European Transport \ Trasporti Europei (2016) Issue 61, Paper n° 7, ISSN 1825-3997

Review of European Regulations and Germany's Action to Reduce Automotive Sector Emissions

B. Kotak[1], Y. Kotak[2*]

[1]Technische Hochschule Ingolstadt, Ingolstadt (bhk8191@thi.de)
[2]Heriot Watt University, Edinburgh EH14 4AS (yk78@hw.ac.uk)

Abstract

The automotive market is currently subjected to unprecedented changes. Currently, automobile sector is facing a transformation from conventional technology, which was primarily operated by internal combustion engines, to a change of technology, driven by alternative fuels or sustainable drive systems such as electric mobility. The major cause of this transformation is to reduce the vehicle emissions. Worldwide, Europe accounts for almost one quarter of vehicle production and registration. Within Europe, Germany has the largest number of automobile assemblies, engine production plants and the highest car ownership rate. Hence, by taking into account the increasing pollution from automobile industry and Europe's (including Germany) position, this article investigates the determinants of European environment and climate protection regulations/directives. It also describes the actions taken by Germany to follow and achieve these regulations. This article provides the implications of these regulations and the actions taken by Germany. It has been found that, since, the impact of each regulation individually is quite difficult to measure, all regulations collectively play an important role in emission control.

Keywords: European automotive regulations, vehicle emission control, Germany actions, automotive market status

[*] Corresponding author: Y.Kotak (yk78@hw.ac.uk)

1. Introduction

In Europe (EU), as elsewhere in the industrialized world, the demand for automobiles has grown substantially since past decade. Passenger cars are responsible for over 70% of passenger travel and buses takes around 527 billion passenger kilometres per year (ACEA, 2015). The commercial vehicles such as trucks and vans transport more than 76% of freight. In terms of manufacturing, EU produced 17.2 million vehicles in 2014 followed by 13.4 million vehicles (25% of global production) in first quarter (January to September) of 2015 (19% of global production). Overall, according to European Automobile Manufacturers' Association (ACEA) statistics, there are 287 million vehicles on Europe's roads (ACEA, 2016).

Within EU, Germany has the largest automotive market. It accounts around 30% of all passenger cars production and 20% of new registrations of EU. Germany produced almost 15 million vehicles in 2014, which is almost equivalent to 18% of total global production (German Trade & Invest, 2016). Considering the whole EU (including Germany), it has been noticed that, alongside electricity generation, the transport sector constitutes the largest source of greenhouse gas (GHG) emissions (Frondel, Schmidt, & Vance, 2011). In February 2015, it was analysed that, transport sector is responsible for 25% of EU total carbon emission. Understanding the determinants of these trends, complete EU has emerged as a major priority within the scientific and policy arenas. Increasing pollution from automobile is the major concern and a role player in these areas (Ritter & Vance, 2013). Hence, this article initiates with an overview of worldwide and EU vehicle production and registration (section 2 and 3). The following section (section 4) investigates the EU environment and climate protection regulations/directives. Please note, the word Regulation and Directive are used interchangeably in this article for better understanding of the reader. These regulations are the measures that EU government is taking, towards reduction of CO_2 emission. These measures are imposed by setting up the limits of CO_2 emissions from vehicles and its components such as air conditioning system and coolants. To increase cleaner transport, EU government is also trying to promote the use of alternative fuels i.e. Biofuels, Compressed Natural Gas (CNG), Liquefied Natural Gas (LNG) and electric mobility and increasing public awareness by regulations like energy labelling. Germany, as a member of EU, is required to follow and fulfil all these regulations. Therefore, section 4 also includes the steps taken by Germany to achieve these desired goals set within the regulations. Lastly, section 5 is the results and discussion section, which describes the impact of these regulations and the actions taken by Germany (as mentioned in section 4). It is expected that, this review of government regulations to reduce CO_2 emissions will be significantly helpful to researchers, academicians and vehicle manufacturers.

2. Worldwide automotive market

2.1. Vehicle production

Worldwide, during first three quarters (January to September) of the year 2015, it was noticed that there was a 1.4% increase in passenger car production as compared to 2014. European Automobile Manufacturers Association has categorised five major regions for vehicle manufacturing worldwide (i) EU (including Russia, Turkey, Ukraine, Belarus, Kazakhstan, Serbia, Uzbekistan) (ii) North America (of which the US) (iii) South America (of which Brazil) (iv) Asia (China, Japan, South Korea, India, Indonesia, Thailand, Taiwan, Australia, Malaysia, Pakistan, Philippines, Vietnam) and (v) Middle East/Africa. The percentage share of passenger car production in the year 2015 is described in Figure 1. From

the figure, it can be noticed that European region market covers 25% of worldwide car production. According to ACEA market report, the percentage of European region could have been more, but Russia and Turkey only contributed 1.7% and 1%. The North American region (including US) contributed 19% of the total of world passenger cars production, out of which 13% is from US only and rest is from North American areas. However, South America region participated by 4%, which is almost five times less than North America region. According to market researchers, South America region would have contributed more if there would be less interest rates and inflation in Brazil. Nevertheless, 50% of the worldwide car production was from Asia region. The major contributing countries in Asia region are China, India and Thailand. They contributed 24.2%, 4.6% and 1.2% to the global car production respectively. Lastly, Middle East/Africa contributed 2% of total worldwide car production, which is expected to be increased in upcoming years (ACEA, 2015).

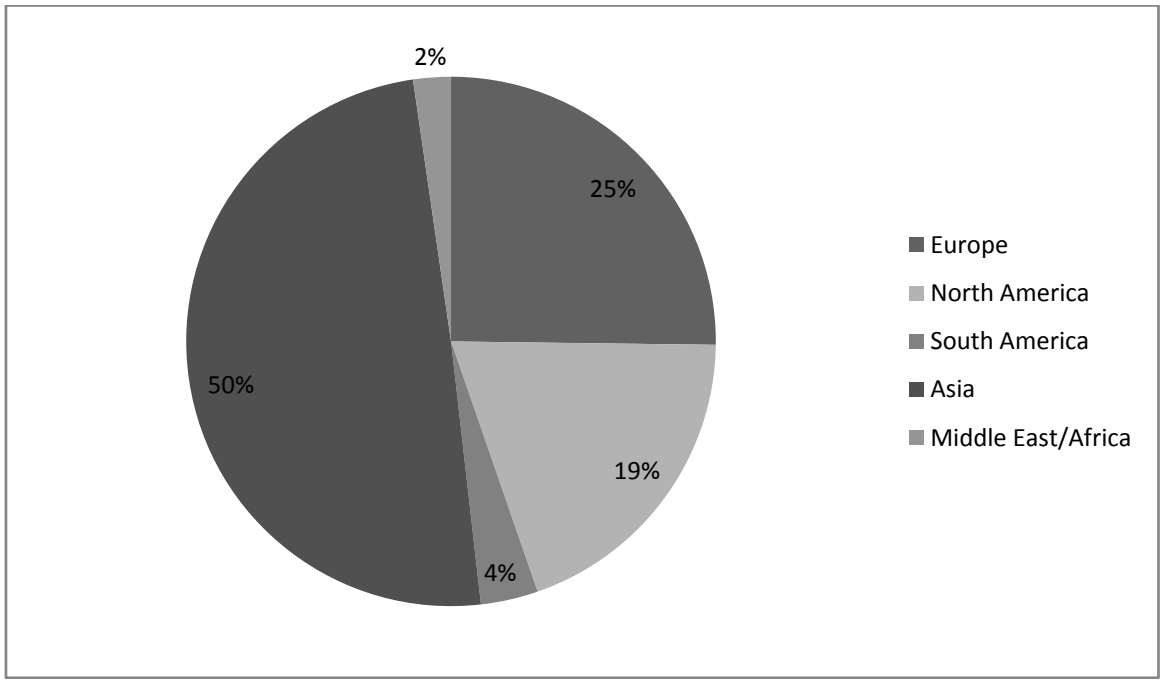

Figure 1: World passenger car production

Figure 2 describes the percentage difference of car production in first three quarters of the year 2015 to the year 2014. From the figure it can be analysed that, Indian passenger car production increased by 7.7% due to strong domestic sales and improved economic sentiment following the election of a new government. China is holding the second position by producing 4.8% more passenger cars as compared to previous year. Following the similar trend, US, Germany and South Korea produced 3.7%, 1.8% and 1% of more cars due to their increase in domestic demand.

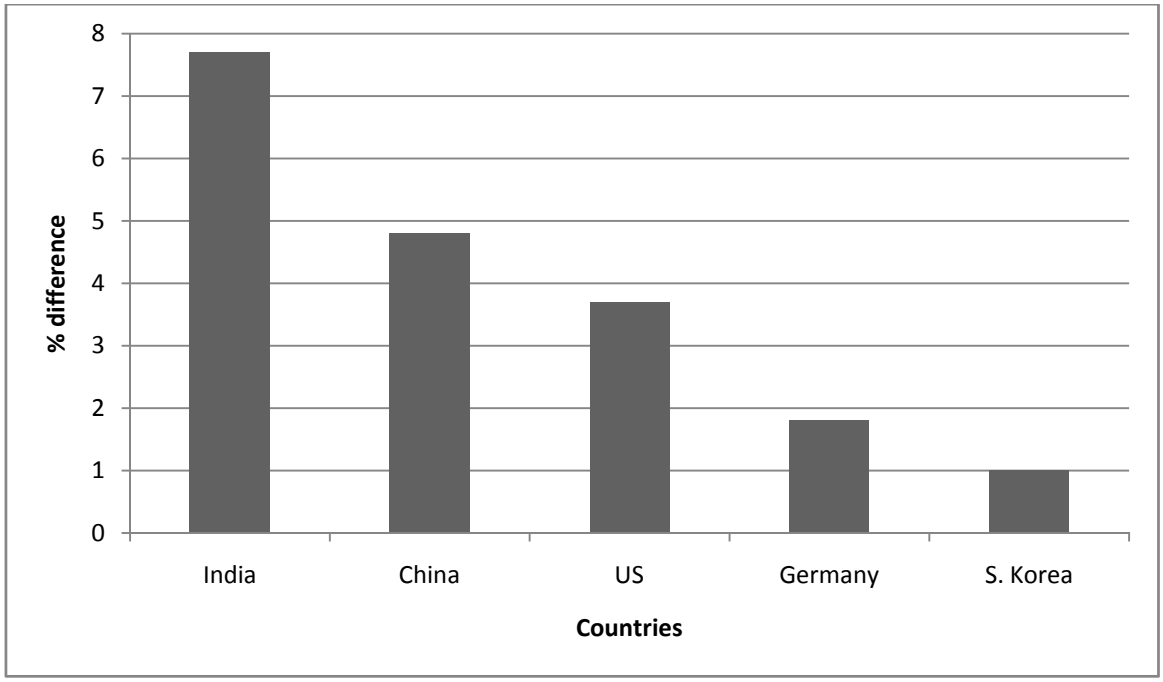

Figure 2: Top five countries of passenger cars production in year 2015

From Figure 1 it can be noticed that, globally, EU holds second position in terms of passenger car production during the first three quarters of the year 2015. For commercial vehicle production, the figures are not available for first three quarters of the 2015 but it is expected that, 3.2 million units of commercial vehicles would have been produced in the year 2015 (from January to December).

2.2. Vehicle registrations

It has been noticed that, the worldwide demand for automobiles has increased by 0.9% (53.2 million units of vehicles). Similar to vehicle manufacturing, comparing the first three quarters of the year 2015 to the year 2014, Fig. 3 describes the worldwide registration of new passenger cars. During the same period of time, the passenger car sales in European countries and Turkey rose by 8.8% and 36.6%.However, according to market researchers, this figure could have been higher but Russian and Ukraine markets went down by 33.3% and 61.2%, due to geopolitical issues. Overall, the contribution by the EU region is 24% of total vehicle registration. The North America region accounted for 24%, out of which 20.5% of global market is covered by US and rest is from North American areas. Since banks are cautious about lending money, the credit remains a key constraint to vehicle demand in Brazil and hence the passenger cars demand was dropped by 20.6% as compared to last year. Overall, the contribution of South America was 5% to global passenger cars registration. As compared to last year sales, there was a rise of 4.3%, 4.4% and 4.9% of passenger cars sales in China, South Korea and India. Lastly, Middle East/Africa registered 5% of world passenger cars, which was a decrease of 3.2% as compared to the previous year.

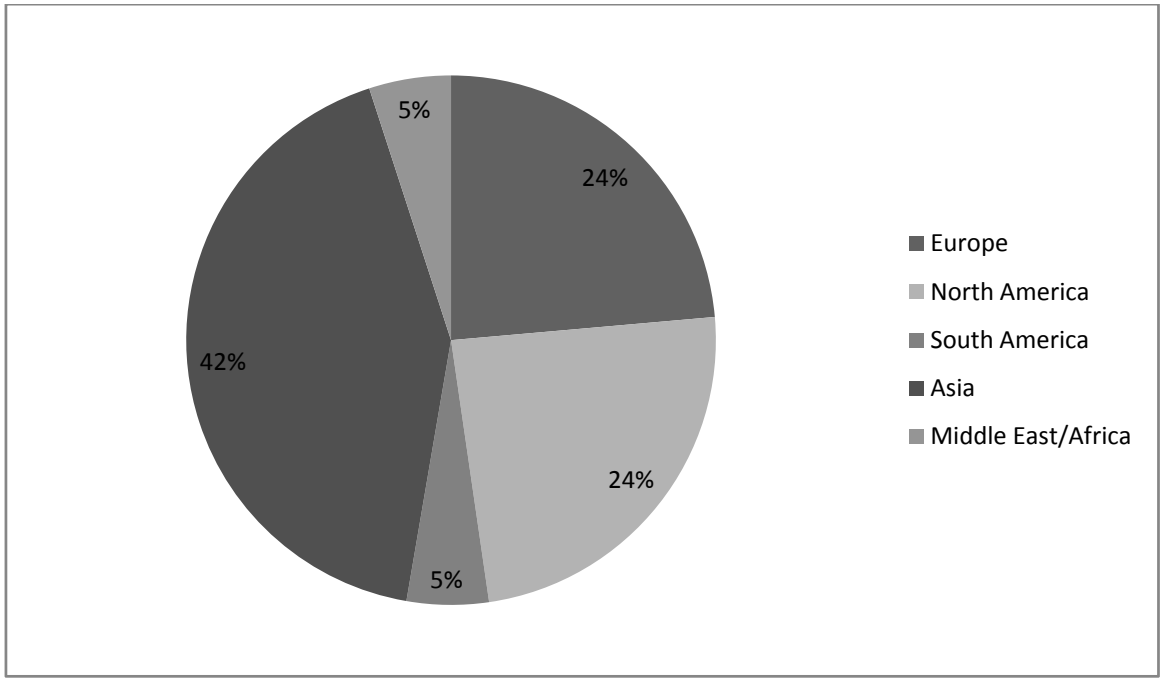

Figure 3: World new passenger car registrations

3. Europe automotive industry status

According to European commission, the automotive industry is crucial for Europe's prosperity. The sector provides jobs to 12 million people and accounts for 6.3% of the EU's GDP. The European automobile industry is one of the major industries, as it delivers the quality products as "Made in Europe" around the world and generates the €95.1 billion trade surplus. In addition, the automobile industry is the largest private investor in R&D in EU. In 2014, over €41.5 billion were invested into R&D and about 6000 patents were granted to the automotive sector [109]. According to ACEA map (ACEA, 2016) there are 292 automobile assembly and engine production plants in EU (see Fig. 4). There are 26 countries listed in figure and out of which Germany has the highest number of plants. These plants operate across EU and produce engines, passenger cars, light commercial vehicles, and trucks and buses. Please note that, automotive suppliers as well as some of the many smaller sized vehicle and engine manufacturers are not included in this overview for reasons of complexity.

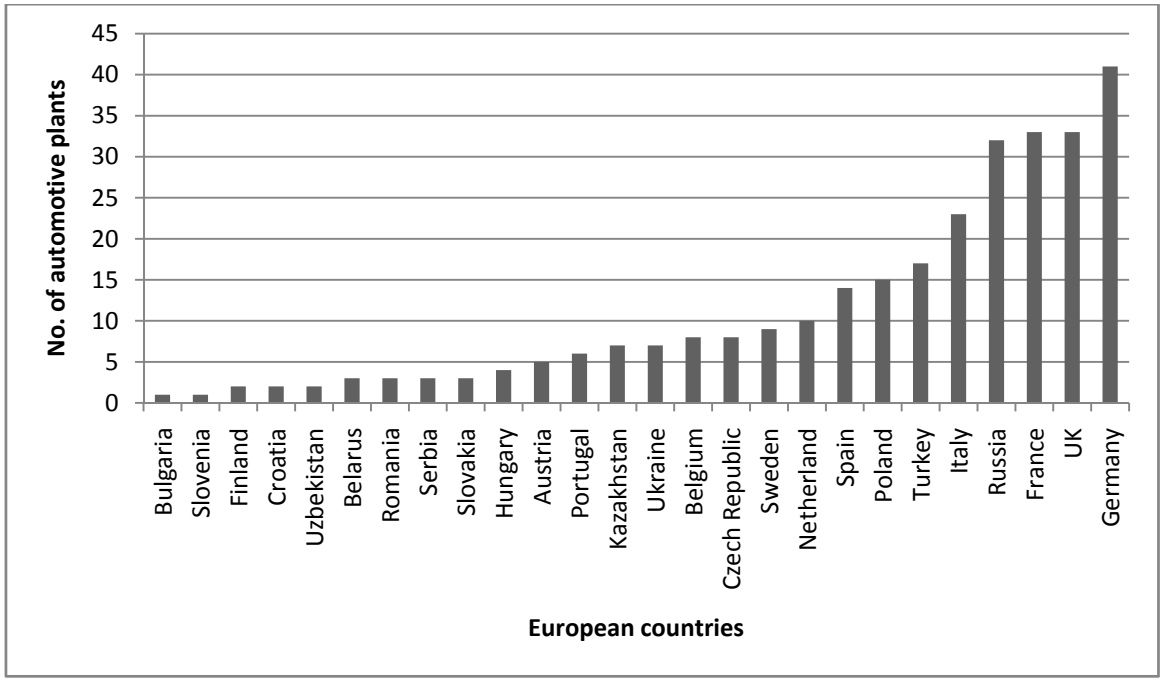

Figure 4: Automobile assembly and engine production plants in EU

From Figure 4 it can be noticed that, Germany has the largest number of automobile assembly and engine production plants. There are 44 such plants in Germany and out of them, 21 are listed in world's top 100 automotive industries,18 are listed in top 50 suppliers of EU and 6 of them belongs to top 25 global supplier list by size (German Trade & Invest, 2016). In the first three quarters of the year 2015, Germany produced more than 4.2 million passenger cars, which is a rise of 1.8% as compared to the year 2014. From an international prospective, vehicle manufacturing industries of Germany have multiple advantages (Federal Ministry of Economics and Technology, 2010), (a) infrastructure for energy, transport and telecommunication (World Economic Forum (2010) (b) motivated and skilled workforce (c) highly productive manufacturing plants (d) low labour cost (IW Köln (2009) (e) diversified and productive research environment and (f) high international standards.

Comparing the first three quarters of the year 2015 to the year 2014, it was noticed that, there was a significant rise of 5.5% in passenger car sales in Germany. According to ACEA statistics (ACEA, 2016) almost 38 new cars were registered per 1000 inhabitants in the year 2014 and according to researchers the demand for cars in Germany will continue to increase at a rate of 0.2% per year until 2030 (Ritter & Vance, 2013). Hence, it can be said that, Germany is a major role player in automobile sector in EU.

It is a well known fact that, automobile sector is one of the major contributors to environmental pollution. Road transport is the second largest greenhouse-gas (GHG) emitting sector in European countries (Official Journal of the European Union, 2009). From the year 1990 to 2012, CO_2 emission from transport sector is increased by 20.5% in EU (European Commission (2016) and according to recent statistics (February 2015), it is responsible for a quarter of EU carbon emissions (Casinge, 2015). As Germany is the major role player of automotive production and car ownership in EU, it holds the foremost responsibility towards emission control and reduction. Hence, section 4 describes the European regulations and the contributions of Germany to follow these regulations.

4. European environment and climate protection regulations

4.1. Reduce CO_2 emission by setting limits

The aim of this regulation is to reduce the emissions by setting limits of emission control to passenger cars and light commercial vehicles. Since past few years, these regulations have attained major attention in EU.

4.1.1. Reduction in CO_2 emissions of new passenger cars

This Regulation (EC) No. 443/2009 was enforced in June 2009. This regulation is based on strategy adopted by EU in 1995 as Directive 1999/94/EC relating to the availability of consumer information on fuel economy and CO_2 emissions in respect of the marketing of new passenger cars (Official Journal of the European Union, 1999). The 1995 strategy had three major pillars (a) Voluntary commitment by car manufacturers to reduce CO_2 emissions (b) promoting fuel efficient cars through fiscal measures and (c) consumer information achieved through labels showing a car's CO_2 emission. The regulation EC 443/2009 requires that the new cars registered in the EU should not emit more than an average of 130 grams of CO_2/km by 2015. This limit was phased in between 2012 and 2015. Initially in the year 2012, the limit was set to 65% of cars. In the successive years, this percentage was increased to 75% in 2013, 80% in 2014 and reached to 100% for 2015. It is targeted that, the current limit of 130 grams of CO_2/km will reduce to 95 grams of CO_2/km by the year 2021.

If the average CO_2 emissions of a manufacturer's fleet exceed its limit value in any year from 2012, then for each car, the manufacturer has to pay €5 for the first g/km over the limit, €15 for the second, €25 for the third and €95 for every successive g/km. From 2019, every g/km over the limit will be charged at €95.

However, small manufacturers that register less than 1000 cars in the EU per year are exempted from this legislation, whilst those that register between 1000 and 10,000 cars per year can propose their own emission reduction targets. Further, the Commission has set out rules for monitoring the CO_2 emissions of new cars. Monitoring reports can be found under annexure of Regulation (EC) No. 443/2009 (Official Journal of the European Union, 2009).

4.1.2. Reduction of CO_2 emissions from light commercial vehicles

This Regulation (EU) No 510/2011 was established in June 2011. Light commercial vehicles are categorised into (a) the vehicles which are used to carry goods weighing up to 3.5 tonnes and (b) vehicles which weigh less than 2610 kg when empty. According to this regulation, new light commercial vehicles registered in the EU should not emit more than an average of 175 grams of CO_2/km by 2017, which is less than 3% of 2012 targets. Moreover, this target will reduce to 147 g CO_2/km from 2020. This law is phased in from 2014 to 2017. In 2014, an average of 70% of each manufacturer's newly registered light commercial vehicles must comply with this rule and will increase to 80% in 2016 and reach to 100% in 2017 (Official Journal of the European Union, 2011).

If the average CO_2 emissions of a manufacturer's vehicles exceed its limit value in any year from 2014, the manufacturer has to pay an excess emissions premium for each registered vehicle (European Commission, 2016). This rate of premium is exactly the same as mentioned in EC 443/2009 law for new passenger cars (see section 4.1.1).

However, manufacturers responsible for fewer than 1000 new registrations per year in the EU are exempted from having a specific emissions target. Though, the manufacturers responsible for less than 22,000 new registrations per year need to propose their own emissions reduction targets (European Commission, 2016). Further, the Commission has set

out rules for monitoring the CO_2 emissions which can be found from Article 8 of Regulation (EU) No 510/2011 (Official Journal of the European Union, 2011).

4.2. Energy labelling

In recent study, researchers found that, although consumers show interest in obtaining automobile energy-efficiency information, they often cannot find appropriate data (Koo et al., 2012). Hence, EU government has implemented the vehicle labelling Directive 1999/94/EC. It is "*to ensure that information relating to the fuel economy and CO2 emissions of new passenger cars offered for sale or lease in the Community is made available to consumers in order to enable consumers to make an informed choice*" (Official Journal of the European Union, 1999). It means that, vehicle manufacturers should inform customers about fuel consumption and CO_2 emissions in a standardised manner. According to directive there are four major provisions, (a) A label: based on fuel efficiency and CO_2 emission displayed near to each car model at the point of sale, (b) A guide: prepared on fuel economy and CO_2 emission, (c) A poster or display: describing the fuel consumption data and CO_2 emission of all car models displayed at the point of sale. It can include electronic displays as well, as per Commission Directive 2003/73/EC and (d) Promotional literature: should be set that contain fuel consumption and specific CO_2 emissions data of the car models Official Journal of the European Union, 1999). The detailed presentation of all these data is presented in report by AEA (Brannigan et al., 2011).

In addition, German Energy agency (dena) also recommends that automobile buyer should ask for passenger vehicle label. Subsequently, an official ordinance was passed in 2004, named as Passenger Vehicle Energy Consumption Labelling (Pkw-EnVKV) to provide information about fuel consumption and CO_2 emissions in new passenger vehicles. Initially, the passenger vehicle label was designed to provide a short description of all energy data. Later on, the label was improved in 2011 and was simplified for customer to understand CO_2 emission of cars, by implementing a colour scale with letters (VDA, 2016).

4.3. Air conditioning system and coolants

In May 2006, Directive 2006/40/EC was established with an aim to cut back the emissions of fluorinated greenhouse gases used in vehicles (passenger cars and light commercial vehicles) air conditioning systems. According to this directive, from the year 2017, there is a complete ban on vehicles having air conditioning systems designed to contain fluorinated greenhouse gases with a global warming potential higher than 150. GWP is the climatic warming potential of a fluorinated greenhouse gas relative to that of carbon dioxide. It is calculated in terms of the 100 year warming potential of one kilogram of a gas relative to one kilogram of CO_2 (Official Journal of the European Union, 2006).

Germany was the first member state of EU to replace R12 coolant (ozone depleting refrigerant) with R134a (more environmentally friendly). However, considering the Directive 2006/40/EC, R134a is not a viable option to continue because it exceeds the limit of 150GWP. Hence, EU introduced R1234yf as an alternative to R134a. The key reason to use R1234yf is, because it is highly compatible with existing technology of air conditioners.

4.4. Alternate fuels

European Directive 2009/28/EC came into existence in April 2009. The aim of this directive is to promote the use of energy from renewable energy, so as to limit GHG and increase cleaner transport. According to this directive, till the year 2020, transport sector

would consume 10% of its energy from renewable energy. It also states that all member states should build the necessary infrastructure for using renewable energy sources in the transport sector (Official Journal of the European Union, 2009). This directive is also part of 2020 Climate and Energy package (European Commission, 2016). According to this package, there are three targets, (a) 20% cut in greenhouse gas emissions (from 1990 levels), (b) 20% of EU energy from renewable sources and (c) 20% improvement in energy efficiency [101]. The targets differ according to national wealth. The target set for Germany is to achieve a 10% mixture of renewable energy in all road transport fuels by the year 2020 (Ayres, 2014). To attain this goal, Germany is trying to utilise four most researched alternate fuels.

4.4.1. Biofuels

Biofuels are largely popular for sustainability and environmentally friendly mobility. To reduce fossil fuel dependency and CO_2 emission, bioethanol and biodiesel are considered to be most helpful forms of biofuels. According to researchers, it is the most compatible option for today's mobility and can be used as additive to fossil fuels to reduce CO_2 emission (VDA, 2016). Adding biofuels to conventional fuel results in an immediate reduction in CO_2 emissions for the entire vehicle fleet (VDA, 2015).

4.4.2. Compressed Natural Gas (CNG)

According to the European Commission, CNG is also identified as an alternative to reduce CO_2 emission. CNG is produced by compressing natural gas that has been to up to 3,600 psi into a high-pressure container (Cummins Westport, 2014). CNG can be used for all road vehicles over short to medium distances. It is analysed that, CNG vehicles can save CO_2 emission up to 10-20% as compared to petrol and diesel vehicles. According to German Energy Agency DENA, German automotive industry should involve CNG vehicles into the market up to 4% by 2020.In the year 2014, there were 970000 vehicles in Germany (NGVA Europe, 2014). In addition, German government is supporting CNG vehicles by installing more than 920 filling stations.

4.4.3. Liquefied Natural Gas (LNG)

LNG is considered as one of the most important alternative fuels to diesel fuel (VDA, 2015). According to researchers, one of the major reasons to utilise LNG in road transport (heavy commercial vehicles) is due to its energy characteristic of high calorific value (European Commission, 2013). The major benefits of using LNG are, (a) it has higher hydro-to-carbon ratio in comparison to conventional fuels and hence, the specific CO_2 emissions are lower and (b) LNG does not contain sulphur, which results in negligible SOx and PM emissions (CNSS, 2014).

4.4.4. Electricity (Electric mobility)

Reduction in transport emission is a key element for mitigating the risks of climate change. To overcome this issue, alternative drive technology (electric mobility) has gained significant importance in several academic and public disclosures, whereas vehicles based on internal combustion engines have been perceived as close to their development limits (Berggren & Magnusson, 2012) (Dombrowski & Engel, 2014). The scientific debate has witnessed a strong interest in alternative drive technology (Hekkert & Van den Hoed, 2006) (Suppes, 2006) (Schoots, Kramer & Van der Zwaan, 2010) and optimistic scenarios about their market diffusion and cost reduction (Offer, 2010) (Thiel, Perujo & Mercier, 2010). However, historical study shows concern regarding the rates of penetration and diffusion of

alternative automotive technologies (Kromer, Bandivadekar & Evans, 2010). This has several reasons like climate protection, scarcity of fossil fuels, increasing demand of mobility that demonstrates the need of alternative drive technology, specifically electric mobility (VDA, 2016) (Chan et al., 2009).

Hence, since long time, German government is in favour of electric mobility. Many legislations, programs and initiatives came into effect accordingly. For example, the National Electric Mobility Platform (NPE) published a report in 2011 describing the policies and measures to increase the number of electric cars (EEA, 2014). In 2012, NPE published another report about the progress made towards implementation of its recommendations since the publication of its primary report (Germany Trade & Invest, 2014). The aim of National Electromobility Development Plan is to have one million electric vehicles on roads by 2020 (Germany Trade & Invest 2015). Moreover, Table 1 lists important policy framework, funding and R&D activities by Germany to increase the share of electric vehicles into market.

Table 1: Policy framework for deployment of electric mobility

Year	*Policy*	*Description*
2007	Integrated Energy And Climate Programme	To achieve climate protection goals, German Federal Government declared the promotion of electric vehicles in its Integrated Energy and Climate Programme.
2007	Lithium-Ion Battery (LIB) Alliance	Germany's High-Tech Strategy aims to combine the forces of science and industry in important fields of the future by using public funding together with private R&D investment. Lithium-Ion Battery Alliance (LIB2015) has around 60 partners from the academic and industrial spheres. With an industrial consortium comprising BASF, Bosch, Evonik, Li-Tec and Volkswagen, the aim is to develop future generations of high power, affordable lithium-ion batteries by 2015. With its mix of several joint industry projects, inter-institutional alliances and young researcher groups, the alliance covers all aspects of research and development on lithium-ion batteries. The group of companies involved, made a commitment to invest €360 million in lithium-ion battery research, out of which €60 million will be invested by Federal Ministry of Education and Research (BMBF) (The Federal Government, 2015) (Federal Ministry of Education and Research, 2010) ((Federal Ministry of Education and Research, 2013).
2008	National Strategy Conference Electric Mobility	National Strategy Conference Electric Mobility in November 2008, which, in turn, paved the way forward for the creation of the National Electromobility Development Plan.
2009	Economic Stimulus Package II	To counter global recession, the Umweltprämie ("environmental premium" but more commonly known as the "scrapping bonus") was introduced to promote demand for new vehicles as part of the Konjunkturpaket II ("Economic Stimulus Package II").
2009	National Electromobility Development Plan (Die Bundesregierung, 2009)	The goal of the National Development Plan for Electric Mobility is to advance research and development, market preparation and introduction of battery powered vehicles in Germany (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, 2009).
2010	Joint Agency For Electric Mobility (GGEMO)	The Joint Agency for Electric Mobility (GGEMO) was set up by the Federal Ministry of Economics and Technology (BMWi) to coordinate all federal government electromobility activities. The agency supports both the federal government and the National Electric Mobility Platform to implement and further develop the National Electromobility Development Plan (Germany Trade & Invest, 2014).
2010	National Electric Mobility Platform (NPE)	The German Federal Government constituted NPE, consisting of representatives from politics, industry, science, local authorities and consumers. It consists of seven working groups of around 20 members in order to direct and shape the road map for the realization of the objectives laid out in the NPE (EEA, 2014) (Germany Trade & Invest, 2014).
2011	Government Program Electromobility	In response to the findings of the second report of NPE, the Federal Ministry of Economics and Technology (BMWi) and the Federal Ministry of Transport, Building and Urban Development (BMVBS) adopted this program (Germany Trade & Invest, 2014).
2014	Electric Mobility Act	The German parliament (Bundestag) adopted Electric Mobility Act on March 2015. The act aims to apply certain privileges to promote the use of electrically powered vehicles in road traffic and establishes certain powers for the introduction of special identification for privileged, electrically powered vehicles and of specific privileges for these vehicles in road traffic (Mayer, 2015) (Ayres, 2014).

5. Results and discussion

One of the most important objectives of EU is to improve the air quality. The quality and purity of air is vitally important to the health and wellbeing of the general public. All sectors need to contribute to help reduce the level of ambient air pollutants and road traffic should make important contributions as part of an integrated and coordinated approach dealing with both air emissions and greenhouse gas emissions. It is analysed that, world's one billion motor vehicles account for almost one fifth of global CO_2 emissions and in EU, passenger cars are responsible for emission of 12% of its CO_2 emission. Hence, as discussed in section4 about environment and climate protection regulations, EU legislation sets mandatory emission reduction targets for new cars. According to these targets, by the year 2020, all new cars sold in EU should not emit more than 95g/km of CO_2. If these targets are not achieved by manufacturers, they have to pay penalty for each registered car. There are specific rules for small manufacturers (manufacturers selling between 10000 and 300000 cars per year) as well. Small manufacturers have to apply for a fixed target of a 25% reduction from their 2007 average emissions for the period 2012 to 2019, and a 45% reduction from the 2007 level till 2020. Hence, many manufacturers are trying to form groups and act jointly to meet the emission targets. However, manufacturers selling between 1000 and 10000 cars per year can propose their own target for reduction of emissions, if they cannot or do not wish to join a group. The target is subject to approval by the European commission based on agreed criteria. In addition, manufacturers selling less than 1000 new cars per year, as well as special purpose vehicles i.e. vehicles built to accommodate wheelchair access, are excluded from the scope of the legislation (European Commission, 2016).

As discussed in section 4.4, another approach to reduce emission from vehicles, is to choose alternative fuels. According to researchers, alternate fuels are urgently needed to break the over-dependence of European transport on oil. Presently, vehicles with internal combustion engines i.e. running on conventional engines systems (petrol and diesel engines), are by far the most popular choice of Europeans. Transport in EU is 94% dependent on oil and out of which 84% is being imported, which costs around €1 billion per day, thus impacting the environment (European Commission, 2016). However, it is significantly difficult to change the technology of 94% of vehicles immediately. Hence, in order to continue with conventional engines systems, without any major modification, manufacturers are trying to introduce vehicles with alternate fuels into the market.

Another measure to reduce the CO_2 emissions from new passenger cars is to make consumers aware about the vehicle's energy efficiency and CO_2 performance i.e. energy labelling (see section 4.2). However, an independent evaluation of the effectiveness of the Directive as well as reports from the Member States concluded that, there was a need for a revision of the Directive to ascertain better and more consistent information for consumers (ODYSSE-MURE, 2014) According to Fraunhofer survey report, compliance of Directive is satisfactory but yet labels and posters are not displayed on all vehicles and also the consumers are not aware about the Directive provision. It has also been noticed that, Fuel economy and environmental impact are not major factor in vehicle purchase decisions. Fuel consumption is mostly only important because of the cost, but not due to environmental issues. The major factors influencing consumer decisions are car reliability, safety qualities, comfort and cost/price. Size, engine power and manufacturers' image are quite important as well.

In accordance with the objective of the Kyoto Protocol to reduce the CO_2 gas emissions that are causing climate change, the Directive 2006/40/EC (see section 4.3) aims to cut back

the emissions of fluorinated GHG used in air conditioning systems in motor vehicles. In terms of reducing fluorinated GHG, it is believed that R1234yf has potential to achieve a new low global warming potential (GWP). However, research done by German Motor Transport Agency on four different vehicles using R1234yf as a coolant indicated that, due to its lower ignition temperature property it was difficult to prevent fire in all vehicles in the event of accidents (SAE, 2014). In addition, the risk of releasing hydrofluoric acid makes it potentially dangerous to rescuers in the event of a collision (Gaved, 2013). Thus, German vehicle manufacturers are trying to find other alternatives and have resumed the development of whole CO_2 air-conditioning systems. Currently, more than sixteen types of CO_2 system components have been manufactured and are under tests.

In the category of alternate fuels, Biofuels are categorised first, because they can be used in all modes of transport (Ninh, 2014) i.e. passenger cars to commercial vehicles. Ethanol and biodiesel are the two most widely used biofuel blending components available today. Fuel quality experts from EU (ACEA), the US and Japan joined in producing the biofuel guidelines. With the help of all these experts, in March 2009, World Fuel Charter Committee (WWFC) introduced the first edition of guidelines for both biodiesel and ethanol (ACEA, 2009). These guidelines provide information to fuel suppliers on, how to maintain good biofuel quality from production to retail sale, information about test methods and good fuel management practices. However, many organisations and individuals commented (questioned and suggested) on these guidelines and hence, WWFC is formulating these comments. Beyond all of these, the major drawback of both guidelines is, they both represent the recommendations for global market which differs from the standard of any particular region or country.

CNG is also considered as the cleanest burning alternative (Clean Energy, 2013) and produces low emission as compared to conventional car engines (AFDC, 2013). In addition, CNG can also be mixed with biogas to make fuel more environmental friendly (Clean Energy, 2013). The major advantage of using CNG as an alternate fuel in EU is the ample availability of CNG due to the well-developed natural gas grid, which creates a sufficient base for the infrastructure deployment. According to Natural & bio Gas Vehicle Association (NGVA) report, there are around 1 million natural gas vehicles on the road and around 3000 CNG filling stations in total (NGVA Europe, 2013).

The most suitable alternate fuel for long-distance road freight transport, for which alternatives to diesel are extremely limited (Total, 2014) is LNG. The low deployment of LNG vehicles is highly influenced by the insufficient infrastructure of LNG filling stations. Currently, there are no LNG filling stations in Germany but substantial progress was made recently by the approval of a model for the build up of LNG filling stations (NGVA, 2014). However, drilling the gas well for LNG can lead to leakage of methane. Methane is 30 times more potent gas, as compared to CO_2 and hence, it can create serious global warming potential. But, this problem could be solved, if drilling companies invest in technology to prevent methane to escape into atmosphere (Davenport, 2014). There are several studies (Schafer, Heywood & Weiss, 2006) (Lane, 2006) (Tan, Culaba & Purvis, 2004) (Hackney, Neufville, 2001) (Maclean et al., 2011) (Cebola, Ceca & Rizo, 2015) which present the life cycle assessment of vehicle fuels and technologies and its environmental impact.

Another environmental friendly alternative for transport industry is electric mobility, which is basically dependent on electricity. It is noticed that electric mobility is becoming more and more important internationally. The government of all countries as well as business professionals and scientific communities worldwide are setting ambitious goals for electric

mobility. By the end of year 2014, Germany launched 17 models (including Battery Electric Vehicle (BEV), Plug-In Hybrid Vehicle (PHEV) and Range-Extended Electric Vehicle (REEV) models) into market followed by 12 models by the end of 2015. According to researchers, electrified vehicles can make significant contribution to protect environment and avoid emissions (VDA, 2015 & 2016).

Despite the significant advantages, alternate fuels are being held back by three main barriers (a) the high cost of vehicles (b) a low level of consumer acceptance and (c) the lack of recharging and refuelling stations (The Green Optimistic, 2014). It is a vicious circle. Refuelling stations are not being built because there are not enough vehicles. Vehicles are not sold at competitive prices because there is not enough demand. Consumers do not prefer to buy the vehicles because they are expensive and the unavailability of stations. Hence, EU has launched Clean Fuel Strategy in January 2013 (European Commission, 2016) to overcome these issues together. According to this strategy, the European commission ensures the build-up of alternative fuel stations across EU with common standards with respect to their design and use. In addition, on October 2014 another Directive 2014/94/EU was made on the deployment of alternative fuels infrastructure (Official Journal of the European Union, 2014). This directive aims to (a) establish standard rules on rolling out the EU's alternative fuels infrastructure (i.e. electric car recharging stations or natural gas refuelling points) in different EU countries and (b) lay down minimum requirements for building up this infrastructure, to be implemented as part of every EU country's national policy framework.

The major issues in electric mobility are high cost, heavy weight of the batteries, limited range of the vehicles, low energy density, lack of recharging points with a common plug and limited selection of vehicle models. Hence, German Federal Government has invested €1.5 billion for its development (Germany Trade & Invest, 2015). Several projects on electric cars are held by the electric utility RWE, in particular its subsidiary RWE Effizienz GmbH which specializes in providing energy efficiency infrastructure (RWE Effizienz GmbH, 2014). Furthermore, a Swiss concept called Park & Charge functions on the German e-mobility market, which supports the utilization of the already existing network (Park & Charge, 2014). In addition, six major companies, Daimler, BMW, Bosch, EnBW, RWE and Siemens, created a joint-venture Hubject GmbH, which tries to build an integrated electric charging infrastructure in the whole country and thus support the deployment of e-mobility (Hubject, 2014). Similar to the Hubject GmbH is a concept called Ladenetz, which is involved in the deployment of electric charging infrastructure on national level (Ladenetz, 2014).

6. Conclusion

There is an urgent need to reduce emissions of GHG from all sectors of the global economy in order to avoid dangerous climate change. A number of policies and commitments have been put in place over recent years in EU to ensure that emissions from automotive sectors start to reduce. From the above discussion it is analysed that, the European Commission has well-advanced plans, that are proposed and approved regulations which demands for climate friendly applications, from automotive manufacturers. Germany, the major vehicle producer and consumer, is actively following these Directives. In addition, Germany has also set its individual emission targets which are even more stringent than the European Directives. It has been noticed from the analysis that, it is quite difficult to measure the impact of each Directive. However, it is believed that, all Directives bundled together play an important role in emission control.

Approaches like consumer awareness i.e. via energy labelling could be a possible solution. According to the European government, it may also increase the competition between manufacturers to develop fuel-efficient models. However, the effectiveness of the provisions is probably limited to individual cases (Dena, 2016) (VDA, 2015). A major effectiveness in general and an impact on consumer decision is not yet noticed.

In terms of technological advancement like reducing fluorinated GHG from air conditioning system and coolants from cars, the automotive market is currently subject to an unprecedented change. Presently, a transformation is taking place on traditional internal combustion engines, running on petrol and diesel to alternative fuels like, biofuels, LNG, CNG and electricity (electric vehicles). From the status of alternative fuels, it can be noticed that the lack of infrastructure is one of the main issues for consumer to adopt this advancement. Hence, by now it is quite ambiguous to determine which alternative fuels will have great success in future. Overall, this study provides a deeper understanding of government practices for reducing CO_2 emission through automotive sector, which will be helpful to researchers, academicians and vehicle manufacturers.

Reference

ACEA (2009), Biodiesel Guidelines and Ethanol Guidelines. Issue: March 2009.

ACEA (2015) *Transport Policy*. Available at: http://www.acea.be/uploads/publications/Transport_Policy.pdf

ACEA (2015). *Economic and Market Report: EU Automotive Industry Quarter 3 2015.* Available at: http://www.acea.be/uploads/statistic_documents/Economic_and_Market_Report_Q3_2015.pdf

ACEA (2016) *Vehicles in Use.* Available at: http://www.acea.be/

AFDC, (2013). *Natural Gas Vehicle Emissions*. Available at: http://www.afdc.energy.gov/vehicles/natural_gas_emissions.html

Ayres, A., (2014). "Germany's water footprint of transport fuels", *Applied Energy* 113, pp. 1746-1751.

Berggren, C., Magnusson T., (2012), "Reducing automotive emissions-The potentials of combustion engine technologies and the power of policy", *Energy Policy*41, pp. 636-643.

Brannigan, C., Skinner, I., Gibson, G., Kay, F., (2011). Report on the implementation of Directive 1999/94/EC relating to the availability of consumer information on fuel economy and CO2 emissions in respect of the marketing of new passenger cars. *AEA*. AEA Ref: ED56923- Issue Number 2.

Casinge, E., (2015). Energy Union pushes for e-mobility and alternative fuels in transport. Available at: http://www.euractiv.com/section/transport/news/energy-union-pushes-for-e-mobility-and-alternative-fuels-in-transport/

Cebolla, R., Ceca, M., Rizo, S., (2015). An integrated method to calculate an automobile's emissions throughout its life cycle, *Energy* 83 (1), pp. 125-136.

Chan, C.C., Wong, Y.S., Bouscayrol, A., Chen, K. (2009), "Powering Sustainable Mobility: Roadmaps of Electric, Hybrid, and Fuell Cell Vehicles", *IEEE,* 97 (4).

Clean Energy, (2013). *About Natural Gas.* Available at: http://www.cleanenergyfuels.com/about-clean-energynatural-gas-fueling/aboutng.html

CNSS (2014). *Liquefied Natural Gas (LNG).* Available at: http://cleantech.cnss.no/air-pollutant-tech/nox/liquefied-natural-gas-lng/

Cummins Westport (2014), *Compressed Natural Gas*. Available at: http://www.cumminswestport.com/compressed-natural-gas

Davenport, C., (2014), Study Finds Methane Leaks Negate Benefits of Natural Gas as a Fuel for Vehicles. Available at: http://www.nytimes.com/2014/02/14/us/study-finds-methane-leaks-negate-climate-benefits-ofnatural-gas.html?_r=0

Dena (2016), The car label. Available at: http://www.pkw-label.de/pkw-label.html

Die Bundesregierung (2009), *German Federal Government's National Electromobility Development Plan*. Issue: August 2009.

Dombrowski, U., Engel, C., (2014). "Impact of Electric Mobility on the after Sales Service in the Automotive Industry", *Procedia CIRP* 16, pp. 152-157.

EEA (2014). *Country profile -Germany*. Available at: http://www.eea.europa.eu/

European Commission (2013). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions – Clean Power for Transport: A European alternative fuels strategy.

European Commission (2016). *Climate Action*. Available at: http://ec.europa.eu/clima/index_en.htm

Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (2009), *The Federal Government's National Development Plan for Electric Mobility*. Available at: www.bmub.bund.de/N44798-1/

Federal Ministry of Economics and Technology (2010). "In focus: Germany as a competitive industrial nation". Issue: October 2010.

Federal Ministry of Education and Research (2010). Ideas. Innovation. Prosperity. *High-Tech Strategy 2020 for Germany.*

Federal Ministry of Education and Research (2013). *Electric Mobility – Rethinking the Car*.

Frondel, M., Schmidt, C., Vance, C. (2011) "A regression on climate policy: The European Commission's legislation to reduce CO_2 emissions from automobiles", *Transportation Research Part A: Policy and Practice* 45(10), pp. 1043-1051.

Gaved, A., (2013), RAC, *Daimler ups campaign against R1234yf while German firefighters demand refrigerant warning sticker*. Available at: http://www.racplus.com/news/daimler-ups-campaign-against-r1234yf-while-german-firefighters-demand-refrigerant-warning-stickers/8657092.article

Germany Trade & Invest (2014). Available at: http://www.gtai.de/GTAI/Navigation/EN/welcome.html

Germany Trade & Invest (2015). *Electromobility in Germany:Vision 2020 and Beyond.* Issue 2015-16.

Germany Trade & Invest (2016). *Industry Overview: The Automotive Industry in Germany* .Issue 2015-16.

Hackney, J., Neufville, R., (2001) "Life cycle model of alternative fuel vehicles: emissions, energy, and cost trade-offs", *Transportation Research Part A: Policy and Practice* 35 (3), pp. 243-266.

Hekkert, M.P., Van den Hoed, R., (2006), "Competing technologies and the struggle towards a new dominant design: the emergence of the hybrid vehicle at the expense of the fuel cell vehicle?" *Greener Management International* 47, pp. 29-43.

Hubject (2014). Hubject-Connecting emobility networks. Available at: http://www.hubject.com/pages/en/index.html#1-1-home.html

IW Köln (2009): Lohnstückkosten – Deutschland bleibt im Hintertreffen, iwd No. 50/ 2009.

Koo, Y., Kim C.S., Hong, J., Choi, I., Lee, J., (2012). "Consumer preferences for automobile energy-efficiency grades". *Energy Economics* 34(2). pp. 446-451.

Kromer, M.A., Bandivadekar, A., Evans, C., (2010), "Long-term greenhouse gas emission and petroleum reduction goals: evolutionary pathways for the light-duty vehicle sector", *Energy* 35, pp. 387-397.

Ladenetz (2014). Available at: http://ladenetz.stadtwerke-ffb.de/index.php?id=495&L=1

Lane, B. (2006), Camden, *Life Cycle Assessment of Vehicle Fuels and Technologies*. Issue: March 2006

Maclean, H., Lave, L., Lankey, R., Satish., (2011) "A Life-Cycle Comparison of Alternative Automobile Fuels", *Journal of the Air & Waste Management Association* 50 (10), pp. 1769-1779.

Mayer, C., (2015), Noerr, *German Bundestag Passes Electromobility Act*, Available at: http://www.noerr.com/en/press-publications/News/german-bundestag-passes-electromobility-act.aspx

NGVA Europe (2014). Available at: http://www.ngva.eu/

NGVA Europe, (2013). NGVs & refuelling stations in Europe.

Ninh, P., Repova, Z., Cretu, A., Laugesen M.S., Bentzen, K., (2014), E-mobility NSR, *Current Status and Future Perspectives on Standards and Alternative Fuels Infrastructure*. Issue: September 2014.

ODYSSE-MURE (2014), *EU 5 Passenger Car Labelling on Fuel Economy Rating*. Directive 1999/94/EC.

Offer, G.J., Howey, D., Contestabile, M., Clague, R., Brandon, N.P., (2010), "Comparative analysis of battery electric, hydrogen fuel cell and hybrid vehicles in a future sustainable road transport system", *Energy Policy* 38, pp. 24-29.

Official Journal of the European Union (1999). Information on the fuel consumption and CO_2 emissions of new cars. *Directive 1999/94/EC of the European Parliament and of the Council.*

Official Journal of the European Union (2006). Emissions from air conditioning systems in motor vehicles. *Directive 2006/40/EC of the European Parliament and of the Council.*

Official Journal of the European Union (2009). Promotion of the use of energy from renewable sources. *Directive 2009/28/EC of the European Parliament and of the Council.*

Official Journal of the European Union (2009). Reduction in CO_2 emissions of new passenger cars. *Regulation (EC) No 443/2009 of the European Parliament and of the Council.*

Official Journal of the European Union (2011). Reduction of carbon dioxide emissions from light commercial vehicles. *Regulation (EC) No 510/2011 of the European Parliament and of the Council.*

Official Journal of the European Union (2014). Electric and gas-powered vehicles — recharging/refuelling stations. *Directive 2014/94/EC of the European Parliament and of the Council.*

Park & Charge (2014). Available at: http://www.park-charge.ch/e/index.htm

Ritter, N., Vance, C. (2013) "Do fewer people mean fewer cars? Population decline and car ownership in Germany", *Transportation Research Part A: Policy and Practice* 50, pp. 74-85.

RWE Effizienz GmbH (2014). E-World. Available at: http://www.rwe.com/web/cms/de/1391742/rwe-effizienz-gmbh/

SAE (2014), *Executive Summary*. Available at: http://www.sae.org/standardsdev/tsb/cooperative/executivesummary.pdf

Schafer, A., Heywood J., Weiss, M., (2006), "Future fuel cell and internal combustion engine automobile technologies: A 25-year life cycle and fleet impact assessment", *Energy* 31(12), pp. 2064-2087.

Schoots, K., Kramer, G.J., Van der Zwaan, B.C.C., (2010), "Technology learning for fuel cells: an assessment of past and potential cost reductions", *Energy Policy* 38 (6), pp. 2887-2897.

Suppes, G.J., (2006), "Roles of plug-in hybrid electric vehicles in the transition to the hydrogen economy", *International Journal of Hydrogen Energy* 31 (3), pp. 353-360.

Tan, R., Culaba, A., Purvis M., (2004) "POLCAGE 1.0-a possibilistic life-cycle assessment model for evaluating alternative transportation fuels", *Environmental Modelling & Software* 19 (10), pp. 907-918

The Federal Government (2015). *The new High-Tech Strategy Innovations for Germany*.

The Green Optimistic (2014). Green Cars, More Complex than You Think. Available at: http://www.greenoptimistic.com/2014/04/25/green-car-rankings-overview/#.VAQFSPmSzT-

Thiel, C., Perujo,A., Mercier,A., (2010). "Cost and CO_2 aspects of future vehicle options in Europe under new energy policy scenarios", *Energy Policy* 38, pp. 7142-7151.

Total, (2014), LNG´s Advantages. Available at: http://www.total.com/en/energies-expertise/oil-gas/explorationproduction/strategic-sectors/lng/challenges/LNG-advantages

VDA (2015). *Annual Report 2015*. Available at: https://www.vda.de/en/topics/environment-and-climate/

VDA (2016). *Environment and Climate Change*. Available at: https://www.vda.de/en/topics/environment-and-climate/

World Economic Forum (2010). *The Global Competitiveness Report 2009-2010*. Available at: http://www.weforum.org/reports/global-competitiveness-report-2009-2010