of respectively 57.7% and

61.8% between 2010 and 2011, while in a longer trend (2006-2001), China market growth was nine times.

In this vein, some EU companies, among the big six players, have shown a bigger ability to internationalised their markets. Daimler (owning Mercedes brand) and BMW had stunning performance, in which a role was played by world-wide known *allure* of some brands, especially at the top-end (fitting upper- and middle-class in emerging and mature economies), and by a close care to develop innovative business solution. For instance, simply enthusiastic are the comment reported in BMW 2012 annual report: "2012 – the most successful year in the history of the Company. Our success is built on the desirability of our products. More than 1.84 million BMW, MINI and Rolls-Royce vehicles were delivered to customers in 2012, beating the previous year's record by more than 10 %. All three of our automobile brands set new records. In addition, more than 117,000 customers purchased a BMW or Husqvarna motorcycle. Our Financial Services business also continued to grow and contributed to the positive performance in sales figures. Thanks to strong demand for our premium vehicles" (BMW 2013, 15).

As shown in Figure 29, for its motor-vehicle branch, Daimler claimed for 2012 that about 60% of its revenue was made outside of Western Europe, mainly in the NAFTA market and in Asia.

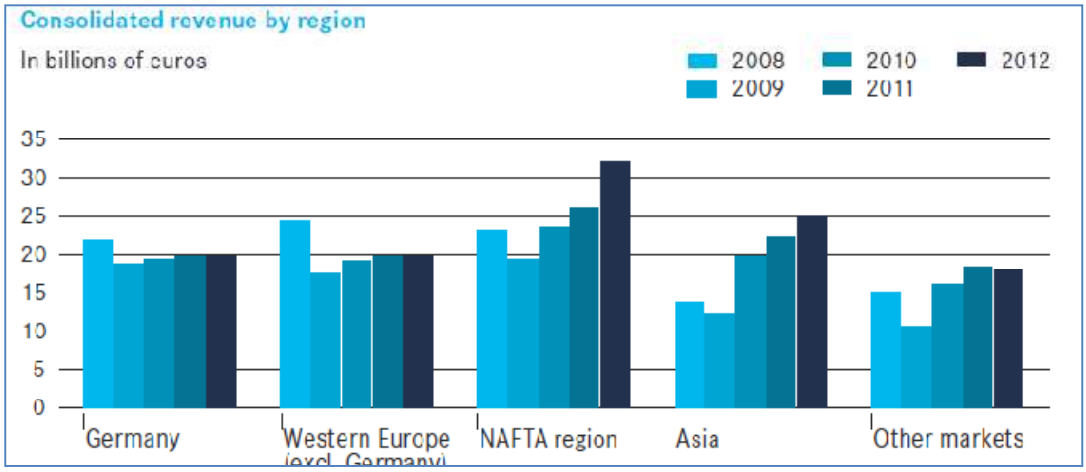


Figure 29 – Daimler revenue by region - (Daimler 2013, 91)

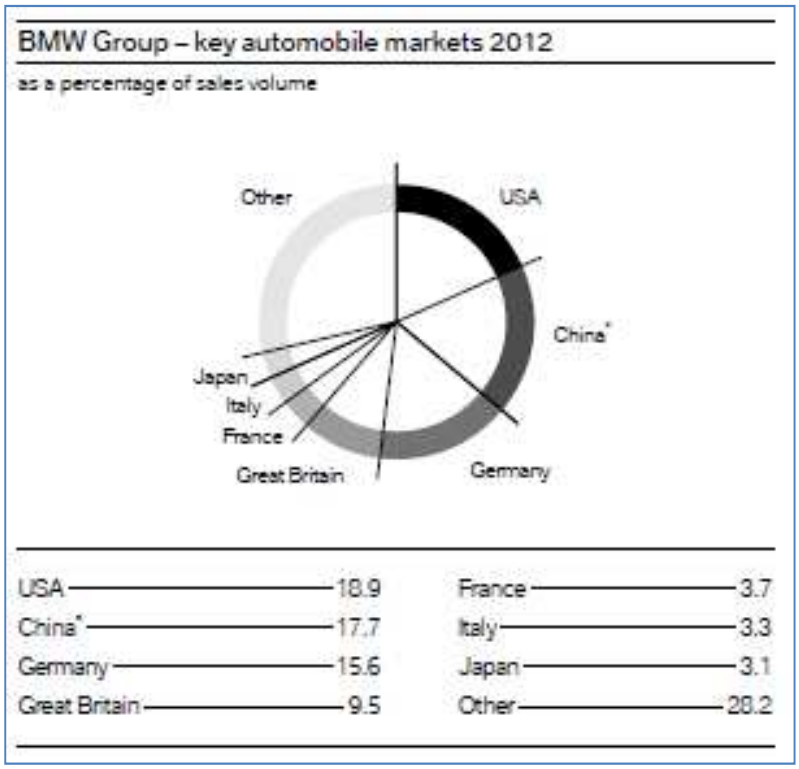


Figure 30 – BMW Automotive Segment sales volumes by country - (BMW 2013, 24)

The whole German automotive sector benefitted of the new global situation. The German industry has traditionally been export-oriented, with a first-class skilled workforce (and a first-class training schools), and a great variety of SMEs companies organized in clusters. Thus, "the auto industry in Germany thrives as a result of the diversity of companies active in the sector: large and medium-sized auto manufacturers alike are to be found in Germany, as are system and module suppliers, not to mention numerous small and medium-sized tier 2 and 3 suppliers. In fact, around 85 percent of auto industry suppliers are medium-sized companies. All of these suppliers provide up to 70 percent of value added within the domestic auto sector – ensuring that the German auto industry remains at the forefront of the competition" (Germany Trade & Invest 2012, 9).
However, like for the aviation operators, it seems that there is not a winning model. Renault, Volkswagen and PSA have similar elements in term of export, covering a mix of geographical areas and models. Renault and Volkswagen have all of them good results; actually Renault (in itself without Nissan) has even achieved a relevant target: in "2012, for the first time in our history, more than half of our sales came from markets outside Europe" (Renault 2013, 3). Such an outcome was the result of excellent sales in Brazil, Russia and Argentina, although "the faster pace of expansion in international markets (+9%) was not sufficient to offset declining sales in Europe (-18%). As a result, volumes fell by 6.3% overall in 2012, to 2.5 million vehicles sold worldwide" (Renault 2013, 4).

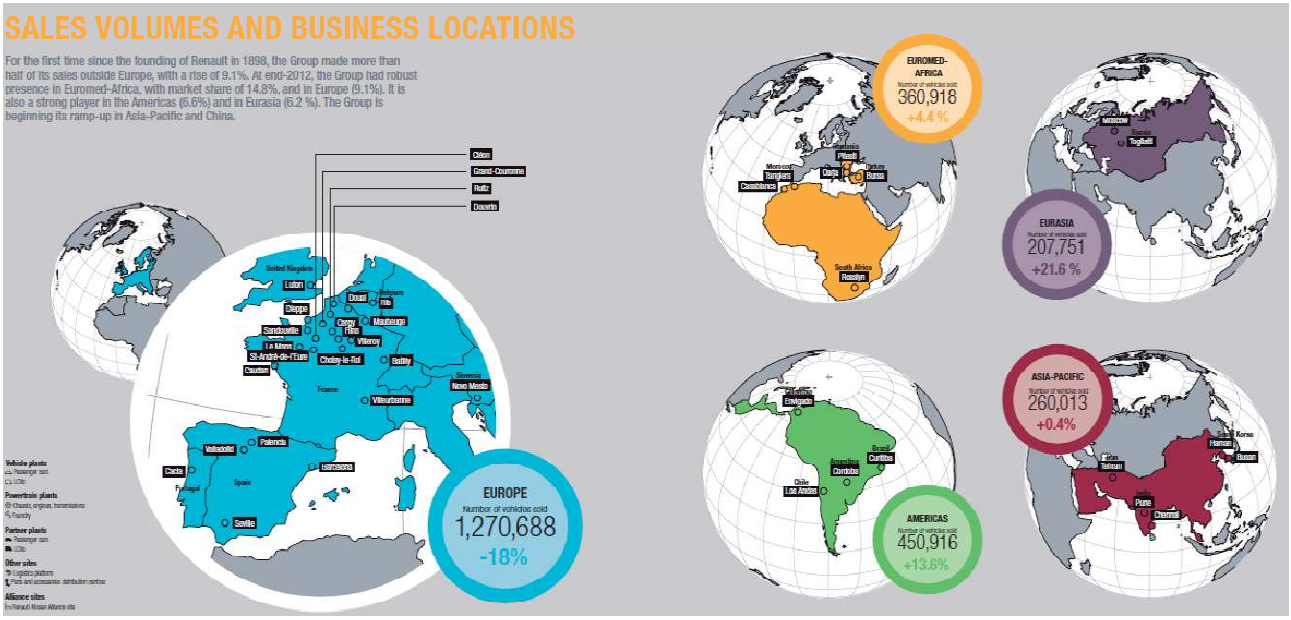


Figure 31 – Renault sales volumes 2012 - (Renault 2013, 9-10)

And PSA results seems to be far from bad in term of exports, totalling about 40% of the total production (PSA 2013), not so different from Fiat results (not counting Chrysler data), especially when compared to the Volkswagen data, which reported for 2012 the European market covering circa 50% of the total (Volkswagen 2013, FIAT 2013).

In thousand units	2011	2012	Change
Europe	2,063	**1,758**	-14.8%
Russia	75	**78**	4.9%
Latin America	326	**283**	-13.2%
Rest of the World	224	**259**	16.0%
China	404	**442**	9.2%
Total assembled vehicles	**3,092**	**2,820**	**-8.8%**

Figure 32 – PSA motor vehicles sold by region 2012 - (PSA 2013, 10)

Therefore, keeping in mind the role of exports for the success of motor-vehicles OEMs, other factors must be put in the equation, like market segments covered, volumes of production, EU market differentiation, alliance and so on.

4.1.2 Future business landscape: Industrial integration, geographical dispersion

Looking ahead, and beyond issues of straightforward capacity, car manufacturers face a number of challenges that will likely require significant restructuring to realign production capacity with changing patterns of demand, including coping with:

- *Higher prices of automotive fuels driven by increasing demand for oil and policy interventions to reduce CO2 emissions. This will likely accelerate the trend towards*

smaller more fuel-efficient cars which command lower profit margins. Furthermore, the bulk of demand in the rapidly growing Chinese market is for smaller cars.

- *A changing geographical pattern of demand. Most trend sales growth will be in the BRIC countries and other emerging markets while mature OECD markets will remain relatively stagnant.*
- *Ongoing globalisation, which will likely influence minimum efficient scale economies and the configuration of companies worldwide.*" (OECD 2009, 110-111)

As reported by all the stakeholders, the motor-vehicles market will become less geographically concentrated and the share of world-wide sales in mature economies will decrease further (even in absolute numbers).
Two conflicting factors will be relevant here.

1. The first one is the globalisation of the industry´s supply chain and the international projection of (fewer and bigger) OEMs;
2. The second element is the geographical proximity of production and sales, which is expected to remain in the future. Additionally, a global market means also the need of the car industry to produce vehicles according to different tastes, needs and conditions.

Indeed, "most automakers indicate a preference to continue to produce nearer to their final markets, and this causes a continuing regionalization of production. These regional production strategies reflect a mixture of economic and political influences". Beside the relevant cost of shipping which can be "as much as 10% to the cost of a finished vehicle" (Stanford 2010, 385), further element can back a globalised industry with regional production: exchange rate volatility, "the agglomerating effect of tightly managed supply chains (including the trend towards just-in-time components production and delivery systems that require tight logistics and transport planning, and hence are not amenable to global components sourcing)". Least but not last, "political influences on investment location include a desire to avoid trade protection in key markets, thus stimulating FDI as an alternative to international trade flows." (Stanford 2010, 385)
But there will be also ´regional´ attitude in term of production outline: "Global (or interregional) trade in finished vehicles and components is important, depending on which regional markets are considered, and the leading OEMs clearly 'think globally' in their management and marketing. For example, it is now commonplace for OEMs to produce several different vehicles, customized for different regional markets, from a single standardized global 'platform'" (Stanford 2010, 385)
The above will create an enormous pressure to the European production plants (or, better, at least many of those) which are (and will) experiencing over-capacity and decreasing European market volumes. To use the EC words, in the coming decade, "important changes are expected in the global automotive industry in several areas that are likely to profoundly reshape the industry and its markets worldwide. While the European market is mature, third markets are growing fast, changing the trade flows and the automotive value chain. The intense competitive pressure is growing further and EU companies are increasingly being challenged on their home market and developing opportunities in third markets." (EC 2012, 3).

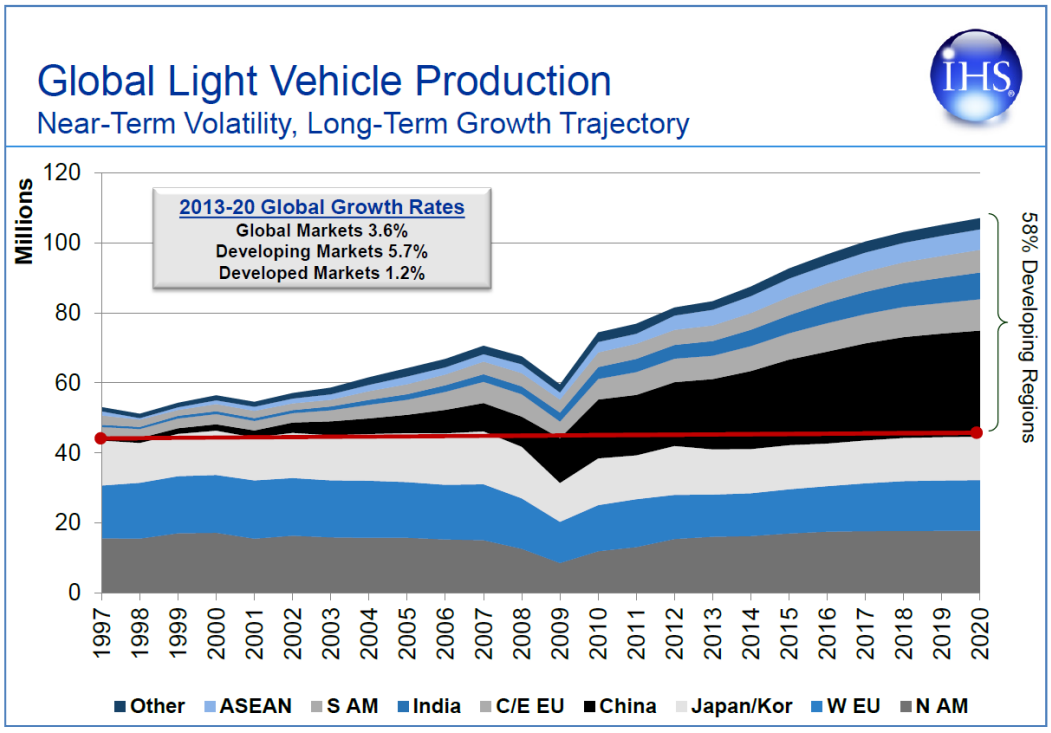


Figure 33 – Global Light Vehicle Production 1997-2020 - (IHS 2013)

To mitigate those disruptive trends, it has been already largely assessed that "automotive investment is not instantaneously mobile; even a low-cost region must develop a complex supply network, infrastructure, and demonstrated quality and logistics capabilities before it becomes attractive as a site for automotive investment. […] It cannot be accomplished simply by closing a plant in a high-cost region and opening a new one in a lower wage location." (Stanford 2010, 391) Moreover, in the medium-term, the car industry can face limits in its de-localisation and ability to develop further abroad-based plants. The case of Curitiba region firstly had "provided an attractive opportunity to foreign investment by major auto manufacturers […], but also how the key factors that played an important role in attracting auto investments outside of old core regions (such as fiscal incentives, low labour costs) have been largely exhausted; further expansion in such regions will depend on developing competitive advantages based on agglomeration economies, labour skills and general expansion of the economy." (Bailey, et al. 2010, 313)
This means that we can expect a new wave of changes both in Europe and abroad.
Out of Europe this trend will lead to consolidate the existing clusters of production, developing local skills, solutions and services currently fed from abroad. And, this while, in opposition, it is expected a further de-localisation, in order to meet new growing markets (Africa, next-11 etc.).
More closely to European OEMs and their suppliers, they are witnessing failing sales in their EU ´domestic´ market, greater loses in such a vital part of their business and good performance in foreign activities. This can push, in the short- and medium-run, some the European OEMs to drop their care to the ´home´ market, looking after those new expanding opportunities abroad. FIAT leadership and its aim to weaken its Italian roots, focusing on a global perspective, gave a first indication of this trend (Griseri 2012). The core concept of outsourcing and developing foreign plants, which is surely led by an overall concern regarding production cost and price struggles, have been primarily driven by the need to have on-site plants for those (fast-growing) markets. The European industry experience is indeed telling us that "competitiveness in motor vehicle sales depends on a complex range of factors: purchase price, operating price, quality and technological criteria. Vehicle sellers do not compete primarily on grounds of offering the lowest selling price

(indeed, the most financially successful OEMs are those that have successfully developed their brands, and their prices, as 'premium')" (Stanford 2010, 391).
The academic surveys overlap with the stakeholders' statements. The car supply industry umbrella organisation representative "proposed to talk not of quantity but of the value added in terms of production" (Forum automobile and society 2012, 3-4). In this vein, in the mid-term the European automotive industry can address its effort towards high-value segment (as premium vehicles) and areas (design and R&D). This can cope with globally regionalised markets, keeping in Europe the more attractive slice of the industry. Such a trend has been already experienced by the European shipping industry, which has been able to focus on the most valuable part of the industry, e.g. high-end segment, cutting-edge innovation, specialised productions.
Such a program, coupled with the over-capacity of the European car industry, will conduct soon to a new outline, involving also relevant and painful changes concerning the number of European plants and on the workforce (EC 2012).
In these framework conditions, it has been noticed that *a European common strategy* is highly required, and that "the common belief that Europe could be a leader in global exports and enter significant innovation processes" will be rather difficult to be obtained, "as across the continent there were several, fragmented innovation clusters, such as in Italy, Germany and France. The key need to combine all their strengths, learn the best practices, identify and remove the weaknesses and coordinate among each state" (Forum automobile and society 2012, 5).
On the other way around, such a proposal clashes with the current situation of the European car industry, and its differences: "one between North and South, another between premium and non-premium, and a third between companies who went internationally a long time ago vs. those who have attempted it only recently" (Forum automobile and society 2012, 3-4). Those differences are particularly relevant, even more if we consider how the most successful EU OEMs are based in North-Europe, they cover the premium market and they went convincingly abroad a long time ago. Other ones don't have premium products, are more exposed to South-Europe market´s weaknesses and have a different grade of internationalisation. PSA's current troubles are rooted in this un-favourable constellation.
Beside industrial alliances, when achievable, a synchronization factor can be recognised in the European legislation (and in particular about energy saving and pollution limits), which can be seen as a "driver for industry progress and not an impediment", even more considering how, as an average the industry "wages costs were below 20% of the total price while the cost of resources were 40%" (Forum automobile and society 2012, 2).
A parallel encouragement to hold the leadership can come from the Free Trade Agreements, and this in order "to improve market access in third countries. It has highlighted that acceptance of international regulations under the 1958 UNECE Agreement is the best way to remove non tariff barriers to trade and has pointed to the need to strengthen bilateral regulatory cooperation with third countries, with a view to eliminating non tariff barriers in the automotive sector." (EC 2012, 6)
Wrapping up the debate, the *CARS 21 Group* identified the following EU car industry competitiveness factors:

- *High innovation capacity;*
- *Strong position in trade and responsiveness for foreign demand;*
- *Cost control;*
- *Social dialogue;*
- *Regional clusters;*
- *Large home market, key segments and sales value;*
- *Strong value chain;*

- *Qualified labour and cost of labour* (EC 2012, 74-76).

4.1.3 Expected future market dynamics

> *Premium vehicles are objects of desire all over the world.* (Daimler 2013, 65)

The declining predominance of mature economies in the motor-vehicles market will have a further development in the next decades. North America and Europe will have a less significant weight, while Asia and emerging economies will gain a lion share.

> *In the high car ownership scenario, the world passenger vehicle stock reaches 3.3 billion units by 2050, which is four times the 2010 global stock. This growth in vehicle stock is almost entirely driven by the emerging economies. India and China are responsible for 56% growth, given their large shares in world population and given the fast income growth in China, and become the major car markets. Their share of global vehicle stock in the non-OECD regions rises from 30% to 70% over the period 2010 - 2050* (ITF 2012, 31).

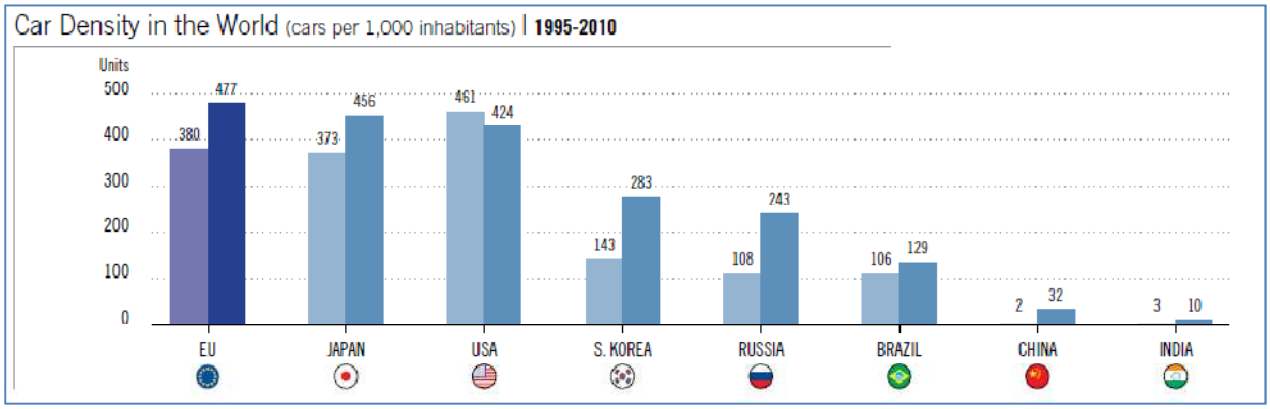


Figure 34 – Car Density in the World - (ACEA 2012a, 74)

Two elements will support this trend.

a) Mature economies

To some extend mature economies can be defined as saturated markets. In a broader context, "historical patterns both across countries and time suggest that automobile ownership tends to rise with GDP per capita", but this happened *and presumably will happen in the future* in "a non-linear way". Surely, we have evidence that "ownership rises slowly with income, then rapidly at middle income levels, before slowing at higher income levels as saturation levels are reached" (OECD 2009, 105).

However, this trend is definitely not linear and it is influenced by several extra factors, including geographical patterns, cultural and social values and available transport alternatives. The position of Portugal and Denmark in Figure 35 gives a clearer indication that GDP is not the only key factor. Some studies noticed how "in most countries this levelling off occurs at a per capita GDP between US$25.000 and US$30 000 (prices of 2000 at PPP)", although "for the USA the turning point is at US$37.000. The observed patterns can be the result of a range of explanatory factors including saturation, higher fuel prices, declining rates of transport infrastructure expansion, ageing, urbanization, macroeconomic shocks, income inequality, the advent of the online economy, etc." (ITF 2012, 43).

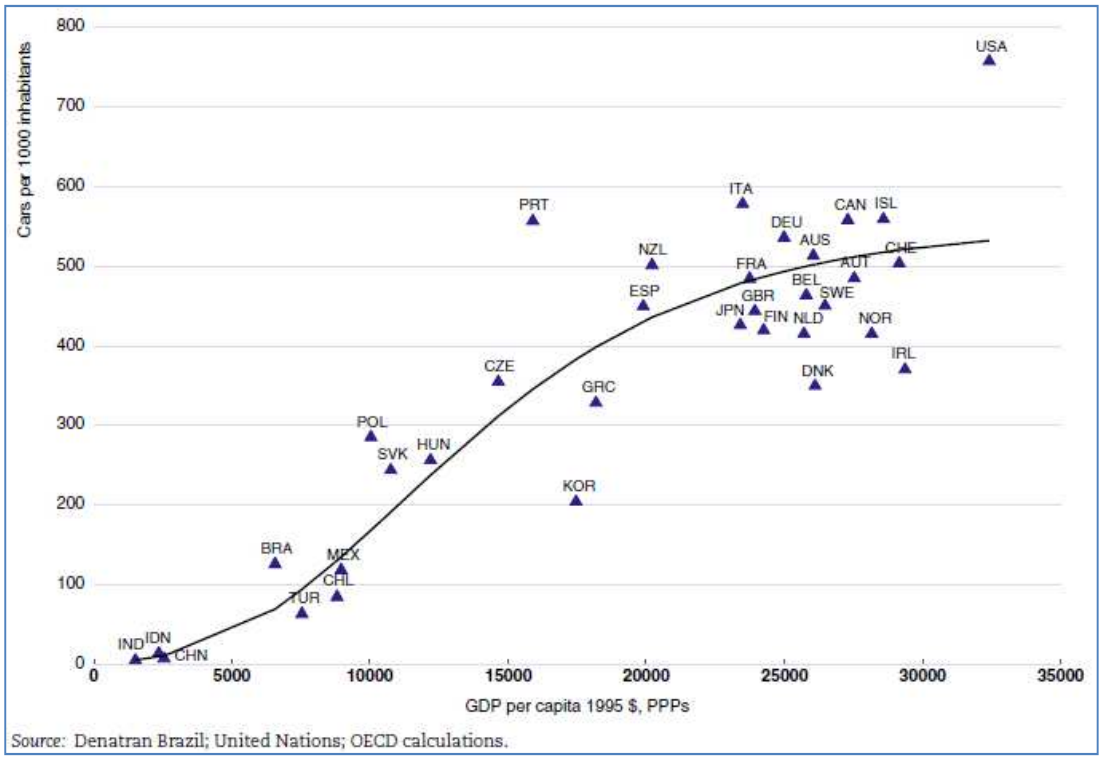


Figure 35 – Car Diffusion and GDP pro-capita - (OECD 2009, 105)

Considering the rising relevance of shared economies, new attitudes towards car ownership, energy cost and environmental concerns, there are enough elements to claim that, to some extent, mature economies have reached not only a peak in car ownership but also – in a broader horizon – mobility increase (Goodwin 2012). Finally, North-American and (even more) European young consumers are showing less interest about car ownership; the number of kilometres travelled – by car – by younger generation is declining (Florida 2012).

b) Emerging economies

"By contrast, rapid increases are foreseen in China, which is already now the second largest market for cars" (OECD 2009, 89). Actually, China *was* the second largest market in 2009, but it was the first in 2012, giving confirming how quickly are the changes occurring in the car industry (KPGM 2012a). Beside the Chinese and Indian markets, "Eastern Europe and Latin America would register the biggest growth by 2020" all together "accounting 55% of the total sales" (Forum automobile and society 2012, 2).

Such a relevant change, a sort of turning point for the industry, will have strong consequences for the EU motor-vehicles producers. On the medium term, "import duties and taxes in China or India discouraged European exports and infringed an increase in local production, from which resulted the need for the automotive industry to collectively urge a transformation of the legislation regarding the production in Europe and the supply to those markets" (Forum automobile and society 2012, 2).

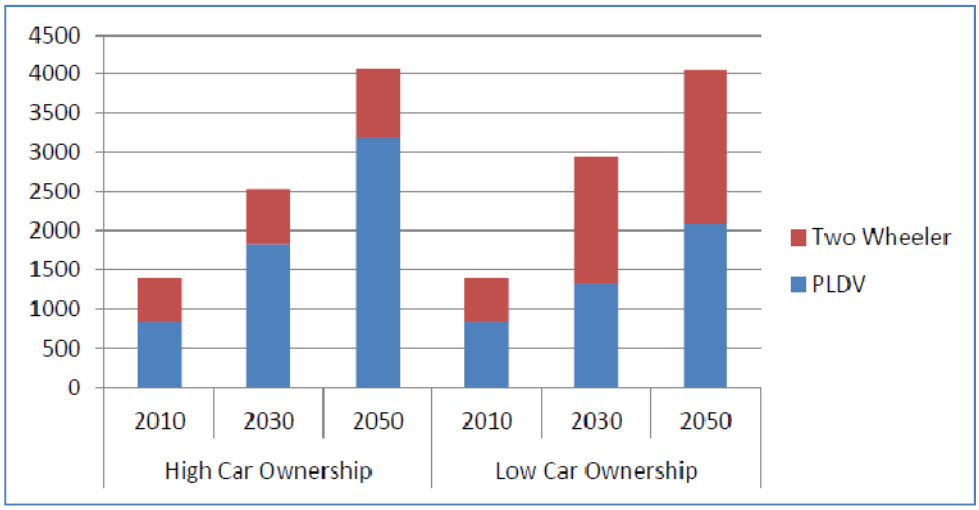


Figure 36 – Global private vehicle Stock: ITF high and low ownership scenarios (PLDV stands for Passenger light duty vehicle) - (ITF 2012, 33)

A wider numbers of globalised customers, with a greater self-confidence on their national and local heritage, could also re-position the value and the *allure* of "Buying European", and probably they will ask for more personalised vehicles, according to local and personal tastes and needs. In other words, "the industry has become more consumer driven. […]. The consumer will be dictating the terms" (IBM 2008, 5).

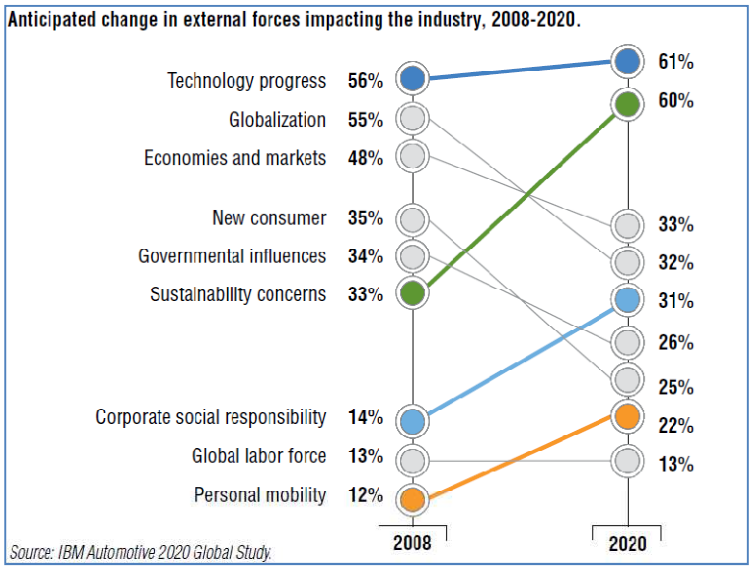


Figure 37 – Key drivers for automotive industry - (IBM 2008, 4)

In addition to the above tendency, the role of ICT will impact more and more the car industry. Given its characteristic of being a sort of cocoon, the motor-vehicle has to act accordingly, e.g. offering a whole array of facilities and services as one can get at home. Such a task will become a market *must*: "New requirements to incorporate information and interactivity quickly drive up costs and complexity. At the same time, the auto industry must be more creative to capture a larger share of the consumer's attention and overall transport spends – both in and beyond usage of vehicles. Automotive enterprises have long used information technology to improve productivity and efficiency, reach new markets and optimize supply chains." (IBM 2011, 1) Naturally, other mega-trends will impact the industry, well beside the electric mobility: "Connected vehicles, personalisation with a focus on social media integration, vehicle to vehicle and vehicle to

infrastructure communication" (Forum automobile and society 2012, 2).

	Production		Sales	
	CAGR (2010 - 2020)	Percentage of Global volume	CAGR (2010 - 2020)	% of Global volume
Asia	4.7%	51%	5.1%	44%
North America	3.9%	15%	4.0%	19%
South America	3.9%	6%	4.4%	7%
Western Europe	2.8%	15%	2.5%	16%
Eastern Europe	5.2%	9%	8.8%	8%

Figure 38 – Global Automotive industry and market 2020 - (Forum automobile and society 2012, 8)

4.1.4 Long term strategies and emerging models

Car industry has to face several challenges in the medium-term, challenges driven by mega-trends occurring in the present days and displaying their effects in the long period.
The automotive sector will be strongly impacted by those factors, as shared economies, ageing population, energy cost and environmental concerns, which can harm – also strongly – the industry. On the other side, car manufactures and OEMs are very aware of the incoming engaging questions and – more than other transport sectors´ industries – are actively reacting.
There are two overall paths: i) the transport industry is moving from to be a seller of goods to be a service provider; ii) the OEMs and other prominent actors are colonising new fields, that is, for instance, an OEMs running a car sharing scheme (BMW is maybe the best known), or developing with awareness after-market services (PSA among other ones). This issue involves not only the car industry, which is however the leading the trend, but more generally all the transport sectors. (Considering this issue as an overarching theme, a more developed definition of sales, post-sales and renting markets developments is achievable in chapter 6 of this report).

Figure 39 – Global Mega Trends impacting mobility according to Frost & Sullivan - (Forum automobile and society 2012, 14)

Two crucial developments are – anyway – strictly linked with the automotive industry, e.g. the electric powered vehicle and the autonomous car or driverless vehicles. While both topics are developed in chapter 5 of this report, the electric-car market is also briefly faced here.
After very high expectations in the past three years, the electric vehicles debate and attitude has reached the "valley of disillusion" stage. The current "registrations of new electric vehicles are very low with an average share of 0.06 percent in the countries considered, (EU, USA, Japan, South Korea and China). However, all market participants believe that there is "no going back" from electro-mobility" (University of Duisburg-Essen 2012, VI).
Lost the most enthusiastic prospects, now electric vehicle is increasing its market share at a slow pace. For 2020 in EU it is estimated to have electric vehicles at the 7% of sold vehicles, and in 2030 "about 31 percent of EU-27 new light duty vehicle registrations will belong to electric vehicles." (University of Duisburg-Essen 2012, VI). In more global prospective, "the market model expects a global market development of 86 million vehicles up until 2020 and approximately 99 million vehicles in 2030 with a share of 9 percent of electric vehicles in 2020 and 31 percent in 2030." (University of Duisburg-Essen 2012, VII). This means that EU market will be slower in a first stage, up to 2020, and then be aligned with the global trends.
Although slower than expected (Germany Trade & Invest 2012), the electric-vehicles development is still impressive; additionally, beside the car market, in some countries, "non-passenger car EVs already hold market shares of up to 10%, as do electric bicycles in the Netherlands. In East Asia, especially in China, there is also a clear trend towards electric bicycles." (ICF and ECO 2011, 62).
The main actual growth in electric powered light-vehicles and van sales is coming from commercial operators, as courier and post operators, which can enjoy at the best the benefits of electric-vehicles, although this is still a narrow niche of the total market (ICF and ECO 2011).

Key Findings

In the near-term future, the market penetration of EVs will remain fairly low compared to conventional vehicles. The estimation based on several government announcements, industry capacities and proliferation projects sees more than five million new Electric Vehicles on the road globally until 2015 (excluding two- and three-wheelers), the majority of these in the European Union. The main markets for Electric Vehicle are in order of importance the EU, the US and Asia (China and Japan). Some further target markets like Israel and the Indian subcontinent are also expected to evolve.

In the long term, the share of EVs will most likely increase as additional countries adopt technologies and initiate projects.

1. It can be assumed that in the short run, i.e., until 2015, EVs will not differ significantly from today's cars concerning their outward appearance and function, albeit with shorter ranges than conventional ICE cars.
2. Until 2015, the market penetration of EVs will remain fairly low: compared to global sales forecasts of 53 million conventional cars in 2010 alone, EVs will account for over five million cars until 2015. The main markets for EVs still being the EU, the US and East Asia (China and Japan).
3. As research activities and investments are relatively high, EV technology may advance rapidly and might account for greater shifts in the future than our findings suggest.
4. There is a significant risk of electric 'depression' after 2012 if expectations are not met and market penetration remains low.

Figure 40 – Electric vehicles Key Findings - (ICF and ECO 2011, 7)

Beside technological problems, especially in the interface with the power grid, we face in this issue industrial and political decisions as well as consumers behavioural questions. As reported by the European Commission in 2012, "forecasts on the market penetration of electric vehicles vary strongly. Even with the fastest penetration rates projected, demand for electricity coming from electric vehicles can be met with existing power generation facilities. However, careful coordination between energy and transport policies is needed to enable the larger deployment of electric vehicles to be accommodated by the distribution grid. It is therefore important that the roll-out of the electric vehicles should be accompanied by the deployment of smart grids (enabling cost-effective smart charging solutions and electricity demand management)" (EC 2012, 46).
All together, in 2020 "the dominant power-train will continue to be the internal combustion engine (ICE) - increasingly using alternative fuels (LPG, methane, bio fuels and synthetic fuels as a technology bridge) but electric vehicles (including plug-in hybrids) are expected to increasingly penetrate the market." (EC 2012, 44). The challenges for the electric-vehicles however will become not only a preference for "a portfolio of alternative fuels" (EC 2012, 43), but also by "the (efficiency-oriented) optimisation of internal combustion engine technology and the (flexibility-oriented) development and production of electric vehicles (e.g. in terms of modularization, flexible production)." (University of Duisburg-Essen 2012, IX).

4.2 Waterborne and ship industry

Abstract
The shipbuilding industry is a globalized marketplace dominated by Asian yards: China, South Korea and Japan together hold over 80% of global completions between 2005 and 2012.
European shipyards still hold a strong position in some high-tech and high-value added niche markets, like Cruise vessels, Dredgers, some offshore support vessels and yachting. Furthermore, the European marine equipment industry is home to some of the most successful players globally, and a main driver for innovation in the industry.
The research and innovation capabilities of the European industry places it in a good position to take advantage of the opportunities that lie ahead, like the greening of the fleet, deep-sea exploitation and offshore renewable energies – like wind or waves – where European players are in the forefront in technological terms. But its current competitive position is threatened by the lack of financing, ageing workforce and shortage of skills. Increased competition from dominant and emerging markets alike – as oversupply in some markets are pulling capacity between market sectors and innovation is quickly taken by others, and as intellectual property rights are complicated to enforce at a global level – requiring a steady pace of R&D just to keep a step ahead of competition.

4.2.1 Ships, boats and maritime navigation and communication equipment

The shipbuilding industry caters for a vast bundle of human sea- and inland- related activities, like maritime trade and passenger vessels (tourism, ferries and leisure), aquaculture and fisheries, naval and defence sector, offshore energy exploration and production (E&P), coastal protection and land reclamation, floating structures and factories. The main areas of production activity are new ship buildings, maintenance, repair and conversions, and marine equipment supply and after sales service. These activities are supported by a set of auxiliary activities like shipping companies, ship classification societies, financing and equity holders, education and R&D, maritime brokerage, seaport services, trade and environmental policy regulations. The trade fleet is composed of different ship categories: container ships, dry bulk and liquid bulk carriers (crude oil and product tankers), specialized vessels such as LPG and LNG carriers, and chemical tankers.
Asian shipyards dominate the industry, as a small number of Asian conglomerates concentrate the majority of order books for new ships. It's mainly a three players' game between South Korea, China and Japan.
China (35%) and South Korea (29%) shared almost two thirds of the world order book at the end of 2012. Japan came third with 18% of the world orders, and CESA – the Community of European Shipyards' Association (EU27+ Norway and Croatia) accounted for only 8%. Together, Korea, China and Japan accounted for 81% of global orders at the end of the year. Europe occupies a predominant position in some niche segments of the industry. Actually, European weight in terms of CGT is not very important, but its position in terms of value is stronger, particularly if naval activities are considered (Ecorys 2009).
Other non-trade ship categories relevant for the European shipbuilding industry are cruise ships, ferries and mega-yachts, dredgers, specialized offshore vessels and naval vessels. Although not all productive outputs from the shipbuilding industry strictly relate to the transport industry, it is important to consider all sectors´ outputs since depressive markets in a specific sector indirectly

affects others sectors, as it pushes production capabilities among market segments.
The marine equipment subsector constitutes the supply chain of the yards. It refers, according to EMEC – European Marine Equipment Council, to

> *all products and services supplied for the building, conversion, and maintenance of ships (seagoing and inland). This includes several categories of products, such as propulsion/power systems, navigation/communication/control (electrics & electronics) equipment, cargo related equipment and "Hotel" and related equipment, and also technical services in the field of engineering, installation and commissioning, and ship maintenance (including repair).* (EMEC 2013)

The above is responsible for 50%-70% (or even 80% for more specialized vessels) of the industry value-added with an estimated dimension of 5,000 to 7,000 companies in Europe alone, many of them small and medium sized. This is a high value-added sector and a key source of innovation for the industry, while its spendings in R&D are beliefed to be higher, in relative terms, than shipyards' ones. Maintenance, repair and conversion of ships are important activities within the shipbuilding industry as well. Maintenance operations usually don´t take much time – dry docking generally takes 10 to 12 days, and due to its corrective character, most of the repair centres are located along the main shipping routes (Ecorys 2009). Conversions, on the other hand, can take quite longer and are more similar to new building works, although with more flexible needs. According to the increasing regulatory requirements and potential drive towards greener and more fuel-efficient vessels, retrofitting and modernization of part of existing fleet entails increasing complexity and value for this sector.

Panorama of European shipbuilding industry
There are about 150 large shipyards in Europe, according to the industry report prepared by the European Commission, but only 40 of them are active in the global market for large commercial vessels. These large yards were, as long as 2007, the largest contribution for the European market share (Business Vibes 2012). The above numbers have to be put against a 8,5% market share in tonnage based statistics, which implies a relative higher value of European production, counting for 109.000 direct employees in 2011, compared to 149,000 in 2007 (SEA Europe 2013a). It maintains a leading edge in design, innovation and service of the most demanding ship types.
There are several European countries that feature a long and reputed history in the shipbuilding field, such as Germany, Romania, Italy, Norway and the Netherlands, while Turkey has only entered this market during the 2000s shipping boom, being able to become an important European player. Together, these countries had an order book of 4.1 million CGT by July 2012, with Germany accounting for 1.1 million CGT, Norway, Italy and Turkey with 0.7 million CGT and the Netherland and Romania with 0.5 and 0.4 million CGT respectively (Clarkson 2012).
As better reported in RACE2050 deliverable 6.1, Europe isn't the leader of the shipbuilding industry anymore, as productions have been largely shifted to Asia during the past 40 years. But this industry is still an important economic contributor to several EU member states. Europe's shipbuilding industry is active in many different segments, but is best known for its dominance in some specialized market segments such as cruise ships and luxury yachts, dredging and some naval vessels, which place the European production as a specialized niche player in the competitive global arena. European policies promoting sustainable growth (resource efficient, greener and more competitive economy) provide a perfect match for new opportunities on smart and green ships that lie ahead in the future. In fact new technology does already exist, but the opportunities

are not yet materializing.
However, the current chronic scarcity of finance poses a huge threat to European yards. The economical and financial crisis is affecting Europe far more than other regions. For some stakeholders, the capacity to raise debt and contractual guarantees to leverage new orders is the main issue for European yards, as European banks pulled off the maritime business due to solvency issues, while foreign yards are enjoying state-backed low rate bank loans to help finance new construction. Recently, some contracts are being placed on the availability of finance over technical competences of the bidders (LeaderShip2020 2013). The increased interest of Asian yards in diversifying their offer, getting into relatively small European lead niche markets also poses an increasing threat on European competitive position.
The European competitive position in the Marine equipment industry is comparably far more positive, representing 40% of the world market share in 2008. European equipment industries are world leaders in propulsion, cargo handling, communication, automation, environmental and security systems, having succeeded to retain a strong position supplying not only European but also Asian shipyards, consequently only a few are exposed to a decreasing European shipyards market share. These companies usually have diverse risk management strategies, which reduce the threat of being exposed to a single business chain, and makes them to strong promoters of technological transfer between business areas.
Beyond their strong export position, larger companies have off -shored their production through licensing agreements or building their own production facilities overseas (mainly in Asia). Propulsion is a good example as engines, by their sheer dimension, are easily built near the shipbuilding yard. Wartsila (Finland) and MAN B&W Diesel (Germany) are the two main players in this field and have licensees all over the world.

A Competitive agenda for the EU Maritime Industry - Leadership2020
The LeaderSHIP2015 initiative was launched in 2002, by a joint industry-European Commission coordination group, with the aim of defining a global European shipbuilding vision, and a strategy to ensure its “long term prosperity”. In February 2013, a review of this strategy was publicised – “LeaderSHIP2020 – New Opportunities for the Future”. This document highlights the main challenges and opportunities this industry faces in the future and proposes a set of actions to deal with them. The key strategic elements identified for the EU Maritime Industry are:

1. Improving leadership in selected maritime market segments;
2. Continuing to drive and protect innovation;
3. Strengthening customer focus;
4. Improving industry structure and implementing a network driven operating model;
5. Emphasising production optimisation and shift towards a knowledge based production.

To achieve these aims demands for a set of integrated policy measures, which are identified in the following areas:

- Employment and Skills: There is an increasing shortage of skilled labour in the industry. Therefore, qualified human capital must be retained and an appealing image of the industry as a high-tech enabling industry to attract talented and highly skilled young people needs to be promoted. It also needs to face the increasing complexity of the industry, for a better transfer of knowledge between generations, for life-long learning, and better workforce mobility;
- Market Access and Fair Trade: In many countries, the maritime industry is often considered strategic, as in the EU, but active political support is mainly recorded outside Europe, creating distortions to a fair market (subsidies and protectionism measures). European trade

policy should promote proactively free and fair markets under the international organizations that address these themes – OECD (under WP6), WTO or ILO; pursue the establishing of trade agreements with main trade partners; enforce social, labour and environmental obligations; introduce international reciprocity on public procurement and safeguard intellectual property rights;

- Access to Finance: The lack of funding has become the single most important factor in competing for international contracts; the industry would like to see the European Investment Bank (EIB) to play a bigger part in funding environmentally driven new building projects, having its scope expanded to take projects into consideration that relate to "green shipping and retrofitting". Public Private Partnerships (PPP) are also suggested as a possible way to finance specific non-commercial projects or special interest potentially profitable demonstrative projects.
- Research, Development and Innovation: Aiming to strengthen EU competitiveness through innovation is not an option, but the only way to take advantage of the new market opportunities arising to the maritime industry, namely offshore renewable energy, deepwater mining and drilling, and meeting upcoming energy efficiency and environmental regulations. The document proposes stimulating research through demonstration projects backed up by EC funding, like the 7th Framework Program, and strengthening regional innovation relationships throughout the supply chains through instruments of EU Cohesion Policy.

4.2.2 Main Markets for European shipbuilding industry

Cruise Shipbuilding

The worldwide cruise capacity in 2013 is over 438.000 passengers, hosted in 283 ships. The industry is divided among several operators, concentrated on big four – Carnival, Royal Caribbean, Gentling Hong Kong and MSC Cruises, which represent 90% of global offer and 75% of ship orders. The cruise industry has shown an enviable steady growth since the 1990s (Figure 41), despite the recent economic crisis. The market Compound Annual Growth Rate (CAGR) between 2000 and 2012 was 9%, and it is forecasted to growth at 3% a year until 2018 (Cruise Market Watch n.a.).

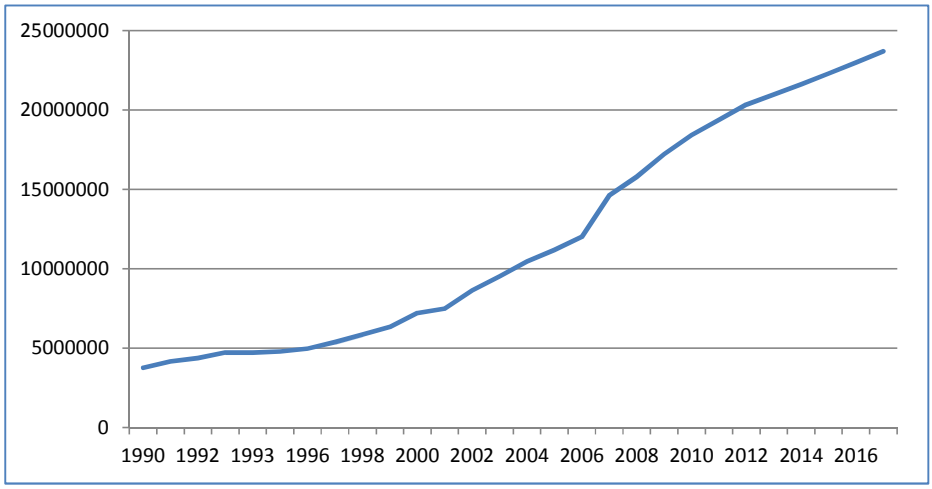


Figure 41 - Cruise Passengers trends - (Cruise Market Watch n.a.)

Twenty-six cruise ships are scheduled to be delivered between 2013 and 2018 (including three

options to concretize), with an overall capacity of over 69.000 passengers, representing an investment of $16.7 billion, of which $2.3 billion were contracted outside EU yards (Mitsubishi-Aida) and China (Blue Star Line – Titanic II and Xiamen China).

Cruise line	Year	Ship	Cost	Tonnage	Capacity	Yard
MSC	2013	*MSC Preziosa*	$760	140000	3500	STX France
AIDA	2013	*AIDAstella*	$575	71000	2174	Meyer
Norwegian	2013	*Breakaway*	$780	144000	4000	Meyer
Hapag-Lloyd	2013	*Europa 2*	$340	39500	516	STX France
Princess	2013	*Royal Princess*	$760	141000	3600	Fincantieri
Ponant	2013	*Le Soleal*	$150	10600	264	Fincantieri
Norwegian	2014	*Getaway*	$780	144000	4000	Meyer
TUI	2014	*Mein Schiff 3*	$525	97000	2500	STX Finland
Princess	2014	*Regal Princess*	$760	141000	3600	Fincantieri
Royal Caribbean	2014	*Quantum*	$950	167000	4100	Meyer
Costa	2014	*Diadema*	$790	132500	3700	Fincantieri
AIDA	2015	*Unnamed*	$645	125000	3250	Mitsubishi
P&O Cruises	2015	*Unnamed*	$760	141000	3611	Fincantieri
Viking Ocean	2015	*Unnamed**	$393	47000	944	Fincantieri
TUI	2015	*Mein Schiff 4*	$525	97000	2500	STX Finland
Royal Caribbean	2015	*Anthem*	$950	167000	4100	Meyer
Norwegian	2015	*Unnamed***	$920	163000	4200	Meyer
Holland America	2015	*Unnamed*	$520	99000	2660	Fincantieri
Viking Ocean	2016	*Unnamed**	$393	47000	944	Fincantieri
AIDA	2016	*Unnamed*	$645	125000	3250	Mitsubishi
Royal Caribbean	2016	*Unnamed****	$1,300	225000	5400	STX France
Blue Star Line	2016	*Titanic II*	$500	56000	2345	CSC China
Carnival	2016	*Unnamed*	$780	135000	4000	Fincantieri
Viking Ocean	2018	*Unnamed**	$393	47000	944	Fincantieri
Viking Ocean	2018	*Unnamed**	$393	47000	944	Fincantieri
Norwegian	2018	*Unnamed***	$920	163000	4200	Meyer
Xiamen international	2018	*China Xiamen*	$485	100000	2000	Xiamen Shipbuilding
Total			**$16 692**		**69158**	

Table 1 - Cruise Ship order book - (Cruise Industry News 2013, and RACE2050 research)

The European shipbuilding industry is undoubtedly the market leader in the segment of shipping, with players like Fincantieri, Meyer Werft or STX Europe (South Korean owned). Other country experiences in this market segment were episodic; even though the EU shipbuilding industry has been the world leader in cruise ship construction and refurbishment for the last 40 years. The renewed competition from the Far East yards is a matter of concern for the EU. Japan's output in this industry has been erratic with previous ships deliveries in 1989-90, 1998 and 2004 (European

Cruise Council 2012), but the growing need from Asian yards to diversity their offer creates a huge threat to European position.

Yard	Value	Tonnage
Fincantieri	6.090	988.100
Meyer Werft	5.875	1.019.000
STX France	1.400	404.500
Mitsubishi	1.290	250.000
STX Finland	1.050	194.000
CSC China	500	56.000
Xiamen Shipbuilding Industry	485	100.000
Grand Total	**16.690**	**3.011.600**

Table 2 - Major players order book 2013-2018 (Million €) - (Cruise Industry News 2013)

The three bigger players in the shipbuilding industry in terms of order book in 2012 are Fincantieri, Meyer Craft and STX Europe. Far East players are currently holds 14% of current order book in value.

Dredging

Dredging is the operation of removing material from the water environment and to relocate it to another place, by use of a specialist floating plant known as Dredger, with the main objective of recover valuable materials or create a greater depth of water for navigational purposes. Climate change and Sea level rise are bringing new opportunities to this industry on coastal protection initiatives. Some of the vessels in this market segment are amongst the most sophisticated and technologically advanced vessels afloat today, and Europe is the world market leader in building and operating this kind of vessels – the top-4 dredging companies, DEME, VanOord, Jan de Nul and Boskalis are all located in the Benelux and together hold 80% of the worldwide open tender market (Ecorys 2009). These companies supplement other emerging opportunities like offshore wind, the oil & gas industry in the Arctic, marine minerals mining and service and maintenance sectors.

Yachting

According to the European Commission (EC 2013c, EC 2009), Yachts (or recreational crafts) are "any type of boat intended for sports and leisure purposes of full length from 2.5m to 24m". These high-value products are characterized by builder-to-consumer and consumer-to-consumer relations and have quite long life-cycles, staying in the market for a long period of time. The production of yachts is very diverse and ranges from production in series to original products built according to the order (EC 2013b).

The yachting industry is comprised in its majority by small and medium-sized enterprises (SME's), as 97% of its business are SME's, a few large companies with more than 1,000 employees and a few "builders for own use". Such a dynamic sector, with an average annual growth rate of 6%, has 272,000 directly employees representing about 37,200 businesses and 23.4 billion euro of annual revenue (EC 2013b). The recreational craft industry is a relevant sector for the European Commission due to its economic and environmental impact in the EU. For that reason, EU has improved market conditions in this sector through legal framework that facilitate free competition across the member states and trade with foreign countries. As the trade with third countries is particularly important to EU, Mutual Recognition Agreements (MRAs) were established with US and Canada, in order to improve the trade of these products through the simplification of the

certification procedures.

Naval

The market of naval ships is an important activity for the European shipbuilding industry, and one where its competitive position is far from marginal in world terms. However, this segment cannot be seen as a fully accessible market being influenced by non-economic factors. The role of competitiveness naturally plays a role here, at least in making ship able to be challenge enemy forces, but all together it is not relevant to the present analysis. We should just to keep in mind that the diminishing defence budgets of European countries – due to economic crisis – is placing a pressure on European yards and marine equipment industries.

The offshore industry and its specialized vessels

The offshore market has been dominated since a long term in rising energy costs to which, apparently, there is no end at sight. Raising energy demand and prices pull the opportunity for more offshore vessels, as Exploration & Production (E&P) CAPEX increases, creating real opportunities for the shipbuilding industry (see Figure 42).

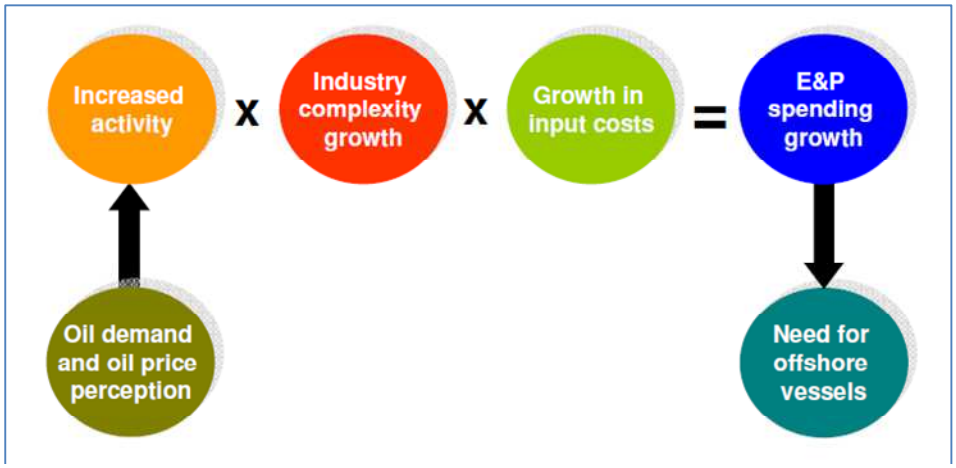


Figure 42 - Several factors that contribute to E&P spending - (Rolls-Royce 2009)

Offshore reserves are the major worldwide source of oil and gas total, and the ever rising price of oil promises to produce similar long-term growth in deep-water drillings, as the majority of prospects in shallower water are being depleted; nowadays offshore drilling is seen as the major source to meet world energetic demand in the future. Deep-water comprises 70% of the earth's surface, and some marine areas in North Western Europe and Northern seas are expected to become future centres for increased deep-water drilling activity. 25% of world remaining resources are believed to be under the Arctic sea. This implies special demand for technology, environmental and safety issues. Most of the world's potentially productive deep-water areas are virtually untouched raising the need to carry out even more complex operations, requiring vessels capable of longer transit times titles and higher deadweight deliveries.

Nowadays deepwater activity is mainly carried out in the golden triangle (Figure 43) US Gulf of Mexico, Brazil and West Africa (Nigeria, Angola) – the North Sea and South East Asia (Malaysia).

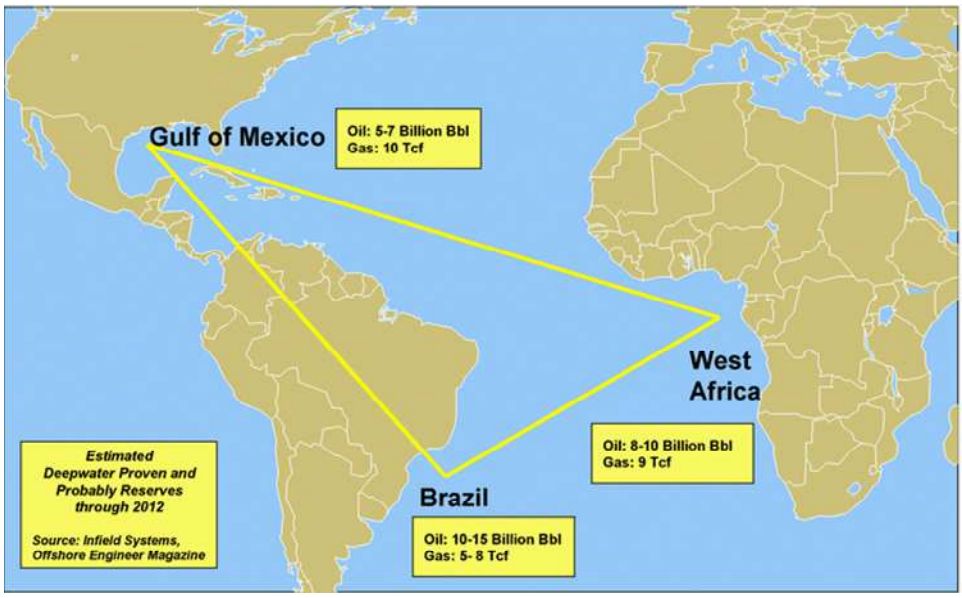


Figure 43 - Deepwater Golden Triangle - (Investor Scopes n.a.)

The global OSV fleet is composed of i) AHTS – Anchor handling tug supply, ii) PSV platforms supply vessels, iii) ERRV – Emergency rescue and recovery vessels, and iv) tankers. In 2012, the total fleet comprised of 2.967 vessels, compared to 1.702 in 2009, covering 13% of the entire world fleet (Westwood 2013). The main trends in this industry are booming opportunities for the shipbuilding industry:

- Growing offshore production
- Growing offshore gas production
- Growing deep water production

Future Prospects for the European Maritime Industry

The EU maritime industry competitiveness relies heavily on its strong research, development and innovation commitment to answer the emerging opportunities that are already pointed out.

Offshore renewable energy (Tidal, currents, wind and waves)

European players have been in the forefront of offshore renewable energy, as can be seen in figure 44. According to a Maritime labour market foresight study (Generation BALT 2013), the European offshore wind energy production amounted to 3GW in 2010 and, in ten years, it is expected to equal an annual 43 GW, which corresponds to a growth ratio of nearly 1.5 GW per year. This is the fastest growing market. UK plans to deliver 18 GW of offshore wind energy by 2020, and Germany is expected to raise 1.7 GW in the same period (Westwood 2013). According to the EU Blue Growth Strategy, by 2030 the annual installation of offshore capacity could exceed that onshore.

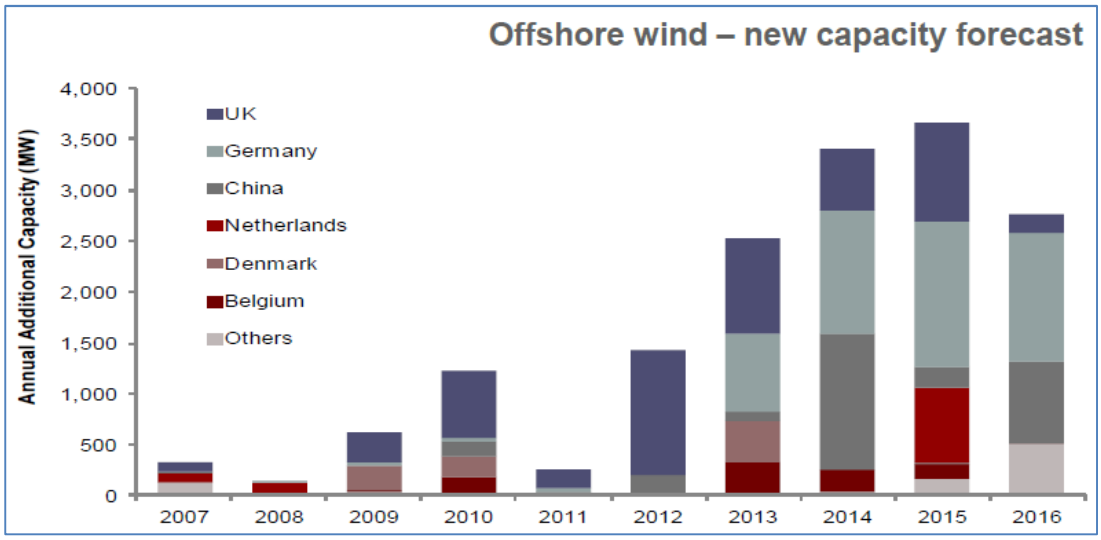


Figure 44 - Offshore wind new capacity forecast - (Westwood 2013)

Tidal energy is also evolving, with several demonstration projects already under way. UK has plans to invest £440 million CAPEX in Tidal energy between 2012 and 2016, assuming 70% of this market share globally. Canada comes second with 11%.

Decommissioning of existing offshore infra-structure

Circa 4 million tonnes of offshore platforms and subsea aging equipments will need to be decommissioned at some point over the next 30 years: 175.000 km of subsea pipelines, 3.000 subsea wells and 6.000 fixed platforms. This might be a business opportunity for highly specialized companies (Rolls-Royce 2009, Westwood 2013).

New trade routes over the Arctic Sea

Arctic polar cap shrinkage due to climate change is creating new navigable waterways throughout the Arctic (Figure 45), opening new prospects for shorter trade routes between the Atlantic and Pacific oceans[4]. Distance savings between Europe and Asia among the Northern Sea Route (NSR) can be over 50% compared to currently shipping paths (The Acrtic Institute n.a.). The actual sailing distance between Yokohama and Rotterdam is roughly 20.000 km through the Suez Channel, but less than 9.000 km via the NSR. Bulk carrier tonnage through the NSR is expected to increase tenfold, from 2 million ton today to 20 million ton by 2020.

[4] It is already in the agenda that, by 2040, ships will be able to travel straight through the Arctic Sea and even North Pole (The Acrtic Institute n.a.).

Figure 45 - Arctic sea-ice in September 1979 and 2007, showing the biggest reduction since satellite surveillance began - (Eccleston 2008)

4.2.3 Market Outlook

According to UNCTAD (2012) the future of the shipping industry will be drawn "against a background of economic uncertainty, faltering demand and the burden of ship tonnage overcapacity". The following trends will reshape the industry future and global seaborne trade patterns:

1. Climate change;
2. Shift in global economic influence;
3. Rising bunker fuel prices and operating costs;
4. Maritime piracy;
5. Growing momentum of sustainability imperatives.

1. Climate change is a major challenge to our society and economy. The generation of greenhouse gas (GHG) by transport modes is at the centre stage of current debate and mitigation actions are gaining increasing relevance in the maritime industry. Climate change impacts on ports and their hinterland connections by accelerated coastal erosion, restrictions on access to docks or increased dredging necessities and structural integrity of pavements and railway tracks within port areas and related hinterland connections. The economical implications of climate change related disruption to transport networks are notorious, requiring appropriate adaptation strategies to deal with them. Paradoxically, climate change also opens new trade routes opportunities by de-icing of the Arctic Sea.
2. The shift in global economic influence from advanced economies to emerging developing countries, deepened by the last financial crisis, is forging an increasingly multi-polar global economy. The share of all developing countries in trade flows has risen from 30% in 1995 to an estimated 42% in 2010, and its share of global GDP is expected to expand from 36.5% in 2010 to

44.5% in 2025. Intra-Asian trade might become the focus of global economy and the largest trading bloc in the world, surpassing NAFTA and the Euro Region, just by 2015. Freight transport is expected to growth between 2.5 and 5.5 times for non-OECD countries, from 2010 to 2050, and between 1.5 and 2.3 times for OECD countries in the same period (ITF 2012). New trade dynamics shall arise from this evolution.
3. Growing demand, constrained and uncertain supply and ongoing risks affecting oil producing regions are supporting a high price trend in the future. Fuel costs account for more than two thirds of shipping OPEX.
4. Other operational costs are also increasing, like insurance against maritime piracy.
5. Environmental regulations in the maritime industry have historically lagged behind those of other industries, but this situation is already changing, with a growing momentum of sustainability imperatives: Key environmental regulations are coming into force to address and mitigate seriously emissions of SO_x, NO_x, PM and CO2 by merchant fleets. The MARPOL Convention annex VI on Air Pollution and Emission Control Areas (ECAs) in NA and EU forces vessels, between now and 2020, to stringent sulphur emissions, leaving two options to operators: burn more expensive but less polluting fuels, namely distillate grade fuel or LNG (mostly for new ships), with a price differential estimated at 50%, or to install bulky exhaust gas scrubbers, which remove sulphur for engine exhaust gas, allowing ships to use cheaper, readily available high sulphur fuel. New Ballast water treatment technologies and NO_x emission mitigation technologies (Exhaust gas recirculation (EGR), selective catalytic Reactors (SCR); humid air motors (HAM)/ Water in fuel (WIF) are some of the possible technical solutions necessary be enforced by shippers in order to comply with future regulations. The progress of marine equipment technology will mainly result from the evolution of two main variables: Economic Growth and Regulatory and Stakeholder Pressures on the Environment (Det Norske Veritas 2012).

A Lloyd´s foresight study points out to an expected increase in merchant fleet size from over 700 million GT today to somewhere around 1,400-1,700 million GT in 2030 (Lloyd's Register 2013), given the scenario considered. The container fleet holds the higher growth expectations (around 2.3 to 3 times) – vessels with capacity over 7,600 TEU are expected to grow even higher – 6 to 6.5 times in this period. Following, in decreasing order of growth rate expectation are Bulk Carriers, LNG carriers and Tankers.
In terms of shipbuilding market for merchant fleet, Chinese and emerging economies shipyards are expected to hold the dominant roles in the future, as South Korea and Japan will lose market share to them – South Korea Market share is expected to fall from 34% to around 22% (measured in GT), while Japan market share will fall from 21% to 9-10%. By vessel type:

- Tankers: New buildings will be dominated by China (44-55%), South Korea (25-27%, falling from around 50% today), and emerging countries (8-20%) in 2030; deliveries in the 2026-2030 period will almost halve today's (2006-2010);
- LNG Carriers: South Korea will gradually lose its hegemony in this specialized vessel type construction, and the market shall be equally divided between Korea and China, while deliveries shall rise between 30% or 40% to current numbers;
- Container ships: This market will expectedly also be divided between Chinese (39-48%) and Korean (40-44%) yards. Chinese share will continue to rise, while Koreans' and Japans' diminishes;
- Bulk Carriers: this market will expectedly be divided between China and emerging economies, with market shares of 40-59% and 26-42% respectively.

A reference is also made to the growth potential of other maritime explorations, like offshore energy – oil, gas and sustainable sources. Oil or gas offshore platform numbers are expected to increase over 220%, from 270 today to 618 in 2030. Accordingly, offshore oil and gas supply are expected to rise from 1,500 to around 2,000-2,500 million tonnes and from 1,000 to 1,500-2,000 million tonnes, for oil and gas respectively. Although nothing is said about country of build, it is well known that Korea dominates this market nowadays, and China is working very hard to step in even strongly.
Finally, some growth prospects are given for sustainable offshore energy production. Offshore wind parks are expected to rise 100 times, from under 900 turbines today to over 90,000 in 2030. Wave energy devices are expected to evolve from current 22 to over 22,000, and the predicted number of tidal and ocean current energy devices will be around 50, from current 11.

4.3 Rail equipment industry

Abstract
The rail equipment industry not only 'successfully' navigated through the downturn of the past years, but the scenarios available describe a sound development for this sector. Additionally, the EU rail industry appears to be conscious of the challenges to be tackled. The role of the European industry is indeed challenged by fast growing Asian firms which can harm the European leading position. Besides R&D, innovative business models and original (and even extreme) new strategies are claimed as essential.
In terms of markets trends, Asia will experience a slowdown of its astonishing expansion (unless a new wave of investment is unleashed in China and India), but other markets could become attractive (Africa, next-11, Americas, Russia). Urbanisation will be another driving force.

> *Conducted for the fourth time, UNIFE's World Rail Market Study 2012 reveals that the industry is successfully navigating the economic downturn witnessed at the end of the last decade. The study also points to a positive outlook for the future. Spurred on by favourable conditions, the attractiveness of rail as a mode of transport is continuing to gain ground.* (UNIFE 2012, 5)

Since the second half of the 1990s, the European rail sector had experienced a large-scale restructuring and the industry has seen,

- *a concentration of the number of leading companies;*
- *players becoming global organisations through mergers/takeovers and/or through the establishment of subsidiaries;*
- *strengthening of technical and commercial innovation;*
- *significant cost reductions (10% to 30% on new products according to [French] Fédération des Industries Ferroviaires, FIF);*
- *productivity gains of 5% to 8% annually (FIF data);*
- *development of new areas of competencies previously provided by railway operators* (Eurofound 2004, 1-2).

These trends starting from the 1990s continued over the next years, leaving on the stage 3-4 big European players as truly international companies, with more developed economies of scale. The world leader of this sector is Bombardier (see box) followed by three fully European companies (Alstom, Siemens, Ansaldo), which are also present world-wide. Although with some teething troubles, these big European companies were able to consolidate their market shares. Moreover, the European rail manufacturing industry, pushed by strong development in emerging economies (and by the need of service and maintenance of the already existing networks) passed through the economic crisis with minor damages (UNIFE 2012).
This was possible due to a series of factors.
Firstly, those companies benefited from the great "domestic" European markets, both in terms of high speed train programs, as well as of replacement and renewal of European rail systems. European companies (including here Bombardier) covered about 80% of European needs (Worldwatch 2010).

Box on Bombardier
Bombardier is a Canadian corporation, which covers both airspace industry (headquarters in Canada) and the rail sector (headquarters in Germany). Bombardier Transport, that is, Bombardier rail branch, is a member of UNIFE, the European rail equipment umbrella organisation. They claimed to have in 2010 about 34,000 rail-related employees all around the world, 25,600 of whom were based in Europe (mainly in UK and Germany) and merely 2,200 in Canada.

Secondly, according to the American rail lobby advocates, European rail producers benefitted from continental (in scale and scope) infrastructural investments, which sustained national and continental demand. Even though Japanese and South Korean firms caused some headaches for their European counterparts (UNIFE 2012) there was not a proper USA industry able to compete for the NAFTA market (Worldwatch 2010).
Thirdly, as well as their Japanese and Korean peers, European firms stepped into emerging economies, often paying the price of technological transfers, but acquiring notable contracts and opening subsidiaries and factories out of Europe. Consequently European companies have shown a good ability to be internationally present, as well as globally the driving force of research and innovation. Not only has the European rail industry been able to preserve its market through research, innovation and internationalisation, due to new ambitious high speed train European programs, like the Spanish ones, the old continent witnessed the growth of companies, like the Spanish Talgo and CAF-Construcciones y Auxiliar de Ferrocarriles, nowadays widely considered first-class firms.
This window of opportunity has been closed a few years ago, because the Chinese government allowed bidders to enter the Chinese market only under the clause of technology transfers. This (and Chinese domestic R&D programs) generated in the medium-term two Chinese *colossi*, namely CSR and CNR. Very quickly, those two Chinese companies were able not just to become "independent" in the domestic market, which was an inexorable outcome, but to also step out and enter other emerging markets (UNIFE 2010, 98). This is paving the way to fierce competition in terms of final cost (definitely in favour of the Chinese firms), but also through end-to-end deals, which included fully integrated projects, covering all the aspects of new infrastructural system (from the power plants, to the rolling stock, from the signalling system to the financial funding). The African countries and Indonesia are good examples for this trend (KPMG 2010, 38).

4.3.1 Future business landscape and trends

We have several forecasts, expectations and normative scenarios about the role and the weight of the rail transport sector in the next decades. However, especially if compared to the aviation sector, the rail equipment industry is quite cautious in making medium- and long-term foresight, focusing on five- or ten-year prospective, or even shorter.
We have, however, forecasts about the Pkm and Tkm envisioned for 2050. As reported in the previous chapter, for ERRAC (2012) Europe *only* should reach in 2050 1,650,000 billion Pkm moved by train (15.3% of the passengers transport market) and about 1,600,000 billion Tkm (22.2% of the EU feight transport market). For instance, using 2010 as a baseline, this implies an annual growth of about 3.0% for the rail market in Europe. TransVision data for 2050 give – in its baseline forecast

– to rail about 1,222 Tkm billion (TransVisions 2009); Freightvision claims to rail between a range of 414.2 and 1,150.0 Tkm billion (Freightvision 2010, 12).
However, neglecting wild cards and the most extreme conservative scenarios, it is largely expected to have a growth of the rail mobility. According to Thompson (2010) the rail transport will grow worldwide on average of 3 % annually, according the following table:

Years	2010	2020	2030	2050
World Tkm (million)	7.160.469	9.761.684	12.060.442	20.058.703
Growth compared to 2010		36,33	68,43	180,13
World Pkm (million)	2.189.583	2.993.766	3.330.377	6.504.528
Growth compared to 2010		36,73	52,10	197,07

Table 3 - World up to 2050 Tkm and Pkm scenarios - (Thompson 2010)

For the same author, China and India will display growth above the average, while, more or less, all the other areas, including Africa and South-America, will display growth below the 3%. EU-15 is forecasted to have a +1.6 % for passengers and +1.8 % for freight, while EU-10 is expected to gain for the first a +3.5% and for the latter +2.6% (Thompson 2010).

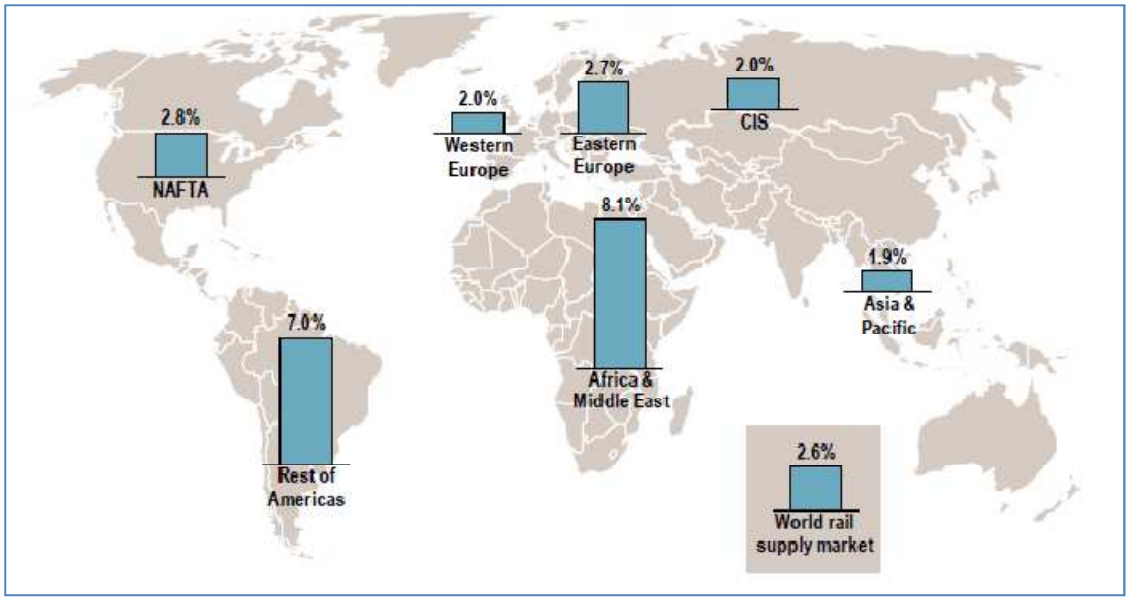


Figure 46 - Regional growth rates in the rail supply market (CAGR 2015-2017 compared to 2009-2010) - (UNIFE 2012, 9)

The rail equipment industry forecasts have a shorter time frame. For UNIFE, Western Europe should have a 2.0% CAGR and Eastern Europe a 2.7% in 2015-2017 compared to 2009-2011. The most dynamic areas will be Africa and South-America, while Asia and Pacific will have a growth lower than Europe, well below the world average of 2.6%.

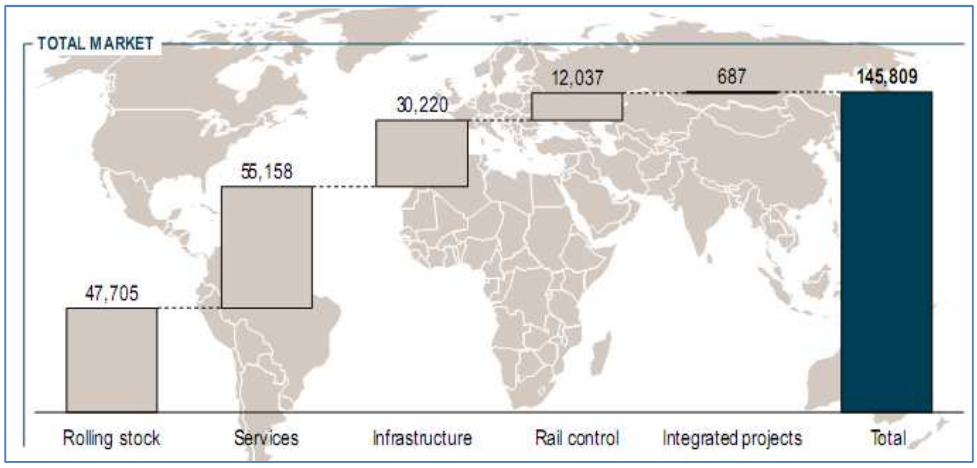


Figure 47 - Current rail supply market - (UNIFE 2012a, 6)

Also Bombardier envisioned a growth for the current decade, with a decline of its Asian opportunities and big potentialities in Africa and South-America. Services will have a larger part of the market, considering how rolling stock manufacturers are more and more involved in the post-sales business and in the maintenance issues, while rolling stock and infrastructure investment are expected to have a lower than average growth.

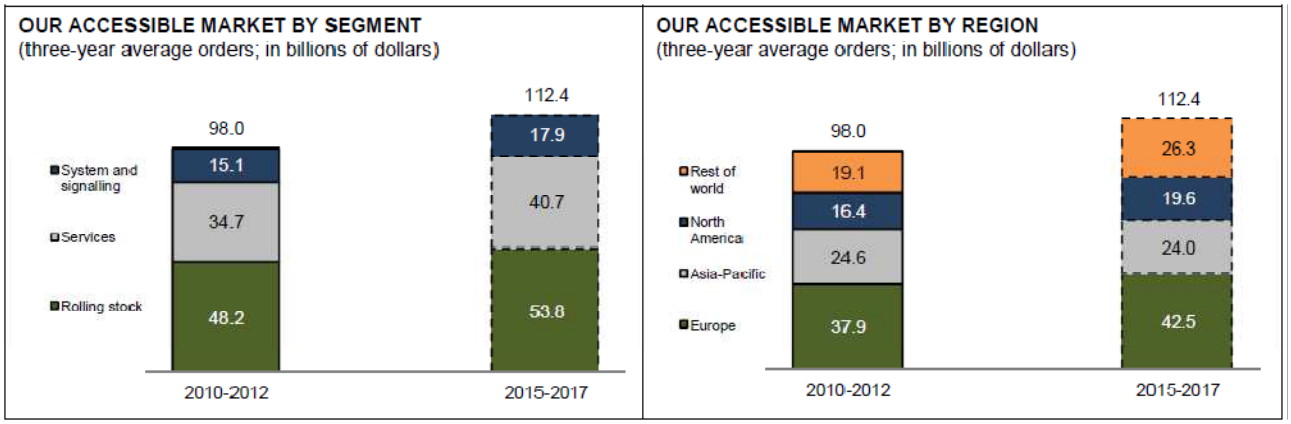


Figure 48 - Short terms forecast by Bombardier - (Bombardier 2012, 91)

We should also keep in mind the role of the EU policies, the environmental concerns, the cost of energy and transport dynamics, which, all together, especially in the urban areas, should favour the rail market. Particularly, in its White Paper, EU proposed a shift toward rail transport. Among the targets, 30% of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050, facilitated by efficient and green freight corridors. By 2050, it is aimed to complete a European high-speed rail network, tripling the length of the existing high-speed rail network by 2030 and maintaining a dense railway network in all Member States. By 2050 the majority of medium-distance passenger transport should go by rail. Additionally, a fully functional and EU-wide multimodal TEN-T 'core network' by 2030, with a high quality and capacity network by 2050 and a corresponding set of information services; and by 2050, connect all core network airports to the rail network, preferably high-speed; ensure that all core seaports are sufficiently connected to the rail freight and, where possible, inland waterway system.

4.3.2 Expected future market dynamics

The market dynamics are showing how the EU rail equipment industry is already under pressure by its Chinese peers and how such a challenge is becoming more and more relevant, to the point to losing EU leadership in the sector. New actors are already near to achieve (regional) dominant position, and others are entering the stage, while the traditional players (mainly EU based) are reducing their business opportunity (Worldwatch 2010).

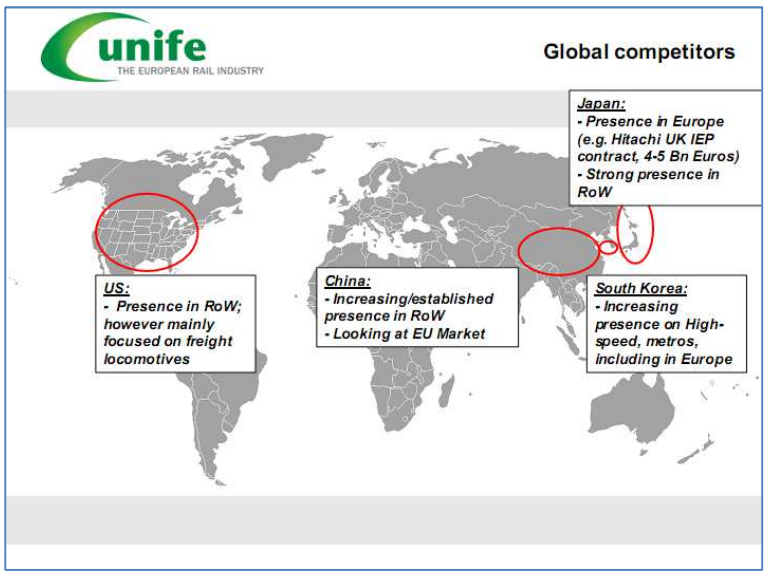


Figure 49 - Global competitors - (RFE 2012b)

There is definitely a "Chinese threat", considering the advantages of the rail Asian firms: low cost products, exploitation of technology transfers, robust domestic R&D development, integrated projects proposal, political and financial ability to enter new markets (KPMG 2010) and naturally nowadays solid domestic market opportunities (UNIFE 2012). Additionally, while European rail markets are claimed to be open to any company, EU industry states how many other foreign markets have *de facto* hurdles (alike Japan), or are partially accessible (as CIS area), or – as China – reachable only under the condition of technological transfers (RFE 2012a). This harms the potentiality of EU firms, which at home already suffer of fragmented bids and patchy networks systems´ management, signalling and rules.
This can lead to "potential barriers to innovation", bearing in mind the "way in which the competitive market, economic regulation, industry structure (including ownership) and incentives operate may act against innovation." (Amoore and Jaiswal 2012, 16)

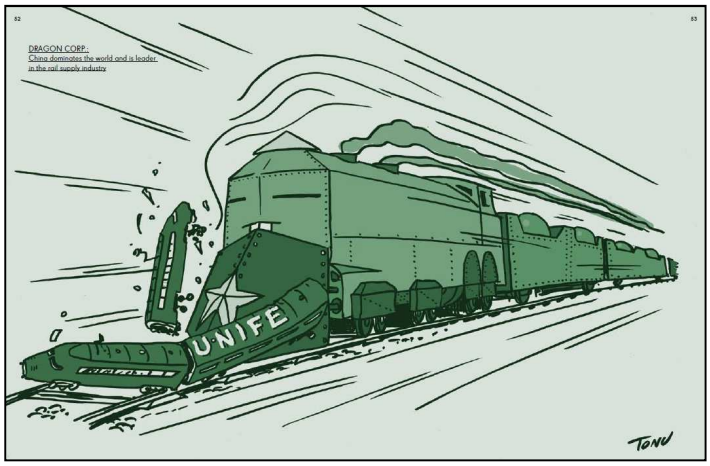


Figure 50 - Chinese manufacturing industry wiping away European firms - (UNIFE 2009, 52)

Thus, the EU industry needs to take actions in order to give appropriate answers to this situation. While the next paragraph will pass through the business preparedness requested to the industry if it wants to be able to cope with this new situation, here we move the attention to the political framework conditions which have been proposed as useful for the EU competitiveness.
On the one hand, the American rail lobby stated that EU rail supporting policies were fundamental in supporting the industry through massive investments. Those actions did not only develop more sustainable transport systems, but guaranteed a platform for the local industry, developing appropriate and cutting-edge technologies.

> *Since the early 1990s, EU policies have been reshaping the continent's rail landscape in a variety of ways. They prioritize the construction of new cross continental lines, increase travel speeds and safety, and harmonize national rail systems. These goals are to be achieved with greater modularity for intercity and urban rail equipment, more collaborative R&D efforts, and the introduction of both a European Rail Traffic Management System (ERTMS) and a European Train Control System (ETCS). ERTMS and ETCS are intended to boost the capacity of existing rail networks and improve the safety of operations. In helping to bring about a more integrated and attractive continent-wide rail system that draws passengers away from car and plane travel, these changes will also create additional markets for rolling stock."*
> (Worldwatch 2010, 16)

It is also true that the European high speed train networks are, at the end of the day, basically "national" systems, but surely, as in China, EU policies supported the industry, generating appropriate economies of scale and offering to the companies a greater market size.
After such euphoric years, beside the positive claims of Worldwatch, the debate is now analysing how appropriate were those investments, also considering the tremendous financial and budget constraints we are experiencing. Already four years ago, in a study commissioned by CER, it was claimed that "EU needs to play a role in financing investment but we do not believe that role is proving effective at present. First and foremost, we believe projects – and especially projects of the size of many of those on the TEN-T – need rigorous appraisal with full consideration of alternatives before Commission funding is supplied" (ITS and CER 2009, 61). Additionally, there was stated "Commission's contribution should be concentrated on projects determined on the basis of traffic demands, particularly in international traffic, market needs and business cases." (ITS and CER 2009, 10).

BOX – Criticizing TEN-T

"Since their inception in the early 1990s, the development of trans-European networks (TEN) has been viewed by the Commission as a major element in integrating national markets to develop the 'Single Market' for the entire EU and promoting economic and social cohesion via the freedom of movement of persons, goods and services throughout the EU. The white paper's investment objectives were, consequently, almost entirely bound up with development of the trans-European transport network (TEN-T). The TEN-T are multi-modal and multi-dimensional, consisting of roads, railways, airports, international sea ports, inland ports, traffic management systems and, since 2004, motorways of the sea. [...] In 2001, the white paper identified several problems with respect to the realisation of the TEN, and in early 2003 the Van Miert High Level Group was appointed to undertake a comprehensive review of progress with the TEN-T. In their review, the group noted candidly that "an examination of all the priority projects selected by the Christophersen Group might give the impression that they do not have a perfect coherence." (ITS and CER 2009, 51)

While megaprojects seem – today – less achievable than in the past decade, EU still faces the lack of a coordinated signalising system. Such a European integrated and single system has the goal to homogenize technical features, including different voltages, loading gauge, coupling systems, signalling and control systems. Such coordination would be beneficial for the whole rail industry, such as saving resources, time and transport costs. A unique system should guarantee smoother connection through the EU national borders, allowing competition among domestic and international operators, reducing operational burden (and thus dropping time and cost). But the benefit could be felt also by the equipment industry, because of the homogenized standards which should reduce the fragmentation of production and service, and thus lead to greater economies of scale (RFE). This has been a successful development beyond Europe. As underlined by the rail industry,

> *de facto, ERTMS specifications and standards are becoming an international reference for the development of new lines in many emerging countries and even in industrialised economies. [...] Statistics show that non-European countries account for nearly 50% of the total ERTMS investments worldwide. Three non-EU countries – China, Saudi Arabia, and Turkey – are amongst the top five investors of ERTMS equipment. China, South Korea and India have launched major ERTMS investment programmes. Recently European companies have won one of the most comprehensive contracts for the supply of rail infrastructure, rolling stock and signalling equipment for railways in Saudi Arabia. Outside Europe, the ERTMS is already in service in China, South Korea, Taiwan, India and Mexico.* (RFE 2012c)

Two other overall factors can harm the rail development.
The first is the lack of internalisation of "safety, congestion and environmental damage", which will "highlight the true cost of operating a rail system" (CER, EIM and UIC 2013a, 11), a topic developed in RACE2050 deliverable 6.1.
The second point is the infrastructural one. Considering that such an issue is discussed in deliverable 5.1, here we would like to summarize some main points. Several rail infrastructures seems to be near to saturation, considering how "many key routes in Western Europe are already at or near to full capacity during the morning and evening peak travel times for commuters" (Amoore and Jaiswal 2012, 20). Additionally, in order to reach the 2011 Transport White Paper,

which asks for a massive shift to rail use, the networks need to be enhanced and made be able to cope with additional request. However, without any political goal in the agenda, the "natural" growth of the freight and passengers using rail will ask for infrastructural improvements. This will address the issue of a more efficient management system, alike ERTMS, and more ICT which can also increase the use of the systems. Last but not least, "Further capacity will be released by the reduction or even elimination of the need for maintenance possessions, through the development of new track forms, automated maintenance and the contribution of less damaging vehicle track interaction to a greatly reduced need for infrastructure maintenance." (Amoore and Jaiswal 2012, 20)

4.3.3 Long term strategies and emerging models

The rail equipment industry and the service companies are re-shaping the boundaries of their activities. Just to give a couple of examples, the equipment industry is definitely more involved in the service sub-field (which represents a noticeable €55 billion each year, that is 38% of the total market). In the implementation of new projects, end-to-end deals are more and more common. The traditional landscape of the market, with Original Equipment Manufacturers (OEMs) and their tiers of suppliers is more and more embedded in big package deals, which cover a broader range of service, well beyond transport, and involving financing, energy, planning. More than post-sales activities, the market is moving to Build–operate–transfer (BOT) or Build–own–operate–transfer (BOOT).
Furthermore the main rail operators are enlarging the mobility offers, which now encompass rail journeys, car sharing, bike-sharing, hotel reservation, car rental, package tour etc.
This is pushing manufacturers to build products that they subsequently provide operational services or maintenance for, as in the automotive realm is made for car-sharing. The EU rail equipment industry is also shifting from a mere material supplier to a holistic system supplier and operator. However, when compared to the car manufacturers, the rail industries are lagging behind although this factor has the potential to become an even greater key factor for the future of European transport industry, making use of the many infrastructures with a long-life-cycle.
As pointed by Amoore and Jaiswal, the EU rail equipment industry has several challenges, mainly:

- *Higher integration of different transport modes required to respond to a comprehensive mobility demand by users (door to door and producer or importer to point of sale);*
- *To provide the technical capability for future increase in rail traffic, with product innovation in control command, infrastructure and passenger and freight rolling stock;*
- *Improved interoperability of the rail system to develop new rail services and remove inappropriate barriers to trade;*
- *Coordination and integration of long, medium and short distance transport, both public and private;*
- *Providing a suitably qualified work force by making the rail sector attractive to young engineers.* (Amoore and Jaiswal 2012, 7)

Reading that list, it seems that the core technological factors keep their relevance, especially when it is time to calculate energy efficiency and costs. But "railway energy efficiency will continue to improve as a result of progression in diesel technology *combined* with operational improvements"

(Thompson 2010, 16 Italics added). Indeed OECD studies underline how relevant can be a new management style in achieving a more efficient rail system, and thus opening greater opportunities for the market.
This is strictly linked also to the question of shrinking public budget. This is leading to a final cost struggle, in which advanced technologies can be seen as a burden more than added value. "The key task for Europe's big three train-makers – Bombardier's Berlin-based train making operation, France's Alstom and Siemens – is to denude their designs of features that are not strictly necessary to do a cost-effective job – and prove to customers they have done so. If they cannot, Chinese manufacturers stand ready to supply far cheaper alternatives. […] The temptation in many circles – particularly the [UK] Department for Transport's rail division – may be to argue for a rejection of the sophisticated European and Japanese manufacturers' products" (Wright 2010).
Energy saving and environmental friendly device are counter evidences that high-tech solution are still successful, but never the less give evidence of a better focus for R&D program and the relevance of better management and operational solutions.
Additionally, economies of scale are necessary, and the bright sample of Airbus has been proposed also for the rail sector:

> *In the mid-2000s, there was a* ballon d´essai *for replicating Airbus's success in the rail sector. Speaking of the European rail industry's dominant role, "The Chairman of the Deutsche Bahn Board, Hartmut Mehdorn, took this idea a step further by suggesting in an interview with Les Echos on 10 May, 2004 that European train constructors should follow the example of the aerospace industry and create a single European player with national participation like Airbus"* (Eurofound 2004, 6).

4.4 Aerospace

Abstract
The Aerospace Industry is expected to thrive during the next thirty years supported by increasing levels of air travel demand, mainly from emergent economies, and improved air traffic management operability. Main drivers for future technological development should continue to be energy efficiency and environmental sustainability. With a global leading role in Large Commercial aircrafts' and helicopters' final assembly and marketing (mainly due to successful consolidation efforts in the past), the European Aerospace Industry holds a strong competitive position in the global market place for major components and subsystems supply, second to North American counterparts. The main threats to the European Aerospace Industry's future competitiveness lie in its ability to further consolidate into innovation-driven conglomerates, capable of establishing risk-sharing partnerships with main OEMs for product development, and on new commercial product assembly competitors arising from countries like BRIIC, Canada, and Japan, whose impact on future market distribution can already be noticed.

The aerospace industry (AI) is a highly competitive, capital intensive and technologically driven industry, covering defence, space and civil aviation areas. Manufacturers of AI operate on a global level and focus on different size-classes, typologies and components of aircrafts and aviation ancillary systems.
Nowadays, this is a highly co-operative industry with risk-sharing partnerships along the supply chain, particularly between Original Equipment Manufacturers (OEMs) and 1st tier suppliers, requiring large financial efforts and risk-taking innovations. In its horizon, it overlooks a healthy foresight of future orders, mainly from emergent civil aeronautics markets, but it's faced with rising budget cuts in defence spending, to which it is also largely exposed.
Commercial aviation main Original Equipment Manufacturers (OEMs) are segmented in the following business areas:

- Large Commercial Airplanes – LCA: market characterized by an intense duopoly between Boeing and Airbus;
- Regional Aviation – jets and turboprops: Bombardier, Embraer and ATR hold together almost two thirds of the market;
- Business Aviation – market dominated by American players as Cessna, Bombardier and Golfstream. Europe present with Falcon (Dassault);
- Helicopters: A European game park, with Eurocopter and AgustaWestland sharing also almost two thirds of deliveries.

4.1 Industry Structure

The structure of the aerospace supply chain is cooperative and globalized, led by OEM organizations (like Boeing and Airbus), who increasingly partnership with Tier 1, Tier 2 and Tier 3

suppliers. The OEM's prime functions include design and product specification, large scale integration and final assembly of subsystems, marketing and servicing of the aircrafts. OEMs seek increasingly collaborative and long-term partnerships with lesser prime suppliers in order to develop new products and technologies, developing *Risk and Revenue Sharing Partnerships* (RRSP). RRSP facilitate the access to resources and to better risk managements, lowering the production costs and allocating the development risks to the players more suited to handle them. This trend has lead to further consolidation in the supply chain, with suppliers buying-in and integrating adjacent capabilities in order to enhance its role as entire sub-systems providers. Their economical results are also increasingly tied up to final products overall market performance.

First tier suppliers provide the supply of major components and entire subsystems to OEMs. These including Engine Manufacturers, Avionics, flight control and navigation systems, fuel systems, landing gear, airframe components (like wings or elevators) etc. Their scope of expertise covers almost all different technological requirements involved in airplane manufacturing. Tier 2 suppliers manufacture and develop parts as the hydraulic pumps, motors and controls, whereas Tier 3 suppliers are responsible for the supply of basic products and components such as piston, solenoid, cylinder and connectors (Clearwater 2010).

The propulsion industry fits into the first tier suppliers range. It constitutes an oligopolistic market, in the way it is dominated by three major manufacturers: i) USA's United Technologies' Pratt & Whitney (P&W), ii) GE Aviation, with its "CFM International" 50/50 joint venture with France's SNECMA, and iii) British Rolls Royce (RR). Another example of an important joint venture in this industry joined P&W, RR, Japan's JAEC and MTU Aero Engines of Germany to produce one of the most successful commercial jet engines in aviation history: V2500. As a result of all the alliances made between the manufacturers, this segment of the market is less competitive than others in aviation. This industry is also characterized by a high percentage of Maintenance, Repair and Overhaul (MRO) in their sales share, as the majority of their profits and revenues come from renting propulsions', spare parts and maintenance activities. Other European players in this industry include Avio S.p.a. (Italy), ITP Engines (UK), MTU Aero Engines (Germany) and Volvo Aero (Sweden), backed up by a myriad of components suppliers.

Avionics (aviation electronics) are the components that comprise the electronic aircraft systems, such as flight controls, system monitoring, anti-collision and pilot assistant/interface systems. Advanced avionics have an enormous impact on the manufacturers' competitiveness, as they can alter the costs of the aircraft operation and maintenance. The major players in the global avionics sector are Rockwell Collins, Honeywell International and L-3, while the biggest Europeans include Thales, Diehl Aerospace, Liebherr Aerospace. Europe industry has a leading role in pilot-night systems for helicopters, Traffic alert and Collision Avoidance Systems (TCAS) or fly-by-wire technology – EADS´s Airbus and Eurocopter were the first to introduce this technology in civil airplanes and helicopters (Clearwater 2010, Ecorys 2009).

LCA's landing gear market is actually a duopoly between Messier-Bugatti-Dowty (Safran), which is the current world leader in aircraft landing and braking systems, and USA's Goodrich, now also part of United Technologies. These two companies are the two major Tier 1 suppliers of Boeing and Airbus. A third player, Liebherr, focuses its activity nowadays in the regional and business jets sectors, but may be a competitor in the LCA market in the near future.

Messier-Bugatti-Dowty

Messier-Bugatti-Dowty is an example of present integration equipment suppliers: Messier-Dowty, Messier-Bugatti and Messier Services were three Safran subsidiaries. In combining three highly complementary organizations under a unique insignia, Safran created a world leader in aircraft

landing systems and on-ground movement, better equipped to develop new technologies in response to future market requirements.

Composites suppliers present a growing potential to thrive in the Aerospace sector as they enable for more light-weighted aircrafts – Composites are 20-35% lighter than more traditional aerospace materials like Aluminum and titanium, have a higher strength-to-weight ratio and, finally, can take the most complex forms. The 787 Dreamliner is the first airplane to exhibit 50% (by weight) of its airframe structure, including the entire hull, built in composite materials, which compares to 5% in the first 737 series (Clearwater 2010). Although composites are relatively more expensive at present, their costs are expected to decline significantly over time.
Airlines' MRO represent also a major value-added business for aviation industry players. It consists mainly of engine maintenance (42% of total revenues), heavy maintenance visits and modifications (21%), airframe, components and line maintenance. The increased technological complexity of aircraft subsystems requires specialized services which in turn are leading to a greater involvement of first tier industry suppliers into this sector. While in the 1970s and 1980s more than 80% of the US aircraft maintenance was made in-house, nowadays this percentage is about 20%. The five major MRO companies are the Singapore Technologies Aerospace (ST Aerospace), Lufthansa Technik AG (LHT), Air France Industries KLM Engineering & Maintenance (AFI KLM E&M), Hong Kong Aircraft Engineering Company Limited (HAECO) and TIMCO, from the USA.
The Europe's competitive position in MRO is very strong, as LHT and AFI KLM E&M have about 25% of the global market share, followed by importance by Rolls-Royce and MTU Aero Engines.

4.4.2 Air Space Management

The steady growth of traffic in airspace is leading to more and more congestion, particularly in consolidated markets such as Europe and the USA. Europe has an average of 26,000 flights per day and a very high density of airports, which makes management of its airspace even more complex. This is even more remarkable, as nowadays Air Traffic Management (ATM) relies on "obsolete" technologies like radar, radio beacons or voice communications.
To deal with this situation there has been an investment to develop a Global air transport system (ATS) that would structure airspace and air navigation services. European Commission is developing a *Single European Sky,* a legislative framework that aims to increase the overall efficiency of air traffic management (ATM) system, generate additional capacity and accommodate air traffic flows through the restructuring of the European airspace. The idea is to organize Europe's airspace in functional blocks instead of national borders, allowing for savings and efficiency improvement. The technology requirements to meet these objectives of European ATM network are assured by SESAR, the Single European Sky Research Programme (Eurocontrol 2011). One of the main challenges in the development of ATM's will be the integration of Europe's Single European Sky and SESAR with USA's Federal Aviation Administration (FAA) NextGen program, and other regional programs, in order to achieve a global ATM system.
The application of these programs is estimated to save three billion gallons of fuel, four million flight hours in delays and 29 million metric tons of carbon emissions globally per year (Deloitte 2012a), which will increase the potential for further consumer/passenger price drops in the Airlines' Industry and consequently raising air travel demand.

4.4.3 Future competition in the Industry

New players are aiming at the LCA lucrative duopoly. These players intend to compete with Boeing's 737 and Airbus's A320 in the medium-range sector, the largest segment of the $100 billion-a-year global jetliner market.
Generally regarded by all competitors as highly likely to succeed, the Commercial Aircraft Corporation of China (COMAC) is backed up by a strong support of Chinese Public Authorities to the Aerospace Industry[5]. COMAC is developing the C919, a 168-seater narrow body expected to have its maiden flight in 2014 and be ready for roll-out in 2016. Their goal is that, over the next 15 years, they are capable of capturing 50% of China's twin-engine single-aisle aircraft demand (Flightglobal 2012b), leading to 2000 C-919 produced during the coming 20 years (Deloitte 2012a). Comac has already grabbed an order book of 380 Planes, mainly from Chinese customers (Chang 2012).

Figure 51 - LCA Emerging Competition – Comac and Irkut

Competitor's beliefs are that COMAC will initially sell to the domestic market and to countries with close links to China, but eventually they will have a product capable of competing with Boeing and Airbus (Flightglobal 2012b, Aviation Week n.a.).
Russians are also developing a new aircraft prototype that aims to conquer both Russian and international single-aisle markets, the Irkut MS-21. Irkut is a subsidiary of the Russian United Aircraft Corporation (UAC), a Russian state company created to join together the major Russian aerospace companies: Irkut, Sukhoi, Aviaexport, Ilyushin, Tupolev, Yu. Garin, Sokol, V.P. Chkalov (United Aircraft Corporation n.a.). Irkut's MS-21 is appealing for Russian and international markets with improved opex from reduced weight due to the extensive use of composites, and respect for the environmental requirements of noise and CO2 emissions. Irkut's MS-21 backlog has already reached 235 aircrafts by the end of 2011, their aim is to sell up to 200 planes in India until 2025 (The Economic Times 2012).
Both these players are also active in the smaller regional market: COMAC is still developing the ARJ-21 and UAC has recently seen the first commercial flight of its Sukhoi Superjet. Together with the Japanese Mitsubishi Heavy Industries Regional Jet (MRJ), these three players are already actively competing with Bombardier, Embraer and ATR for order books.

[5] After many attempts, as those in the 1970s with the Y-10 and the Y-7, the Chinese government decided in 1993 to unite the entire aviation industry, creating the Aviation Industries of China (AVIC). In 2008 the whole industry was restructured and COMAC was created to develop and produce large commercial aircrafts the fight the western hegemony in this market.

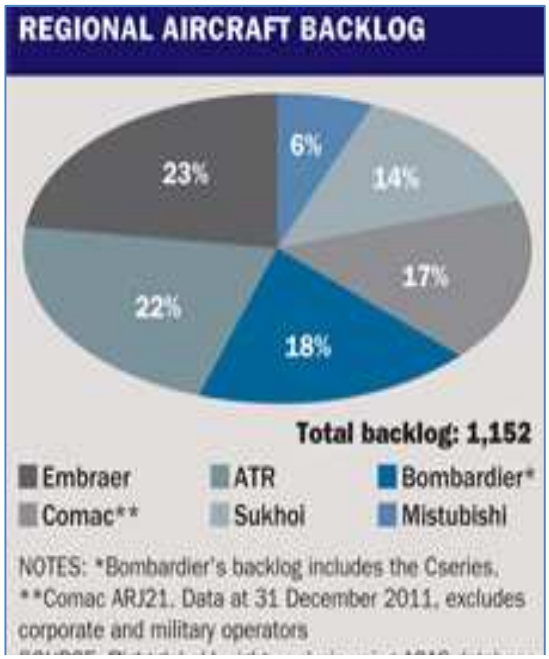


Figure 52 - Regional aircraft backlog in 2011 (Flightglobal 2012b)

4.4.4 Internationalization of the AI

The AI industry runs on globalized supply chains. Components and subsystems enter the final OEM assembly lines coming from all over the world, where the expertise, the technical know-how and the capabilities to produce them at the most favourable conditions are. The internationalization of key players in the industry is fostered mainly for reasons of gaining or expanding – by mergers or take-overs – technological capabilities and skills on adjacent equipments and gradually become systems integrators and preferred suppliers. Rolls-Royce, a "European" player, has become a leading industry supplier in the USA with a significant and growing presence. As they advertise in their website: "Today, more Rolls-Royce products are built in the USA than anywhere else in the world" (Rolls Royce 2013). The list of companies with production sites or regional offices abroad, as this case exemplifies, are innumerable.

Promoting local marketing and servicing to strategic markets and/or complying it local content requirements in public military procurement abroad are also behind internationalization efforts. For this matter, the case of world-leader Eurocopter is symptomatic – as the need to comply with local incorporation in public procurement tenders led them to raise a global network of facilities they now conveniently manage, with competitive advantage over direct competitors, to give local technical support and service to local civilian and military customers alike.

In what matters internationalisation in the "big league" LCA competition amongst Airbus and Boeing, two opposite strategies seems to be pursue by the two contenders: while Boeing only assembles commercial airplanes in the USA, Airbus, besides the European assembly lines in Toulouse and Hamburg, has built in September 2008 a third line in Tianjin, China (Airbus 2013). The above is depicted in order to serve "better" the Asian market demand for narrow body airplanes, considering that the 100th aircraft left the line in September 2012. Airbus is also completing a fourth assembly line in Mobile, Alabama, to address the North American Market, benefiting from a relative low-cost manufacturing base on USA. This unit will have the capacity to assemble four A320 a month (against an output of around 40 airplanes a month from European

assembly lines), with the first delivery scheduled for 2015. Despite its relative low production, this can be a "game-changer" move from Airbus to compete in the North American Market – the biggest regional market worldwide for narrow bodies and where Boeing sales enjoy a robust 80% market share (The Economist 2012), making Airbus a truly globalized assembler.

4.4.4 Global Market Outlook

The growth of the world wealth is leading to population increase living in bigger cities, more likely to produce more travelled miles. This reflects very notoriously in the aviation market, as the aviation demand is rising and there is a very significant increase in the number of first time flyers. Nowadays there are more than 17,170 large aircrafts, but the expectations are that in order to accommodate the increasing number of travellers, caused by an estimated global annual traffic growth of 4.7%, this number will double to 35,490 in 2031, with 28,200 new deliveries (Airbus 2012). This means that air traffic, measured in revenue passenger kilometres (RPK) will keep doubling each 15 years, as seen in the figure below, achieving 12.8 trillion RPK in 2031, 150% bigger compared to 2011. Boeing's forecast is considerably more optimistic than the one of Airbus. It predicts a demand of 34,000 new airplanes for the next twenty years, constituting a fleet of 39,780 airplanes by 2031, representing an increase of more than 130% from nowadays fleet.

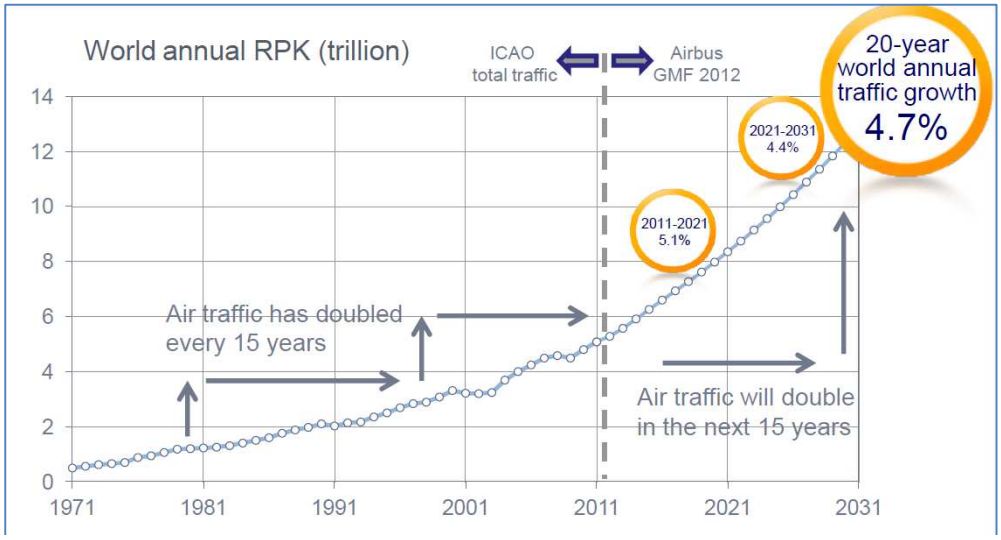


Figure 53 - Air traffic remains a growth market - (Airbus 2012)

Much of future growth will be based in Asia. Asian market became the largest market already in 2011, and is expected to double the size of European or North American markets by 2031.

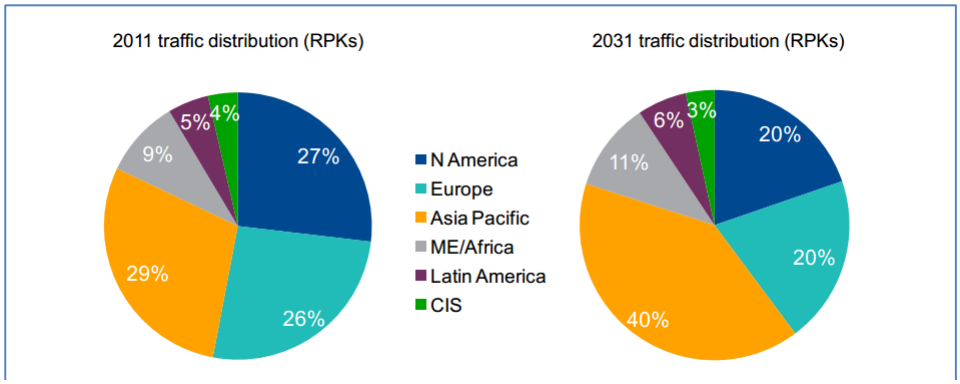


Figure 54 - World Traffic Split by domicile (Rolls-Royce 2012)

Demand growth – Large Commercial Aircraft

Airbus, on its Global Market Forecast (Airbus 2012), forecasts global demand for new airplanes will surpass 27,000 between 2011 and 2031, while Boeing goes even further pointing to a figure over 34,000**Fehler! Verweisquelle konnte nicht gefunden werden.**. Both agree their biggest market will be the Asia-Pacific region, which will absorb over 35% of new deliveries over this period, against a figure around 20% for both Europe and North America.

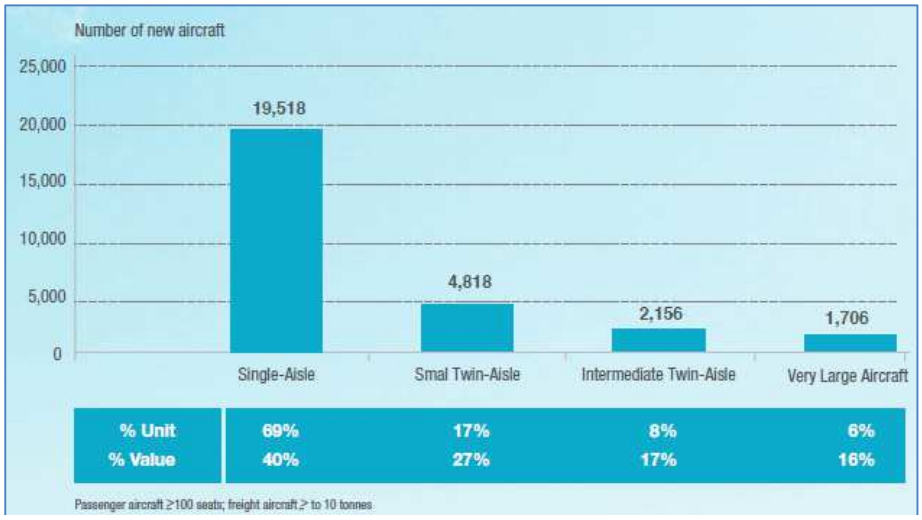


Figure 55 - 2012-2031 new aircraft deliveries - (Airbus 2012)

Demand growth – Regional Aviation

In the regional segment Bombardier, in its Outlook Report (Bombardier 2012b), expects that 12,800 aircrafts with 20 to 150 seats will be delivered until 2031, raising the total number of units from 11,200 to 17,000 aircrafts, while Embraer foresees more than 7,000 aircrafts with a seat range of 30 to 120 to be needed until 2030.

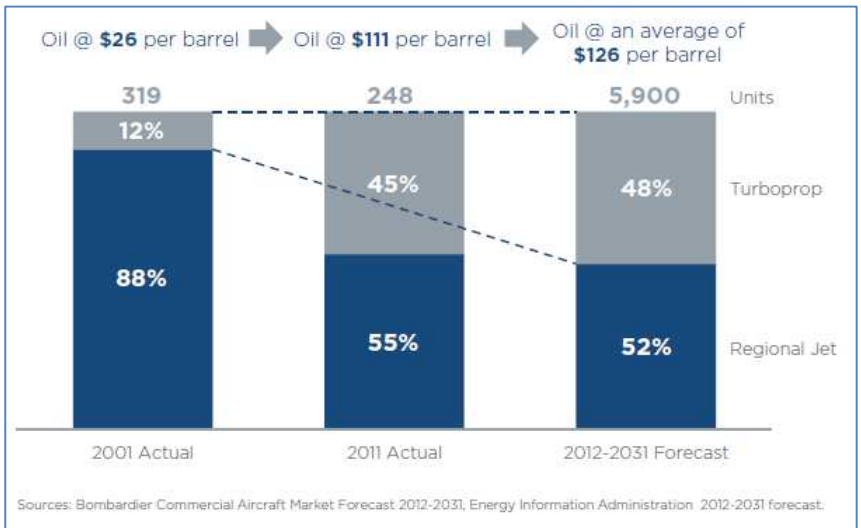


Figure 56 - Deliveries by engine type 20 to 99 seats - (Bombardier 2012b)

4.4.5 Demand growth

Helicopters

Frost & Sullivan expects the helicopter segment to grow from 24,625 units in 2009 to almost 37,000 units in 2015, 22% of them were delivered to customers in Africa, Asia Pacific and Middle-East (Clearwater 2010).

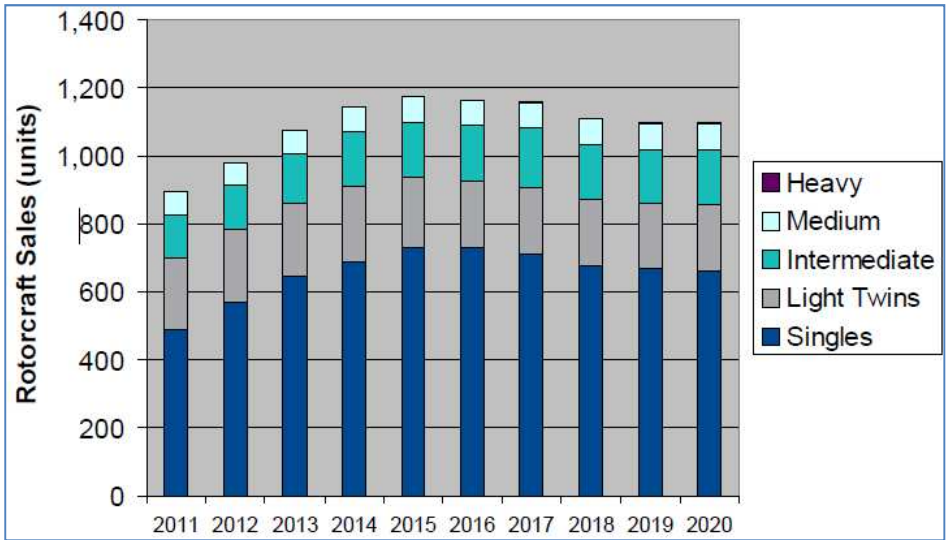


Figure 57 - Civil Rotorcraft estimated sales - (Rolls-Royce 2011)

Honeywell forecasts between 4,700 and 5,200 new helicopter deliveries concerning the period of 2011-2016 (Honeywell 2012), and Rolls-Royce, on their part, predicts 10,900 civil rotorcraft deliveries from 2011 to 2020 (Rolls-Royce 2011). According to RR market drivers for future sales are:

- Emerging market interest in twins for urban areas in some markets (Europe, Japan);
- Emerging markets (e.g. India, Brazil, China);
- Enhanced value proposition and performance through application of new technology;
- Fleet demographics – 43% of global fleet over 25 years of age;
- China – impact of opening of civil airspace to be determined;
- Used rotorcraft availability;
- Access to favourable financing terms.

Business Aviation

According to Clearwater's *Aerospace Global Report 2011* (Clearwater 2010), business jets are expected to grow at 3.6% until 2029, with 15,500 aircrafts delivered by that time. The value of the aircrafts delivered is expected to almost twofold from 127 USD billion in the period of 2000-2009 to 407 US$ billion by 2020-2029.

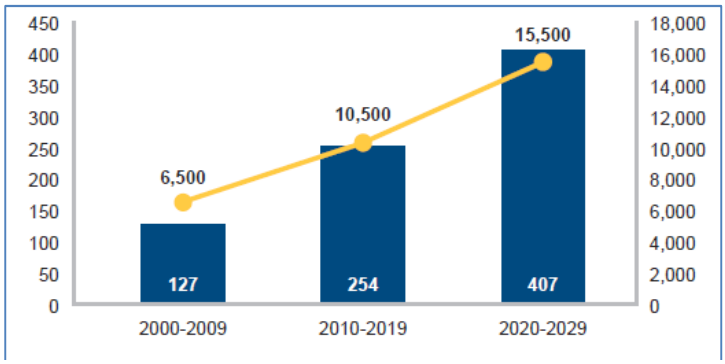


Figure 58 - Market forecast for Business Jets - (Clearwater 2010)

Bombardier presents a forecast for the business jet market for the period of 2011-2031. In this forecast the 15,200 business fleet in 2011 is expected to double to 31,500 units in 2031. This is achieved through the delivery of 24,000 new aircrafts in this 20-year period, and the retirement of 7,700 aircrafts (Bombardier 2012a).

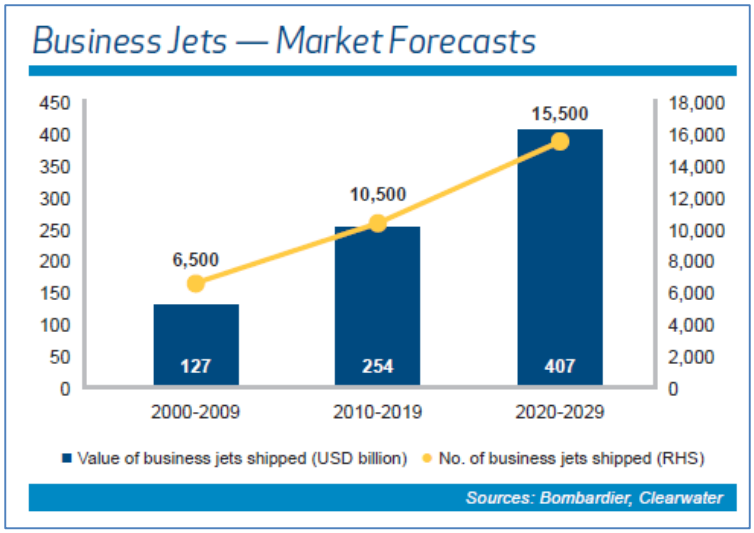


Figure 59 - Market forecast for the business jets 2000-2029 - (Clearwater 2010)

5. Technology innovation and market challenges

5.1 Global markets developments

Abstract
A competitive transport sector provides the basis for sustainable socio-economic development in Europe. Global market trends are challenging the system by structural changes, such as on-going internationalization, especially in services, privatization in the transport sector and investments in infrastructure, as well as a global shift of demand towards upcoming economies. Beside this, the global market development is also driven by policy and regulation influencing the openness of markets. This is especially important in transport, which is characterized by a history of state owned infrastructure and providers.
On the regulation side different strategies in export, restrictions of resources, tax policy for imports and requirements of locating the companies production, to name only a few, may transform frame conditions, as economic and political power is also shifting towards east and south. In this complex system with global linked policies and economics, the European transport industry has a competitive advantage in its strong base of innovative R&D, production and global exports. The challenge will be to improve adaptability skills meeting the needs of a new world of transport, which will be formed by needs and demand from emerging countries more than in previous decades. This need for adaption and transformation includes the opportunity for innovation. The key issue for ensuring competitiveness will be to understand different perspectives and follow new approaches.

5.1.1 Global markets developments

Race2050 “aims to identify key success factors for a sustainable growth of the European Transport industry and for policies which can increase its strength in a long perspective up to 2050”. To identify relevant technological innovations and market challenges for sustainable growth and a competitive EU-Transport industry the notions of ‘success’ needs some clarification. In a first step success may be defined as economic competitiveness of the transport industry, which is indeed an important aspect of strength. The notion of ‘sustainable growth’ goes beyond this. To ensure a successful European transport industry one must not only focus on growth and economic wealth of branches. Transport builds the basis of the transport system, the backbone of European economy and society. Therefore ´success factors for a sustainable growth of the industry’ have to consider this system supporting functions, which leads to a more integrated definition for ‘success’ and ‘competitiveness’.
In an integrated perspective the transport sector has to be competitive on a global level and has to fulfil its task of enabling the socio-economic system as a basis for economy and society. This includes also not to conflict with strategies and policies focusing on other important fields, such as

environmental issues like greenhouse gas emission reduction and limitation of energy use or inclusive, affordable mobility for European citizens. Due to the complexity of the systems and the system-inherent interrelations decision-making and elaboration of strategies is a challenge itself. Against this background the chapter aims:

- to give an overview on the most important trends who will affect competitiveness and sustainable development of the transport sector with regard to functional relevance,
- to identify potential challenges coming up with those trends and
- to interpret the relevance of the results concerning a sustainable growth policy and their implications for political and economic strategies.

Challenges for sustainable growth and competitiveness arise from global trends on political, economic and socio-economic level. This chapter aims to give an outlook on the topic by providing an overview on the main influencing trends which may affect current competitiveness of the European transport sector. In general those trends are expected to cause a transformation of the economic situation and of the landscape of competitiveness on a broad scale. Different fields of the transport sector will be affected by global market developments; they have to be considered when formulating strategies to support competitiveness. As the kind of change may differ significantly depending on the influencing level, both the influencing trends and the challenges have to be distinguished – which has been done according to the systematisation in table 4.

Influencing level	Economy	Policy	Society
Influencing trends in Affected fields	• R&D activities • Supply • Demand • Price policy • Investment decisions	• Financing • Subsidies • Taxation • R&D spending • Legal frame	• Demand • Consumer decision • Acceptance • Income & spending • Values & Behaviour
Transport system & infrastructure		Challenges	
Transport technologies			
Mobility services			
Resources: Energy, basic and rare earth materials			

Table 4 – RACE2050 influencing levels and affected fields.

Adapting successfully to changing markets and framework conditions will be of main importance for the EU-transport industry, as well as for others. This on-going transformation will cause certain challenges due to the need of adapting to new frame conditions. This is especially crucial in terms of competitiveness, which could be defined as a relative position of a single unit (regional market, company etc.) compared to the range of competitors. Any impact – external influences or internal changes of a unit increasing or decreasing their strength and power – would matter for competitiveness. As there are numerous external and internal influencing factors the identification of challenges comes with uncertainty.

In order to protect and increase the competitiveness of the EU- transport sector the successful adaption to the changing environment is essential for business and political strategies. This goes beyond a stable global position of the transport industry. A competitive European transport sector builds the basis for socio-economic development; in terms of competitiveness also the ability to fulfil this purpose has to be considered. Therefore political and business strategies have to focus beyond economic growth and return on investment by addressing the notion of 'competitiveness' as a transport system supporting European economy and society at its best. This will enable sustainable economic development, quality of life and flexibility to adapt and meet future needs. Coming from a certain distribution of global socio-economic disparities the last decades showed a

geopolitical and economic shift of power coming along with economic growth, control of resources and influence. Thus the landscape of competition is in transition due to new competitors establishing or strengthening their position as well as their economic and political influence. Beside, focussing on each single trend also the overall transforming character of their combination for the whole system has to be considered.
Therefore the relevant trends in the complex field of global market development and their arising challenges for competitiveness have been analysed following three leading questions:

1. Quality: what is influencing the global market development on a big scale and how?
2. Quantity: how significant is the impact?
3. Change, Volatility, Flexibility: how is the overall situation expected to change as a consequence of trends and their interactions?

5.1.2 Economy

There are several trends which will create challenges for the transport sector as they are changing the frame conditions for the industry.
On one side structural changes, such as on-going internationalization especially in services, privatization in the transport sector and investments in infrastructure, are powerful aspects affecting the market conditions. They are difficult to predict as they are closely linked to political decisions, not to mention market driven economic developments, such as GDP-growth and its regional distribution. The global distributions of mobility demand and supply in quantity and quality have already changed in the last decades and will develop further. Huo and Wang estimate for example that “the sales of private light-duty passenger vehicles in China could reach 23–42 million by 2050, with the share of new-growth purchases representing 16–28%. The total vehicle stock may be 530–623 million by 2050” (Huo and Wang 2012), based on simulation of income-level and private car ownership.
Strong growth countries as the BRIC states have the financial power for huge investments. Their demand will drive the markets. Beside them new upcoming countries have to be taken into account, while the development of the Western countries is and will be characterized by restructuring of the transport system. This includes not only special characteristics of regional markets. Disparities in standards and provisions for transport – which have to be met by industries e.g. for security and safety, environment or employment protection – are also relevant. On one side they could serve as cost factor and barrier for market entry as home industries may benefit from their history by already having developed solutions appropriate to the requirements. On the other side adaption to different or changing frame conditions could also stimulate innovation.
Beside the global shift of demand and further differentiation of the market according to the disparate levels of the transport system, there are also general trends bringing challenges for the transport industry. The shortage of resources (see also scenarios on oil production and chapter 5.2), cost disadvantages of Europe compared to developing countries and different political frame conditions will affect the competitiveness (Hirsch 2008).
Acceptance of change and willingness to adapt to those trends will be the key factor for competitiveness, while innovation is the way to follow this path; thus research and development are the key features strengthening the competitiveness of the European transport industry. With their highly-skilled work force companies have a good basis to increase their competitiveness.

5.1.3 Policy

Global market development is not only driven by demand and supply on a free market. Policy and regulation are influencing the openness of markets. This is especially relevant in the transport sector as it is characterized by a history of state owned infrastructure and providers. The long-term characters of infrastructure investment as well as the high cost for building and maintaining characterize the special situation of this market. Transport provides basic functions for society and economy. Thus an appropriate transport system is a relevant political issue in all countries of the world bringing certain needs for regulation, financing and decision making for future development. Investments and cost recovery for infrastructure as well as decisions for certain suppliers affect the market. In this regard, it will be essential in which fields technologies and infrastructure investments will be focused; and how pricing policy for mobility will look like. Due to the different levels of quality and expansion of the transport system, again it will be crucial if transport industry will be able to adapt.
Beside this perspective, on the transport system the support of the own transport industry is also influencing competitiveness. One recent example is the support of the development of new technologies by subsidies e.g. for E-Mobility (Zheng, et al. 2012). Another issue is the policy on resources needed in the transport industry. In the last few years especially the situation in the field of rare earths showed the importance of the issue. As China is one of the main producers and exporters of such resources, this almost monopolistic situation is closely connected to policy decisions (Umbach 2010). Export restrictions, tax policy for imports and requirements of locating the company's production in the country gave an impression about the dependency and the relevance of political contracts. In the transport sector the situation of energy as the basis resource is the main factor bringing challenges, as already proven by several energy crises of the past decades. Those political uncertainties bring crucial challenges as they can occur on a short-term, having deep impacts and affect the basis of the transport industry. The current economic internationalization brings challenges as it provides opportunities for global players in economy to abscond from national regulations – due to a lack of international ones. Policies seeking for national advantages may cause imbalances of competitive advantages; thus international agreements will be of major importance ensuring at least equal political frame conditions for industries.
With the developing economies not only new competitors come up. With the shift of economic power also rules of markets that were dominated by other regimes as well as law and mind-sets – compared to the colonial and after phase (e.g. use of subsidies) – gain more influence. To find ways to deal with this will be a challenge for both, transport industry and policy.
Especially policy concerning energy and resource policy will be crucial for the transport sector, again especially with regard to global imbalances concerning resource availability, market protection and regulations for trade. The importance of those issues has already been reflected in political reactions, e.g. the strong effort from the US to gain autarchy from foreign energy imports.

5.1.4 Society

Concerning society, the main important trend driving the demand of mobility is population growth in combination with economic growth and increasing incomes in developing countries. The OECD (ITF 2011) expects world population to grow up to 9 billion in 2050, which should lead to 3 or 4 times more global passenger mobility as in 2000, and 2.5 to 3.5 more freight activities.
Especially the regional diversification of population growth will affect the EU-transport sectors'

competitiveness – as the already on-going global shift of demand for transport is about to change in regional dimensions of competitive advantages. According to the UN population scenarios (United Nations 2004), especially Asian regions will grow fastest; combined with strong GDP growth rates in countries, such as China with 9-10% since 2008 or Indonesia with 4.6 to 6.5% in the same time (World Bank 2013). Together with the pace of current urbanization the demand in those markets will dominate the frame conditions for the transport sector. As demand is not only a matter of quantity, especially the ability to adapt to different needs for mobility will be a key factor for competitiveness. Beside technical developments fitting the needs of the Asian customers, this includes also economic and cultural knowledge for market entry as well as legal approvals to support their own industries. Thus transport systems, technologies and services providing solutions for mass public (and private) mobility in urbanized areas, especially of Megacities, will drive the market. Industries that are able to develop solutions to those needs will have the greatest competitive advantage.

Beside Asia also Eastern, Middle and Western Africa are expected to “grow unusually fast” (United Nations 2004). Different from the situation in Asia this will not automatically lead to excessive growth of mobility demand, due to lower GDP development. Also the US is expected to experience population growth due to immigration, while for Europe stagnation or low growth rates are expected – depending on region (United Nations 2004). While growth in parts of Asia and Africa will increase the demand for new infrastructure, especially for rail and public urban transport following the still increasing rates of population living in cities (see also D6.1 of RACE2050), the European, American and partially also for the Asian market will develop differently. Based on given infrastructure improvement of the system concerning safety, accessibility and energy efficiency are the main needs combined with maintenance issues. The challenge here will be to provide solutions to optimize the use of given infrastructure concerning efficiency, financial issue, safety and accessibility. Especially new mobility services may serve this market needs, as they are able to provide more flexible, individualized public transport – for example shared-car services in combination with public transport, which are enabled by the use of ICT-Soft- and Hardware solutions.

Beside this also increasing income and wealth will bring up new mobility needs in countries, especially in the BRIC states. The increase of car owners in China illustrates the most outstanding example for what this development could signify on a global level. Hot spots of car demand have already shifted from Europe and the US towards Asia in the last decades (see also D6.1 of RACE2050). The process is likely to continue, supporting competitiveness for industries already present in those markets or those which can provide unique solutions (e.g. ICT based solutions). Beside the qualitative aspects one of the main challenges will be to compete with low price production of Asian transport industry, meeting the needs of their own markets. Based on the experience of the European transport industry the know-how in the fields of safety, multi-modal mobility and traffic system coordination may be the main competitive advantage. The research and development capabilities of Europe based on high-skilled and educated work force in the industry are the preconditions of such competitive advantages. As the educational system is a long-term investment, this advantage is one that cannot easily, and in a short run, be overtaken.

Concluding to the trends and challenges coming up with society change, the key issue for transport industries competitiveness will be to build on the regional different, given infrastructure and mobility culture adapting to the market needs and providing solutions. As the hotspots of demand already changed and will shift further to developing countries in Asia, Africa and the BRIC countries, the main challenge of European transport industry is to analyse the regional situation to be able to compete with home industries in such countries; the latter are likely to have advantages

concerning know-how of the market, mobility and business culture. In this vein, the main chance for the European transport industry is to build on the high level of technological development and experience in Europe, which provides a profound basis for the described needs.

5.1.5 Conclusion

The analysis of the global market development found several changes concerning economic, political and social trends, which are about to lead to fundamental transformation. Structural changes, as current internationalization in R&D, production and services, global shift of demand hotspots for mobility and the shortage of resources are main factors leading the transformation process. On the regulation side political reactions and attempts to control disadvantageous developments on a national base will cause interacting effects. Due to the complexity arising from this situation a forecast would have to stick on the level of hypothesis.
The situational analysis allows to point out the main challenges for the competitiveness of the European transport sector and to give ideas about promising starting points for strategies to deal with the development. As the main result one could state the transport world is about to change fundamentally and won't be the same as before. With shifting markets and demands not only the regions of demand for mobility with their user preferences are changing. Europe's transport industry will have to realize that due to this shift a transformation will occur which will also affect the way how economic and political decisions are made about which kind of mobility will be preferred and how regulation of investment and market regulation will be formed. Experience based on the history of the European transport system (as well as on the economic and political system) will be and is already about to be reassessed under different perspectives from upcoming markets and competing industries. This will not only affect the design of infrastructure, supply of services but also values in business and trade as well as mind-sets for policy and planning in transport.
Europe has a competitive advantage in its strong base of innovative R&D, production and global export activities, which are based on highly-skilled work force and long-term experience.
Concerning the described on-going transformation of global markets, the main challenge for the European transport industry will be to improve adaptability skills toward a new world of transport, which will be formed by needs and demand from emerging countries more than in the decades before. The need for adaption and transformation includes the opportunity for innovation.
Successful improvement of competitiveness will also depend on political decisions and how the intra-European market will grow. The need to maintain and adapt the given infrastructure according to new strategies concerning energy efficiency, integrative mobility and economy supportive services may also stimulate innovation leading to interesting solutions for new markets and thus strengthening the competitiveness on a global level.

5.2 Energy issue

Abstract
Energy issues will become more and more central in the future. The transport sector is still heavily dependent on fossil fuels and its price development. It is highly possible that there will be a rise in the real price of energy in the coming decades. In the near future the use of fossil fuels in transport will increase, despite programs and guidelines for energy efficiency and a reduction of emissions. There are challenges and opportunities concerning this topic. A lot of countries deal with the challenge of energy security and develop strategies to become more independent of the fluctuating energy price. This also affects future developments in the transport sector and is therefore a topic of global interest.

5.2.1 Development of Energy Price

The energy price is influenced by several factors. Based on the past developments the three most important factors have been identified:

1. General trend of increasing prices
2. High volatility
3. Global shift of drivers in demand

These characteristics are also estimated to have the highest influence on the energy price in the future. The global energy consumption increased by 45% between 1990 and 2010, but with clear regional differences. The energy consumption in the US increased by 19% and in Europe by 5% (The Economists Intelligence Unit 2011). In China the growth rate during this period was significantly higher, 149%. India's energy consumption increased by 116% (The Economists Intelligence Unit 2011). Due to the drastic growth, China has overtaken the US as the world's largest consumer of energy.
The energy price always showed strong fluctuations. Both the price for industrial energy uses as well as for private use change quickly. A steady growth since the beginning of this millennium has been observed with a peak in 2008. In 2012 the end-use price for energy has again almost risen to the peak level of 2008 (International Energy Agency 2012). Because of the rising demand in the fast-growing economies in Asia (population growth, increasing income and standard of living) the energy prices have drastically increased since the early 2007 (International Energy Agency 2012). This sharp increase in 2007 can also be explained with declining capacities in the non-OPEC countries and increasing exploration costs. Although the energy price has recently dropped below the peak level of 2008, a further increase is expected in the future due to increasing consumption (see figure 61).

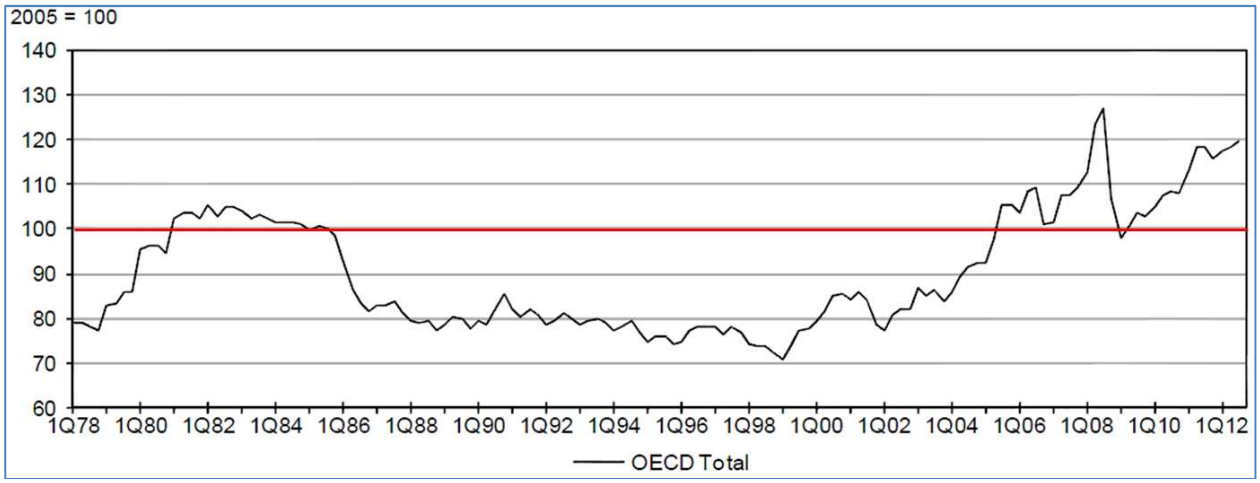


Figure 60 - Total energy real world end-use price index for industry and households 1978-2012 (International Energy Agency 2012)

The energy price is strongly linked with the oil price. The development of the different oil prices shows a general increase in recent years. The previously mentioned characteristics for energy price development, meaning the general trends for increasing price, high volatility and global shift in the drivers of demand, are also apparent in the oil price development (see figure 62).

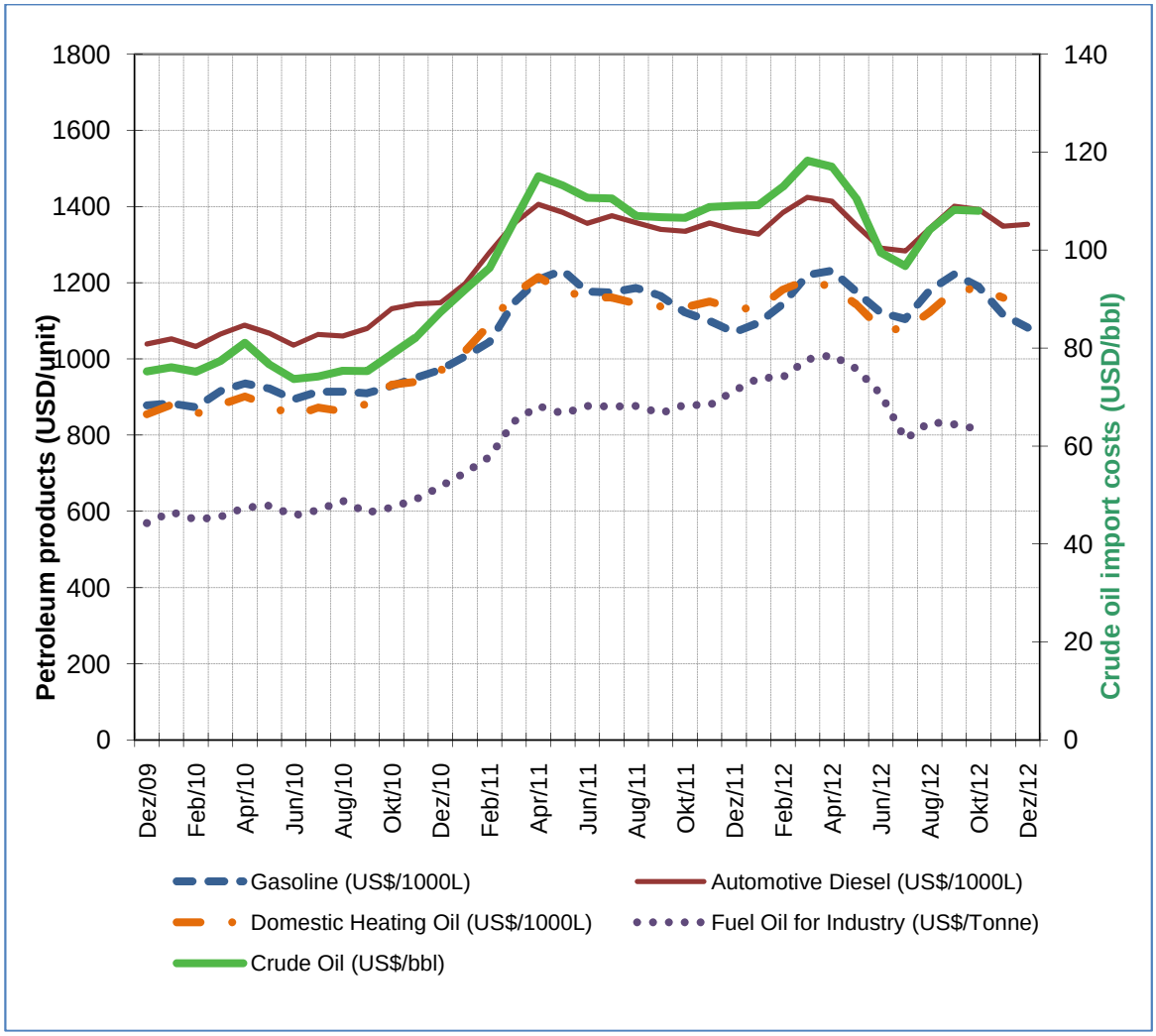


Figure 61 - End-use price petroleum product prices and average crude oil import costs in the world (International Energy Agency 2012)

It is highly possible that there will be a rise in the real price of energy in the coming decades. Except for occasional short periods of correction, the economic growth of the giant economies of the developing world – China, India, Indonesia, Vietnam, Turkey, Brazil, and so on – is unstoppable (The Economists Intelligence Unit 2011). A study conducted by the Economic Scientists Unit poll of 767 executives showed that 9 out of 10 people believe that real energy prices are going to increase over the next 40 years and 74% of the respondents think that the economic implication of rebalancing from West to East will create energy problems (The Economists Intelligence Unit 2011). Justified is the assumption of increasing demand due to the high population and the enormous economic growth especially in China and India.
Rising energy prices do not only have a tremendous impact on the transport providers but also on the transport industry. The development of energy prices influences directly the production costs for industrial and equipment industry and therefore is an important topic for the competitiveness of the transport sector.
The industry in the European Union faces two components, which raise the energy price:

- Net importer for raw materials

The European Union is net importer of raw materials. Thus, the energy price is linked to all corresponding prices of raw materials. This causes a dependency on commodity prices at the market and also the suppliers (Russia, MENA countries) of raw materials.

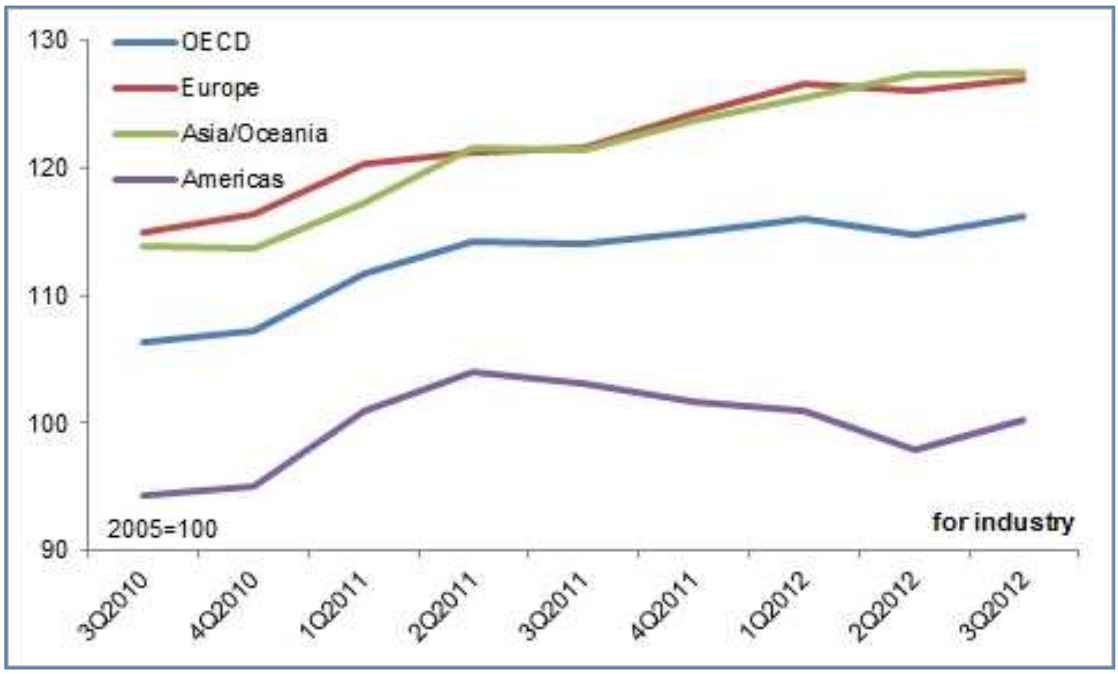


Figure 62 - *End-use price index for energy industry and households in different regions 2010-2012* (International Energy Agency 2013)

- High taxes for energy and raw materials

Taxes for energy and raw materials have large differences within the European Union (see figure 4). Compared to other OECD-countries overseas, the taxes are higher in almost all countries of the European Union (figure 5). This fact applies to nearly all raw materials and on electricity. European companies proclaim that they are losing their competitiveness against foreign markets. (Die Presse 2013).

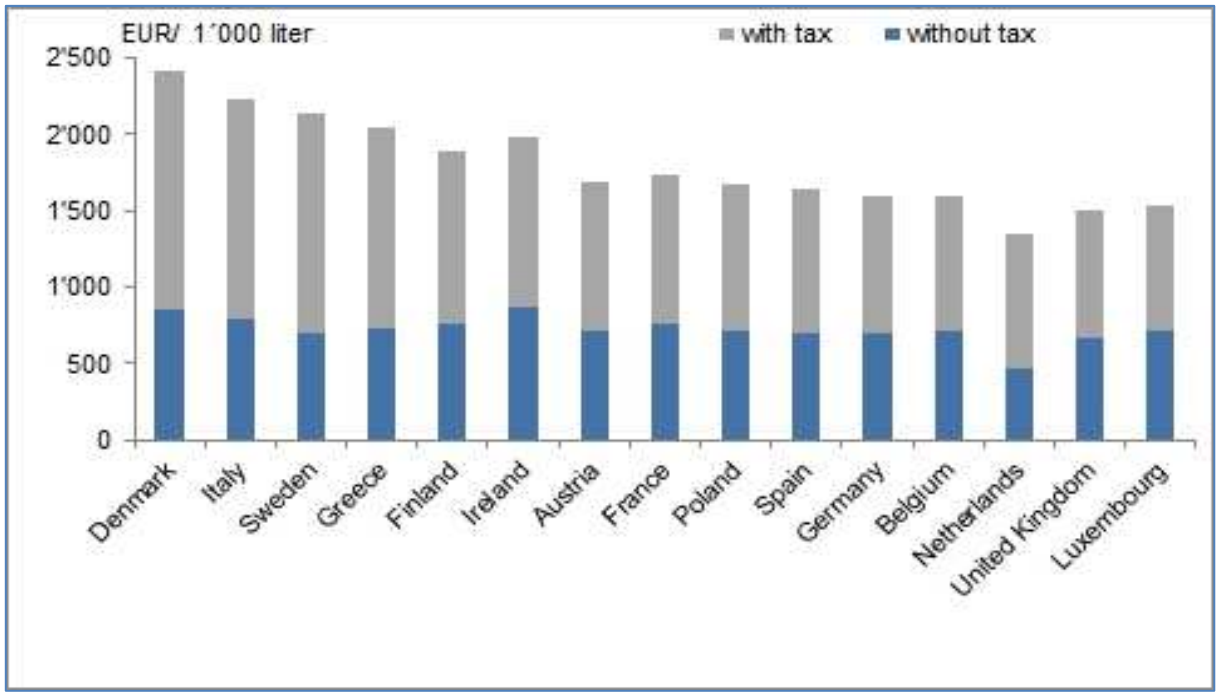


Figure 63 - *Comparison of consumer prices of liquid fuel in selected EU countries with and without taxes in February 2013* **(Energie Informationsdienst 2013)**

Figure 1:

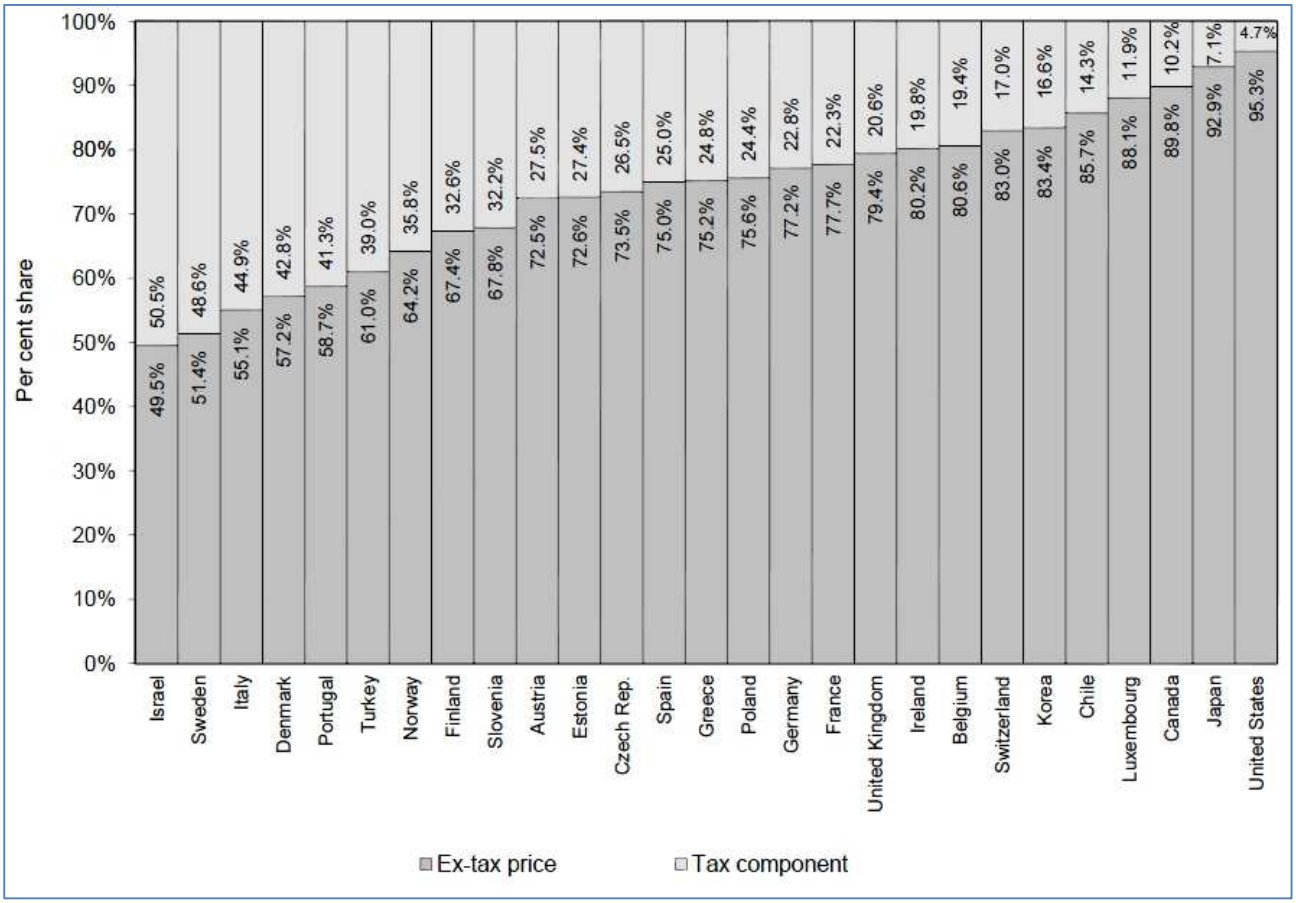


Figure 64 - *Percentage share of tax for non-industrial light fuel oil of total price 3rd quarter 2012* **(International Energy Agency 2012)**

Energy price could be an important measure for competitiveness of European Union's Transport providers and equipment industry. Therefore the development of the energy policies for the future needs to be focused on ensuring the energy security.
The Economist Intelligence Unit points out two major energy challenges over the next 40 years:

1. The rapidly rising demand for energy, particularly in developing countries, by increasing supply.
2. The realisation of the above mentioned goal while also achieving substantial reductions in carbon emissions.

The challenge is to bring these two themes in line. That means to find a way to ensure economic growth without intensifying the climate change. In 2010 nearly 90% of global energy comes from fossil fuels. Only 8% account to renewables like hydro, solar, wind and others (The Economist Intelligence Unit 2012).

5.2.2 Energy issues in Transport

Energy is the engine for transport. The dependency of the transport sector from fossil fuels is still very heavy. In 2010 more than 25% worldwide, in the EU even more than 30%, of the final energy consumption is attributed to the transport sector. In EU-27 the share of energy consumption in transport increased in the last 20 years. The road transport consumes more than 80% of the energy in the transport sector (figures 6 and 7).
The transport sector is very dependent on energy prices. In particular, the fluctuating prices of crude oil and petroleum are crucial for the transport sector. Although the means of transport become more efficient and alternative fuel penetrates the market, energy consumption in the transport sector continues to increase. That is mainly due to the still growing transport sector. In a mid-term this trend will continue, although the rise in recent years significantly weakened in the EU.

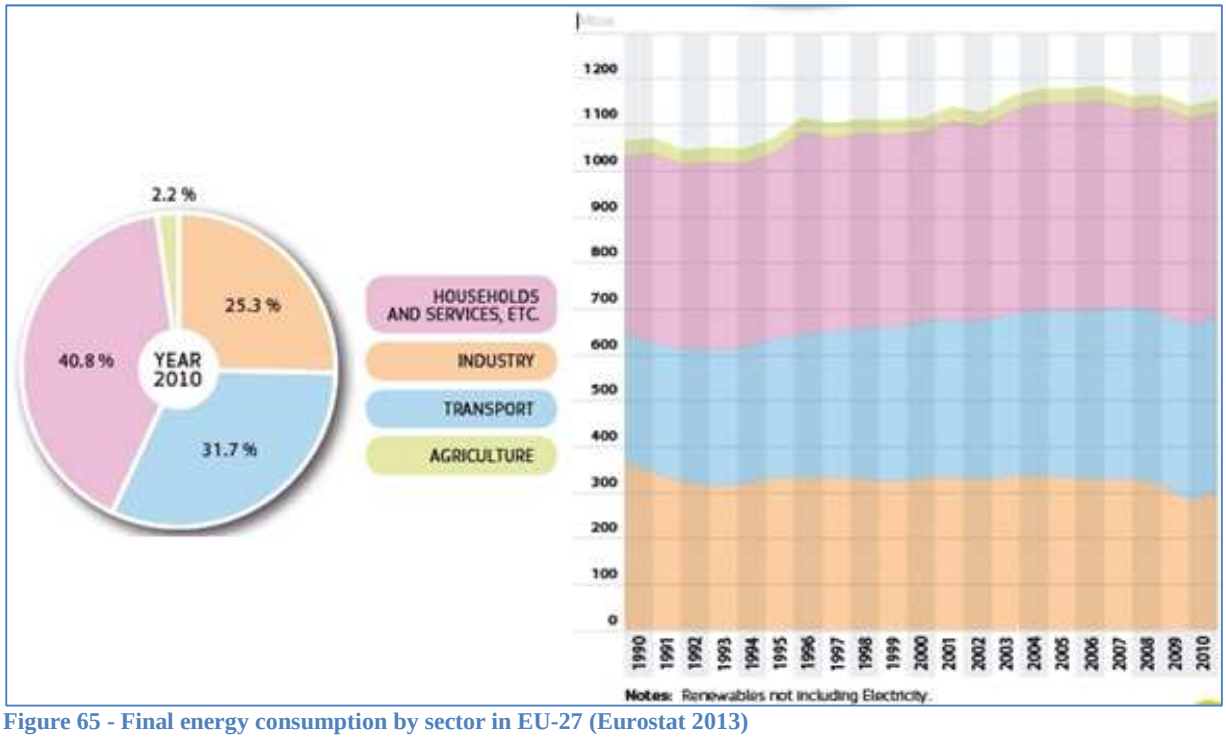


Figure 65 - Final energy consumption by sector in EU-27 (Eurostat 2013)

Particularly in China, India and South Africa mobility is increasing and especially in the private transport a significant growth can be seen. The growing consumer society worldwide leads to an increasing demand for private cars as well as for growing demand in air travel. Especially the energy-intensive industries in transport gain weight.

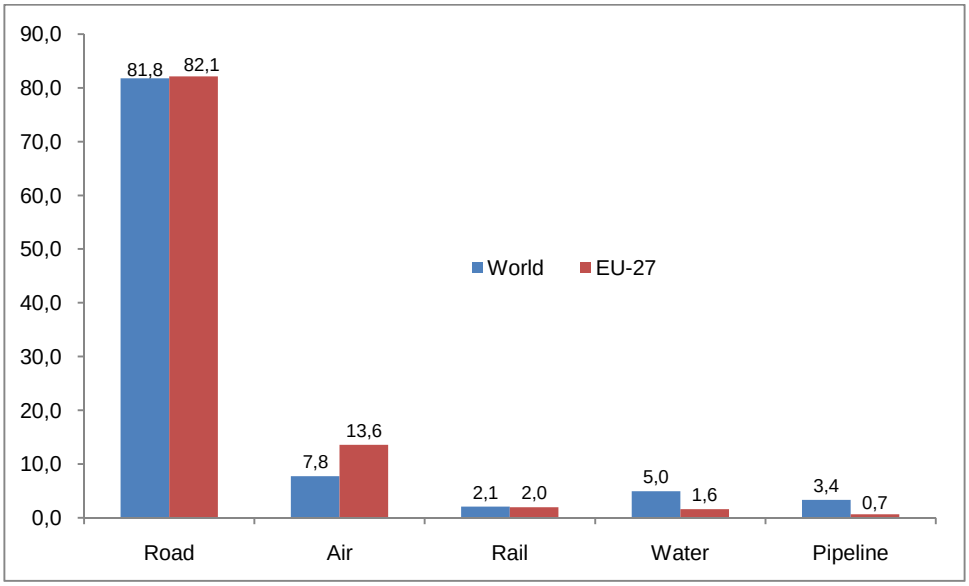


Figure 66 - *Final energy consumption by Transport sector in 2010* (Eurostat 2013) *and* (U.S. Departement of Energy 2012)

The near future of energy issues in transport will be dependent on fossil fuels, although there are some efforts in policy and technologies that could cause a change in a long-term perspective. The Directive 2009/33/EC on the promotion of clean and energy-efficient road transport vehicles for example show that energy issues in transport become more interesting and were integrated in political planning (European Parliament 2009). The USA National Conference of State Legislatures also points out effective state policy options for increasing domestic fuel production and promoting fuel diversity (National Conference of State Legislatures 2012). Despite these programs and guidelines for energy efficiency and a reduction of emissions, in the near future the use of fossil fuels in transport will increase. It will take time until the technological advance can compensate the need of fossil fuels in transport, especially in the still growing aviation sector.

5.2.3 Energy Security Challenges

Energy security is a very important issue for all nations and markets due to the increasing demand, the volatility of a spatial variation in the energy demand and also the need for CO2 reduction. Some countries are trying to strengthen their position to improve the energy security. China, for example, is investing abroad. They construct complete infrastructures in foreign countries (e.g. in Africa) in order to extract raw materials to satisfy their need for energy. The United States increasingly relies on the resources in their own country. Driven by a combination of advances in drilling and advanced technologies, USA is aiming to become completely self-sufficient in the energy market. The European Union´s way is different. Versatile political ideas and approaches of the individual member states as well as existing bilateral agreements with suppliers of raw materials (e.g. German-Russian gas pipeline agreement, LNG contracts between Spain/France and Algeria) have to be considered before harmonizing the EU´s energy policy. Furthermore, the lack of own raw materials results in a different energy strategy.

The already mentioned economic implication of rebalancing from West to East and the resulting energy problems will test the individual energy security systems. The three approaches dealing with this challenge will be considered more in detail.

China´s strategy

Chinas enormous demand for energy increased at the mid-90s. Until the 90s self-reliance and self-sufficiency were the key objectives. The own oil production could supply the consumption. But in the mid-90s the domestic oil production couldn't meet the demand anymore and enterprises started to seek oil in foreign markets (Zhang 2011).

With China´s admission to the World Trade Organisation (WTO) in 2001 they became one of the major players in the global trading system. China´s energy security became essential for economic security. So, the 11th Five-Year Plan (2006-2010) prioritized expanding and securing domestic energy supplies in China. For the first time energy conversation through economic efficiency, reduction of poverty and environmental preservation were put on the agenda. The transformation process from a planned economy to a market-oriented economy took place with a twenty per cent reduction target of energy intensity (based on 2005 level) for all provinces and energy-related industries. The main energy strategies, based on this Five-Year Plan, are:

- diversifying energy resources by increasing production of natural gas and nuclear power, developing clean energy technology to generate gasoline and diesel from coal, and increasing the use of other renewable energy sources such as wind power and solar energy;
- enhancing the existing oil and natural gas supply sources and exploring to find more new energy resource locations at the global level; diversifying import routes by reducing import dependence from the Middle East, and increasing imports from Central Asia and Russia in order to reduce transport risk;
- strengthening energy exploration and production (E&P) of new oil fields domestically and encouraging international cooperation in offshore oil exploration and production;
- increasing the number of Strategic Petroleum Reserve sites and raising mandatory stockpile requirements for major oil firms (Zhang 2011).

Despite plan to increase renewable energy up to 15 per cent of the total by 2020 (9.5 per cent in 2008), (World Bank 2010) the biggest efforts are made in financial outward foreign direct investments (OFDI, see figure 6). The global financial crisis and turmoil in many parts of the Middle East and Northern Africa forced China to diversify energy sources.

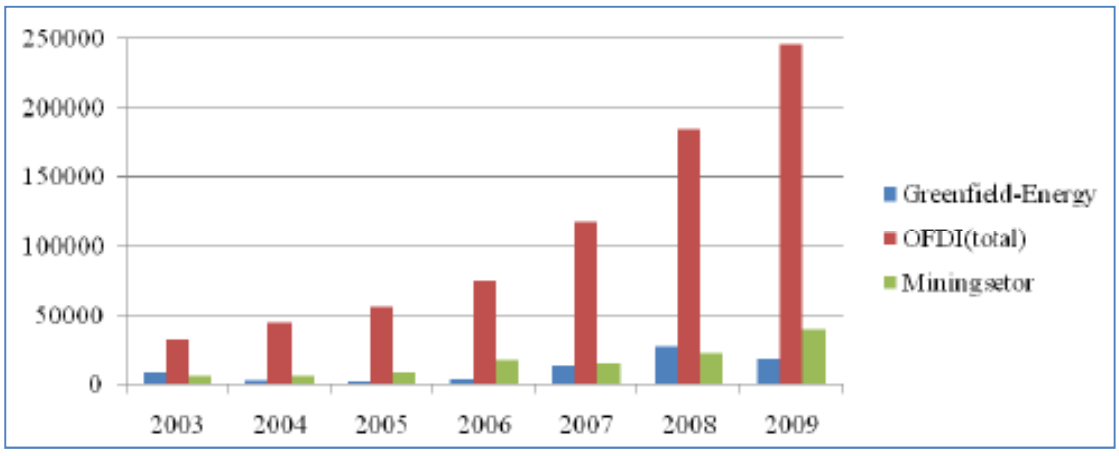


Figure 67 - China´s accumulated OFDI vs. OFDI in Energy sector (Zhang 2011)

In addition to importing oil from abroad to meet domestic energy demands for the short term, Chinese enterprises have also started investing directly in foreign firms to assemble long term and more secure energy supplies. These enterprises have engaged in acquisitions and mergers, portfolio investments, such as foreign bonds, stocks, and financial derivatives (Zhang 2011).
On a long-term strategy the focus of China´s energy security is clean energy. An unusual level of cooperation between government and industry with investments in sciences and technology in the energy sector led China to the global leadership in clean energy. Fighting Climate Change and forcing renewable energy are positioned strategically in China´s energy structure. Forecasts suggest that the renewables share in the country´s overall energy mix might reach 28-32 per cent by 2030 and 30-45 per cent by 2050 (Weber 2012).

European Union´s strategy

In order to strengthen the competitiveness of the production site of European Union, energy supply needs to be secured. Historically, the European Union was strongly dependent on foreign power. In particular, the agreements with Russia should ensure the EU's energy supply. In 2007 EU imports were about 50% of its energy needs. Barring significant changes, the European Commission expects this figure to rise up to 65% by 2030 (The Economist Intelligence Unit 2012). Approximately half of the EU's imported energy in the form of oil and natural gas comes from Russia. Europe's growing dependence on Russian energy has fuelled speculation that Moscow will use the "energy weapon" to try to influence future foreign or economic policy in Europe (Belkin 2008). The Russia-Ukraine and Russia-Belarus gas and oil crises have been characterized by many European observers as "wake up" calls, exposing Europe's energy security vulnerability even to unintended supply disruptions (Belkin 2008).
The global energy market is getting tighter. The energy demand in Asian countries and the Middle East causes, that EU, as the world´s largest energy importer, is likely to be more vulnerable to supply risks (European Comission 2010).
Therefore the Energy strategy for 2020 focuses on five points:

1 Achieving an energy efficient Europe
2 Building a truly pan-European integrated energy market
3 Empowering consumers and achieving the highest level of safety and security
4 Extending Europe´s leadership in energy technology and innovation
5 Strengthening the external dimension of the EU energy market

The Green Paper 2013 shows the current policy framework and also demonstrates first values, which were established for the 2020 targets. The three headline targets for 2020 are:

- GHG emission reductions of 20% relative to emission in 1990
- 20% share for renewable sources in the energy consumed in the EU with specific target for the Member States
- 20% savings in energy consumption compared to projections

All targets are on a good way. In 2011 GHG emissions were estimated at 16% below 1990 levels. In 2010 the renewable share was 12.7% and primary energy consumption has been decreasing since 2007 after the peak in 2005/2006. In the transport sector GHG emissions for cars have led to substantial reductions (European Commision 2013).
A major challenge in the EU is to create a single market, which provides energy products and energy services for all consumers at an affordable price in compliance with the above mentioned EU´s climate policy goals. Full implementation of the internal market legislation is critical to keep prices in check and help meet targets cost-effectively (European Commision 2013). Energy

efficiency is another target of EU, reinforcing industrial competitiveness by making the industry sector more efficient (European Comission 2010).
The European grid infrastructure is lacking. The grid needs to be modernized to enable renewables and to develop an equal competition with traditional sources (European Comission 2010).
European Commission points out that, to ensure the de-carbonization goal, a technological shift is also necessary. The EU is facing fierce competition in international technology markets. Countries such as China, Japan, South Korea and the USA are pursuing an ambitious industrial strategy in solar, wind and nuclear markets. EU researchers and companies need to increase their efforts to remain at the forefront of the booming international market for energy technology. If it is mutually beneficial, the EU should cooperate with third countries in specific technologies (European Comission 2010).
But despite all efforts, it remains essential to establish strong international partnerships, especially with the neighbours. Restructurings, such as the nuclear phase out in some countries, establishment of a European energy grid or demand shift on the global energy market are essential.
The expansion of natural gas as an environmental clean energy source is widely seen as the most problematic factor in the next two decades for the EU member states (European Comission 2010). At first glance, the EU seems to be in a very favoured position: unlike any other region of the world, the EU is geographically surrounded by many gas-exporting countries. Eighty per cent of the global gas reserves are within a range of 4500 km; most of those reserves can be connected to the EU by pipelines (Umbach 2010). However, most of those gas export countries are considered as politically unstable.
Therefore it is very important to be able to integrate European energy policy objectives within the contracts in order to pursue a milestone for an international energy policy with the common objectives of supply security, competitiveness and sustainability.

USA strategy

“Every US president since Richard Nixon has trumpeted the benefits of energy independence and outlined strategies to end fuel imports, including investing in renewables, nuclear, biofuels and coal. But today, with advances in drilling technologies and the recent surge in the development of oil and gas from shale rock, the country is inching closer to the elusive goal” (Richardson 2013).
Historically, USA energy policy was characterized by import of energy sources. After the USA oil production peaked in 1970, their production declined more and more and the imports of fossil fuels increased (figure 9). The United States is projected to become the largest global oil producer by around 2020 (overtaking Saudi Arabia until the mid-2020s) and starts to see the impact of new fuel-efficiency measures in transport (International Energy Agency 2012).

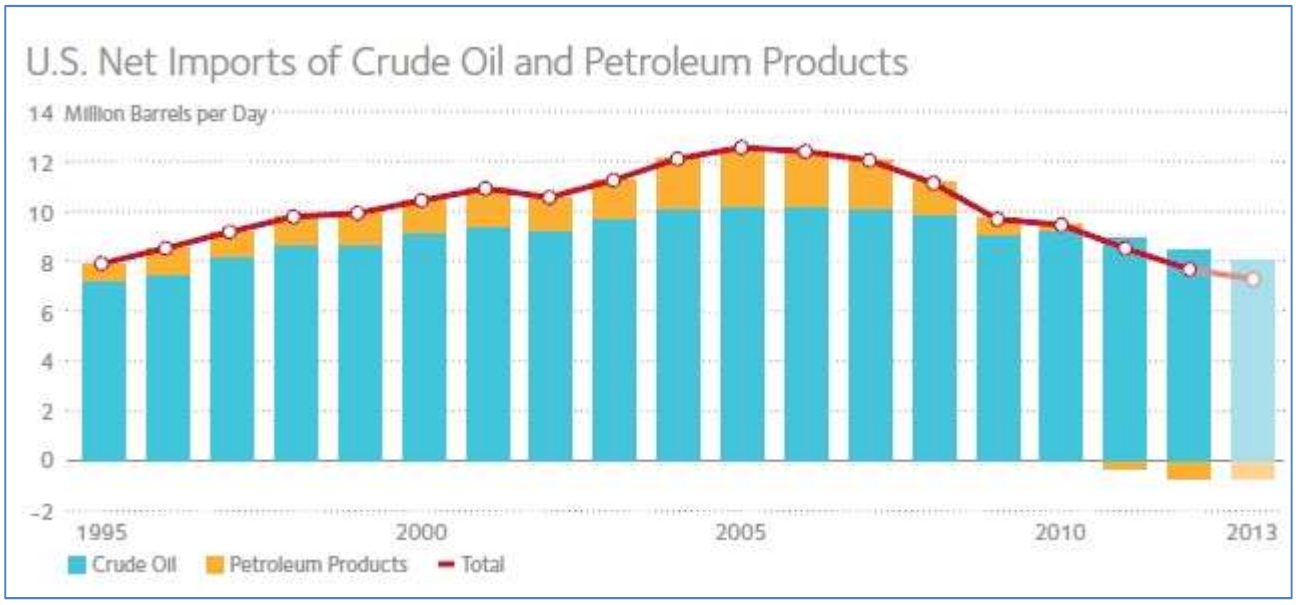


Figure 68 - USA net import of crude oil and petroleum products 1995-2013 (Energy Security Leadership Council 2012)

The resurgence in oil and gas production in the United States could change the whole energy market. The transport sector in the USA is huge and needs new ideas. The excessive reliance on oil exposes the entire economy to the vagaries of the global oil market at a cost that has become increasingly unsustainable. Oil dependence is one of the greatest threats to USA national security (Energy Security Leadership Council 2012). The new independence of the global energy market and its prices will bring lots of benefits for the country, like employment growth, manufacturing competitiveness and of course a decreasing trade deficit. But the Energy Leadership Council believes that it is a big opportunity and recommends a strategy of a conscious approach to the newly developed opportunities. The four main targets should be:

1. Reducing Oil Use Through Advanced Technology
2. Maximizing Domestic Energy Production
3. Reforming and Streamlining Regulatory Structures
4. Global Developments with Long-Term Implications for USA Energy Security

Energy security in the USA is determined by the role of oil in the economy. The biggest part is the transport sector where oil is still indispensable. “Most importantly, we must transform our transport sector so that oil is no longer its primary fuel” (Energy Security Leadership Council 2012). Despite the new oil and gas sources the future strategy for the U.S has to be an improvement of fuel efficiency and an adaption of alternative fuel vehicles to avoid a dependency of oil prices again.

Energy Security Leadership Council recommends that a maximisation of domestic energy production is necessary for the economic competitiveness. But for a long-term perspective the focus will shift to sustainability and safety. In this context, reforms and regulations will become very important and needs to be introduced to improve energy security and promote environmental sustainable goals. Global developments with long-term implication for the energy security need to be observed (Energy Security Leadership Council 2012).

An energy policy for renewables, which does not exist in the USA, could be an example in the long-term. There are no national targets for renewable energy (RE), though RE in the USA is maturing and evolves from a niche market to an increasingly competitive alternative to fossil fuel-based generation (Weber 2012). Primarily hydropower, but also solar photovoltaic and wind-power have experienced a boom over the last decade. The National Renewable Energy Laboratory (NREL)

confirmed that renewable energy could cover 80 per cent of USA electricity demand by 2050 (Weber 2012).

5.2.4 Conclusion

The different energy security strategies show that a rethinking of the energy topic already has taken place. Energy efficiency and the support of renewables is an important topic in all observed strategies. But securing energy in a short-term perspective forces policymakers to focus on fossil fuels. Although the energy conservation is the most important issue in energy policy, the utilization of nuclear energy is also essential to maintain the global environment and energy security together with the improvement of the renewable energy.
Beside policy measures social and technological efforts will support renewable energy sources and alternative fossil fuels in a long-term perspective. The increasing energy price, technological efforts in alternative powertrains and behavioural change, especially in the transport sector, has the potential to force a rethinking of actual energy usage.
For the transport sector the technological efficiency of conventional power trains almost reached its maximum. Evidence to move away from fossil fuels is becoming more and more visible. Alternative mobility concepts are becoming increasingly important. Probably the change towards a sustainable and environment friendly energy policy is closer than expected.
But even if the first signs of moving away from fossil fuels in mobility exist and many countries accelerate the promotion of renewables; energy strategies indicate a shift away from fossil energy sources only in the long term perspective. Technological efforts of renewable energy sources still take time and cannot replace the already existing system which is based on energy of fossil fuels. But several forecasts suggest that the consumption of fossil energy will peak at 2030 (Ujita and Duan 2012), and the clean energies, especially the renewable energy will play an essential role during the second half of the century.

5.3 The Challenge of New Materials

Abstract
Novel materials with improved properties are a prerequisite for more sustainable, efficient and environmentally friendly transport means. The transport industries have already begun to utilize advanced materials such as nano-materials, for specific applications. Advancements in materials science and especially in nano-technology offer new possibilities for a wide range of structural and (multi)functional nano-materials with unprecedented properties. For example, certain nano-composites as well as nano-engineered metals have the potential to significantly reduce the weight of aerospace, automotive and naval structures. In this sub-chapter several interesting and important application areas are reviewed, such as high-strength light-weight materials for vehicle structures and engines, self-healing materials and sophisticated coatings, materials enabling high performance power sources, smart materials for adaptive structures, and materials for improved transport infrastructures.

Unless a major disruption occurs, the global use of powered vehicles is likely to increase significantly in the next few decades. The growing demands pose a major challenge: to develop and implement innovative materials, which are a major prerequisite for more sustainable, more efficient and more environmentally friendly transport means.
Important features of advanced materials which enable significant benefits for transport systems can be broadly divided into the following main categories:

- High-strength light-weight materials
- Materials for more efficient engines
- Self-healing materials and sophisticated coatings
- Materials enabling high performance power sources
- Materials for improved transport infrastructures
- Smart/adaptive materials

Major advancements in recent years in the broad field of nano-technology, regarded as one of the key technology fields of the 21-st century, have the potential to impact on a wide range of applications and industries, including transport (PWC 2009). In particular, Nano-technology brings new opportunities in the form of novel structural and (multi)functional nano-materials with unprecedented properties. These materials are in the main focus of the present chapter.
A recent report of the European Commission (European Commission 2012) identified transport as one of the economic sectors with the highest use of nano-materials, in particular in the aerospace industry (e.g. lightweight materials, resistant paints and coatings for aerodynamic surfaces), and the automotive industry (e.g. scratch-resistant paints and coatings, plastics, lubricants, fluids, tyres). These are just a few examples of a wide range of applications, in which the use of novel nano-materials is likely to significantly expand in the future. In the following we will elaborate on selected topics in more detail.

5.3.1 High-strength lightweight materials

A major role of nano-technology in the transport field is providing lighter and stronger materials for vehicle construction. Materials with exceptional specific strength (strength to weight ratio) enable light-weight and strong structures for vehicles in all transport domains. Less weight means lower fuel consumption, less pollution and lower greenhouse gases emissions. Several nano-materials have the potential to significantly reduce the weight of aerospace, automotive and naval

structures, while maintaining (or increasing) their strength and toughness. Nano-structured metals, such as nano-structured aluminium and titanium alloys, can improve the mechanical properties and enhance corrosion resistance. For example, titanium with nano-grains is thermally stable at high temperatures is and has good corrosion resistance. It is foreseen that nano-grained titanium will be used for strong lightweight parts for the automotive and aerospace industries (Observatory NANO report 2009).
Advanced carbon-fibre composites are already used in parts of aircraft structures (instead of titanium and aluminium), providing the necessary strength while reducing weight. The relatively high cost of composites is likely to decline thanks to improved manufacturing processes. Similar composites are also in a process of adoption in ground transport. Experts estimate that multifunctional composites could reduce ground vehicles weight by 20 per cent. Existing high quality carbon fibres have specific strength (strength/density) fifty times higher than the specific strength of steel and are excellent load-bearing reinforcements in composite structures. But much more significant reduction of weight (and consequently of fuel use and GHG emissions) can be achieved by new generations of novel nano-composites.
In recent years much attention has been paid to the exceptional properties of carbon-based materials such as various types of Carbon Nano-tubes (CNT) and Graphene, and their possible combinations with other materials. The tensile strength of individual nano-tubes could be close to a few 100 GPa (gigapascal) and their elastic modulus is in the terapascal range, which is much higher than traditional carbon fibres. Moreover, nano-tubes are more flexible and can sustain large strains under compression (Endo, Strano and Ajayan 2008).

Material	Young's Modulus (GPa)	Tensile Strength (GPa)	Density (g cm^{-3})
SWNT/MWNT	~1000	~100-200	~0.7-1.7
High tensile steel	210	1.3	7.8
Toray Carbon fibers	230	3.5	1.75
Kevlar	60	3.6	1.44
Glass fibers	22	3.4	2.6

Figure 69 - A comparison of the mechanical properties of carbon nano-tubes compared with other structural materials, making them attractive for composite applications in various types of vehicles (Endo, Strano and Ajayan 2008, 28)

These exceptional properties of nano-tubes have attracted much attention; however there are still technological challenges in creating continuous CNT-based fibres and practical structures which exhibit comparable properties. Much research efforts are invested in this area. For example, recently MIT researchers have produced carbon fibres coated with carbon nano-tubes, so that the resulting fibres can be woven into composites. Such (and similar) composites are obviously highly attractive for use in airplanes, cars, trains, spacecraft and satellites (PhysOrg 2013).

5.3.2 Materials for propulsion systems

Novel materials enable not only strong and lightweight vehicle structures but also lighter and/or more efficient engines, which could consume significantly less fuel.
In particular, nano-materials can significantly contribute to increased aero-engine performance

and efficiency, with reduced environmental impact and maintenance cost, mainly thanks to higher specific strength and better thermal properties. Main potential applications for aero engines include nano-structured strengthened alloys and protective coatings, multi-functional materials for adaptronic designs, and high temperature nano-functional materials for sensors and actuators (Max Planck Institute 2009).

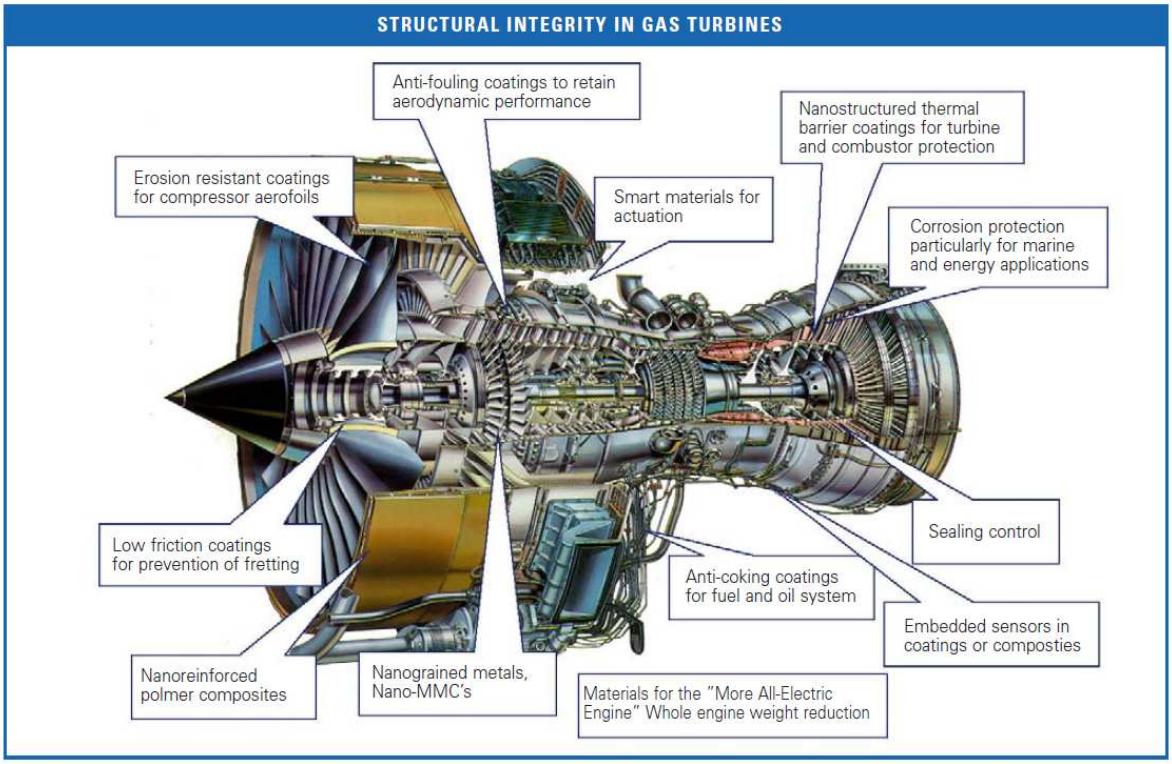


Figure 70 - The role of nano-materials in the aeronautics propulsion systems sector (Max Planck Institute 2009, 215)

In the emerging area of fuel cells and hydrogen-based propulsion (see section 5.5 below), nano-structured materials are being pursued to greatly improve hydrogen membrane and storage materials and the catalysts needed to realize fuel cells for alternative transport technologies at reduced cost. For example, as catalyst support material for precious metals (e.g. platinum), carbon nano-materials can help to enhance the power density of fuel cells and reduce the amount of platinum.

As one of the current bottlenecks is safe and efficient hydrogen storage, research is underway also to develop safe, strong and lightweight hydrogen fuel tanks (National Nanotechnology Initiative 2013). A major challenge is an efficient reversible hydrogen storage material. Possible solutions could be provided by novel micro-porous materials with an extremely high specific surface area or nano-scale complex hydrides with catalytic nano-clusters.

The development of new (automotive as well as aeronautic) systems in general, and in particular propulsion systems, are mainly driven by more and more severe requirements such as reduced fuel consumption and reduced fuel cost, improved emission control (minimal GHG emissions), decrease of noise pollution, and increased safety. For example, for aerospace applications such requirements are expressed in the goals of the Advisory Council for Aeronautics Research in Europe (ACARE). ACARE targets for the year 2050 are reducing CO_2 emissions per passenger kilometre by 75%, reducing NOx emissions by 90% and perceived external noise by 65%, all relative to the year 2000 (Advisory Council for Aviation Research and Innovation in Europe 2012). Here is

an excerpt from ACARE vision for 2050:

> *All aircraft entering service are highly efficient and produce very low noise levels. They are economically feasible because of flexible, cost effective design, certification and manufacturing processes. They have radically new configurations that are adaptable to the mission cycle, exploiting morphing structures and systems enabled by intelligent controls. These new vehicles have fully integrated, embedded/distributed propulsion systems, utilising novel forms of energy, including electrical energy, as well as energy conversion, harvesting and storage. They are built with a new generation of materials and structures including nano- and biomimicry technology" (ibid).*

Indeed, in this context Airbus pursues research on nano-composites to be incorporated in future Airbus airframes, and adopted three step-wise approaches to nano-composite developments: nano-augmented, nano-engineered and nano-enabled (Edelmann 2008). These efforts stem from Airbus vision that the company's future airframes will require high performance, robust and cost-efficient, multi-functional materials for maintenance-free, actively controlled and environmentally-friendly structures.

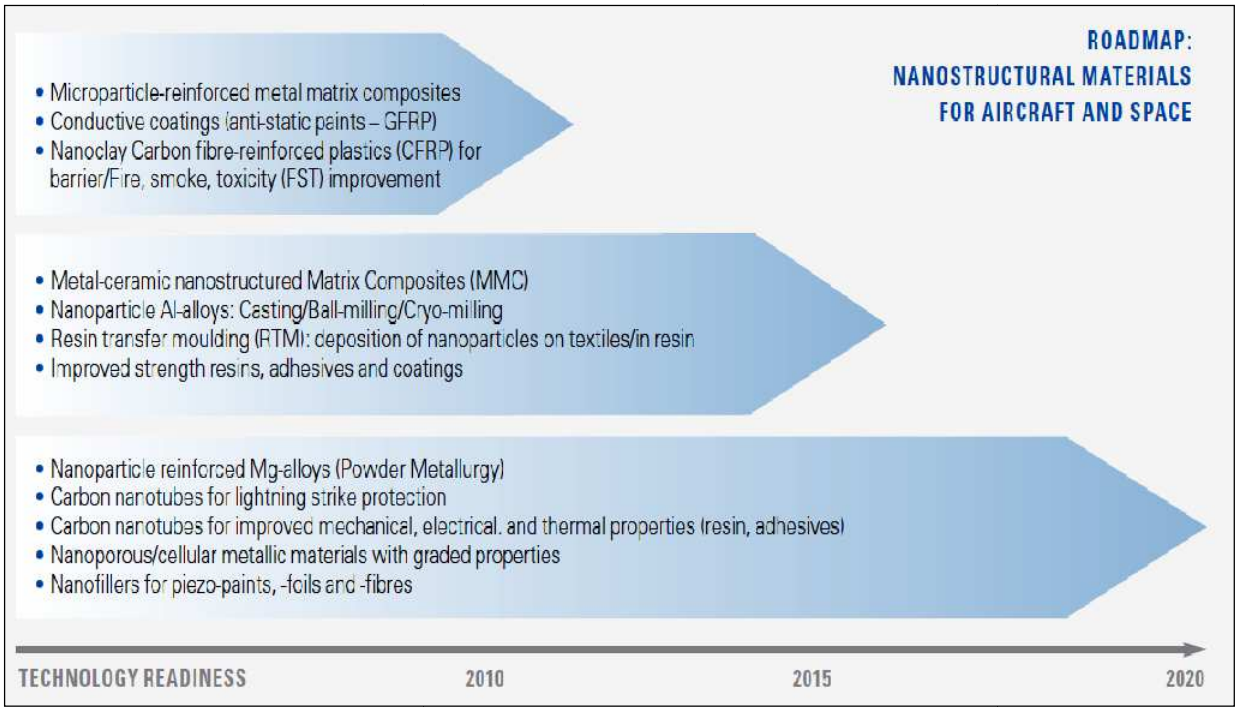


Figure 71 - Roadmap: Nano-structural materials for aircraft and aerospace (Max Planck Institute 2009, 214)

In many applications, e.g. aero-gas turbines, materials still are the limiting technology. Novel approaches to materials engineering, such as those offered by nano-technology, may help in achieving these goals.
Some examples of types of nano-materials and their benefits for future aircraft include:

- Nano-alloys, nano-ceramics and nano-composites – improved strength/toughness, corrosion resistance, temperature resistance.
- Nano-multifunctional materials – smart/adaptive structures (embedded sensing/actuating functions), morphing.
- Nano-layers, nano-coatings (coatings containing nano-particles) – corrosion/wear resistance, electromagnetic/optical shielding, thermal protection.

The following figures present a roadmap for nano-structural materials for aerospace and specific applications of nano-materials in aircraft.

Figure 72 - Nano-materials applications in aircraft (Max Planck Institute 2009, 214)

5.3.3 Advanced materials for aerospace and automotive applications

In a broad view, applications of nano-engineered materials in automotive products include high-power rechargeable battery systems; thermoelectric materials for temperature control; lower-rolling-resistance tires; high-efficiency/low-cost sensors and electronics; thin-film smart solar panels; and fuel additives and improved catalytic converters for cleaner exhaust and extended range.

The following more detailed list includes a wide range of potential applications of nano-materials in aerospace and automotive domains (Max Planck Institute 2009):

- Improved present and future design by using new structural materials and coatings. Composite materials consisting of nano-scale elements with extraordinary mechanical properties can result in novel outstanding performances, enabling for instance the application of novel coatings with unprecedented resistance.
- Carbon nano-tubes (CNT) and other nano-scale elements as sensors and actuators for adaptronics (a.k.a "smart structures", namely structures with embedded sensors that monitor changing state conditions and/or structural health, actuators that apply forces on the structure, and control unit – to afford continuous adaptation to varying external conditions and assure optimal functioning).
- Morphing materials and structures (e.g. wings with changing shapes according to varying flight regimes, thus significantly improving aerodynamic efficiency);
- Nano-structured thermoelectric functional materials;
- Mechanical alloying of light metal alloys with nano-particles; Nano-particles for conditioning of matrix systems of fibre-matrix composites.
- Self-healing materials and sophisticated coatings and paints – for higher durability, enhanced wear resistance and more efficient maintenance. Paints and coatings are already

a large part of the entire nano-technology market in the automotives industry, including novel scratch-free, self-cleaning surfaces (Magazine 2008).

- High-power rechargeable battery systems;
- Lower-rolling-resistance tires;
- High-efficiency/low-cost sensors;
- Thin-film smart solar panels;
- Fuel additives and improved catalytic converters for cleaner exhaust and extended range.

The following figure exhibits a variety of existing and envisioned nano-materials applications in a car structure.

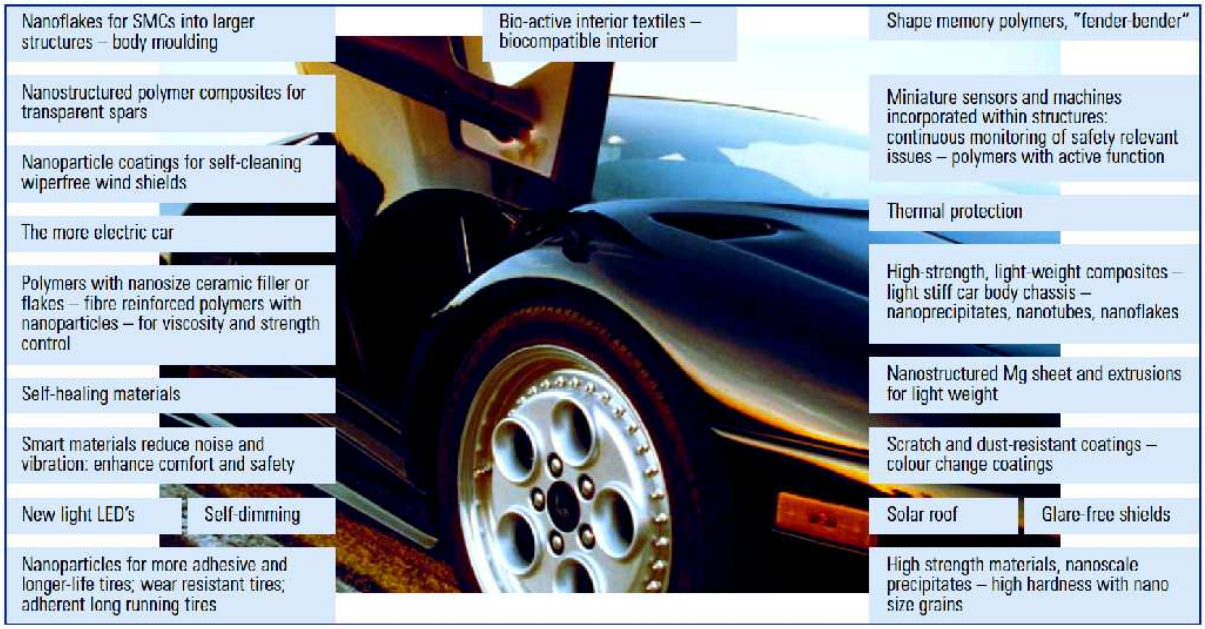


Figure 73 - The role of nano-materials in the car structure (Max Planck Institute 2009, 217)

A recent example in the area of nano-engineered metallic alloys is a new technique for creating ultra-strong magnesium alloys that maintain good ductility, developed by researchers from North Carolina State University. Such lightweight alloys could replace *steel certain parts in vehicles* (Green Car Congress 2013).

Additional interesting automotive innovations enabled by nano-materials exist such as nano-catalyst catalytic converters (which use less rare metals than conventional converters), nano-liquid that makes tires puncture-proof, metallic nano-particle additives for oil that enhances performance of engines, nano-particle-based mirrors and windows that filter sun rays, fog, smoke, and other pollutants and more. Surely many more innovations are yet to come.

5.3.4 Materials for improved and novel power sources

Advanced materials are being developed for high performance power sources: batteries, fuel cells, and capacitors. Specific nano-materials are being used in new types of high-power-density and light-weight batteries.

For future electric cars powerful batteries are critical, as they could enable a considerably larger range. Much effort is therefore invested in R&D of new generations of high-performance batteries.

For example, researchers at Swiss Federal Institute of Technology (ETH Zurich) have recently developed a nano-material composed of tiny tin crystals, which enables much more energy to be stored in lithium ion batteries (ScienceDaily 2013).

5.3.4 Improving Transport Infrastructures

In addition to contributing to building and maintaining lighter, smarter, more efficient, and "greener" vehicles, aircraft, and ships, nano-technology offers various means to improve the transport infrastructure (The US National Nanotechnology Initiative 2013):

- The performance, longevity and resilience of highways, bridges and various components in infrastructures can be improved (and their cost can be reduced) thanks to nano-engineering of various materials such as steel, concrete, asphalt, etc. New capabilities such as generating and transmitting of energy could be incorporated into infrastructure materials.
- Embedding nano-scale sensors inside infrastructure materials will enable enhanced and cost-effective maintenance capability, by providing continuous structural monitoring of the condition and performance of bridges, tunnels, rails, and pavements over time.

5.3.5 Supply chains and transport of goods

New nano-technology-based materials could make future supply chains more efficient, thanks to several developments and improvements:
Stronger packing materials with improved insulation and protection from chemical or UV effects will lower the risk of damage and so will decrease the shipping cost of several types of goods. Ultra-light materials could decrease the weight of many products and so lower the energy costs of the transport process. In addition, as already mentioned before, advancements in nano-materials may lead to more efficient engines that consume less fuel. Thanks to nano-materials and miniaturization enabled by nano-technology, less material will also be needed for powerful ICT components. Reduction in the size of existing products would mean a drop in transport requirements and warehousing needs.

The EU perspective
The EC has recognized that technological innovations can lead to a more efficient and sustainable transport systems and to a significant reduction of GHG emissions by acting on three main factors: *vehicle efficiency* through new engines, materials and design; *cleaner energy use* through new fuels and propulsion systems; *better use of networks and safer and more secure operation* through information and communication systems (European Commission 2011).
The European Road Transport Research Advisory Council (ERTRAC), in its Strategic Research Agenda, set the goal to improve by 50% the overall efficiency of the transport system in 2020 compared to 2010 (European Road Transport Research Advisory Council 2013). Novel materials with special properties such as high strength to density ratio are certainly a major enabler of sustainable, efficient and environmentally friendly transport means.
The Association of German Automobile Manufacturers (VDA) announced that Nano-technologies are core competencies for maintaining the competitive edge of the automotive industry, offering a multitude of novel applications (Nanotechnologies in Automobiles 2008).
Research projects within the EU Framework Programmes (in particular the NMP thematic area)

have addressed these aims. One among many examples is the ongoing FP7 large-scale integrated project SARISTU (Smart Intelligent Aircraft Structures), coordinated by Airbus with a budget of 51 Million Euro, deals with airfoil morphing, self-sensing and multifunctional structures through the use of nano-composites, utilizing the electrical properties of carbon nano-tubes (SARISTU - Smart Intelligent Aircraft Structures 2013). One of SARISTU expectations is to significantly reduce the fuel consumption of future airliners, and at the same time to reduce noise.

According to the EC plans, one of the challenges of the forthcoming Horizon 2020 Framework Programme will be "Smart, Green and Integrated Transport", including "Reducing the weight of aircraft, vessels and vehicles and lowering their aerodynamic, hydrodynamic or rolling resistance by using lighter materials, leaner structures and innovative design." (European Commission 2011)

The EARPA* thematic network FURORE identified lightweight concepts and advanced multi-material structures as major "breakthrough technologies" for future vehicles (European Automotive Research Partners Association 2005).

The European GENNESYS project led by Max Planck Institute analysed the future trends and needs in advanced analysis for the development of nano-materials and nano-technology (in the context of advanced analytical techniques for materials characterization by Synchrotron-radiation and neutron sources). The entire European research community as well as policymakers were actively involved (Max Planck Institute 2009). Potential benefits of nano-materials in transport systems were thoroughly studied in this major project (along with other application areas), and some important finding are included in this chapter.

*European Automotive Research Partners Association

5.4 The Challenge of Information and Communication Technologies

Abstract
ICT products are crucial to the transport industry. For example, in today's cars there are up to 100 microcomputer-based systems called Electronic Control Units (ECUs).
In this sub-chapter we cover existing and emerging technologies that could re-shape the transport industry. We briefly discuss automotive embedded systems, telematics and intelligent transport systems, the connected car and Internet of Things, autonomous vehicle technology and multi-modal transport systems.
The advancement of ICTs is also related to the effective exploitation of alternative engines. Gas and diesel engines will improve mostly due to electronics advances. ICTs will also impact driver assistance systems, including warning systems, error correction, and collision mitigation. The EU has competitive advantages in some areas, such as core Auto ECUs, and Advanced Driver Assist Systems (ADAS). In the area of Electric Vehicle ECUs, the EU is less competitive and needs to do more to stay in the game.

In 2010 the Information Society Unit at the Institute for Prospective Technological Studies published a report on the competitiveness of the European automotive embedded systems industry (Juliussen and Robinson 2011). ICT embedded systems are computers programmed to perform specific functions that are located within the system infrastructure. The key automotive trends that are related to advanced use of ICTs are described in the next table.

	Key Information	Comments
Powertrain Trends	• Gas and diesel engine will improve • Electric vehicle importance growing • EV's electricity from many sources • Long-term EV will become leader	• Mostly due to electronics advances • EV is a when-question, not if-question • Battery, engine-generator, hydrogen • Is it in 2025 or 2035?
Driver Assist and ADAS Trends	• Mostly warning systems • Mostly for luxury cars • Driver error correction emerging • Collision mitigation emerging • Future integrated systems	• Lane, blind spot, speed, parking • Ultrasound park assist is exception • Stability control and others • Improves safety systems effect • Based on ICT
Connected Car Trends	• Multiple communication links • Telematics applications and services • Connected navigation systems • Connected auto control systems	• Embedded, driver phone and others • eCall, safety and infotainment functions • Traffic information and others • Remote diagnostics and others
Entertainment Trends	• Digital radio receivers • Digital music player interfaces • Internet radio emerging • Premium audio systems	• Satellite radio in some regions • USB, iPod and streaming Bluetooth • High bandwidth communication link • Surround sound music systems

Figure 74 - Key Automotive Trends (Juliussen and Robinson 2011)

We can see, for example, that gas and diesel engine will improve mostly due to electronics advances. ICTs will also take an important role in driver assistance systems, including warning systems, error correction, and collision mitigation. Another important trend is the connected car based on multiple communication links, several telematics applications, connected navigation systems, and connected auto control systems.
Automotive ICT products are crucial to advancing the automotive industry. In a luxury car today, there are up to 100 microcomputer-based systems that are called Electronic Control Units (ECUs).

The number and variety of ECUs per car has increased and they are becoming more complex and more costly. A possible solution to that is a layered system architecture which is part of the AUTOSTAR standard, which is considered to be a disruptive technology and its development was led by the EU automotive industry.
Embedded software systems have three layers:

- Operating systems, that manages the software used by the ECU and control hardware devises connected to it.
- Driver software, or specific programs that control and provide interface between the ECU and the sensors, buses, actuators, that are connected to the ECU.
- Application software that defines what each ECU will do.

5.4.1 Telematics and Intelligent Transport Systems

The term 'telematics' was coined some 30 years ago and it evolved in Europe into Intelligent Transport Systems (ITS) in 1994. Transport Telematics systems (and ITS) use telecommunication and information technologies in order to provide advanced services for users of transport systems in areas such as traffic management, emergency calls, and collision avoidance.
Intelligent Transport Systems (ITS) include the following main technologies (Wikipedia 2013):

- Wireless communications: ITS is assisted by several connectivity technologies, such as UMTS for long range communications, IEEE 802.11p at 5.9 GHz for mid-range communications, and infrared or RFID for short range communications.
- Computational technologies: Vehicle electronics is moving towards fewer microprocessor modules with hardware memory management and Real-Time Operating Systems. The new embedded systems will include model-based process control, artificial intelligence, and ubiquitous computing. Floating car data: These are methods for obtaining travel time and speed data for vehicles. The methods include triangulation, vehicle re-identification, and GPS.
- Sensing technologies: These include tiny microchips equipped with diverse sensors and actuators that can detect and communicate different types of information. A group of sensor can form a network of nodes where some nodes act as sensors and other as gateways. In ITS both vehicles and infrastructure may include sensors.
- Inductive loop detection includes detectors that can be placed in roads to detect vehicles as they pass through the loop's magnetic field. These sensors and detectors help in counting vehicles and estimating their velocity.
- Video vehicle detection: Video footage is being processed and analysed as vehicles travel the road so that learning is taking place, and the results are lane by lane video speeds, counts, and occupancy readings. ITS are part of the European Transport Policy as stated in the ITS Directive, and there are also other European standards in this area (Nowacky 2012).

The EU adopted the following definition of Co-operative ITS:
“Co-operative systems are ITS systems based on vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I, I2V) and infrastructure-to-infrastructure (I2I) communications for the exchange of information. Co-operative systems have the potential to further increase the benefits of ITS services and applications.”
The Connected Car concept, which is similar to ITS, is related to the future advance of the Internet, including Internet of Services and Internet of Things. In the future, sensors, actuators, and processors will be embedded in products and things with the provision of connectivity, and will provide new functionalities to users. Service categories that will be enabled by the Connected Car will include safety, eco services (reducing the impact of mobility on the environment), pricing

services (linking payments to location and timing), and entertainment (IMobility Challenge project 2013).
The following table describes future embedded software opportunities for the EU automotive industry.

	Key Information	Other Information
Connected Car Application Software	• Many applications emerging • EU is behind USA in telematics • eCall can be basis for telematics apps • Multiple communication links emerging	• For car, driver and passengers • Link to ECUs become important • eCall is EU chance to catch up • ECU, driver and infotainment links
ADAS Software = Driver error correction	• Software intensive systems • Many applications emerging • Builds on driver assist applications • EU has ADAS system and sensor expertise	• Sensor-based systems • Major life and cost saver • Warns or corrects driver errors • Leverage into software leadership
V2V and V2I Software = Communication vehicle-road	• Many applications possible • EU's CVIS R&D project is important • More EU development needed • Early EU deployment create expertise	• Safety, traffic and fuel-savings • Public and private cooperation • To complete system architecture • Systems and software experience
Autonomous Driving Software	• Builds on ADAS and V2X systems • Progressively more autonomous functions • Compute, sensor and software intensive	• Deployment likely after 2020 • Complex ECUs and software • Large software opportunities

Figure 75 - Future Embedded Software Opportunities (Juliussen and Robinson 2011)

Many applications will emerge in the connected car area, such as the remote management of ECU software. The eCall regulation provides the motivation for manufacturers to implement remote ECU diagnostics. ADAS technology is software systems that can correct drivers' errors saving lives and costs. They are based on pattern recognition technology. There are also opportunities in the areas of V2V and V2I, and eventually autonomous driving, all will be based on embedded software technologies.
Future innovations in the automotive industry will also be based on electronics and on embedded software (IBM 2012). Since software content will increases in the future, cloud technologies will become a viable solution in order to manage and distribute the software. The connected vehicle of the future will be able to use real-time remote diagnostics and perform self-repair. Software updates will be delivered to vehicles automatically through cloud computing technologies. Cloud computing will also assist the complex processes of global (distributed) product development and vehicle manufacturing.

5.4.2 Active safety technologies

The European Thematic Network FURORE is a platform for discussing breakthrough technologies related to vehicles in the year 2020. The FURORE network published an R&D technology roadmap for future road vehicles (Furore - Future Road Vehicle Research 2007).
According to FURORE, there are several breakthrough technologies that will enable active safety in road vehicles in 2020, such as image enhancement (night vision), image recognition, vehicle-vehicle warning system, and break/steer-by-wire. In the short term research needs include (among others) better and cheaper sensor/actuator technology, as well as methodologies and protocols for physical, information networking and human-machine interfaces. Research needs for the medium term highlight the introduction of affordable partially-autonomous vehicles with a high degree of on-board intelligence. In the long term the research needs include the transition to fully-autonomous vehicles (see below).

5.4.3 The Internet of Things

The Internet of Things (IoT) and the concept of the Connected Car are closely related concepts, and some transport applications of IoT already exist. The idea behind IoT is that every-day objects, as well as a multitude of sensors (and possibly actuators as well), can be connected through a network such as the Internet, to form an infrastructure for new applications. Such applications may include waste management, urban planning, emergency response, smart meters, and many more. A closely related term is Machine to Machine communication (M2M), which also refers to devices that are connected to the Internet, using a variety of fixed and wireless networks and communicate with each other and the wider world.

In principle, there could be considerable benefits in connecting transport systems to the IoT. IoT can provide in the framework of smart cities application such as urban noise map, pedestrian traffic data, intelligent adaptive lighting and smart parking. Take Smart Parking, for example. Libelium , the IoT platform provider, already developed an IoT platform where sensors are being buried in parking spaces enabling the detection of arrival and departure of cars (Website 2013). Libelium also rank among the top 50 IoT applications traffic congestion which includes monitoring of vehicles and pedestrian levels to optimize driving and walking routes.

The combined availability of inexpensive electronics, ubiquitous networks and (cloud) computing now makes it possible for any device to be equipped with a communications module to communicate status and information, which in turn can be aggregated, enriched and communicated. For example, data gathered by the traction control systems in cars can be use to tell drivers where the roads are slippery. Such data was available to onboard computers in cars for many years, but now thanks to the advent of ubiquitous M2M it can be combined, enriched and communicated (OECD 2012).

Multi-modal transport system refers to the use of two or more modes involved in the movement of people or goods from origin to destination. This type of transport is needed in order to promote the efficiency of urban transport while reducing its negative impacts. One of the technologies mentioned with respect to multi-modal transport is GIS-T data models which provide several modelling elements to integrate multiple transport networks. Such elements include location referencing, spatio-temporal data structures, and multiple representations (Chen, et al. 2011). The model was tested in the city of Guangzhou and it provides qualitative geospatial information that enables planners to evaluate infrastructure capacity.

The potential of IoT/M2M for economic and social development is being increasingly recognised by policy makers. Projects and studies in several countries make extensive use of the IoT or M2M concepts or are evaluating their potential, for example the Dutch SPITS-projects for Intelligent Transport Systems, the European Union's "Internet of Things Expert Group" and the Korean government's "Master plan on the establishment of Internet of things". The Korean project includes intelligent metro bus stop services among many other applications.

Many M2M initiatives are focusing on private cars. Here are some examples (OECD 2012):

- eCall – EU initiative for emergency services in cars.
- OnStar and Sync – examples of services offered by car manufacturers to car owners, varying from theft protection to navigation and emergency services.
- Saab has demonstrated a car equipped with an Android tablet, which let users install a variety of apps and monitor thousands of car parameters. This could lead to new Internet-based services related to the car.
- The Brazilian government has required new cars to be equipped with the SIMRAV anti-theft device, which makes use of GSM to track a car.

• Pay as you drive insurance makes use of vehicle tracking using GPS and M2M.
• Several OECD governments are looking into dynamic road pricing using GPS and M2M enabled solutions.
• Companies are using GPS and M2M for fleet monitoring, including monitoring the freshness of cargo.

Another important trend that can be accelerated by the increased connectivity between vehicles, users and the outside world is ICT-based car pooling and car sharing. Currently there are approximately 1.7 million car sharers in 27 countries. This statistic includes peer-to-peer services, which allow rentals of individually owned cars. France leads in this trend, with around 430,000 subscribers in 2013 (IGEL; Knowledge Wharton 2013).

5.4.4 Fully Autonomous Vehicles

Autonomous cars are the most advanced manifestation of the Connected Car concept, combined with development of cheap and powerful sensors. Google has already demonstrated one aspect of this combination, and has field-tested a fleet of self-driving cars relying mainly on sensors and computer program to find their way on open highways and congested urban areas alike (Naughton 2013). The data from the sensors is essentially combined into an Advanced Driver Assist System (ADAS). At the current stage of development the cars are still limited in some aspects like incapability of human-like deduction, and the cost of sensors is high.
It has been suggested by (KPMG; Center for Automotive Research 2012) that the combination of connectivity-based solutions (i.e. Internet of Things) and sensors could provide the best driving experience and best emulate human driving, minus human errors that are responsible for most of accidents. While connected vehicle network is already technologically feasible in principle, it depends on a reaching a critical mass of connected vehicles on the road, and still requires a dependency on sensors to handle situations in which unconnected elements – such as human beings or natural obstructions – suddenly appear on the road. The following figure exhibits the current status of relevant sensor-based solutions (camera, radar, LIDAR) and connected-vehicle solutions.
The technological solutions that should enable autonomous driving are still mostly young and costly. It has been suggested by (KPMG; Center for Automotive Research 2012), however, that by 2025 the convergent autonomous cars (containing both sensors and capable of V2V and V2I connectivity) will penetrate the market in full force. This forecast is in concert with BMW's recent declaration to produce fully automated cars by 2025 (Jaynes 2013).

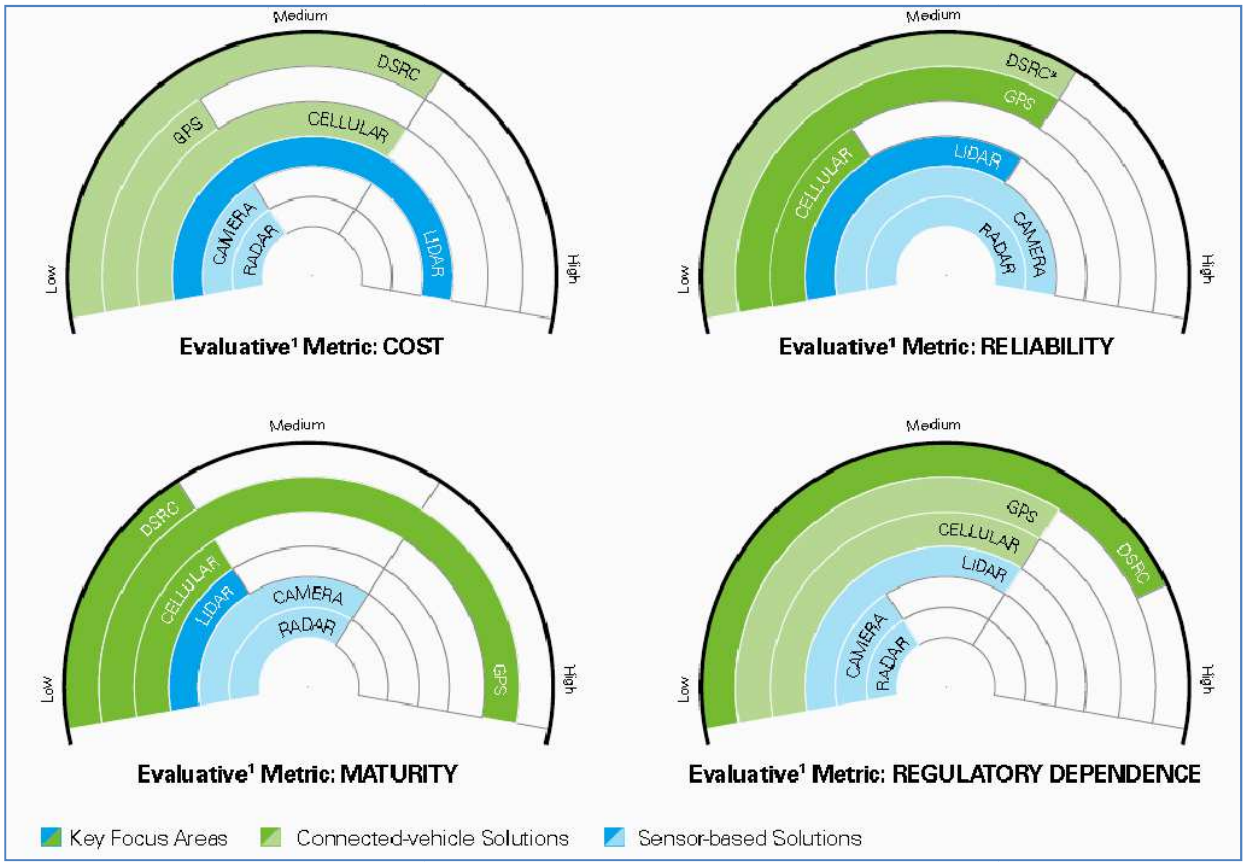


Figure 76 - The maturity of sensor-based solutions (camera, radar, LIDAR) and connected-vehicle solutions (Dedicated Short Range Communications – DSRC, GPS, cellular) for autonomous driving. (KPMG; Center for Automotive Research 2012, 13)

Effects of Autonomous Technologies for Transport Service

The effect that fleets of autonomous vehicles would have over the transport service sector cannot be underestimated. It is expected that, should fleets of autonomous vehicles come into being, they will replace human drivers in several vital service transport sectors, including –

- Cargo delivery (trucks and other road delivery vehicles) – since autonomous vehicles consume less fuel than human-controlled cars, and since their maintenance costs are expected to be highly reduced (since they are involved in less accidents, and do not drive recklessly) many delivery companies will find themselves forced to replace human drivers with autonomous vehicles, resulting in improved delivery system.
- Taxies and busses – According to Yossi Prashker, ex-chief scientist in the Israeli Ministry of Transport, sixty percent of the costs of public transport go to cover the wages of the human drivers (Tzezana 2013). When considering this state of things, it is clear that the public transport sector will undergo a transition towards the assimilation of the safer, cheaper and generally more efficient autonomous vehicles.
- Car-share companies – Several companies nowadays are developing models for sharing cars between individuals, so that each person can use the others' cars when they are not needed by the original owners. This type of model fits autonomous vehicles extremely well.

According to research conducted by the Earth Institute at Columbia University, it is estimated that the autonomous cars will provide "better mobility experiences at a radically lower cost". Of particular note is their conclusion that "economies of scale are reached quickly... Results are consistent for a wide range of residential areas," and, "Sustainability benefits are substantial with fleets of shared, driverless vehicles." (Burns, Jordan and Scarborough 2013)

Effects of Autonomous Technologies on City Shape

All of the above data suggests that the transport service sector is about to undergo an autonomous revolution that will result in a more efficient industry (Godsmark 2013). The regulator, however, will be forced to set some rules and conditions regarding the use of autonomous cars in cities, as well as human-controlled cars, since the combination of both on the same road could lead to accidents. Indeed, it is yet unknown how a fleet of autonomous cars will interact with a single human driver on the road.

It is for this reason that cities and city regulations might be reshaped around autonomous technologies. At certain high-pressure hours of the day, for example, human drivers might be forbidden from entering the city without handing over the control to their autonomous car. It is entirely possible that in other cities, human driving will be banned altogether, and human-driven cars will be replaced by autonomous taxis and autonomous shared cars.

These developments will lead to radical reshaping of the cityscape. At the present, approximately 30 percent of the area in some cities is dedicated solely to parking, taking up much valuable space (Mcohen 2013). Autonomous taxis and shared-cars, however, could each take the role of up to thirteen private cars, leading to a sharp decline in the number of parking spots needed in the cities of the future.

The EU Perspective

Intelligent Transport Systems (ITS) are part of the European Transport Policy as stated in the ITS Directive, and European standards exist in this area (Nowacky 2012). The EU transport industry is already competitive in some ICT areas, and it needs to be more competitive in others. In core Auto ECUs the EU is a leader in several domains, and AUTOSAR will preserve that position. In the Electric Vehicle ECUs area the European industries are less competitive and need to make more efforts in order to stay in the game. In the area of Advanced Driver Assist Systems (ADAS) the EU is leading and it needs to retain that position. The EU has initiated promising R&D projects in the areas of V2V and V2I, and the combination with ADAS is important to the future of autonomous driving systems. In the area of the connected car the EU is behind the USA. Some of European OEMs are heavily involved in producing innovative software and hardware. BMW is a software innovator and leader in AUTOSAR, M-B is very competitive in driver assist technologies and ADAS. The EU has strong Tier 1 companies, such as Bosch and Continental that excel in multiple segments and in software development. In the area of automotive semiconductors, Europe has top suppliers, such as ST Micro, NXP, and Infineon.

5.4.5 Additive Manufacturing / 3D Printing

Additive manufacturing, or under its more commonly known name – 3D printing – is a manufacturing method based on injection of micrometer-sized drops of polymer or metal at specific spots, or on sintering of metal or plastic powder into pre-specified shapes. The technology is relatively easy to operate, and can be used to manufacture all sorts of complex shapes, including ones with open pores in their middle (a feat that typical manufacturing methods are incapable of performing).

3D printing is already being used to manufacture parts of transport vehicles in the near future, it seems highly likely that this trend will increase in the near future. CFM International prints components for its jet engines, for example, that increase fuel efficiency by 15 percent (Franzen 2013), and GE predicts that by 2020 some 100,000 parts found inside the engines of GE and CFM

will be 3D-printed as well (GE 2013).
An entire electric car was already printed, that is (according to popular publications) "as strong as steel, half the weight" (George 2013). While the printing feat took around 2,500 hours, it involved no human work, demonstrating once again that the manufacturing process is extremely easy to reproduce even without human expertise which is often difficult to obtain. In a recent similar project, a team of students printed a 3D-printed Formula race car that accelerated from 0 to 100 km/h in merely four seconds and reached 141 km/h at its top speed (3D Printing Industry 2012).

The EU Perspective
Unfortunately, the largest 3D-printing companies (Stratasys, Z Corporation, 3DSystems, Objet) were all founded outside Europe. However, as the market and the companies evolved, some of the above opened offices in Europe (3ders 2011). The nature of 3D printing, however, ensures that 3D printers could be assimilated into manufacturing processes in European factories without a hefty investment in human training. As a result, many European transport companies and projects make use and advance 3D printing processes. These include (but are not limited to) –

- **BMW** saved 58 percent in costs and 92 percent in time by 3D printing jigs and fixtures (Chatterjee 2012).
- **Daimler** has funded the development of a large 3D printer for use in automotive production. According to DesignNews, the system should replace some of the "costly and time-taking sand-casting and die-casting processes used to make large, metal functional components and technical prototypes" (Thryft 2013).
- **Airbus** and the South African Aerosud opened a collaborative project called Aeroswift, in which they aim to develop a large titanium 3D printer for making titanium components for aircraft and satellites. The printer is expected to manufacture "large, complex parts at a rate 10 times faster than traditional manufacturing methods" (Thryft, Biggest Fastest Titanium 3D Printer 2012).
- **Rolls Royce** has opened the MERLIN FP7 project in 2011. The project's concept is to reduce the environmental impact of air transport using 3D printing techniques in the manufacture of civil aero engines. According to the project's description, MERLIN will develop 3D printing techniques "...to allow environmental benefits including near 100% material utilisation, current buy to fly ratios result in massive amounts of waste, no toxic chemical usage and no tooling costs, to impact the manufacture of future aero engine components. All of these factors will drastically reduce emissions across the life-cycle of the parts" (BioInfoBank Library 2013).
- **AMAZE** is a recently started project (coordinated by the European Space Agency). The project's goal is to rapidly produce large defect-free 3D printed metallic components up to 2 metres in size, ideally with close to zero waste, for use in aeronautics, space, automotive, nuclear fusion and tooling. The project's aspiration is to help EU manufacturers reach a world-dominant position in 3D printing of high-value metallic parts by 2016 (CORDIS 2013).
- **The Fraunhofer Additive Manufacturing Alliance** in Germany is the largest interdisciplinary European alliance of competence in this area. It collaborates with national and international partners, aiming to enhance the performance and competitiveness mainly of small and medium-sized enterprises in all sectors, including the automotive and aerospace industries (Fraunhofer 2013).

- **EPMA**, the UK-based European Powder Metallurgy Association has recently established a new group dedicated to the application of powdered metals in additive manufacturing (Galbraith 2013).

The above list clearly demonstrates that the 3D printing trend has been embraced by European transport companies, who seek to make the best use of it in order to achieve a new level of efficiency in manufacturing.

5.5 The Challenge of Future Fuels

Abstract
There is no doubt that energy is one of the key issues humanity will have to deal with in the next few decades. An increasingly large fraction of the world use of energy is consumed by transport. It is supplied mostly by the use of fossil fuels, which are found in limited amounts and are exposed to many various factors (geographical, geopolitical, etc.) limiting their distribution worldwide.
The transport sector needs to find alternatives, preferably renewable ones, to fossil fuel consumption. In this sub-chapter we briefly review the various alternatives, including hydrogen fuel cells, electric batteries, hybrid engines and bio-diesel. Each is described in some detail, and the sub-chapter ends with a review of various reports concerning the future of usage of the above renewable fuels.

Introduction
Energy has become a key exchange coin for humanity. No country can continue its economic growth or maintain civilized standards of living without the support of energy sources. And yet, energy is seemingly becoming scarcer and more valuable the further we look into the future. In 2030, our world will require 50% more energy than today, and 45% of the growth will stem from the Far East (International Energy Agency 2007). The transport sector will account for a significant part of the energy consumption in the future (as the second largest energy consuming sector), and is expected to increase by nearly 2% per year in the upcoming two decades. Almost all of the energy supplied to the transport sector comes from oil, and by 2030 almost 75% of the expected increase in the demand will come from the transport sector (U.S. Energy Information Administration 2010). The information about current and future consumption of energy in the transport sector by OECD and non-OECD countries has been drawn together by (Atabani, et al. 2011), and is presented in figure 18.

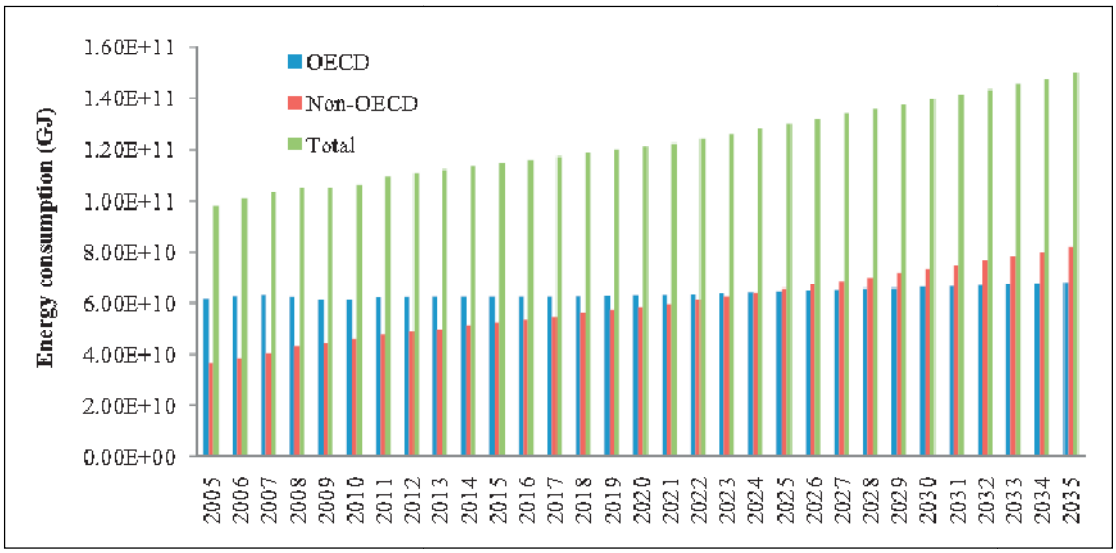


Figure 77 - *Total world, OECD and non-OECD transport sector energy consumption between 2005 and 2035* (Atabani, et al. 2011, 2072)

There is frequent and on-going debate about the exact date for peak oil – the time when oil production would reach its peak. Current opinions about peak oil place it in a range of dates between 2013 and about a hundred years from now. Regardless of production, the oil share out of the world energy consumption is believed to decline in the future from ~35% to 30% in 2035 (U.S. Energy Information Administration 2010).

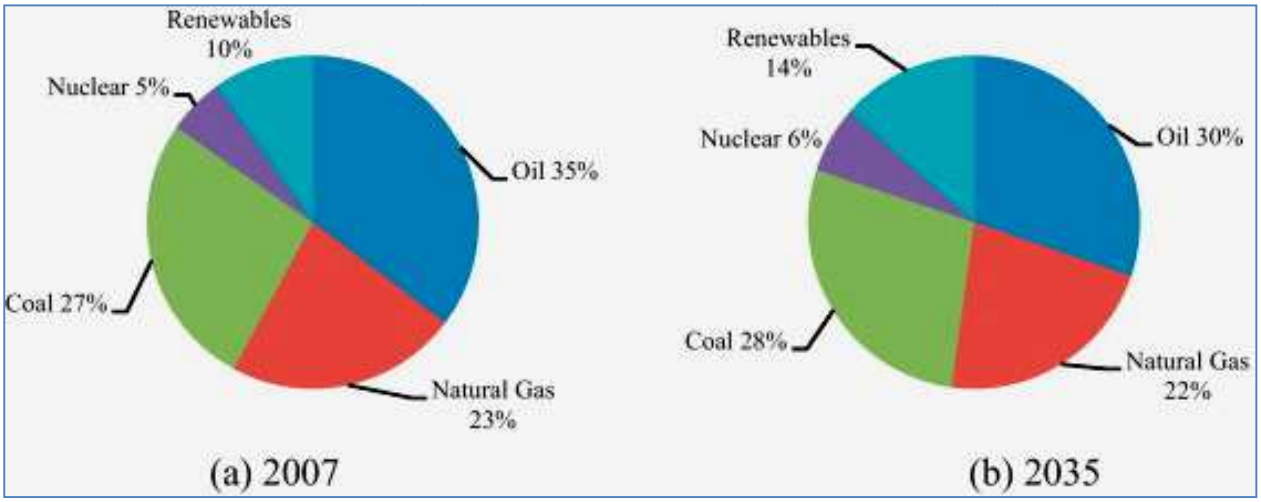


Figure 78 - *A detailed analysis of energy consumption by type, in 2007 and in 2035.* (Atabani, et al. 2011, 2073)

The above information clearly explains why it is vital for human civilization to find replacement for the fossil oil currently used in the transport industry. In addition, the vitality of oil prices and the limited supply (which can be easily disrupted) are further reason for this sub-chapter to deal with possible future alternatives for fossil oil.

5.5.1 Hydrogen Fuel Cells

Fuel cells produce electricity by converting the chemical energy of a certain fuel. Of all fuel cells currently in existence, hydrogen is the most popular and common fuel. Fuel cells have been used in the past by NASA to power satellites, and are currently being used to supply power to a wide variety of transport vehicles, including automobiles, airplanes, and ships. Hydrogen fuel cells

exhibit multiple benefits, as follows:

- *High throughput*: hydrogen fuel cells exhibit energy efficiency of 40-60%, with maximum theoretical efficiency of 83% (U.S Department of Energy 2011) - which makes them much more efficient than the conventional internal combustion engine (which has around 14-26% energy efficiency) (US Department of Energy, Energy Efficiency and Renewable Energy 2013). In practice, however, the average efficiency of a hydrogen FCV at the NEDC driving conditions (New European Driving Cycle) only reaches between 36% (Helmolt and Eberle 2007) and 52% (Garbak 2010).
- *Easily produced*: hydrogen is produced easily by reformation of natural gas, or by the use of electricity. It is anticipated that hydrogen production will be enabled using energy from renewable fuel sources, including nuclear.
- *Low greenhouse gas emissions*: In the present, hydrogen made from natural gas and used as fuel in a vehicle powered by a fuel cell, produces only about half of greenhouse gas emissions of a gasoline internal combustion vehicle (The National Hydrogen Association 2009).
- *Extremely high reliability and durability*: fuel cells do not contain major moving parts, and do not make use of combusting elements which degrade the engine. They therefore enjoy an extremely high level of reliability (Fuel Cells 2000 2013) and a durability of over 120,000 km with only 10% degradation at most (U.S. Department of Energy 2013).

Under this set of advantages, it should be no surprise that several car companies have announced plans to develop and introduce into the market an FCV in the next couple of years. These companies include Toyota (Squatriglia 2011), Mercedes-Benz (Edmunds.com 2013), Hyundai (Korzeniewski 2012) and General Motors (Priddle 2008) among others. It is not expected, however, that this technology will gain wide-spread popularity in passenger cars in the next 10-20 years (Wald 2009), partly since it requires a large-scale change in infrastructure – at a time when only ~10 hydrogen refuelling stations exist in the USA (Energy 2013).

Hydrogen Production

Hydrogen production deserves special mention due to the unusual processes by which it occurs. While the exact amount is not monitored and therefore difficult to quantify precisely, it has been estimated that in 2004 around 57 million tons of hydrogen were produced, with most of the production coming from processing fossil fuels (Hydrogen Ambassadors 2008). By 2011, approximately 10-11 million tons of hydrogen were produced in the U.S. (Lipman 2011). Half of the globally produced amount is used to produce ammonia which serves as fertilizer, while the other half is being used to process petroleum-based compounds into fuels (Bellona 2002). While the by-products of hydrogen production from fossil fuels can negatively impact the environment, utilizing methods for collection of the polluting particles and of CO2 at central natural gas reformers could supply millions of cars with hydrogen – meaning millions of exhaust-free cars.

While hydrogen production currently depends on fossil fuels, with only 4% coming from electrolysis of water, there is great hope for renewable hydrogen in the future. Hydrogen production by water electrolysis could be cheaper than gasoline, and if renewable energy is being used to power the electrolysis process, then the resulting hydrogen could be considered renewable as well (as the substrate material for the process can be seawater – which is abundant on the Earth).

5.5.2 Biodiesel

Biodiesel has the potential to replace some of the fossil fuels. It is produced from different kinds of sources (Singh and Singh 2010), which include vegetable oil originally produced for human dietary consumption (such as rapeseed, soybean and sunflower oil), non-edible vegetable oil (such as the one produced from algae (Ahmad, et al. 2011)), waste or recycled oil and oil produced from animal waste (chicken fat, fish oil, etc). Currently, over 95% of biodiesel is produced from edible oils. Since biodiesel can be produced from all the above sources, it is a 'safer' alternative to the limited amount of fossil fuels that exist on the Earth today. In addition, biodiesel is easily biodegradable, enjoys minimal toxicity and exhibits a significantly lesser amount of toxic emissions, and can replace ordinary diesel fuel in internal combustion engines (Cetinkaya, et al. 2005). Biodiesel is currently in use in the USA, as well as many European countries. A recent study from 2006 examined the potential of 226 countries to create biodiesel in an affordable and even profitable manner. The results reveal an upper limit worldwide volume potential of 51 billion litres from 119 countries, 47 billion of which could be produced profitably even today (Johnston and Holloway 2006) (according to factors that include production volume, estimated price, corruption in the country, travel safety, and GDP). The five states indicated as the top potential producers are Malaysia, Indonesia, Argentina, the USA and Brazil, followed by the Netherlands, Germany, Philippines, Belgium, and Spain. A massive amount of biodiesel is being produced each day (more than 400,000 barrels per day by 2011 (Administration 2013)), with 44% being produced by the EU-27 states, 13% by Asia & Oceania (with Thailand being top producer in that category, standing at 10,000 barrels per day), and North, Central and South Americas together standing at 41% of world production. The entire Middle East, in comparison, produced only 100 barrels in 2011 – an extremely minor fraction of world production.

Rank	Country	Volume Potential (lts.)	Production Cost ($/lt.)*
1	Malaysia	14,540,000,000	$ 0.53
2	Indonesia	7,595,000,000	$ 0.49
3	Argentina	5,255,000,000	$ 0.62
4	USA	3,212,000,000	$ 0.70
5	Brazil	2,567,000,000	$ 0.62
6	Netherlands	2,496,000,000	$ 0.75
7	Germany	2,024,000,000	$ 0.79
8	Philippines	1,234,000,000	$ 0.53
9	Belgium	1,213,000,000	$ 0.78
10	Spain	1,073,000,000	$ 1.71

Figure 79 - Ten countries with the largest biodiesel production potential. (Johnston and Holloway 2006, 24)

One primary objection raised against the use of biodiesel is based on the fact that production from edible oils increases existing environmental issues as deforestation, and inflicts a heavy toll on food production. Partly as a result, the prices of vegetable oil plans have increased in recent years (Balat 2011). Moreover, the demand of biodiesel far outweighs the means for production. Even if all of the corn and soybean crops were transmuted to biofuel, they would only meet 6% of diesel demand (Hill, et al. 2006). For that reason, many researchers focus on producing biodiesel from biomass that requires less fertilizers, less land to grow on (or land that cannot be used for ordinary agriculture), and less energy to transform the biomass into biodiesel.

Ideas for future sources for biodiesel include desert plants such as the desert date, which grows in many parts of Africa and South Asia (Chapaqain, Yehoshua and Wiesman 2009). Most people do

not like the taste of the fruit of the desert date, and use it as food only when no other option is available (Cook, et al. 1998). In Sudan alone, over four million tons of the fruit are annually produced naturally, and about 5% of the weight consists of oil (Mohamed, Wolf and Spies 2002) that could be extracted and used as bio-diesel.

The desert date serves as a fine example for the capabilities of non-edible plants to serve as bio-diesel. It is only one in a long list of non-edible plants with similar potential. Other plants on the list (as indicated by Atabani & Mekhilef et al) include jatropha or ratanjyote or seemaikattamankku (Jatropha curcas), karanja or honge (Pongamia pinnata), Aleurites moluccana, Pachira glabra nagchampa (Calophyllum inophyllum), rubber seed tree (Hevca brasiliensis), Desert date (Balanites aegyptiaca), Croton megalocarpus, Rice bran, Sea mango (Cerbera odollam), Terminalia belerica, neem (Azadirachta indica), Koroch seed oil (Pongamia glabra vent.), mahua (Madhuca indica and Madhuca longifolia), Tobacco seed (Nicotiana tabacum L.), Chinese tallow, silk cotton tree (Ceiba pentandra), jojoba (Simmondsia chinensis), babassu tree and Euphorbia tirucalli (Atabani, et al. 2011).

While the list above may seem impressing in first reading, oil production from the above plants is not deemed efficient enough to replace oil altogether.

Microalgae are another source for biodiesel. While similarly to plants they harvest the sun's energy via photosynthesis to create biomass, they are much more efficient than traditional crop plants, at least in part since they do not have to support the entire plant macro-structure, but instead can be grown in a bioreactor. Microalgae also enjoy higher growth rates than ordinary plants and high oil content. According to estimations made by (National Renewable Energy Laboratory 1998), oil yield per acre from algae is 200 times the yield of vegetable oil. This is not surprising, seeing as some algae produce up to 50% their weight in oil. Since microalgae are not expected to replace feedstock or areas used for agriculture, it is quite possible that they will become the most likely source to meet global demand for oil. However, the technology for cultivating and upscaling the bioreactors still needs to be upgraded, refined and become more efficient cost-wise (Demirbas 2007).

Last but not least, genetically engineered plants and organisms (GMOs) have the potential to produce a large amount of biodiesel under the most strenuous conditions and at high rates (Janaun and Ellis 2010). However, the EU in particular is facing a trust crisis at present regarding the safety and environmental impact of genetically modified organisms and crops, and it is therefore unlikely that GMOs will be grown in most EU countries.

The European Union is largely regarding biofuels as a useful and necessary energy resource, and is thus the world's largest biodiesel producer. The EU parliament has decreed in 2009 that out of all fuels used in transport, biofuels should constitute at least 10% (World Energy Council 2010) by 2020. The same decree also seeks to achieve a 35% reduction in greenhouse gas emissions by utilizing biofuels, and by 2017 the target is about to rise to 50%. Many EU countries implemented tax reductions and other financial devices and methods in order to support production and/or consumption of biofuels. Among all the countries in the EU, France and Germany in particular exhibit high consumption rates of biofuel because of specific blending laws.

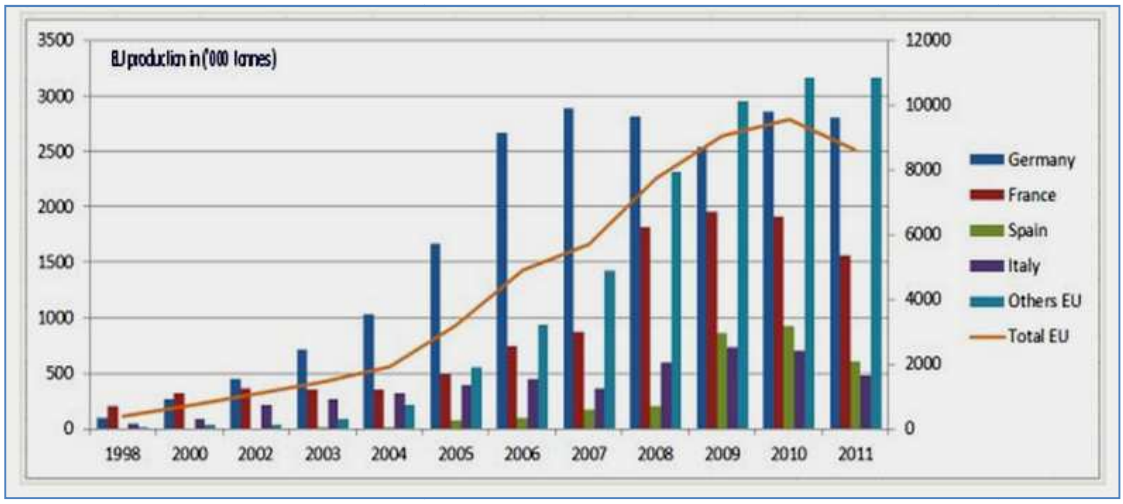


Figure 80 - Biodiesel production by year and leading countries in the EU. (European Biodiesel Board 2013)

How did the EU come to dominate the world market in biodiesel production? In 1992 the Mac-Sharry CAP reform was implemented, under which were established mandatory shares of land for raising non-food plants (EURLUX 1992). By 2005, over 95% of the lands set aside under the reform were dedicated for biofuel crops. The mandatory set aside was suspended in 2009, though, as the potential food shortage and rising prices became evident (Sorda, Banse and Kemfert 2010).
France and Germany, as the most productive countries (biodiesel wise) in the EU, can serve as a fine case study for our needs. In France, biofuel production quotas enjoyed tax rebates of 0.15 euro/litre for biodiesel in 2009, and 0.33 euro/litre in 2005. Evidently, the tax rebates have been reduced over the years, but they have served their initial purpose of setting a firm base for biodiesel production industry in France. Germany has chosen a similar path by eliminating fuel excise tax exemptions since 2007, and replacing them with tax rebates and requirements to meet certain quotas (Kutas, Lindberg and Steenblik 2007).

Future of biodiesel

It is expected that acceptance of Kyoto protocol and similar clean development strategies will lead to more biodiesel production worldwide, and to a larger consumer market. According to Atabani & Mikhelif, the total bio-fuel demand in EU will reach 30.3 million tons by 2020 (Atabani, et al. 2011). While the prospects of biodiesel are promising, it would seem that this type of fuel will only reach significant success if it won't compete with agricultural lands that are used to produce food for human consumption. As the price of vegetables and vegetable oil will rise, so will biodiesel derived from edible crops seem less appetizing, so to speak. It would therefore seem that GMOs and microalgae are the best future sources for biodiesel.

5.5.3 Electric Battery Vehicles

The term 'electric car' is often used by laymen in vain. Electric cars, after all, can be powered using fuel cells (that utilize hydrogen to create electricity). This fact means that we must distinguish between electric cars as a general, and electric cars powered by batteries, which are portable sources of electrical energy.
There are many different kinds of batteries for different vehicles. These include (but are not limited to) nickel iron, sodium sulphur, lithium iron, lead acid and nickel cadmium batteries. (Husain 2003) In all cases, the battery is based on chemical energy that is transmuted into electrical energy –

which the motor uses to produce mechanical energy. All batteries can be recharged, usually by a plug-in cable.
After its heyday in 1900-1910 (Mom 2004), in more recent time electric battery vehicles were originally limited to niche applications, such as electric busses used in the Atlanta Olympics in 1996 (Smart Communities Network 2004) and in the 2008 Beijing Olympics (Beijing 2008 Olympic games 2008), electric garbage trucks, electric tractors etc. However, electric battery passenger cars are relatively new on the scene. There is much hope regarding their impact on the auto industry since they can significantly reduce pollution in cities (owing to the fact that they expel no real greenhouse gas emissions or volatile pollutants). While electricity production in power plants would still have a negative effect on the environment, it is much easier and more efficient to dispose of pollutants and greenhouse gas emissions when they are produced at one place instead of at the tail-end of hundreds of millions of cars.
Should electric battery cars dominate the consumer market, they are expected to significantly reduce CO2 emissions by as much as 30% in the U.S. (U.S. Energy Information Administration 2013) and 40% in the UK (My Electric Car 2012). Battery electric cars are not always cleaner than gasoline cars, at least one study concludes that in certain countries like Germany, the reduction in greenhouse gases would be marginal (1%) at best (Palm 2009), since the German plants that deliver marginal electricity are fuelled by coal – which emits more CO2 than gasoline. This stands in stark contrast to the almost zero-emissions of France's nuclear power plants. The utility of electric battery cars should therefore be considered separately for each country.
The leader in electric battery cars manufacturing is the Renault-Nissan Alliance, which has manufactured and sold nearly 90,000 vehicles since the end of 2010, 43,829 of which were sold in 2012 alone (Crowe 2013).
Despite the success in electric battery car sales, this type of passenger cars still has a long way to go before it is fully integrated in the market, due to several limiting factors:

- Cost: electric cars are much more expensive than traditional vehicles, or even hybrid vehicles (Committee on Assessment of Resource Needs for Fuel Cell and Hydrogen Technologies; National Research Council 2010).
- Infrastructure: There is currently a lack of public / private recharging stations, with only ~6,000 public electric fuelling stations throughout the whole of the U.S. (US Department of Energy 2013)
- Range Anxiety: Current battery electric cars are limited by range, according to the amount of power the battery can contain.

Uncertainty about the Market: The owner of a battery electric car is solely dependent on electric fuelling stations at best, or on battery swapping stations (where a new battery can be swapped for the car's used one in a hurry). In the case of the Israeli electric battery vehicle company Better Place, this meant that once the company has declared bankruptcy, the owners of the cars found themselves at a very real danger of being stranded with a useless vehicle. This uncertainty about the market makes clear why many customers are hesitant of moving on to an electric battery car.

Hybrid Electric / Combustion Engine Cars

There is a large variety of cars making use of a hybrid electric / internal combustion engine. The main feature of such an engine is that it receives power from both sources. The two main categories of hybrids are series hybrid electric cars and parallel hybrid electric cars. In the first type, the internal combustion engine generates power that is transferred to electric motors installed at the wheels. The car controls the amount of power transferred to each wheel, and as a whole gains flexibility regarding driving conditions. This type of hybrid is the most suitable for

driving patterns that involve many stops and starts, such as busses and delivery vehicles. In the second type, parallel hybrid electric cars, both electrical and combustion engine are connected to the mechanical transmission. The power sources work alternately. At times, only the internal combustion engine supplies power to the wheels, with the electrical power source providing a boost when needed. In other vehicles, the electric system may be enough to power the car alone for some time. (Momoh and Omoigui 2009), further distribute hybrid cars by degrees of hybridization.

- Full Hybrid Electric Cars: full hybrid cars can be powered by the combustion engine alone, by the battery alone, or by both at the same time. The battery must therefore have a high capacity. This type includes the Prius model.
- Assist Hybrid Electric Vehicles: these cars may not be run on electric power alone, since the electric motor only serves to assist and boost the combustion engine when needed. In this case, the battery size and capacity can be lower than that used in full hybrids.
- Mild Hybrid Electric Vehicles: these types of vehicles are similar to conventional ones, with the main difference being that the starter motors are oversized, and thus the engine can be turned off when the car is braking or stops in place, and restart easily. The electric motor is essentially used to restore the combustion engine operation before the injection of fuel.

Other types of hybrid electric vehicles include the Plug-In Hybrid Electric Vehicle (PHEV) which is a full electric hybrid capable of recharging itself from the national electricity grid instead of recharging from the combustion engine's operation. These cars can be used for daily urban driving in particular, and only need be dependent on gasoline for longer rides.

5.5.4 Battery Storage and Electromobility

Germany has set itself the goal of becoming the lead market and provider for electric mobility by 2020, and a bold aim of its “National Electromobility Development Plan” is one million electric vehicles on the road by 2020 and possibly reaching 5 million in 2030. In 2009, more than EUR 500 million in R&D funds was set aside to fulfill this goal. In 2011 the Federal Ministry of Economics and Technology (BMWi) and the Federal Ministry of Transport, Building and Urban Development (BMVBS) have upgraded this commitment by a further EUR 1 billion to the end of the current legislative period.

Large budgets are invested in R&D of battery technologies, improved battery integration within the vehicle, energy management in the entire vehicle, appropriate standards as well as production processes. The current focus in battery technology is on second generation lithium-ion technology, towards the development of post-lithium-ion technologies. The near term goal is energy density level of 200 Wh/Kg in 2015, and significant reduction on storage capacity costs.

The German National Plan for Electric Mobility has established six R&D "lighthouse projects" which are already running (each one of them incorporates several specific projects run by different consortia): battery technologies, drive technologies, vehicle integration, lightweight design, recycling and ICT & infrastructure. Notably, the activities in the area of batteries are run by 21 consortia with a total budget of EUR 601 million. The following table shows some selected leading projects in battery technologies (Germany Trade & Invest 2013).

Batteries Lead Technology Areas (selected examples)

Thematic Area	Project	Content
Materials Development & Cell Technology	ALPHA-Lion Lithium Metall E-Lab KoMBat	Development of **3rd and 4th generation cells** using high energy materials **Test facility** for the preparation of coated lithium metal powders designed for optimum processability **Electrolyte laboratory**, high-throughput synthesis (automatic electrolyte analyser) **Carbon materials** for next-generation lithium batteries. Lab-scale materials
Innovative Battery Designs	FutureBatt Lithium/Luft-Bat. KPPP	Research into **next-generation battery systems** (standard pouch cells) Development and production of a **commercially viable lithium-air battery** **Cost-effective** product, process and production development of lithium energy storage devices
Safety & Testing	SafeBatt BALSAC K-LIB	Passive/active measures for creating **safe long-life battery systems** Battery laboratories with **test facilities** for the development and production of energy storage devices Research into **test procedures and standards** for safety assessment
Battery Life Modelling & Analysis	Balanse E-DriveBattery Lastkollektive	**Aging mechanisms** in lithium-ion batteries Smart **control and connection designs** for modular EV battery systems Creation of an **industry specifications document** on the battery life of electric vehicles
Process Technologies for Mass Production	Competence E PEB SSLBa TT-Lion K-LIB NP-LIB CHaR-Li iFaaB	Integrated "**Research Factory**" for future electrical energy storage devices and drive systems **Development centre for battery production technologies** Core process development for **cell production** Processes and facilities for the **production** of thermodynamically stable **thin film solid-state batteries** **High-performance manufacturing** of lithium-ion cells Facility for **research** into and optimisation of lithium-ion cell manufacturing Test facility for **high-performance battery materials** Integrated **manufacturing concept for advanced automotive batteries**

Source: Progress Report of the German National Platform for Electric Mobility (Third Report)

Figure 81 - Examples for battery lead technology areas (Germany Trade & Invest 2013)

Detailed drive and vehicle integration technology roadmaps (see below) were drawn up for projects dealing with highly integrated drive systems (including on-board charging technology), electric motors, and power electronics/inverters, as part of the NPE's second report published in 2011.

Drive Technologies R&D Lighthouse Technology Road Map

	2010	2012	2017/19		2020
Electric Motors	Permanent Fe-based magnets and Cu/Al coils	• Electric motor designs optimized for automotive applications • Alternative magnet materials and recycling • Alternative electric motors	Alternative designs and materials	Innovative materials and manufacturing processes	Costs reduced by 2/3
Power Electronics	Parts and components from non-automotive applications	• Integrated circuit packaging (ICP) modules and components • Research into modularity and scalability • Increased integration (electronics, mechatronics)	Automotive standards achieved, standardized solutions available	Research into increasing functionality and reducing costs as market expands	5% more efficient
Drive Systems	Low level of integration	• New topologies and highly-integrated approaches • Energy and thermal management • Charging technologies and power grid integration	New system designs	Modular electric powertrain kits optimized for different requirements and suitable for large-scale production	Power density doubled
Production Technology	Low production volumes	• Automated production facilities for inverters and electric motors • Concepts for moving from small to large-scale manufacturing	Automated manufacturing solutions capable of flexible output levels	Development & optimization for large-scale production (process engineering and complete chain)	30% more reliable

Source: Progress Report of the German National Platform for Electric Mobility (Third Report)

Figure 82 - Drive technologies R&D Lighthouse technology road map (Germany Trade & Invest 2013)

5.5.5 Eco-oriented Solutions: Solar Roadways and Charge-as-You-Drive Systems

An emerging technology under development, that if matured could become an important enabler (or accelerator) for widespread use of electric cars, is the so-called Solar Roadway: a series of

structurally-engineered solar panels that are driven upon. The idea is to replace the current asphalt roads with solar road panels that will collect and store energy and supply it to the electricity grid. Additional benefits are that the solar road panels can self-heat for snow and ice removal in cold climates, thus enhancing safety. The Solar Roadway, if realized, could make all-electric vehicles much more practical, because recharging stations could be placed in along the road, with no dependence on the existing conventional electricity grid (Solar Roadways 2013). An even more significant impact could be the possibility (currently under investigation) to use mutual induction to charge the batteries of electric vehicles while they are driving down the Solar Roadway (Kulkarni 2013).
Naturally, wireless charge-as-you-drive systems could revolutionize electric vehicles even if based on the conventional electric grid (without solar roadways). Research is underway in this direction. Researchers at Stanford University have recently designed a high-efficiency charging system that uses magnetic fields to wirelessly transmit large electric currents between metal coils placed several feet apart, based on a technology called magnetic resonance coupling. The long-term goal is to develop an all-electric highway that wirelessly charges cars and trucks as they cruise down the road. In fact, with this technology the battery could have more energy at the end of the trip than in the beginning (Shwartz 2012). Obviously, such technologies have the potential to dramatically increase the driving range of electric vehicles.

5.5.6 Possible Futures for Alternative Fuel Technologies

In this section we will compare between the results obtained in previous foresight studies regarding the future of transport technologies and the viability of several alternatives to fossil fuels.

MIT - On the Road in 2035

In 2008 a team of MIT researchers published the results of a research program meant to assess the technology of light-duty vehicles and fuels that may be developed and introduced into the market by 2035. The report – On the Road in 2035 – was a successor to the original report produced in 2000. The researchers analysed new vehicles and fuel technologies according to certain factors such as performance, cost and life-cycle emissions. Additional factors regarding production included development and manufacturing time, and possibility of replacing current vehicles and fuels (Bandivadekar, et al. 2008).
The team's conclusion is that a reduction of up to 50% in fuel consumption is feasible by 2035. In the early years, most of the improvement will stem from improvement in conventional engine production and transmission, as well as developments in materials science and technology that will reduce the weight of the vehicle and the drag it experiences. However, these same factors are likely to bring a slight increase in the cost of the vehicle. It should be noted that the report deals mainly with the US, while in Western Europe many efficiency gains have already been assimilated in vehicles, and thus have a lesser potential for the future (Contestabile, et al. 2011).
In the long term the researchers predict that hydrogen fuel cells in particular may become assimilated into vehicles and make a significant impact on fuel use. Plug-in hybrids (PHEV – hybrid vehicle with batteries that can be fully recharged by plugging a cord to an external power source) would also enter the market in large numbers.

NHA – The Energy Evolution: An Analysis of Alternative Vehicles and Fuels to 2100

A detailed analysis of alternative vehicles and fuels up to the year 2100 has been issued in 2009 by the US National Hydrogen Association (NHA). While the affiliation of the authors suggests a strong

bias towards hydrogen and fuel cells technology, the report has been independently reviewed by the US Department of Defence, which lends it some credibility. The results of the study support those of the above MIT study and indicate that only rechargeable battery electric (BEV – battery electric vehicle) and vehicles operating on hydrogen fuel cell (FCV – fuel cell vehicles) meet multiple demands: energy security, air quality and greenhouse gas emission reduction. In general, FCVs are expected to also exhibit better performance on the road, owing to their low weight in comparison to BEVs (The National Hydrogen Association 2009).
A hypothetical scenario which depicts FCVs dominating the American market is described as the "best scenario for America", owing to the fact that it will cut current greenhouse gas emissions by 80%, allow the USA to reach petroleum energy quasi-independence by 2050, and eliminate nearly all urban air pollution by 2100. The costs of adding hydrogen pumps to gasoline stations are estimated at 9 billion dollars. By 2023, though, revenues should have paid back the entire investment. And perhaps most importantly, all the hydrogen needed as fuel can be produced domestically – a fact that will have major geopolitical impact, should this scenario come into being.

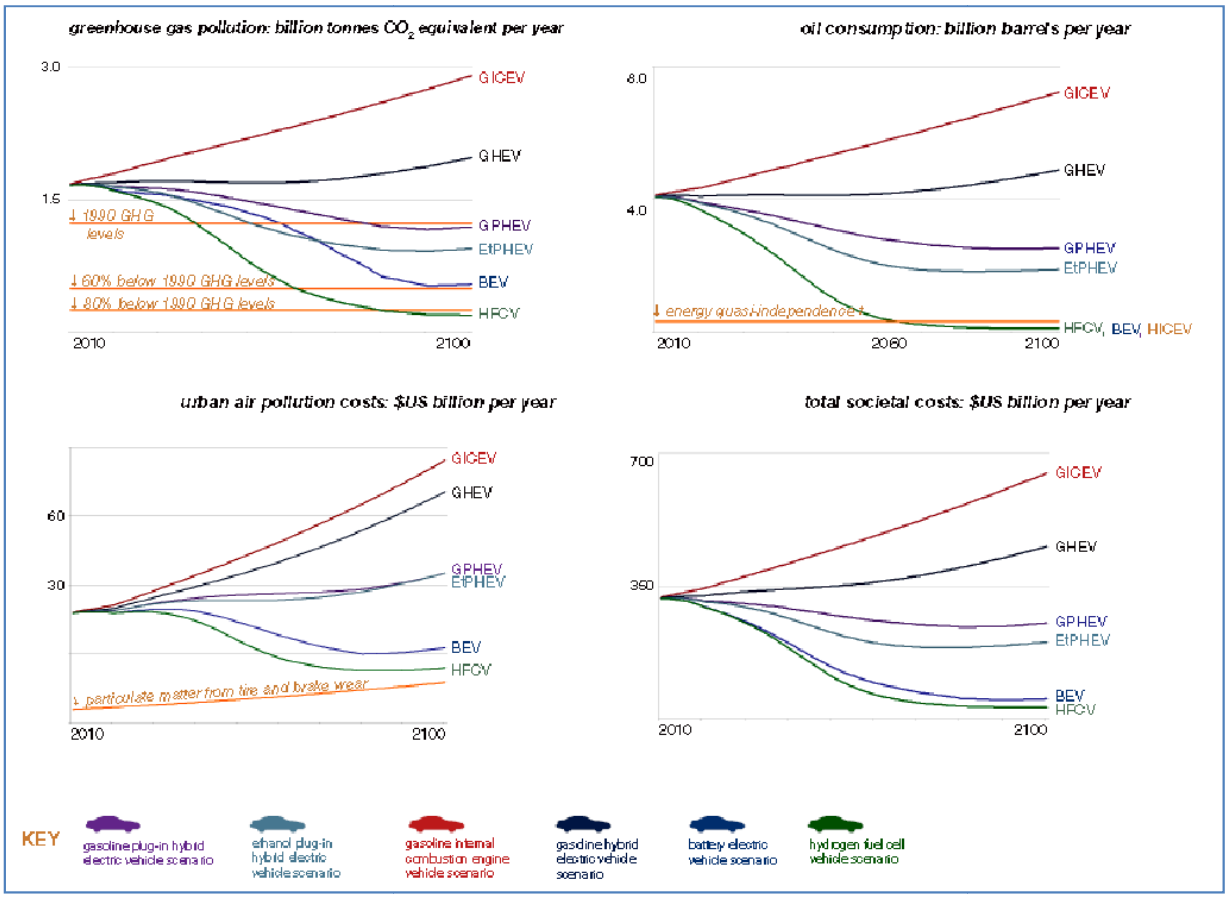


Figure 83 - Comparison of the consequences of different vehicle types dominating the market. The results clearly show that hydrogen fuel cell vehicles 'win the race' in all four categories. The results were computed, incidentally, by the US National Hydrogen Association. (The National Hydrogen Association 2009, 2)

The Great Compression: the Future of the Hydrogen Economy

In contradiction to the previous report, Lux Research has released in 2013 a new report detailing the hurdles and barriers that stand in the way of the hydrogen FCV (Lux Research 2013). Their main assertions were:

- Only 33% of the price of hydrogen for the customer will be due to the production cost of the element, while the rest will be due to the costs involved in compressing, storing, and

distributing the hydrogen. These areas are therefore most open for technological innovation.

- Mobile fuel cells of the type of proton exchange membrane (PEM) will have a market of 2 billion dollars in 2030, mainly of forklifts and light-duty vehicles.
- The complex and costly infrastructure required to store and provide hydrogen to passenger cars is the most difficult barrier to overcome before the technology becomes fit for use in passenger cars.

International Energy Agency – Transport, Energy and CO2

In the year 2009, the International Energy Agency (IHA) produced a report that covers the entire transport sector, with a special focus on energy and greenhouse gas emissions. The study is based on a model that transforms historical data into projections for the future up to 2050. The results imply that new cars manufactured worldwide could benefit from an effective reduction in fuel use of up to 30% by 2020, and 50% by 2030. The authors suggest that this reduction could occur by aggressively introducing into the market technologies for saving fuel, and utilizing hybridization. However, since passenger cars are expected to become more abundant by that time, the overall fuel use will remain at present levels. This means that in order to become even more efficient, alternative fuels and vehicles (plug-in electric vehicles, battery electric vehicles, hydrogen fuel cells and biofuels) must take part in a thriving transport market. According to the study, the cost of the technologies and their massive introduction into society and the market constitutes a major barrier for all of them in the short and medium term. There is currently no way to discern which of the above alternative technologies will control the market, or even succeed in the economy of the future. The researchers offer a few important pieces of advice regarding the future:

- It is believed that biodiesel will be needed specifically for aviation, and will see much less frequent use in private road transport.
- Hydrogen fuel cells are a disruptive technology, meaning they are likely to encounter higher barriers than electric cars.
- Due to the last point, the authors believe that electric cars are more likely to 'win the race' into the future in the long term, and become an essential part of the transport industry.

The study shows in particular that the only way to meet global sustainability goals is to aggressively introduce alternative fuel sources into the market, particularly in the private passenger car sector (International Energy Agency 2009).

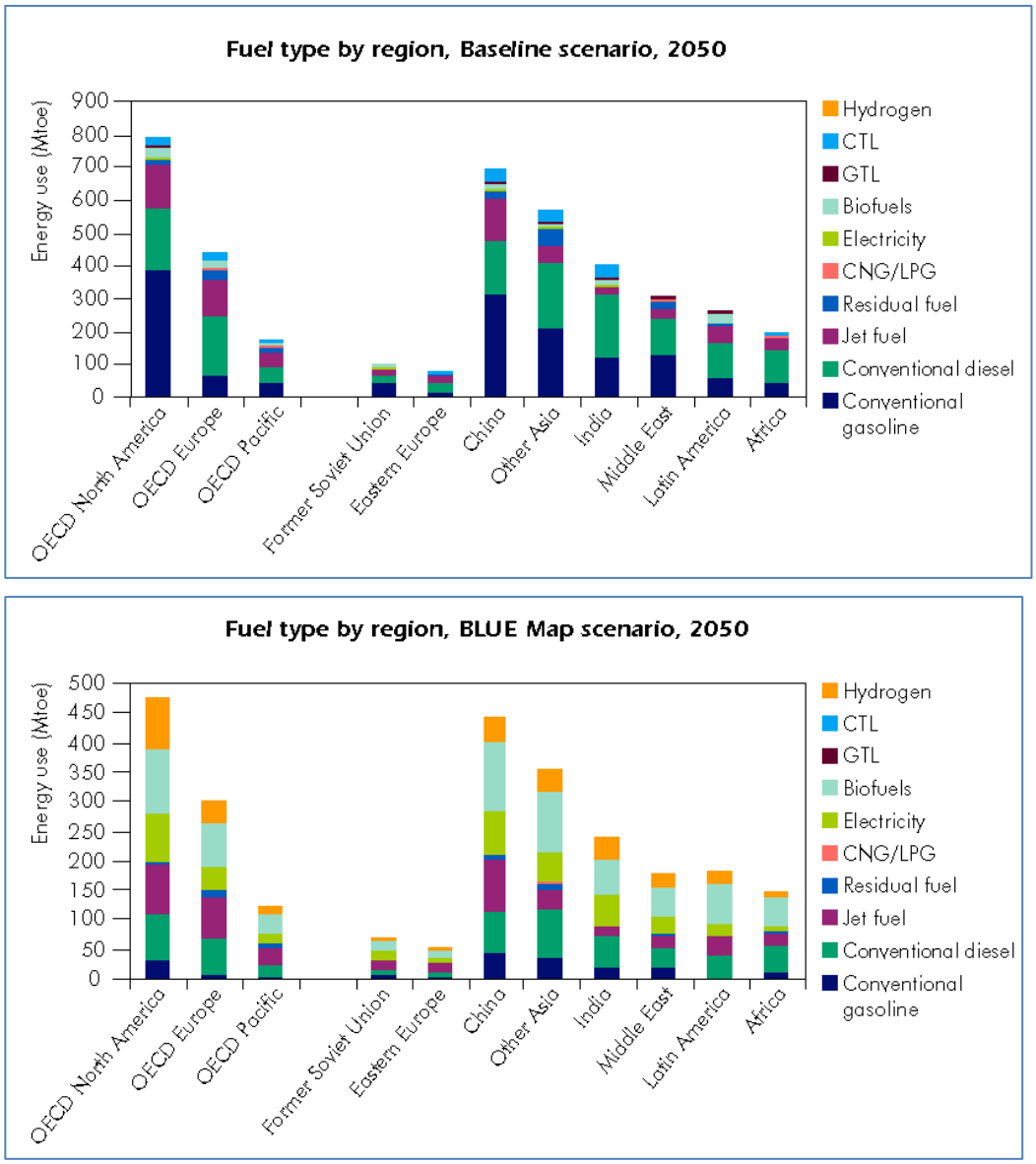


Figure 84 - Fuel types by region, in the year 2050. The topmost graph depicts a baseline scenario, in which CO_2 emissions are not specifically constrained, meaning only minor shifting to non-fossil fuels. In the blue map scenario, strong efficient improvements are envisaged, with a switch towards biofuels, electricity and hydrogen powered vehicles. (International Energy Agency 2009, 74-75)

The EU Perspective

According to the roadmap charted in 2008 for a hydrogen future of Europe in the course of the HyWays project, Europe will need a portfolio of hydrogen energy chains. The stakeholders involved in the project believe that in the early stages of the hydrogen economy (up to 2020), hydrogen production will depend mainly on electrolysis and other processes in which hydrogen is a by-product. However, by 2050 the production methods are expected to become more varied, and include hydrogen production from renewable sources and sources with low greenhouse gas emissions.

In order to reach the above vision of efficient hydrogen production and usage, substantial investment in R&D is required, as well as policy support, since environmental and transport ministries in Europe generally do not place their faith (or, more importantly, their funds) in hydrogen (HyWays 2008).

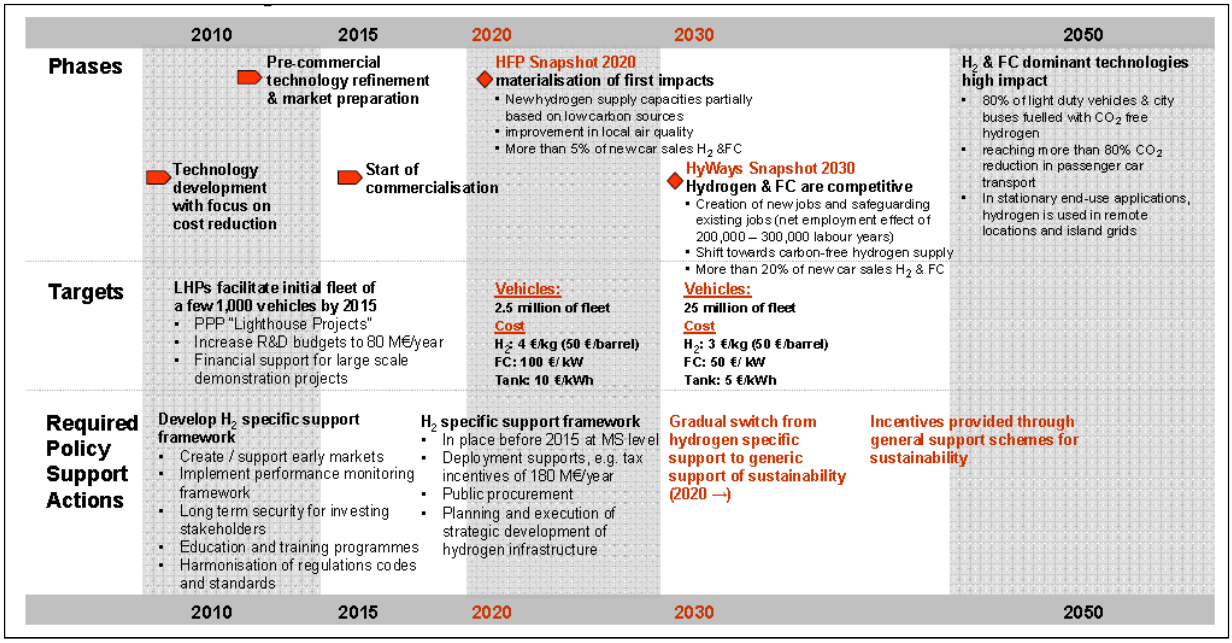


Figure 84 - Summary of the deployment phases targets and main actions for assimilation of hydrogen vehicles into the European market. (HyWays 2008, 4)

Electric vehicles are expected to be operated mainly in urban areas. This fact is paramount when considering their emergence in the European market, since 68% of the EU population (including the associated states) live in urban areas, and 17% of all vehicles are purchased by public administration in the EU (ERTRAC; EPoSS; SmartGrids 2012). It would therefore seem that a large part of the population in the EU is ready for electric cars. Accordingly, model regions were erected in Germany and Austria, and infrastructure was installed for EV use in those areas.
In Portugal, electric vehicles were promoted by public figures and the relevant infrastructure was installed along main highways, as part of the MOBI.E (National Electric Mobility Network) project. In Spain, incentives are offered to buyers of electric vehicles, and support is being given to within the MOVELE project to fund infrastructure (Movele 2013). In France, AutoLib is operating a car sharing project in Paris, with plans for a few thousands vehicles to be spread among more than a thousand stations. In the Netherlands, many operators have installed thousands of charging stations across the country, which can be used with a single authentication card (ERTRAC; EPoSS; SmartGrids 2012). An overview of general EU projects that focus on electric vehicles includes SmartCEM, which takes place in Newcastle, Turin, Barcelona, San Sebastian and Gipuzkoa region. Under SmartCEM, electric vehicle services are provided, along with charging stations and car sharing. Three other projects deal with deployment in Barcelona, Berlin and Turin (Molecules), Bristol, Vitoria-Pamplona, Ljubljana-Maribor (ICT 4 EVEU) and Portugal, Ireland, Galicia-ES and Amsterdam (MOBI.Europe). The insights and results of the above projects are analyzed by the European project Green eMotion (eMotion 2013).
While it is yet unclear exactly which direction Europe is heading, it is safe to say that demand for electric cars will increase owing to the widespread promotion of the vehicles by EU-funded projects.

5.5.7 Concluding remarks

At the moment, the world is highly dependent on fossil oil, with the transport sector demanding an increasingly large fraction of the annual production. There are no signs of the demand for oil

being diminished in the near future. On the contrary: the demand for energy is only expected to grow in the next few decades, with 75% of the increase in demand being related to the transport sector. As a resource of limited amount and geographical distribution, the price of oil tends to fluctuate sharply between decades, and sometimes between months. It is therefore clear why we must find alternatives for fossil oil, or at the very least to develop mechanisms to limit its consumption. A wide variety of transport technologies has been developed as a counter to oil scarcity. These include:

1 Hydrogen fuel cells, that utilize hydrogen gas as a chemical fuel and produce the electricity needed to power the vehicle.
2 Electric batteries, that can be recharged either by an electric plug-in into the electricity grid, or by an internal combustion engine in the same vehicle.
3 Biodiesel and other types of biofuels that can be produced from edible and non-edible crops, from microalgae, from recycled oil and from animal tissues and waste.

It is as yet unclear which technology, if any, will rise to dominate the future markets. Various reports that attempt to analyse the efficiency of each technology raise contradictory points, with some indicating hydrogen fuel cells as the best alternative fuel for the future, while others refute that claim and posit that electric and biofuel–powered cars will have a better chance to take over future market due to the less intensive infrastructural change that they require.
Most reports agree that in the near decades electric vehicles have the best chance to serve as the passenger car of choice in the consumer market. Other markets, and particularly aviation, will still require the use of fossil oils, which might be replaced by the use of biodiesel. Regardless of the contradictory outlooks, it is clear that a large amount of work, research and development is focused on ridding the world of its reliance on fossil fuel.

6 Integration, customization and internationalization

Abstract of the chapter
Globally, concerning integration, customisation and internationalisation the transport industry is facing three trends.
1. While out-sourcing and de-localisation of the supply chain will receive further development, some EU production clusters are showing a strong resilience, and they are truly competitive in the global market. This can lead to more internationalised production system, in which some EU segments can offer first-class products with cutting-edge technological innovations. Vertical and horizontal integration, alliance and joint ventures are expected to remain one way to face a more internationalised market.
2. The traditional borders among transport sub-sectors are crumbling, and more and more companies are developing new initiatives well beyond their core business. The race to offer end-to-end travel service is already open and many companies are stepping in. This is pushing, for instance, Deutsche Bahn to have in its portfolio car and bike-sharing, Daimler is involved in car pooling and car sharing, while Bombardier produces electric buses.
3. In mature economies motor-vehicles ownership is declining, especially among young generation. In such a new market landscape, the industries are already developing new offers and new ideas to meet customers' requests. The ability to cope to this rising trend can be useful also in emerging (and urbanised) economies, where space, energy and pollution issues can force to a limited access to car ownership (as currently in several Chinese cities).

6.1 Breaking borders. Competition and integration in the transport industry

Abstract
While traditional vertical and horizontal integration are still on the agenda of the transport industry, new forms of competition and integration have been detected. Globally, the whole transport demand will grow, and further international alliances (or consolidations) will be required in order to cope with the economies of scale and scope requested by this new market outline. Still, relevant differences occur between mature and emerging economies: generally speaking, the latter are showing a growing demand for motorized mobility and vehicle ownership, while the first are declining markets.
Transport companies (both manufacturing and services ones) are not just developing their core business, but are offering a wider range of services, implementing innovating forms of collaboration, and breaking the traditional bounders among sub-sectors. Infrastructural constraints, environmental concerns and energy costs are (and, presumably, will be) the driving factors of this process.

The globalisation of the industry is steaming ahead. We have seen in the previous chapters how a globalised supply chain is feeding the final OEMs assembling plants in any brunch of the transport industry. It is expected to have a further internationalisation of this process, due to the economies so generated (WEF 2013b). However, the situation is less crystalline than it appears. All the transport industry sectors have been reported a strong geographical proximity between final assembly and sale market, thus further favouring delocalisation. But, on the other way around, long-life industrial clusters in mature economies show a relevant resilience despite the current globalisation. Additionally, several economic and non-economic factors impede a complete outsourcing overseas (Stanford 2010)**.** This will be further challenged by the arrival of not-EU OEMs on the global market. Chinese rail manufacturers or MENA airlines, just to give two examples, are already putting under pressure their EU peers, and the industry picture frame will be more and more crowded in the incoming years.
The above elements are pushing towards a greater consolidation of the EU industry, mainly in order to minimise cost and maximise results. However, if larger economies of scale are request to cope with larger markets, innovative forms of cooperation and novel business models are demanded in order to share opportunities and risk and to meet new demands.
The consolidation and alliance process can assume thus different forms. We can observe, in the rail industry, OEMs becoming suppliers of other OEMS; in the automotive, we have joint ventures limited to a particular production or research, associated – or not – with a more strategic alliance. The latter is a trend under development in the shipping industry and among the aviation operators. The manufacturing industry is further implementing ´Risk and Revenue Sharing Partnerships´, which are gaining an increased relevance, especially among OEMs and 1st tier suppliers in all the sub-sectors (see chapter 3 and 4 of this report for a more detailed description).
A less recurrent, but, nevertheless, relevant challenge is the need of higher integration of different transport services and modes to respond to a comprehensive mobility demand by users. The idea of a seamless journey, which reduces the changes of mode, shrinks the time-budget necessary for a given trip, while offers a greater comfort and reliable performance, which is naturally the desire

of any traveller. Time-table coordination (able to conjugate different transport modes and operators), information desks, information displays have been the first steps towards such a target. Naturally, the trend to a smoother travel found formidable barriers in the lack of coordination among different systems, also due to the lack of incentives of many operators (Mees 2010). National borders, languages hurdles (out of the domestic market) and other framework conditions offered further challenges.
However, ICT development, inter- and intra-modal competition made possible – both on the technological and business sides – to have better results and less fragmented journeys. In this vein, passengers' awareness about the constraint of their time-budget and energy concerns provided a pushing factor to achieve such a goal. Indeed, the issue of a smoother journey and a greater attention to customers' satisfaction became in the past decade more and more present in the political, social and economic debate (WEF 2013a).
Such coordination among modes and companies has been often implemented by public agencies, sometimes with excellent results, but often the coordinating bodies were not able (or truly interested) in developing a fruitful coordination (Mees 2010, esp. chapter 9). Naturally, the market forces are also developing products concerning this niche, starting to offer more and more door-to-door information and, eventually, services. According to the first-mover advantage concept, the first operator able to offer those services, gain a dominant position. The role of start-ups and peer-to-peer no-profit association in this innovative market is very relevant, comparable for the ICT industry.
All together, however, the boundaries among the players are less certain and more blurry. Today Deutsche Bahn offers Bike-sharing service; Bombardier is selling its electric bus; many expect to have in 2020 driver-less cars branded as Google vehicles; Daimler is involved in Carpooling.com, a society involved in peer-to-peer pay-for-pooling service; and Easyjet offers car rental on its website. The automotive industry seems to be leading this process. The OEMs and the researches point out how the motor-vehicles manufacturers are re-thinking, strategically, their missions and their business. As reported by a German study,

> *Conventional notions of the role of the traditional OEM within the automotive industry value chain are slowly but surely being consigned to the past. The classic OEM business model – with its dependence on turnover generated from new vehicle sales – is undergoing a major paradigm shift as value creation returns continue to fall. Not only is the modern driver more discerning in his or her auto-purchasing behaviour, but heightened buyer expectations have created a market in which there is a car for every consumer. As a result, OEMs have found themselves caught up in a "crowding-out" cycle where ever more and better technological features are required to stay ahead of a congested international market.* (Germany Trade & Invest 2012, 6)

Surely many companies are still mainly interested in their core business, but a larger number of firms are breaking boundaries, stepping in other segments (and new markets), acting with innovative business solutions. In other word the industry is entering in a stage characterized by a "holistic" approach concerning mobility, in which the hurdles among transport sectors are weak or vanishing (WEF 2013a).

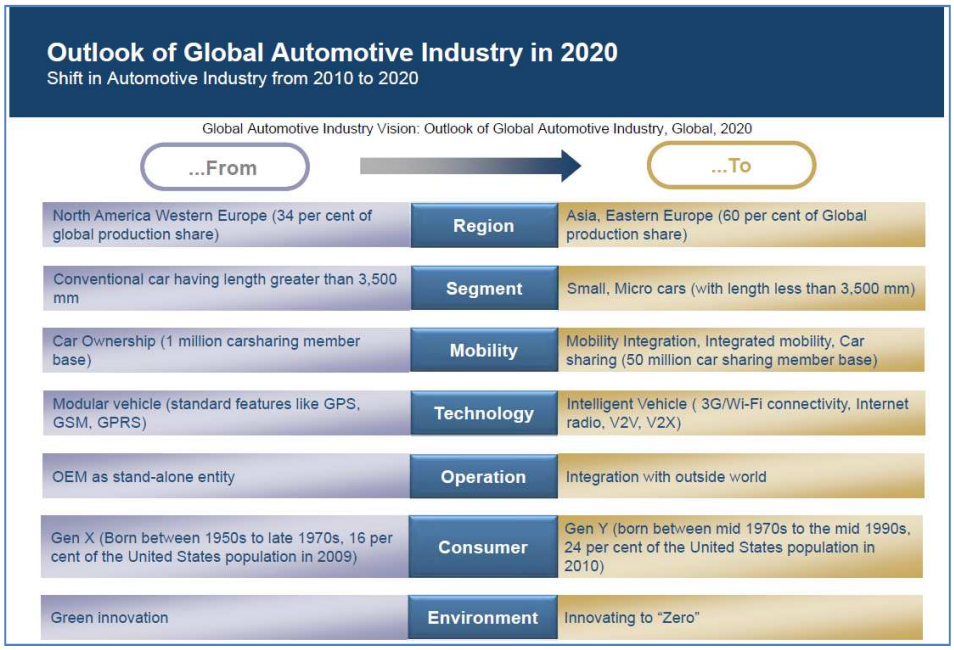


Figure 85 – Outlook of Global Automotive Industry in 2020 - (Forum automobile and society 2012, 16)

The tendency to cover a multitude of sectors and sub-sectors is not completely new. In 1930s Fiat advertised itself as a "Terra Mare Cielo" [Land Sea Sky] company, considering how Fiat was involved in cars, trains, ship and aircrafts manufacturing, covering thus all the transport segments, not to mention that FIAT owned several bus companies, built own and operated a motorway, and had its own car insurance company as well as a financial branch for car leasing (Castronovo 1999). And beside Ford Company vertical and horizontal integration (Bonin, et al. 2003) in the 1930s several European national public-owned railways companies developed road freight transport branches.

The question we should address is therefore which are the real novelties of today industry and market trends (compared to the past), and how such a process will impact the EU transport industry.

Two main factors can be detected. One is the role of ICT in supporting and catalysing this trend. ICT is catalysing this process, offering innovative tools that facilitate such a trend. And, actually, some mega ICT companies, like Google, are taking advantage of this and are developing economies of scale, as in the case of Google map, exploited for driver-less vehicles (The Economist 2013).

The other is the need to better use the existing infrastructure and device, and this due to money- and time-budget constraints, as well as energy, pollution and infrastructural worries. The core of this integrated passenger transport is presented in three clusters as follows:

- *Inter-modality concepts combine the strengths of different transport modes to increase flexibility and efficiency without compromising reliability and comfort. Research focuses on aspects such as barriers to interconnectivity of transport networks, integrated transport planning, physical integration of infrastructure and services.*
- *Integrated passenger information focuses on smart solutions to meet information needs of passengers before and during multimodal journeys, such as schedules, trip planning, and ticketing across transport modes.*
- *Platforms for intermodal coordination support coordination of transport operators and terminal managers in providing integrated transport services. Research covers information*

platforms, interoperability of information and ticketing systems, and standards for physical interoperability. (Transport-research.info 2013, 31)

The above targets are not only business opportunities, but also a highly requested in order to increase the efficiency of the overall transport services. Efficiency here has to be understood as energy reduction, environmental concern and as better exploitation of already existing transport systems. Thus, "since demand for passenger transport is expected to increase further in the coming decades, more efficient use of existing capacity is vital in maintaining the performance of passenger transport sector. This requires better connection between transport modes and better use of each mode's comparative advantage. Integrating and combining transport modes based on their comparative advantages enables more efficient use of the transport system as a whole and offers a wider range of alternatives in passenger transport" (Transport-research.info 2013, 30).
Such a situation has been seen as a great opportunity for many companies, a situation that can lead to a completely new industry panorama. For instance, the rail manufacturing industry, aims to move from selling just products to selling services, as happened for other sectors: "In other infrastructure sectors such as telecommunication, differentiation can in an extreme even lead to switching from selling assets to becoming a service provider, offering accessibility as a service to the previously sold assets" (UNIFE 2010, 102).
For instance, one first step to differentiate the business has been the development of after-market business. Far from being an absolute novelty, after-market services are becoming more relevant in the manufacturing industry. The tendency of transport service industry to outsourcing several services facilitated a growing relevance for the OEMs to develop after-market deal, mainly devoted to maintenance, repair and overhaul (MRO), but which can be extended to long- and short-term leasing. This is affecting all the transport sectors, including the private motor-vehicles MRO, traditionally managed by a multitude of pulverised small repair workshops, which are nowadays more and more linked in networks, often controlled by OEMs.
European chains of motor-cars mechanic repairs – as Motaquip and Eurorepar – are a sign of networking and/or consolidation of once highly fragmented market, with the growing presence of automotive OEMs, like PSA. As reported by IATA, aircraft OEMs are more and more involved in MRO for the airlines buying their products, and Lufthansa´s most strong sector is its MRO service, which is offered to a larger pool of airlines (IATA 2011). Similar trends are experienced in the rail industry too. Again, this is not a completely new observable fact, being in the past the producers involved in the MRO of the devices they produced. But the scale of this involvement seems greater, as the will of the OEMs to consolidate this (profitable) sub-market.

6.2 Post-ownership society. Selling services not devices?

Abstract
In mature economies, the younger generations display a greater interest in shared-economy, while new attitudes induce decreasing ownership of private vehicles. Time-budget and/or money-budget constraints are leading the new mobility behaviours, and forcing the industry to implement new partnership, joint ventures and other form of collaboration able to match those changed demands. Generally speaking, the transport industry landscape keeps its traditional core business, but it is quickly shifting to new concepts, from vehicle ownership to integrated mobility services.
This new approach could have relevant outcomes also in emerging countries, where the urbanisation process and the density of city (plus energy and pollution factors) could discourage mass motorisation and develop post-ownership attitudes.

As a general trend, mature economies´ society is shifting to shared economies, at least in some service and products. This tendency is more evident in young generations, or so-called "Generation Y", and car ownership is highly affected by new attitudes and new behaviors (Deloitte 2012b).
In a broader perspective (and as already sketched in chapter 4 of this report, as well as in RECE2050 Deliverable 5.1), "near the end of the 1975-2010 period, most advanced economies experienced a slowdown in the relationship between income growth and vehicle ownership expansion. This does not mean that ´saturation´ levels of ownership (meaning that further income growth would not translate into higher ownership rates) have been reached, but it is highly plausible that further income growth will have ever more limited impacts on the expansion of the stock" (ITF 2012, 29).

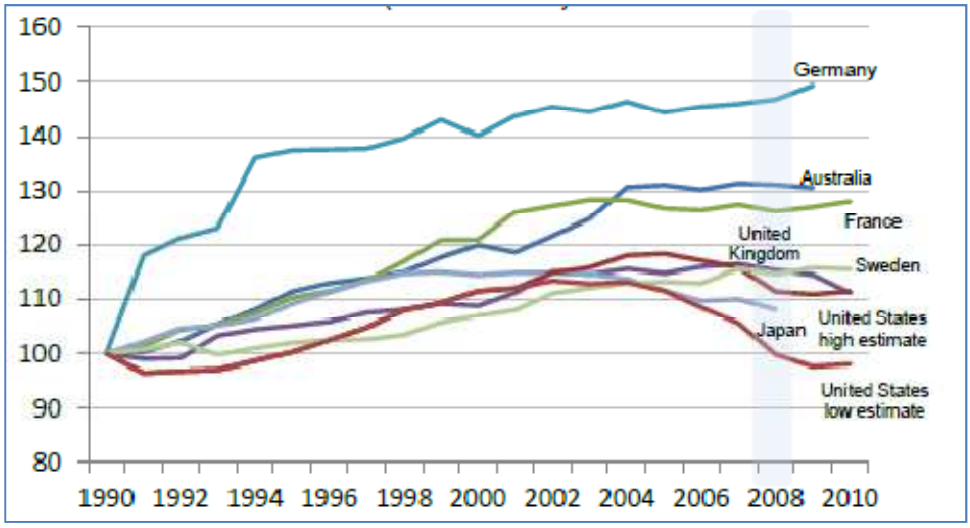


Figure 86 – Pkm by private car and light truck 1970-2010 - (ITF 2012, 44)

Therefore, it has been envisioned that

> *the consumer of 2020 is more likely to be interested in flexible access to different types of transport. Primary ownership profiles are likely to shift to the small luxury segment in line with ´median needs´ (primary daily needs). Bundled in the price would be scalable access to additional vehicles. Lifestyle changes will allow access to luxury or larger vehicles during*

> *weekends, as an example, while a small, efficient vehicle will suffice for daily commuting needs. This model would impact the aggregate production profile for vehicle segments. The other part of this equation is the integration of multiple modes of transport. The emergence of "mega cities" and the growth in public and alternative transport options will be a key influencer to changing lifestyles. This will necessitate the creation of a seamless mobility experience between automobiles and these alternatives.* (IBM 2008, 5)

The above is leading automotive OEMs to rethink their strategy and to improve their ability to cope with highly differenced geographical and social sub-markets. A successful OEM is expected to quickly understand the clientele segments and sub-segments needs, to offer a wide array of solution, which can range from motor-vehicles sale to motor-vehicles leasing, from car-sharing to car-rental. We are thus witnessing a further shift from product-focused to customer-focused enterprise, in which selling devices is only a part of the business. The automotive industry has also further developed its attention to user-involvement, participatory design, developing now a relevant care to end-to-end mobility services.

In order to cope with such a novel landscape, new business models encompassing everything "from enhanced services to leasing and mobility service provision are taking root and providing new market opportunities as [automotive] OEMs seek to reinvent themselves in a changing mobile market. Significant potential exists for OEMs and suppliers to engage with the following auto market trends" (Germany Trade & Invest 2012, 6). The core concept here is that, while car ownership is losing appeal, on the other way around "most consumers don't want to give up access to vehicles". This means the "automakers are challenged to bundle the right mix of cars and other transport modes into compelling, integrated new offerings." (IBM 2011)

Some EU OEMs are making big efforts to cope with these segmented markets. Daimler Financial Services, for instance, "plays a major role in supporting our vehicle sales by offering customized financial services for everything related to automobiles. The comprehensive range of financing, leasing, insurance, fleet management, banking and mobility services makes it easier for private and commercial customers to enter the world of our premium automobiles, and also ensures long-term customer loyalty to our brands around the globe" (Daimler 2013, 56). Additionally, Daimler is developing, with Europcar (the car rental company), *car2go*, a car-sharing company, with a fleet of premium electric-vehicles. And, keeping our focus on Daimler, such a company is involved in carpooling.com[6] (a European on-line peer-to-peer pay-to-use car pooling system), in CharterWay (a platform for freight transport, including second hand sales and after-market services), in Bus Rapid Transit (BRT), while through *car2go* mobile application, any customer can obtain a car in a sharing mode, but also call a taxi (Daimler 2013, 40).

Such a strategy seems to be counter-productive: if I can use car-sharing, or call a taxi, I have less reasons to buy a car; evidently, such an offer fits on the above "the right mix of cars and other transport modes", and thus in the on-going rush to get a solid position in the market for "new features relating to connected vehicles and mobility services requires extensive internal transformation across an automaker's operations".

As reported by IBM 2011 research,

> *To be effective, profitable and efficient, automakers should consider some key factors:*
> • *Demand for inter-changeability of vehicles and mobility services could push automakers to*

[6] It is particularly interesting the interest of OEMs in peer-to-peer services. Carpooling.com is just one example, but peer-to-peer car-sharing is expected to boom in the next years (Frost & Sullivan 2012), creating a parallel market to the traditional car-sharing companies.

expand or potentially rationalize their product lines to respond to new demand patterns.
• The supply chain may need to adjust its manufacturing and distribution strategy to accommodate potentially different demand profiles for vehicles involved in mobility services.
• Captive finance organizations may need to expand their wholesale business to accommodate mobility vehicles and to enable transaction processing capabilities.
• Aspects of the retail model will change as well to develop more relationship-based selling and to intrigue customers with the full product line.
• Elevating alliance management as a critical organizational competency may be necessary to effectively manage new partnerships and extensions of the value chain, particularly as consumer interaction outside the vehicle increases. (IBM 2011)

Naturally, Daimler is only one of the OEMs active in the car-sharing scheme. Quicar by Volkswagen, DriveNow by BMW, Multiycity by PSA and Renault-Way (just to mention some) can be counted as similar initiatives, which can be run in alliance with car-rental firms (ad for Daimler and BMW), or independently.

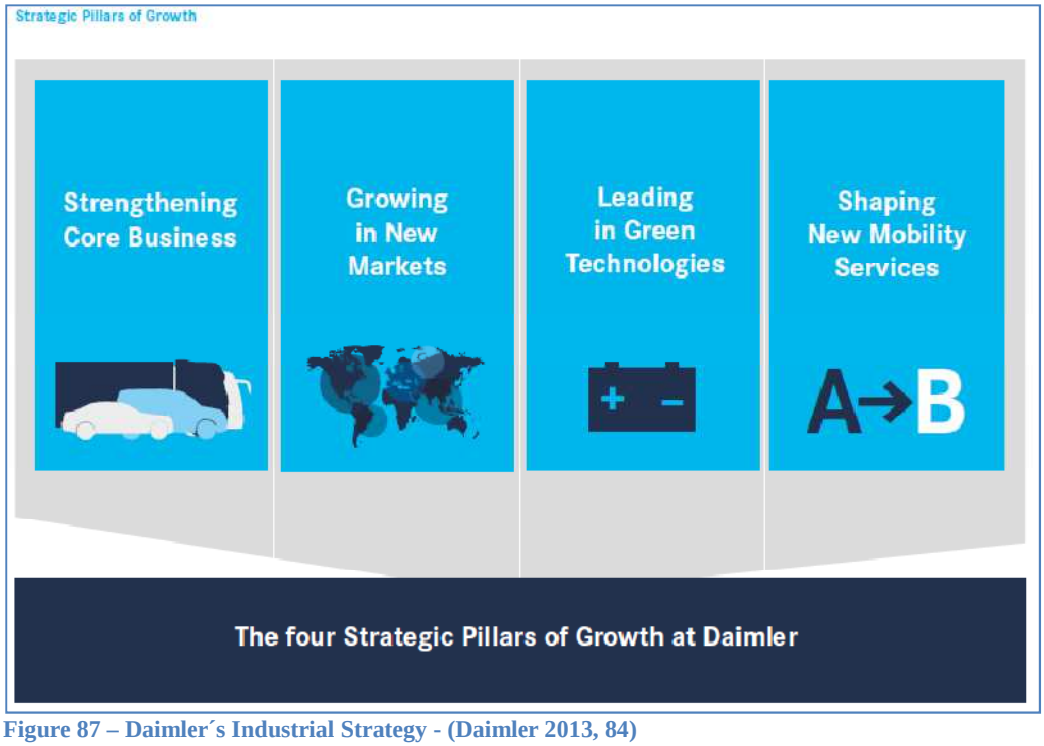


Figure 87 – Daimler´s Industrial Strategy - (Daimler 2013, 84)

Said so, what seems to be an automotive problem limited to mature economies is, actually, a worldwide question concerning all the transport sectors. Surely, car manufacturers are in the most vulnerable trench, and "auto industry companies are determining how to stake their claim in emerging mobility services business models. As congestion, population growth and pollution issues push consumers to consider the limitations of vehicles" (IBM 2011). But indeed not only motor-vehicles producers, but all the transport operators are involved in these new trends. As seen above, airlines and railways operators, car-sharing and car-rental firms, urban transit suppliers and logistic operators are broadening their horizons and moving to a more differenced offer. The shrinking car ownership is a relevant element, and once associated to flexible, supple and personalize travel scheme (supported by ICT) is generating new travel attitude and thus is re-shaping the transport market. So, while Daimler developed *Moovel* as an end-to-end personal

travel manager (Daimler 2013, 85), Deutsche Bahn has its *Fahrplanservices* (travel planner service) application.
As reported by Sixt Annual Report 2012, "the company offers its customers tailor-made products that provide mobility of a few minutes to several years", stressing how the mobility market can largely vary according to "a modern and comprehensive concept of mobility" (Sixt 2013, 26).
To some extent, motor-vehicles premium OEMs and their allied car rental companies are still taking advantage of the car allure, giving to the customers "a high-quality alternative to owning and maintaining a vehicle. They can rent attractive BMW and MINI models at short notice and simply park them at their destination". In addition, those vehicles are "BMW's especially fuel-efficient Efficient-Dynamics engines", e.g. with low consume.
While car ownership decline can be a consequence of new social attitude, in emerging economies the momentum for the automotive industry is still to be achieved. However, the inner contradiction of mass motorisation can lead to motor-vehicles limitations. In emerging economies, pollution, authorities' energy concerns, limited public space available for roads, and general dissatisfaction for the un-efficient car mobility culture can lead to partial limit to the use of cars in the (growing) cities of emerging countries (The New York Times 2012). Car ownership is particularly appealing for its values (personal, private, out of schedule and door-to-door service), but once mass motorisation reaches a critical point it does not offer any more personal *mobility* but degenerates in collective *immobility*. On a personal level, the cost of the car plate can be a lot bigger than the vehicle itself, as in Shanghai, therefore impeding car ownership and pushing for alternative way to drive a car. (Bloomberg Businessweek 2013).
Put in a broader perspective, the massive urbanisation of emerging countries will exacerbate the contradiction of the transport systems based on private car ownership, leading to some sort of limitations, which can vary according to local or national attitudes. While car premium segment sales are expected to last, even in car-hungry developing economies medium and bottom-end motor-vehicles are already facing several challenges. So, the other side of the coin of massive investment in urban transit systems, as envisioned by the rail equipment industry, will be some sort of limitation in car diffusion, or simply, the lack of opportunity to use a car due to massive traffic congestion. As in Europe, also in emerging economies "most consumers don't want to give up access to vehicles" and thus it is easy to expect possible development of car-sharing services. Based on its experience at home, the real challenge for the EU transport industry is to be ready to gain those markets.

7. List of figure

Figures

Tables

8. Reference

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9. Annex

9.1 RACE2050 basics

Project acronym	**RACE2050**
Project title	**Responsible innovation Agenda for Competitive European transport industries up to 2050**
Call identifier	FP7-TPT-2012-RTD-1 [Prospects for transport evolution: challenges for the competitiveness of the European transport sector in the long term]
Grant Agreement no.	314753
Starting date	01/09/2012
End date	28/02/2015
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RACE2050 consortium partners are:

Partner acronym	Partner name	Logo
TUB	TU Berlin, ZentrumTechnik und Gesellschaft, Berlin, Germany	
RCAB	Ritchey Consulting AB, Stockholm, Sweden	
ZHAW	ZurcherHochschulefürAngewandteWissenschaften, Zurich, Switzerland	
ICTAF	Interdisciplinary Centre for Technological Analysis and Forecasting, Tel Aviv, Israel	
TOI	TransportokonomistInstitutt, Oslo, Norway	
VTM	VTM ConsultoresemEngenharia e PlaneamentoLda, Lisbon, Portugal	

9.2 Deliverable basics

Deliverable no.	D4.1
Document name	RACE2050D4.1FINAL
Deliverable name	Report on existing Equipment and Services Transport Strategies
Work Package	WP4
Nature	Report
Dissemination	Public
Editor	Dr. Massimo Moraglio
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