NORTH SEA REGION ELECTRIC MOBILITY NETWORK

e-mobility NSR

Current Status and Future Perspectives on Standards and Alternative Fuels Infrastructure

FDT – Association of Danish Transport and Logistics Centres

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Aalborg, Denmark

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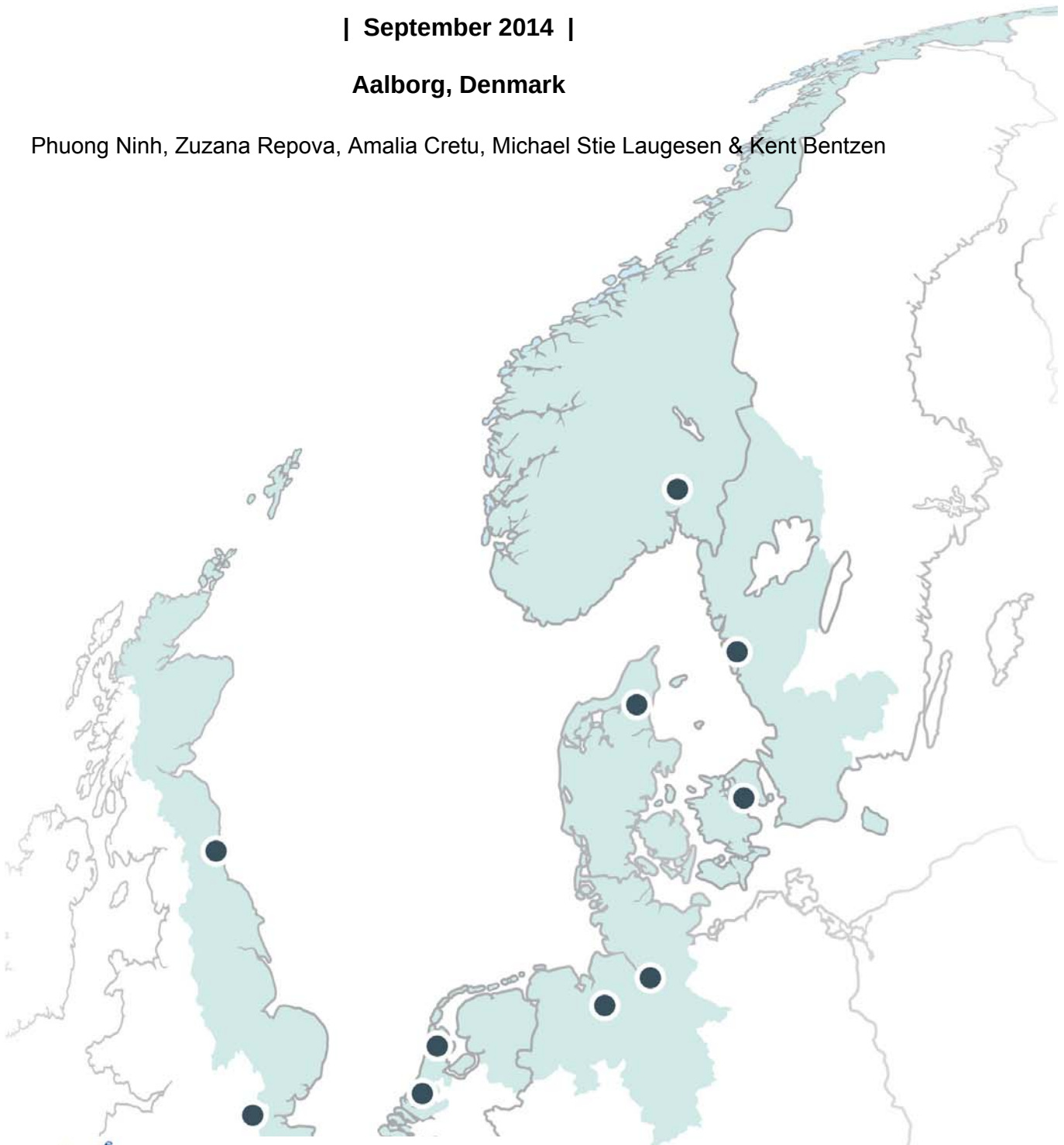

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List of Abbreviations

AC	Alternate Current
BPM	Belasting van Personenautos en Motorrijwielen
BTL	Biomass to Liquids
CEF	Connect Europe Facility
CH_4	Methane
CO_2	Carbon Dioxide
CNG	Compressed Natural Gas
DC	Direct Current
EC	European Commission
EN	European Standards
EU	European Union
EV	Electric Vehicle
FCEV	Fuel Cell Electric Vehicle
FCV	Fuel Cell Vehicle
GTL	Gas-To-Liquid
HEV	Hybrid Electric Vehicle
L-CNG	Liquefied-to-Compressed Natural Gas
LCV	Light Commercial Vehicle
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
MIT	Massachusetts Institute of Technology
NGO	Non-Governmental Organizations
NGV	Natural Gas Vehicle
NGVA	Natural & bio Gas Vehicle Association
NSR	North Sea Region
OCPP	Open Charge Point Protocol
PPP	Public-Private-Partnerships
R&D	Research & Development
RTD&D	Research, Technological Development and Demonstration
SEK	Swedish Krona
TEN-T	Trans-European Transport Network
UN ECE	United Nations Economic Commission for Europe
VAT	Value-Added Tax

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1. Introduction

The purpose of the study is to analyse the current status of alternative fuels infrastructure and future perspectives on related standards, focusing on the policy context of the European Union's (EU) new Transport and Energy Policy for alternative fuels and current state of charging infrastructure and standards for the scored alternative fuel infrastructure. This is of a great importance, because without a functioning charging/fuelling infrastructure the deployment of alternative fuelled vehicles is not viable. The scope of the research is limited to transport[1] in the European Union countries[2] with the main focus on the North Sea Region (NSR) countries[3].

Fossil fuels, like coal, oil, petroleum and natural gas are the main sources of energy in the transport sector, even though their consumption is decreasing[4]. In particular, oil is the main source of energy for transport in European Union countries[5], and according to the European Commission, Europe is heavily dependent on imported oil for obtaining its mobility and transport. In addition to that, there are several underlying reasons why the incorporation of alternative fuels in the transport sector and consequently the deployment of alternative fuel infrastructure are becoming increasingly more important. Even more a European-wide standardized infrastructure would render the deployment of electric as well as other alternative fuel vehicles more efficient.

Firstly, the usage of alternative fuels in transport is considered to be environmentally friendly compared to conventional[6] fuels. The reason for that can be seen in the comparison of the well-to wheel greenhouse emissions[7], which take into consideration the whole fuel life-cycle; well-to-tank and tank-to-wheel (figure 1). This means that they take into account the production of the fuel as well as its distribution. This is of great importance, because even the vehicles with zero tailpipe emissions (tank-to-wheel) can indirectly contribute to the increasing production of greenhouse gas emissions if the energy source comes from fossil fuel based power production.

[1] The study at hand considers only "road transport"
[2] Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, the United Kingdom [European Union, 2014]
[3] Germany, Sweden, the Netherlands, Denmark, the United Kingdom, Norway, Belgium
[4] [The World Bank, 2014]
[5] 94% of fuels in the European transport is oil [European Commission (3), 2013]
[6] Gasoline and diesel
[7] Carbon dioxide (CO2), Methane (CH4), Nitrous oxide (N2O), Fluorinated gases [EPA, 2014]

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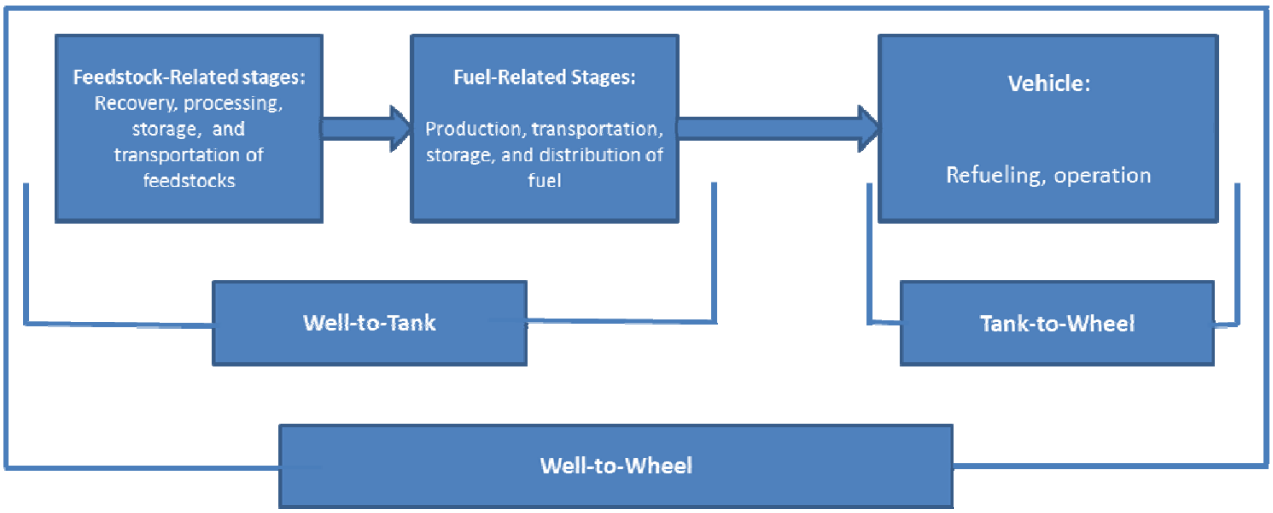

Figure 1: Fuel life-cycle analysis[8]

Because of that, as shown in figure 2, the contribution to the greenhouse gas emissions can be measured for electric and hydrogen vehicles, even though they produce zero or minimal well-to-tank emissions. However, the well-to-wheels greenhouse emissions for alternative fuels are still lower than for gasoline.

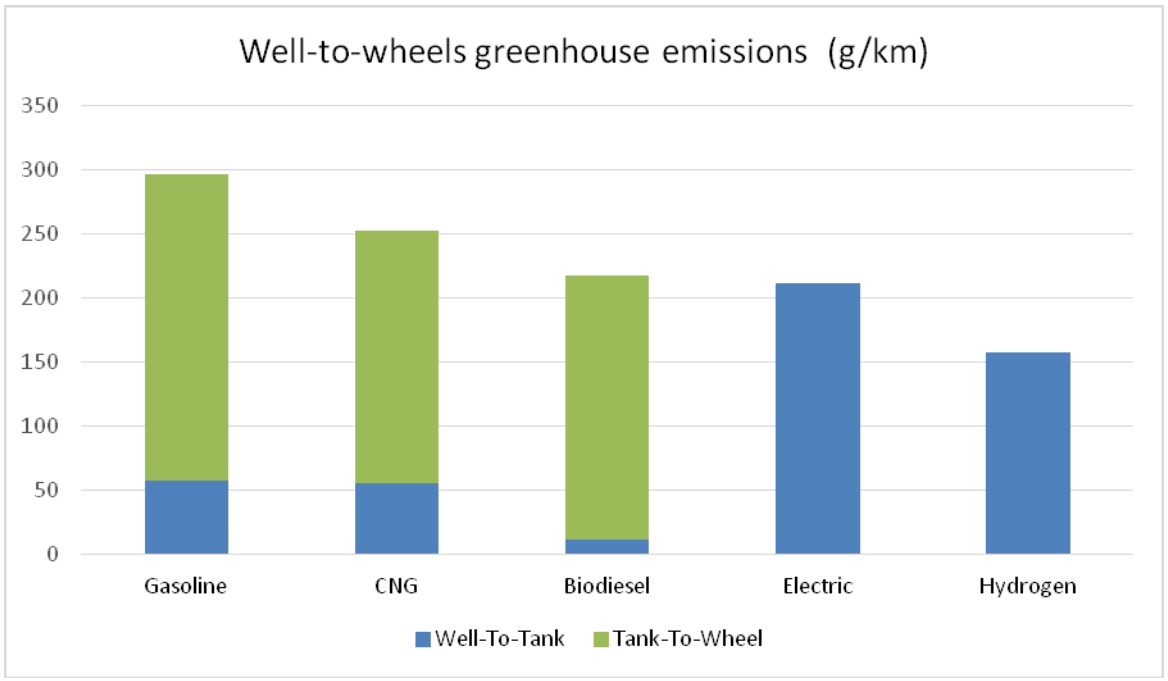

Figure 2: Well-to-wheels greenhouse emissions for different alternative fuels and gasoline[9]

[8] [General Motors Corporation et al., 2001]
[9] [Gao, 2011]

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Moreover, this issue is important since transport contributes significantly to the emission of greenhouse gas in the European Union with its 22% share (figure 3).

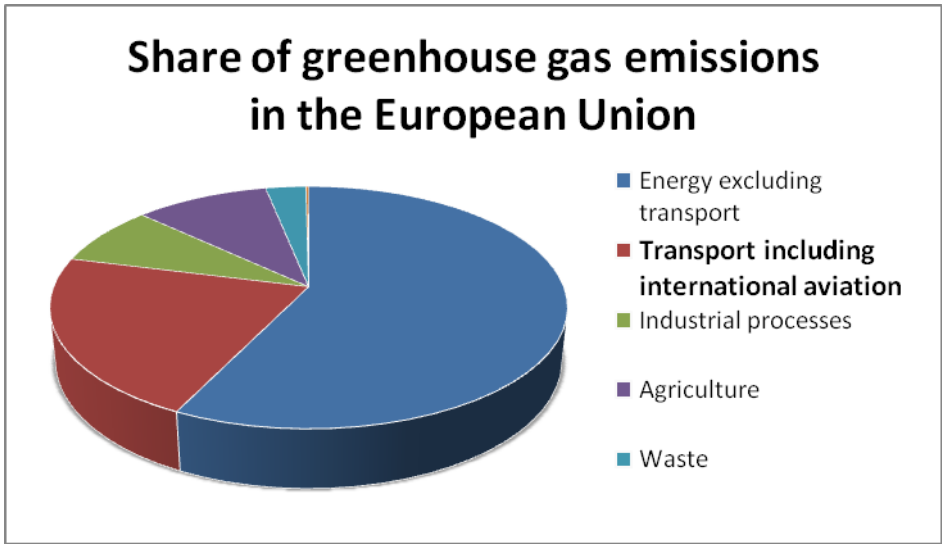

Figure 3: EU Greenhouse gas emissions by sector[10]

The road transportation, in particular passengers' cars transportation, is the most common way of transportation, as regards to land transport in the European Union countries.[11] Secondly, the dependency on fossil fuels in the European transport, in particular oil, negatively affects the balance of trade, as the majority of oil in the European Union is imported. The European "*[…] supply of oil, and thus our mobility, depend to a large degree on politically unstable regions raising security of supply concerns. Price hikes driven by speculation on the impact of oil supply disruptions have cost the European economy an additional € 50 billion per year over the last four years".*[12] Each day EU countries, in total, input energy for a cost of 1 billion Euros.

Therefore, there is a need of actions from the European Union to end this oil dependency in the European economy. A strategy for the transport sector is to gradually replace oil with alternative fuels, which are expected to break down the dependence on oil for the European mobility and transport. *"The main alternative fuel options are: electricity, hydrogen, biofuels, natural gas (in the forms of Compressed Natural Gas (CNG), Liquefied Natural Gas (LNG), or Gas-To-Liquid (GTL)), and Liquefied Petroleum Gas (LPG)."*[13] It is also expected that the uses of alternative fuels will:

[10] [Eurostat (1), 2014]
[11] [Eurostat (2), 2014]
[12] [European Commission (1), 2013, p. 2]
[13] [European Commission (6), 2013, p. 2]

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- Reduce the CO_2 and other emissions
- Increase the cross-border movements of citizens, create jobs in manufacturing and deployment of charging infrastructure across Europe
- Increase investment in goods and services for the build-up and maintenance of the infrastructure for alternative fuels
- Increase the development and competitiveness of the European economy

At present, the main problems that hold back the development and deployment of alternative fuels are:

- The high retail cost of vehicles
- A low level of consumer acceptance
- The lack of recharging and refuelling infrastructures[14]

Especially the lack of recharging and refuelling infrastructures is not only a technical prerequisite for the functioning alternative fuel vehicles, but also one of the main reasons for the low level of consumer acceptance concerning the alternative fuels. This problem has been recognized by a large number of Member States, regional and local authorities.[15] However, the development of alternative fuelled vehicles is facing a vicious circle: investors do not put their capital in building infrastructures for electric vehicles, because there is not enough demand on the market. Successively, vehicles are in high price because of the low demand from consumers. On the other hand, consumers do not want to purchase vehicles because of the high price and the lack of infrastructure. Therefore, actions from the public authorities, in this case the European Union, are needed to force the building up of infrastructures and the development of technologies.

In January 2013, the European Commission proposed for a **Directive[16] of the European Parliament and of the Council on the deployment of alternative fuels infrastructure**. This proposal requires common standards to ensure EU wide mobility and requirements of the minimum coverage infrastructures in each Member State.

On 26th of November 2013, the Parliament committee voted to support and strengthened the initial Commission proposal. The agreements are:

- Member States have to set their national targets that are, at least, in line with the minimum requirements of coverage electric charging points set by the Commission

[14] [European Commission (1), 2013]
[15] [European Commission (3), 2013]
[16] Thereinafter „Directive“

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- Member States have to develop their national policy frameworks to reduce urban congestion and deploy electrified public transport
- Provisions for the use of electricity at airports are introduced, together with the recharging of electric vehicles during off-peak times, when consumption and prices are lower
- Common plugs standards for the whole European Union are supported
- Information to consumers have to be strengthened
- It is possible to implement the Directive in a cost-neutral way and the European funding is available[17]

On 5th of December 2013, Member States agreed on the roll-out of refuelling infrastructure together with the following points:

- Member States would like to establish themselves their objectives and commitments on an appropriate coverage of alternative fuels infrastructures
- Member States proposed for a longer time frame to roll out the infrastructures (2030 instead of 2020)
- Member States agreed on common standards and the strengthen of information to consumers

Due to the fact that the development of alternative fuels and clean vehicles among Member States are in different levels, it is difficult for some countries to fulfil the requirement set by the European Commission in due time. On contrary, some other Member States would like to establish a better network of infrastructures for alternative fuels and create higher numbers of clean vehicles running. Therefore, Member States proposed that they shall establish their objectives and commitments on an appropriate coverage of alternative fuels infrastructure. Because of this, the Annex II in the proposal for a Directive of the European Parliament and of the Council on the deployment of alternative fuels infrastructure is taken out, at the present. Information on the agreed common standards for alternative fuels can be found in this report, in the sub-chapter: Developing common technical specifications.

On 15th April 2014, the European Parliament gave its final approval to the new European Union rules to ensure the build-up of alternative refuelling points across Europe with common standards for their design and use, including a common plug for recharging electric vehicles. Member States are required to submit to the EC their national plan for minimum coverage of infrastructure - refuelling and recharging stations for alternative fuels.

At present, the Directive is under an intensive linguistics control. When finalized, it will be formally adopted by the European Council.

[17][European Commission (4), 2013]

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2. Opportunities and Perspectives of EU´s new Transport and Energy Policies for Alternative Fuels

2.1 Analysis of the political context for the alternative fuels

According to the European Commission, *"A strategy for the transport sector to gradually replace oil with alternative fuels and build up the necessary infrastructure could bring savings on the oil import bill of € 4.2 billion per year in 2020, increasing to € 9.3 billion per year in 2030, and another € 1 billion per year from dampening of price hikes."*[18] On the other hand, "*Support to the market development of alternative fuels and investment in their infrastructures in Europe will boost growth and a wide range of jobs in the region"*.[19] At the same time, it will also "*[…] create new market opportunities for European industry and bolster Europe's competitiveness on the emerging global market"*.[20]

For these reasons, the European Communication sets out a comprehensive alternative fuels strategy and the road to its implementation covering all modes of transport. It aims at establishing a long-term policy framework to guide technological development and investments in the deployment of these fuels and give confidence to consumers. It will ensure the build-up of alternative infrastructures and the implementation of common technical specifications for these infrastructures in the Union.

It is underlined in the proposal that there is no single fuel solution of the future of mobility and all main alternative fuel options must be pursued, including: liquefied petroleum gas (LPG), natural gas (in the forms of CNG, LNG and GTL), electricity, biofuels and hydrogen. Thus, the strategic approach to meet the long-term needs of all transport modes must be built on a comprehensive mix of alternatives fuels. It means that the policy is made without giving any preference to any particular fuel type. The technology and the competitive market among alternative fuels are, therefore, kept in neutrality.[21]

2.1.1 Types of alternative fuels

2.1.1.1 Biofuels (liquid)

Biofuels can be divided into the two main groups; first and advanced generation biofuels (second and third generation), depending on the used sources. This is of a great importance as one of the disadvantages of producing biofuels is that the increase in the number of biofuels crops has a detrimental effect on food prices due to the less food supplies available.[22] The most common biofuels are bioethanol and biodiesel and both of them can be produced from different agriculture food crops.

[18] [European Commission (1), 2013, p. 2]
[19] [European Commission (1), 2013, p. 2]
[20] [European Commission (1), 2013, p. 2]
[21] [European Commission (1), 2013]
[22] [Swanepoel, 2014]

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The greatest advantage of biofuels is that they can be used by all types of transport modes. On the other hand, the main issues in the development of biofuels are: lack of coordination action across Member States when introducing new fuel blends, lack of common technical specification and lack of information on the compatibility of new fuels with vehicles.[23] In the EC Directive on alternative fuels, there is no specific requirement or change regarding biofuels. However, it can be understood that the general requirement for alternative fuels infrastructure and consumers' information will be applied for biofuels as well.

2.1.1.2 Electricity

Another environmental friendly alternative fuel for transport industry is electricity. However, it is necessary to emphasize that the environmental friendliness depends on several things. Firstly, there is difference between whether the electricity is used for purely electric vehicles, which have no tailpipe emissions or for hybrid vehicles, which partly produce emissions from gasoline.[24] Secondly, the environmental friendliness is directly dependant on the initial source of electricity. This means, that even though the car itself does not produce harmful emissions locally, its use of electricity can indirectly contribute to the overall greenhouse emissions, if the plant that generates the electricity is based on fossil fuels. Therefore, in order to be more accurate it is necessary to show differences amongst the well-to-wheel greenhouse emissions produced by electric vehicles with various initial energy sources (figure 4). The lowest emissions are produced by electric vehicles that use electricity from solar power, where the majority of emissions come from manufacturing and the rest from grid - plant.[25]

[23] [European Commission (6), 2013]
[24] [Clean Energy (2), 2013]
[25] [The Green Optimistic, 2014]

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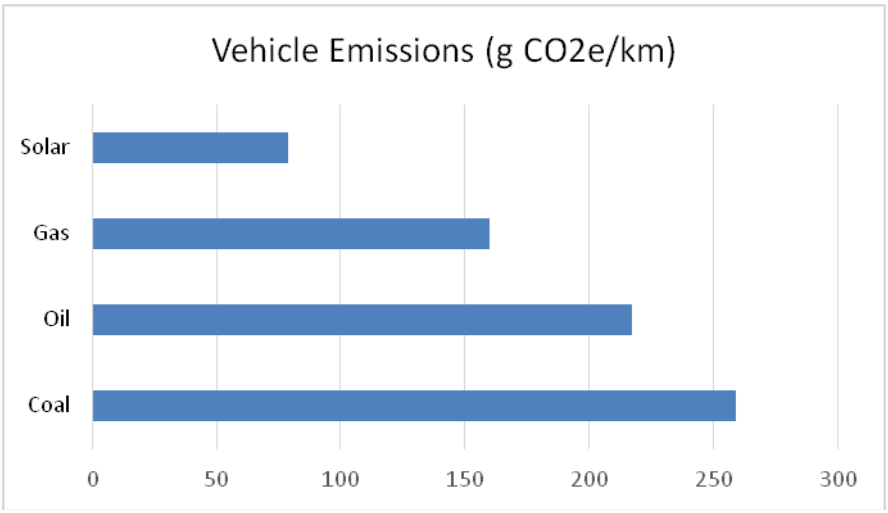

Figure 4: Electric vehicle emissions[26]

However, electric vehicles still possess a great advantage of producing no tailpipe pollutants and noise and because of that, they are suitable for urban usage.

Electric vehicles and related infrastructure technology have been developed rapidly. The environmental friendliness of electric vehicles is tested by many projects, where electric vehicles are deployed for business and personnel uses. The main critical issues are high purchase price of the vehicles, heavy weight of the batteries, limited ranges of the vehicles, low energy density, lack of recharging points with a common plug and limited selection of vehicle models.[27]

According to the proposal from the European Commission in January 2013, Member States shall ensure that a minimum number of recharging points for electric vehicles are put into places, at least the number given in table 1, by 31st December 2020, at the latest. "*Member States should ensure that recharging points for electric vehicles are built up with sufficient coverage, at least twice the number of vehicles, and 10% of them publicly accessible, focussing in particular on urban agglomerations*". [28] As mentioned earlier, this goal was not agreed and approved by all Member States and therefore no longer applicable. However, it is included in this report in order to show what the European Commission expects for the building up infrastructure for electric vehicles in each country and in the whole Europe. By rejecting this proposal from the Commission, all Member States are instead requested to submit their objectives and plans for the minimum coverage for alternative fuels charging infrastructure to the Commission. It is expected to be reviewed and published by the Commission in a very near future.

[26] [The Green Optimistic, 2014]
[27] [European Commission (1), 2013]
[28] [European Commission (6), 2013, p. 8]

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ANNEX II

Minimum number of electric vehicle recharging points in each Member State

Member State	Number of recharging points (in thousands)	Number of publicly accessible recharging points (in thousands)
BE	207	21
BG	69	7
CZ	129	13
DK	54	5
DE	1503	150
EE	12	1
IE	22	2
EL	128	13
ES	824	82
FR	969	97
IT	1255	125
CY	20	2
LV	17	2
LT	41	4
LU	14	1
HU	68	7
MT	10	1
NL	321	32
AT	116	12
PL	460	46
PT	123	12
RO	101	10
SI	26	3
SK	36	4
FI	71	7
SE	145	14
UK	1221	122
HR	38	4

Table 1: Annex II - Minimum number of electric vehicle recharging points in each Member State[29] (the number of the table were not ratified by the Member States and therefore the inclusion of the annex in the Directive was cancelled)

[29] [European Commission (6), 2013, p. 20] At present, the Annex II is removed from the Directive

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Also for supporting the development of electric vehicles, the Commission proposed that the electric vehicles consumers shall have the right to purchase electricity from any registered supplier, regardless of the Member State. The consumers also should have the right to contract electricity simultaneously with several suppliers so that "*[…] electricity supply for an electric vehicle can be contracted separately*"[30]. Moreover, Member States shall ensure that any person can "*[…] establish or operate publicly accessible recharging points and that distribution system operators cooperate on a non-discriminatory basis with any such person*".[31] It is required that the charging price at publicly accessible charging points are reasonable and do not include any additional fee for users, who do not have contractual relations with the charging points' operator.

2.1.1.3 Hydrogen

Hydrogen is one of the cleanest alternative fuels that are used in transport, due to no tailpipe emissions.[32] However, as well as with the electricity, life cycle environmental friendliness is and will always be dependent on the initial source of power. One of the advantages hydrogen brings to the transport sector is the possibility to produce the hydrogen fuel only from renewable energy (e.g. solar, water or wind power).Therefore, using renewable energy to produce hydrogen is very important as it makes hydrogen vehicles purely CO_2 free concerning the well-to-wheel emissions. The hydrogen's technology (fuel production as well as hydrogen powered fuel cell vehicles) is matured in a high level. It is applied in many transport modes: passenger cars, city buses, light vans and inland ships.[33] The hydrogen vehicles have similar driving range and refuelling time compared to petrol and diesel vehicles, which makes them technically competitive. Moreover, hydrogen vehicles have higher efficiency and thus better fuel economy, compared to conventionally fuelled vehicles. Some Member States have seen the promising future of hydrogen vehicles and have planted for their refuelling network. However, it is important to acknowledge the main issues for the market take-up of hydrogen: high costs of new fuel cells technology, the lack of infrastructure and the lack of original equipment manufacturers producing hydrogen vehicles.

[30] [European Commission (6), 2013, p. 14]
[31] [European Commission (6), 2013, p. 14]
[32] [Fayaz et al., 2012]
[33] [European Commission (1), 2013]

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2.1.1.4 Natural gas

CNG (Compressed Natural Gas)

Compressed natural gas is another alternative fuel for road transport. CNG is produced by compressing natural gas that has been to up to 3,600 psi[34] into a high-pressure container.[35] The usage of CNG for road transport has many advantages compared to the utilization of conventional fuels. One of the advantages is the ample availability of CNG due to the well-developed natural gas grid, which creates a sufficient base for the infrastructure deployment. CNG is one *"[…] of the cleanest burning alternative fuels available."*[36] Additionally, the CNG car produce lower emissions compared to conventional engine cars.[37] Nonetheless, in order to become more environmental friendly, CNG could be mixed with biogas[38] or entirely replaced with it.[39] To have a CNG powered vehicle also bring cost advantage in comparison to the fossil fuel powered cars as seen in figure 5 below.

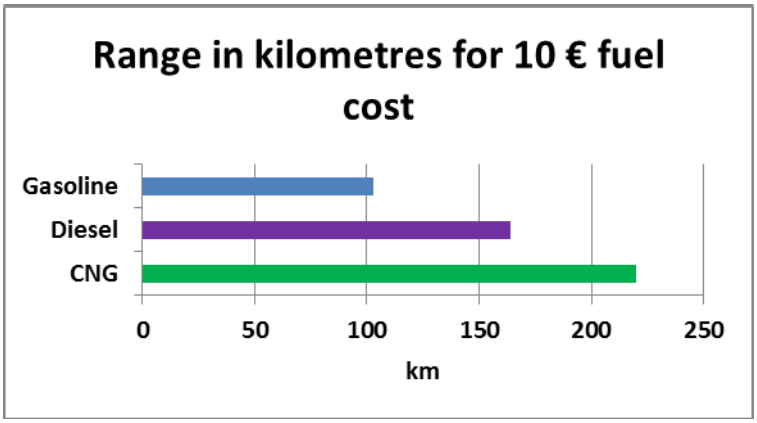

Figure 5: Cost advantage of CNG fuel[40]

"CNG can be used for all road vehicles over short to medium distances".[41] This, together with the fact that they produce lower pollutant emissions, makes the CNG vehicles a very viable alternative for the road city transport, where they have already been used as public buses, utility trucks and taxis.

[34] Pascals
[35] [Cummins Westport, 2014]
[36] [Clean Energy (1), 2013]
[37] [AFDC , 2013]
[38] *"Renewable natural gas—also known as biomethane or biogas—is a model alternative fuel. Produced from animal and crop waste and sewage, it delivers benefits throughout the fuel cycle."* [Clean Energy (1), 2013]
[39] [Clean Energy (1), 2013]
[40] [NGVA Europe (1), 2013]
[41] [European Commission (3), 2013, p. 4]

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LNG (Natural gas in liquefied form)

One of the reasons behind the utilization of Liquefied Natural Gas in the road transport stands in its energy characteristics due to its high calorific value[42] "*LNG is particularly suited for long-distance road freight transport for which alternatives to diesel are extremely limited."*[43] The low deployment of LNG vehicles is highly influenced by the rather insufficient infrastructure of LNG filling stations. The use of LNG can reduce air pollution. "*Because LNG has a higher hydro-to-carbon ratio in comparison to conventional fuels, the specific CO_2 emissions are lower. In addition, LNG does not contain sulphur, which results in (almost) no SO_x emissions and almost no PM-emissions".*[44] On the other hand, the drilling and production of LNG *"[…] can lead to leaks of methane, a greenhouse gas 30 times more potent than carbodioxide."*[45] The methane emissions (CH_4) create a serious problem, because CH_4 has a high global warming potential. However, this problem can be solved *"[…] if oil and gas companies invest in technology to prevent methane from escaping into the atmosphere from gas wells and production facilities."*[46]

GTL (Gas-to-Liquid)

The third alternative fuel produced from natural gas is called Gas-to-Liquid and can also be categorized as synthetic fuel.[47] Vehicles running by GTL produce low emissions. The high cost of advanced engine technologies, however, presently limits the market take-up.

2.1.1.5 LPG (Liquefied Petroleum Gas)

Liquefied Petroleum Gas is *"[…] a gas product of petroleum refining primarily consisting of Propane, some propylene, Butane and other light hydrocarbons".*[48] LPG is the *"[…] most widely used alternative fuel."*[49] Over 7 000 000 vehicles in Europe are already running on Autogas – a common name for LPG when used as a fuel for vehicles.[50]

LPG was regarded as an environmental friendly fuel type due to the lower amount of produced emissions.[51] However, since the EURO standards have been set to lower emission limit, LPG is no longer considered as a low pollutant emission fuel. In spite of that, LPG still has a clear advantage in particulate emissions and is expected to expand mostly in a niche market. The usage of LPG as an

[42] [Total, 2014]
[43] [European Commission (1), 2013, p. 5]
[44] [CNSS, 2014]
[45] [Davenport, 2014]
[46] [Davenport, 2014]
[47] [ASFE (2), 2014]
[48] [Raslavičius et al., 2013, p. 515]
[49] [AEGPL Europe, 2014]
[50] [AEGPL Europe, 2014]
[51] [FuelEconomy, 2014]

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alternative fuel offers several technical advantages as well. For instance the engine oil does not become diluted and therefore does not have to be changed so often.[52] On the other hand, there is one disadvantage, compared to the previously mentioned CNG and LNG fuels, as LPG is dependent on the petroleum, which in current fossil fuel economy can dramatically influence the cost prices as well as selling prices.[53] The dependence on the petroleum also causes that contrary to the LNG and CNG, LPG does not possess the cost advantage against gasoline and diesel vehicles (figure 6).

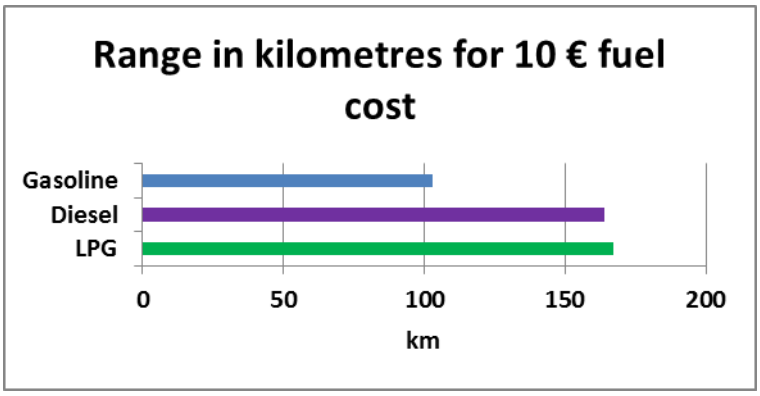

Figure 6: Cost advantage of LPG fuel[54]

2.1.2. Fields of focus

From the status of alternative fuels, it can be noticed that the lack of infrastructure is one of the main issue for further implementing alternative fuels in the market. Besides, the high cost of vehicles (including the battery cells) and the low level of consumer acceptance are also addressed in the Directive. Based on that, the actions from the Directive are focused on the following fields:

- Addressing alternative fuels infrastructure
- Developing common technical specifications
- Addressing consumer acceptance
- Addressing the technological development

1) Addressing alternative fuels infrastructure

One of the major aims of the Directive on the deployment of alternative fuels infrastructure, is to solve the "chicken and egg" problem. The Directive states "*where […] alternative fuel infrastructure is not built, as there is insufficient number of vehicles and vessels, the manufacturing industry does not produce them at competitive prices, as there is insufficient consumer demand, and consumers in*

[52] [LPG-Cars, 2014]
[53] [Clean Technica, 2014]
[54] [NGVA Europe (1), 2013]

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consequence do not purchase them."[55] This proposal provides requirement for necessary number of infrastructure coverage to ensure economies of scale on the supply side and network effects on the demand side. Even though this requirement is not agreed by Member States, as they would like to set up their own objectives and targets, it is a necessary action from the European Commission to encourage public and private sectors in all Member States to invest in infrastructure, in order to create a market take–up for alternative fuels.

The requirement of infrastructures for Member States is expected to attract investments from both public and private sectors. The estimated investment of 10 billion EURO is planned to be paid back via the market take-up.[56] However, the proposal suggests that the direct public funding for infrastructure build-up is not needed, if Member States use the wide range of policy tools at their disposal, such as changes in permissions, regulations and alternative types of Public–Private–Partnerships (PPPs). On the other hand, the European Union funds are available for the market development of alternative fuels and the build-up of their infrastructure.[57] An example of these fund is the Connect Europe Facility (CEF), which has a budget of 50 billion euros to boost transport, energy and digital network. In the transport sector, 26.2 billion euros is available for the Member States to invest in the transport infrastructure. [58]

2) Developing common technical specifications

A main obstacle for the development of electric vehicles in Europe is the implementation of a common plug type. Therefore, the Commission proposes that the standard recharging points for electric vehicles shall be equipped, for interoperability purpose, with a Type 2 connector as described in standard EN62196-2:2012, by 31st December 2015 at latest. Alternate Current (AC) fast recharging points for electric vehicles shall be equipped, for interoperability purposes, with Type 2 connectors as described in standard EN62196- 2:2012. Direct Current (DC) fast recharging points for electric vehicles shall be equipped, for interoperability purposes, with Type "Combo 2" connectors as described in the relevant EN standard, which is to be adopted by 2014. Both AC and DC recharging points should be complied with the technical specification set out, latest by 31st December 2015.[59]

For LNG refuelling points for water borne vessels and motor vehicles, they are required to "*[…] comply with the relevant EN standard, to be adopted by 2014*."[60]

[55] [European Commission (1), 2013, p. 9]
[56] [European Commission (1), 2013]
[57] [European Commission (1), 2013]
[58] [European Commission (2), 2011]
[59] [European Commission (1), 2013]; [European Commission (6), 2013]
[60] [European Commission (6), 2013, p. 21]

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For CNG, connectors/receptacles shall comply with UN ECE Regulation 110 (referring to ISO 14469, part I and II). CNG and L-CNG refuelling points shall comply with the relevant EN standard, to be adopted by 2014.

The technical specifications for petrol and diesel fuels containing biofuels are as following:
"*Petro containing low- blend bioethanol shall meet the standard EN228.*
Diesel containing low-blend biodiesel shall meet the standard EN590.
All fuel pumps serving petrol at refuelling points shall implement the fuel labelling requirements as defined in the standard EN228.
All fuel pumps serving diesel at refuelling points shall implement the fuel labelling requirement as defined in the standard EN590".[61]

3) Addressing consumer acceptance

The use of alternative fuels for the transport sector is still new to the EU citizens, as well as companies and organizations. Besides the technical barriers and lacking infrastructure, another issue that holds the development of alternative fuels back is insufficient information flows to consumers on fuel quality, vehicle compatibility, availability of recharging/refuelling points, as well as the full impacts of clean vehicles on the environment, financial and safety aspects[62]. The lack of information to the citizens or organizations leads to a low level of consumers' knowledge about the offered products (clean fuels and clean vehicles). Consequently, they are not willing to try and purchase alternative fuels vehicles. The promotion and marketing activities concerning alternative fuels and the related vehicles should be implemented stronger in the next actions by the Union and all Member States. On the other hand, any changes in policy and regulation on the national and regional levels to support the development and implementation of alternative fuels should also be distributed to the citizens. Therefore, it is required that clear and simple information of the compatibility between the fuels and the vehicles existing in the market has to be placed at the pumps, at all refilling points, in vehicle manuals, and on the vehicles – "*[…] sold on the territory of the Member States from [the date of the transposition of this Directive], and for all other vehicles registered on the territory of the Member States from the date of the first technical control of the vehicles following [the date of the transposition of this Directive]."*[63] Also, the deployment of policy made for the building up of alternative fuels infrastructure needs to be directed to consumers as well.

[61] [European Commission (6), 2013, p. 22]
[62] [European Commission (1), 2013]
[63] [European Commission (6), 2013, p. 16]

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4) Addressing the technological development

In order to improve the technical barrier, the European Commission proposes that public-private-partnerships should be further developed based on the experiences gained with European Technology Platforms and Joint Technology Initiatives.[64] The private partner can be understood as:

- All type of companies, organizations and citizens who use alternative fuels, their associated infrastructure and vehicles
- Companies, factories that build up infrastructure and make products related to alternative fuels

The users of alternative fuels, their infrastructure and vehicles are included in the technological development, as they are the end consumers. They can give valuable recommendations and requirements to the producers and operators.

Companies and factories who involve indirectly or directly in building up the needed infrastructure for alternative fuels and produce clean vehicles are also very important, because they already have the knowledge and experiences in the technological development. On the other hand, their financial investment to the market will reduce the direct public funding, which is also included in the strategy of the European Commission. The partnership between partners from different sectors should support technology development and accelerate market introduction.[65]

Also, the European Commission addresses that batteries and fuel cells are key technologies and a comprehensive R&D strategy needs to be launched to regain knowledge in Europe. Electrochemistry, as a core scientific knowledge, therefore needs to be promoted in R&D and professional educations. Manufacturing, including hydrogen production from renewable and on-board storage should be given support to regain and strengthen European competition in this field. Further research is needed on dedicated engines and after-treatment of CNG and LNG powertrains and light-weight fuel tanks. The only alternative fuel option for aviation, advanced biofuels, also needs further investment.[66]

2.1.3. National Policy Framework

Together with requirement for action on the alternative fuels, the proposal also makes requirement on the national Policy Framework, which should contain at least the following elements:

1) A regulatory framework

"A regulatory framework shall consist of measures to support the build-up of alternative fuels infrastructure, such as building permits, parking lots permits, environmental performance of

[64] [European Commission (1), 2013]
[65] [European Commission (1), 2013]
[66] [European Commission (1), 2013]

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businesses certification, fuel stations concessions".[67] The changes in national policy to fulfil this requirement will attract investors to join the building up of alternative fuels infrastructures. It is because the information of permission is clearer. It also helps the Member States to control the environmental quality of the asset built to ensure about sustainability of the infrastructure.

2) Policy measures supporting the implementation of the national policy framework

"These measures shall include at least the following elements:

- Direct incentives for purchase of alternative fuels means of transport or building of the infrastructure;

- Possibility of tax incentives to promote alternative fuels means of transport and infrastructure;

- Use of public procurement in support of alternative fuels, including joint procurement;

- Demand side non-financial incentives: e.g. preferential access to restricted areas, parking policy, dedicated lanes;"[68]

This requirement encourages Member States to support the alternative fuels development in both financial and non-financial ways. The financial support can be implemented through tax incentives and direct incentives for purchasing alternative fuels vehicles or building-up of the infrastructures. The public procurement, including joint procurement is also another way to support the private sector by purchasing assets, which are built by the private sector, in order to help them to make cost-recovery faster. This requires a strong cooperation between the public and private sectors to make efficient contracts. On the other hand, non-financial support could be an option to attract the cash-flow from the private sector, without financial payment from the governments, as mentioned: *"[...] preferential access to restricted areas, parking policy, dedicated lanes".*[69]

3) Deployment and manufacturing support

"Yearly public budget allocated for alternative fuels infrastructure deployment, differentiated by fuel and transport mode (road, rail, water and air).

Yearly public budget allocated to support manufacturing plants for alternative fuels technologies, differentiated by fuel and transport mode."[70]

4) Research, technological development and demonstration:

"Yearly public budget allocated to support alternative fuels RTD&D, differentiated by fuel and transport mode."[71]

Although it is possible to involve private sectors to join the development of alternative fuels by non-financial incentives, it is still important that there is national budget in all Member States to support

[67] [European Commission (6), 2013, p. 19]
[68] [European Commission (6), 2013, p. 19]
[69] [European Commission (6), 2013, p. 19]
[70] [European Commission (6), (2013), p. 19]
[71] [European Commission (6), (2013), p. 19]

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alternative fuels in R&D, promotion and deployment plants. Thus, requirements for available national budget regarding all alternative fuels in different transport modes are needed in the national policy frameworks.

5) Targets

- "*2020 national targets for the deployment of alternative fuels in the different transport modes (road, rail, water and air) and for the relevant infrastructure*

- *national targets, established year by year, for the deployment of alternative fuels in the different transport modes and for the relevant infrastructure in order to achieve 2020 national targets."*[72]

Year 2020 is proposed by the Commission as the deadline for building up the requirement coverage of alternative fuels infrastructures in all Member States. It is expected that clean transport will be in a high-level of development as regards to the technology as well as consumers´ acceptance. In order to avoid unequal development, Member States are required to cooperate together when creating their national policy frameworks, and during the process of deploying alternative fuels in the market.

As form of the legal act, it is stated in the proposal that: *"Member States are required to put into place national policy frameworks, for which a minimum set of elements is given in this proposal for the Directive. But the Member States keep the choice of the transposition methods to achieve the objectives set out."*[73] It means that the Member States should, based on the current status of alternative fuels in their nation, their financial budget, their current knowledge and technology, adopt the Directive in the most cost-efficient way. On the other hand, it is underlined that the fragmentation of the internal market through uncoordinated introduction of alternative fuels should be avoided. For this, cooperation between Member States and the Union, and cooperation among Member States are required. It can be done through consultations or joint policy frameworks, in particular, where continuity of alternative fuels infrastructure coverage across national borders. The Commission shall evaluate the national policy frameworks and ensure that there is coherence at EU level.

[72] [European Commission (6), 2013, p. 19]
[73] [European Commission (6), 2013, p. 4]

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2.2 Consequence of the changes in the political context of the Transport and Energy Policies for Alternative Fuels

So far, national targets of infrastructure coverage will be made by Member States, and will be evaluated by the Commission. These targets will create motivation for the private companies to invest in building up infrastructures and create a long-term business relationship with the public sector. Alternative modes of public-private-partnership could be activated by the public sector to create a better cooperation with the private sector, to increase the research and development in technology and attract more financial investments from the private sector. It will require changes in policies and regulations at national level in each Member State.

The changes in policy context in regional and national level, as well as public funded project can be used as promotion tool for the development and deployment of alternative fuels and vehicles.

The implementation of the Directive on alternative fuels will strengthen the consumers´ belief on the future of alternative fuel vehicles. It will create a framework for faster market take-up, which also helps to increase the R&D and investments to the infrastructure for alternative fuels from investors.

The minimum level of infrastructure across Europe and the EU wide standards for the infrastructure will increase the equal development of alternative fuels in all Member States. It gives opportunities for Member States to cooperate and it will create bigger attention to international investors as well as citizens in Europe.

From the users' side, the implement of this Directive in all Member States will bring much more information to them about the alternative fuels and alternative fuel vehicles. It will be possible for them to get access to financial and non-financial incentives by purchasing and using alternative fuels and vehicles.

On contrary for those advantages, which this Directive gives to the development process of alternative fuels, there are some difficulties that should be acknowledged. For example, there is already fragmentation of the alternative fuels markets in Europe. It will be easy for some countries to follow the requirements in this Directive, as they may have already started and moved far with the use of technologies, infrastructure and number of vehicles running. For those countries that are not so far in the development of alternative fuels, it will be difficult for them to create an intensive plan to fulfil the general requirements for all Member States according to this Directive, within the legislative timeframe 2020.

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3. Current state of charging/fuelling infrastructure

3.1. Stakeholders of the alternative charging/fuelling infrastructure

The main stakeholders of the alternative charging infrastructure are composed of the electricity and fuel (gas and biofuels) producers and providers, car manufacturers, engineering companies, national governments and municipalities. As regards to biofuels, one of the stakeholders acting in Europe is Royal Dutch Shell which is *"[...] the biggest fuel provider and marketer with their approximately 46,000 petrol stations"* and has extensive experience with first as well as advanced biofuels.[74] The majority of electric charging infrastructure stakeholders consist of core electricity producers like RWE or E.ON, often in cooperation with major car manufacturers like BMW and Volkswagen.[75] The major stakeholders in natural gas and LPG infrastructure are gas supply chain companies – producers, transmissions and distribution companies, as for instance the Linde Group, a global industrial gases and engineering company. Additionally, the initiatives and platforms that have supported the initial deployment of the alternative fuel infrastructure in most of the NSR countries, are very often funded by national governments and municipalities.

3.2. Current state of charging and fuelling stations of alternative fuels

This part elaborates the current state of charging and fuelling stations in the European Union with a focus on the infrastructure in the NSR countries. The analysis presents each alternative fuel separately in the same order as they have been introduced in section 1.1.1 – biofuels; electricity; hydrogen; natural gas; liquefied petroleum gas. The state of the infrastructures is based on several variables as for instance number of charging/fuelling stations and their allocation.

3.2.1 Biofuels

Concerning the scope of the study at hand, the main focus is on biodiesel filling stations, as biodiesel accounts for the majority of the European Union biofuels market and the European Union leads the world´s production of this alternative fuel.[76] On the other hand, it is necessary to mention that the usage of biodiesel that is produced from food crops should be decreased and the focus should be on the research and development of advanced biofuels (second and third generation) in order to fulfil the environmental objectives set by the European Union. However, the Member States of the European Union were parted by the suggested policy measure of limiting biofuels from food crops to 5%. The main supporters and opponents of the 5% proposal are shown in table 2. Germany, France, Italy,

[74] [Adolf & Witt, 2008, p. 1]
[75] Detailed analysis concerning the electric charging infrastructure is provided in chapter 3
[76] [EurActiv, 2013]

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Spain and the biofuels industry were strong opponents of the proposal since they all have high economic interest in producing and utilizing biofuels, contrary is Denmark, the United Kingdom, the Netherlands as well as several NGOs. In June 2014, after a failed agreement in 2013, the European Union energy ministers came to a compromise of 7% limit for food-based biofuels in transport fuel.[77]

Supporters	Opponents
Denmark	Germany
The United Kingdom	France
The Netherlands	Italy
NGOs[78]	Spain
	European Farmers Association COPA
	Biofuels Industry

Table 2: Influential interest groups divided by supporters and opponents of the 5% proposal[79]

This has also influenced the slower development of the usage of biofuels as alternative fuels in the European transport sector, including the fuelling infrastructure, even though liquid biofuels possess a great advantage as regard to building up the infrastructure due to the utilization of the existing fuelling infrastructure system.[80] In addition to that, the development of third generation biofuels also known as synthetic fuels[81] or paraffinic fuels[82] is slower than expected and thus the infrastructure deployment stagnates as well.

3.2.2 Electricity[83]

Based on the ChargeMap service (table 3), the current amount of electric charging stations in the NSR countries can be considered as sufficient, taking into account the present number of electric vehicles on the roads, and the most developed as regards to other alternative fuels. On the other hand, the difference amongst the countries is significant and thus precludes the mass deployment on European level. Consequently, this divergence increases the possibility that the installed plugs are compatible only with certain vehicle types and because of that it aggravates the international deployment. Therefore, when expanding the infrastructure in the NSR countries (as well as in the whole European Union), it is equally necessary to emphasize the importance of unification of plug types. The Dutch

[77] [Lewis, 2014]
[78] Non-Governmental Organizations
[79] [van Hasselt, 2013]
[80] [Future Transport Fuels, 2011]
[81] BTL (Biomass-to-Liquid) and GTL (Gas-to-Liquid) are labelled as synthetic fuels, which generally *"…refer to a liquid fuel obtained from a specific feedstock such as natural gas, coal, or a biomass."* [Future Cars, 2014]
[82] BTL and GTL should be classified as paraffinic fuels together with HVO (Hydrotreated Vegetable Oil) due to the similar composition and performance [ASFE (2), 2014]
[83] Country-based analysis of the electric charging infrastructure is provided in chapter 3

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electric charging infrastructure is considered as the most developed concerning the number of stations. The infrastructures in Germany and the United Kingdom are also fairly developed, however they mainly focus on separate regions.

NSR Countries	Charging points[84]	Plugs
Germany	2626	7561
Sweden	401	497
The Netherlands	5474	9447
Denmark	272	991
The United Kingdom	1757	3652
Norway	1416	5419
Belgium	501	1496

Table 3: Electric charging points in the NSR countries[8586]

3.2.3 Hydrogen

The current infrastructure of hydrogen filling stations cannot be compared to that for fossil fuels. According to Netinform[87] the overall number of operational hydrogen stations in NSR countries appears to be not sufficient enough in order to provide a functional infrastructure on national as well as international level (figure 7). With the exception of Germany that plans to increase the number of publicly accessible stations (from 15 to 50 public filling stations by 2015) and consequently increase the number of hydrogen stations to 400 by 2023.[8889] However, it is necessary to mention that there exist projects enforcing the deployment of hydrogen fuelling infrastructure. For instance the project called Hydrogen Infrastructure for Transport (HIT) that concentrates on the implementation of the hydrogen fuelling stations along the core TEN-T corridors, which is very important especially in Scandinavia where the number of hydrogen filling stations is low, as seen in figure 7.[9091] The TEN-T programme also provides funding for increasing the hydrogen filling infrastructure in the Netherlands, where the first public hydrogen filling station was opened recently.[92] Scandinavian Hydrogen Highway Partnership is another significant platform for developing international network of refuelling stations, as

[84] Public or semi-public stations
[85] [Chargemap, 2014]
[86] *"The information displayed […] reflect the data available to ChargeMap and might differ from reality, depending on how these countries have been covered by our services."* [Chargemap, 2014]
[87] Info service of Ludwig-Bölkow-Systemtechnik GmbH and TÜV SÜD
[88] [Daimler, 2012]
[89] [King, 2013]
[90] [HIT, 2014]
[91] Baltic – Adriatic; North Sea - Baltic; Mediterranean; Orient / East-Med; Scandinavian – Mediterranean; Rhine – Alpine; Atlantic; North Sea – Mediterranean; Rhine – Danube [European Commission (2), 2014]
[92] [EEO, 2014]

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it coordinates collaboration amongst Norway (HyNor), Denmark (Hydrogen Link) and Sweden (Hydrogen Sweden).[93]

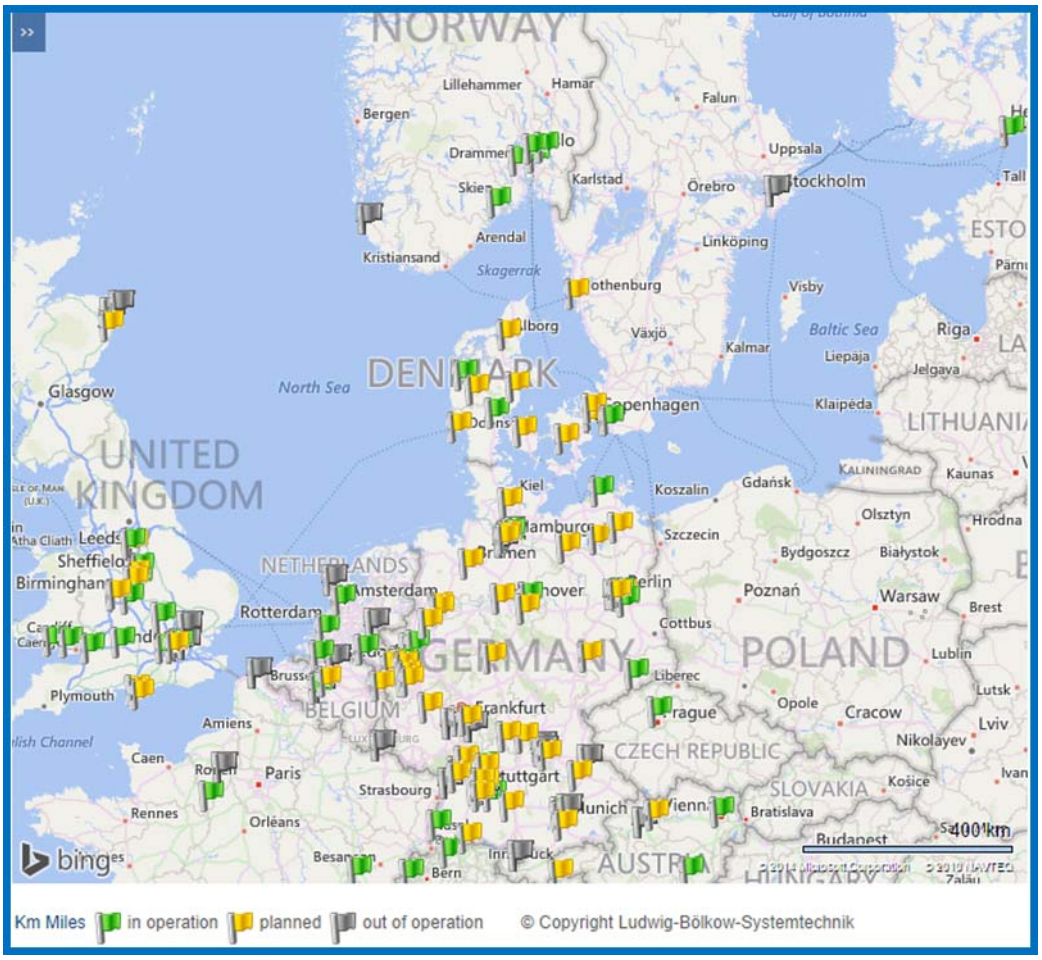

Figure 7: Hydrogen filling stations in the NSR countries[94][95]

3.2.4 Natural Gas

As mentioned in chapter 1, there exist three main types of natural gas used for the road transport; Compressed Natural Gas, Liquefied Natural Gas and Gas-to-Liquid.

Compressed Natural Gas

The development of CNG in the European market is significant, with around 1 million natural gas vehicles on the road and around 3000 CNG filling stations in total, according to statistics provided by NGVA[96] Europe. This is because the existing network makes it is easier to create additional filling

[93] [Scandinavian Hydrogen Highway Partnership, 2014]
[94] [Netinform, 2014]
[95] The displayed data are based on the Netinform and can differ from the latest market situation
[96] Natural & bio Gas Vehicle Association

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stations and support the expanding number of CNG vehicles. Nonetheless, the development of the infrastructure of publicly accessible CNG stations in the NSR countries is unequal (table 4), with Germany leading and its publicly accessible CNG stations that are deployed throughout the whole country.

NSR Countries	Number of stations
Germany	844
Sweden	138
The Netherlands	119
Denmark	7[97]
The United Kingdom	2[98]
Norway	21
Belgium	12

Table 4: Publicly accessible CNG stations in the NSR countries[99][100]

Strategic location and public accessibility are important elements when creating infrastructures for CNG, with maximum distance of 150 km to be adopted by 31st December 2020 at latest. The technical specifications for CNG refuelling points for motor vehicles are required as:

- *"CNG connectors/receptacle shall comply with UN ECE Regulation 110 […]"*[101]
- *"[...] refuelling point shall comply with the relevant EN standard, to be adopted by 2014."*[102]

Additionally, the gas provided for motor vehicles should be at a quality that is required for use in current and advanced technology CNG vehicles.[103]

Liquefied Natural Gas

The market for LNG is not expanding so well due to the lack of refuelling infrastructures as according to NGVA Europe the total number of refuelling stations is minimal (table 5). Also common technical specifications on refuelling equipments and safety regulations hold back the expansion of refuelling infrastructures.[104] There is a need of infrastructure network built up across Europe for the market uptake of LNG. Therefore, the Commission proposed that "*Member States shall ensure that publicly accessible LNG refuelling points for maritime and inland waterway transport are provided in all*

[97] [CNG Europe, 2014]
[98] [MadeGasCar, 2014]
[99] [NGVA Europe (2), 2013]
[100] The displayed data are based on the NGVA Europe; CNG Europe; MadeGasCar and can differ from the latest market situation
[101] [European Commission (6), 2013, p. 22]
[102] [European Commission (6), 2013, p. 22]
[103] [European Commission (6), 2013]
[104] [European Commission (1), 2013]

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maritime ports of the Trans-European Transport (TEN-T) Core Network by 31 December 2020 at the latest."[105] Also," *[…] publicly accessible LNG refuelling points for inland water transport are provided in all inland port of the TEN-T Core Network by 31 December 2025 at the latest*."[106] Moreover, it is required the Member States to cooperate together to ensure that heavy duty motor vehicles running on LNG can travel all along the roads on the TEN-T Core Network. "*For this purposes, publicly accessible refuelling points for LNG shall be established within distances not exceeding 400 km by 31 December 2020 at the latest."*[107] Besides, it is underlined that in a longer perspective, LNG's infrastructure should be also available outside the Core Network, in those ports that are important for vessels not directly operate in transport (fishing vessels, offshore service vessels, etc.). The LNG refuelling point for waterborne vessels and motor vehicles shall comply with the relevant EU standards, to be adopted by 2014.[108]

NSR Countries	Number of stations
Germany	0
Sweden	8
The Netherlands	7
Denmark	0
The United Kingdom	13
Norway	1
Belgium	0

Table 5: LNG stations in the NSR countries (2013)[109][110]

3.2.5 Liquefied Petroleum Gas

The number of LPG vehicles and the deployment is much higher than for other alternative fuels.[111] Infrastructure for LPG is well established, "*[…] with some 28,000 dispensing sites in the EU, but with a very uneven distribution across the Member States."*[112] However, due to the significant divergence between the particular NSR countries, concerning the data from myLPG, the deployment of LPG vehicles on international level is limited (table 6). For instance the difference between the number of stations in Germany and its neighbour Denmark is substantial and therefore it provides less chance for possible cooperation between those two countries. In addition to that, it is difficult to anticipate further

[105] [European Commission (6), 2013, p. 15]
[106] [European Commission (6), 2013, p. 15]
[107] [European Commission (6), 2013, p. 15]
[108] [European Commission (6), 2013]
[109] [NGVA Europe (2), 2013]
[110] The displayed data are based on the research of NGVA Europe and can differ from the latest market situation
[111] Section 1.1.1.5
[112] [European Commission (1), 2013, p. 5]

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mass deployment, as LPG is the least environmental friendly alternative fuel and thus the support from the European Union can be lesser.

NSR Countries	Number of stations
Germany	9077
Sweden	33
The Netherlands	1797
Denmark	5
The United Kingdom	1733
Norway	158
Belgium	735

Table 6: LPG stations in the NSR countries[113][114]

The above analysis administrated an insight into the current state of alternative fuels infrastructure in the European Union and in particular in the NSR countries. The level of the development of the infrastructures is very differential as regards to the fuel types as well as concerning specific countries. Therefore, based on the contemporary situation, the following analysis mostly concentrates on the infrastructure related to electric vehicles. The electric charging infrastructure is seen as the most developed, fairly deployed and thus the most prospective.

3.3 National policies regarding alternative fuels and their infrastructure

This part concerns the national legislative policies related to the use of alternative fuel vehicles. The deployment of alternative fuel infrastructure is very much dependant on the number of alternative fuel vehicles available. Therefore the policies concerning the vehicles influence the related infrastructure as well and because of that this study at hand elaborates those policies. In most of the NSR countries the utilization of alternative fuel vehicles is supported by various tax exemptions and advantageous purchase conditions. Another concession related to the usage of environmental friendly vehicles is free parking areas or reduced parking charges, predominantly in urban areas. These tax allowances and other preferences that concern alternative fuels vehicles are then generally based on CO_2 emissions. Table 7 presents some of the national-policy incentives for each NSR country with a main focus on electric vehicles. The majority of the policies consider tax, purchase and other advantages for individuals as well as on corporate level.

[113] [myLPG, 2014]
[114] The displayed data are based on the myLPG and can differ from the latest market situation

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Based on the above, it can be stated that the support of alternative fuels, as regards to the national policies in the NSR countries is solid and thus establish a firm foundation for the further development of the vehicle as well as infrastructure market.

NSR Countries	National Legislative Policies
Germany[115][116]	• Electric vehicles are exempt from the annual circulation tax for a period of ten years from the date of their first registration. • In the future, all motor vehicles, commercial light vehicles and light vehicles which are completely electric powered or technology neutral with a combined type CO_2 test value below 50g/km (motor vehicles and commercial light vehicles only) authorized by 21.12.2015 will be exempt from motor vehicle tax for a period of ten years.
Sweden[117][118]	• Electric vehicles with an energy consumption of 37 kWh per 100 km or less are exempt from the annual circulation tax for a period of five years from the first registration. The same five year exemption applies to electric hybrid and plug-in hybrid vehicles that fulfil the new green car definition applied for new registrations from 1 January 2013. • A so-called "Super green car premium" (Supermiljöbilspremie) of SEK 40,000 is available for the purchase of new cars with CO2 emissions of maximum 50 g/km. • Some local authorities have reduced parking charges for eco vehicles; the rules vary from one local authority to another.
The Netherlands[119][120]	• Electric vehicles are exempt from the registration tax BPM[121]. Other vehicles including hybrid vehicles are also exempt from the registration tax if they emit maximum 85 g/km (diesel) or 88 g/km (petrol) of CO_2 respectively. Vehicles emitting maximum 50 g/km of CO_2 are exempt from the annual circulation tax. • For leased cars, an income tax measure makes EVs[122] and HEVs[123] attractive. A normal tariff of 20% of the new car value that is added to the yearly income tax is lowered to 0% for zero-emission vehicles or 14% for low-CO_2 vehicles like many hybrids. • Some of the largest cities in the Netherlands have already designated environmental zones with more stringent entry rules for vehicles on the basis of their emission characteristics.
Denmark[124][125]	• Battery EVs and fuel cell vehicles are exempted from the registration tax and annual tax until the end of 2015, for passenger cars this can be very high, up to 180% based on the value of the car. • Locally, there is free parking for EVs in cities. • Already implemented tax exemptions of up to €0.08 per kWh on electricity for hydrogen

[115] [ACEA, 2014]
[116] [Germany: Trade & Invest, 2014]
[117] [IA-HEV (3), 2014]
[118] [ACEA, 2014]
[119] [IA-HEV (4),2014]
[120] [ACEA, 2014]
[121] Belasting van Personenautos en Motorrijwielen
[122] Electric Vehicle
[123] Hybrid Electric Vehicle
[124] [IA-HEV (2), 2014]
[125] [Renewable energy, 2012]

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	production provide a strong case for a renewable hydrogen supply for the infrastructure network. • The existing Danish tax exemption for FCVs[126] is to be continued throughout 2015, ensuring a 180% tax reduction compared to conventional vehicles.
The United Kingdom[127][128]	• Purchasers of electric vehicles and plug-in hybrid vehicles with CO2 emissions below 75 g/km receive a premium of £ 5,000 (maximum) or 25% of the value of a new car or £ 8,000 (maximum) or 20% of the value of a new LCV[129] meeting eligibility criteria. • Electric vehicles are exempt from the annual circulation tax. This tax is based on CO2 emissions and all vehicles with emissions below 100 g/km are exempt from it. • Some local authorities provide exemptions or a reduced charge for electric cars (parking charges).
Norway[130]	• Biofuels, biogas, CNG and hydrogen are all subject to lower, or exempt from, fuel and CO_2 taxes. • Incentives for electric vehicles (EV) are generous, in line with the government ambition to have 50,000 zero-emission vehicles on the road by 2018. All-electric cars, including fuel cell electric vehicles (FCEV)[131], are exempt from purchase tax and VAT, receive a 90% discount on annual road tax, pay no toll or municipal parking fees, qualify for free ferry passage, and have access to bus lanes and thousands of public charging points.
Belgium[132][133]	• Electric vehicles are exempt from registration tax in Flanders. • "Ecology premiums" are available in Flanders for companies investing in the purchase of pure electric, plug-in hybrid and extended range electric vehicles. • For companies under corporate tax system: 120% deductibility of purchase cost of EV 100% of plug in hybrid with CO2 < 60g/km; Additional deductibility of 13.5% on the investment of charging infrastructure.

Table 7: Overview of the legislation related to the alternative fuel vehicles in the NSR countries[134]

[126] Fuel Cell Vehicle
[127] [IA-HEV (5), 2014]
[128] [ACEA, 2014]
[129] Light Commercial Vehicle
[130] [FuelCellToday, 2013]
[131] Fuel Cell Electric Vehicle
[132] [IA-HEV (1), 2014]
[133] [ACEA, 2014]
[134] Table quotes specific parts from the original sources

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4. Stakeholders analysis of the alternative fuel infrastructure

In the following parts of the study at hand the focus will be solely on the utilization of electricity for road transport. This is done based on the current status of alternative fuels infrastructure presented in chapter 2. Firstly, the current state of electric charging infrastructure in the NSR countries is the most developed. Secondly, electricity is seen as the most feasible solution concerning alternation for conventional vehicles and their fuelling infrastructure. Below is shown a summary justifying the choice.

Electricity vs. Biofuels

The most negative attribute of the biodiesel (first generation biofuels) rests in the "food crop" versus "fuel crop" dilemma. Whereas synthetic fuels can be the future of the alternative fuel road transport, however, their development and consequently deployment is slower than expected. For instance the BTL (Biomass to Liquids) is still under the Research & Development phase.[135]

Electricity vs. Hydrogen

When comparing electricity and hydrogen the biggest difference can be seen in the current infrastructure. Hydrogen charging stations infrastructure in the NSR countries is almost at the nought state, whereas electric charging stations infrastructure can be seen as fairly developed.

Electricity vs. Natural Gas (CNG and LNG)

According to the MIT report from 2010 *"[…] an NGV[136] does not have comparable efficiency gains relative to electrification via natural gas generation. In general, 1,000 cubic feet (cf) of natural gas, converted to electricity, yields 457 miles in an EV. This same 1,000 cf in an NGV would only have a range of around 224 miles."*[137] In addition to that, the current charging stations infrastructure for NGV cars in the NSR countries is fairly developed just in regards to CNG. Moreover, the installation prices of CNG stations are much higher.[138]

Electricity vs. LPG

LPG is less „clean" alternative fuel than electricity, under the proviso that the initial source of electricity is environmental friendly as well.[139]

Additionally, according to the EU: *"No action is foreseen for LPG, the core infrastructure is already established."*[140]

[135] [ASFE (1), 2014]
[136] Natural Gas Vehicle
[137] [Forbes, 2012]
[138] [Forbes, 2012]
[139] [Boureima et al., 2009]
[140] [European Commission (5), 2013]

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4.1 Identifying stakeholders of the alternative fuel charging infrastructure in the NSR countries

As mentioned in the introduction, the scope of this analysis is limited to the North Sea Region countries. However, some of the stakeholders scrutinized in the analysis can be from other European Union countries. The reason for it is that the stakeholders often cooperate on international level. Based on the previous researches the alternative fuel charging stakeholders for electric charging stations elaborated in the analysis below are: **electricity producers**, **national governments and local governments, vehicle manufacturers** and **charging network operators**. In addition to that, the country analysis provided below mainly focuses on public or semi-public charging stations and privately accessible charging stations are out of the main focus. This is based on the analysis provided by Eurelectric[141] which divides the electric charging stations into four categories (figure 8).

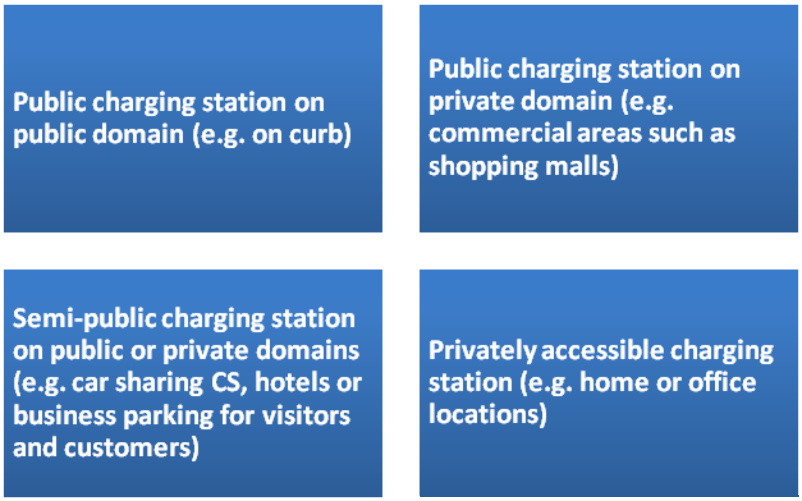

Figure 8: Electric charging stations[142]

4.2 Germany

The majority of electric charging stakeholders in Germany comprise large automobile manufacturers companies like Volkswagen and BMW and electric utilities companies, for instance RWE, E.ON, Vattenfall. Many of the projects that support launching of environmental friendly electric cars are under the electric utility RWE, in particular its subsidiary RWE Effizienz GmbH which specializes in providing energy efficiency infrastructure.[143] The scope of the stakeholders´ approach is mainly concentrated on

[141] The Union of the Electricity Industry
[142] Definitions are directly quoted [Eurelectric, 2013]
[143] [RWE Effizienz GmbH, 2014]

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creating the infrastructure regionally with focus on larger urban areas. Furthermore, a Swiss concept called Park & Charge functions on the German e-mobility market, which supports the utilization of the already existing network.[144] On the other hand, despite the fact that the German e-mobility market is considered as fairly developed, for some of the potential stakeholders the infrastructure market can still be considered as inscrutable and costly. For instance, Siemens AG, one of the largest technological firms, decided to terminate the production of public electric charging stations due to higher costs caused by the slower development of the e-mobility market.[145] One of the disincentives of the development is the incompatibility amongst the functional networks. However, 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.[146] Similar to the Hubject GmbH is a concept called Ladenetz, which strives to pursue the deployment of electric charging infrastructure on national level.[147]

4.3 Sweden

The electric charging infrastructure in Sweden is considerably less developed than the one in Germany (section 3.2). Whereas Germany systematically targets the deployment of the electric charging stations infrastructure so as to provide the infrastructure on a regional level, Sweden targets mostly the larger urban areas. Stockholm region leads with 140 electric charging points allocated in 100 locations (figure 9).[148] There is also the WiCh project that supports the deployment of wireless charging of electric vehicles in the city of Gothenburg and Stockholm.[149] Furthermore, considerable part of electric charging points is located in parallel with major road – for instance TEN-T Core Network Corridor 5 (figure 10).[150]

[144] [Park & Charge, 2014]
[145] [Deutsche Welle, 2013]
[146] [Hubject, 2014]
[147] [Ladenetz, 2014]
[148] [Sunnerstedt]
[149] [WiCh, 2014]
[150] [Sunnerstedt]

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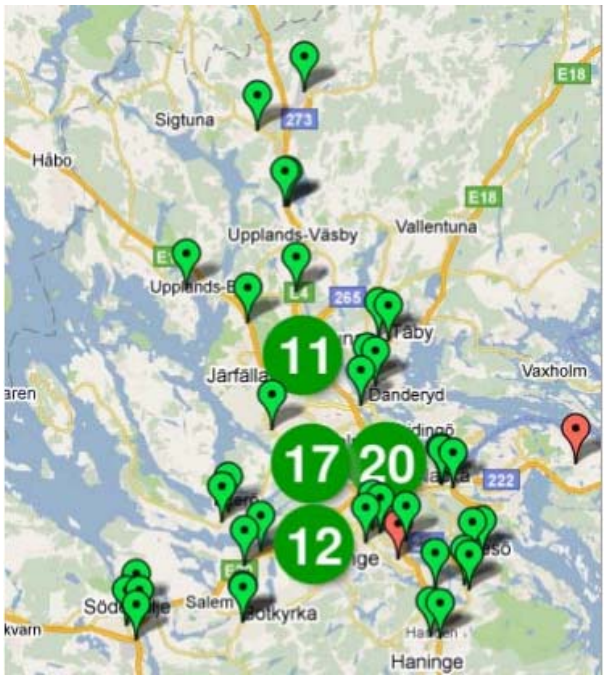

Figure 9: Electric charging points in the Stockholm region[151]

Figure 10: TEN-T Core Network Corridor 5 (Scandinavian – Mediterranean corridor)[152]

Regarding the future of the Swedish electric charging infrastructure a project named Electromobility is of a great importance. The project is led by a non-profit research institute Viktoria Swedish ICT that

[151] [Sunnerstedt]
[152] [European Commision (1), 2014]

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collaborates with many significant institutions like for instance Volvo Group, FKG (Scandinavian automotive supplier association) and Scania Group.[153] Another significant project is called Green Highway, which aims to establish an environmental friendly Sweden-Norway corridor (figure 11). The uniqueness of the project lies in its complexity concerning the geographical scope as the aim is to link small- and medium-sized cities as well.[154]

Figure 11: Green Highway[155]

4.4 The Netherlands

The Dutch electric charging infrastructure follows the "charging pyramid" (figure 12)[156] approach approved and supported by Dutch stakeholders, including governments or car and power companies, so as to pursue the less costly solutions. Many of the public charging stations in Netherlands have been installed by the E-laad Foundation, a consortium that comprises electricity grid operators from different regions.[157] In addition to that, E-laad cooperates with Ladenetz (section 3.2) and Belgian Blue Corner (section 3.8) in order to create a cross-border network for their customers.[158] Another considerable key player on the e-mobility market is the Formula E-Team, a national public-private platform for e-mobility. Formula E-team is a complex platform that supports all aspects of electric transport, including the deployment of electric charging infrastructure. Moreover, the Netherlands also actively strives to broaden the usage of electric freight vehicles, for instance Amsterdam and

[153] [Viktoria Swedish ICT, 2014]
[154] [Nordregio, 2012]
[155] [Nordregio, 2012]
[156] [NL Agency, 2013]
[157] [Open Charge Alliance, 2014]
[158] [E-clearing.net, 2014]

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Rotterdam have joined the FREVUE project, which aims to realise electric lorries as well as the related infrastructure.[159]

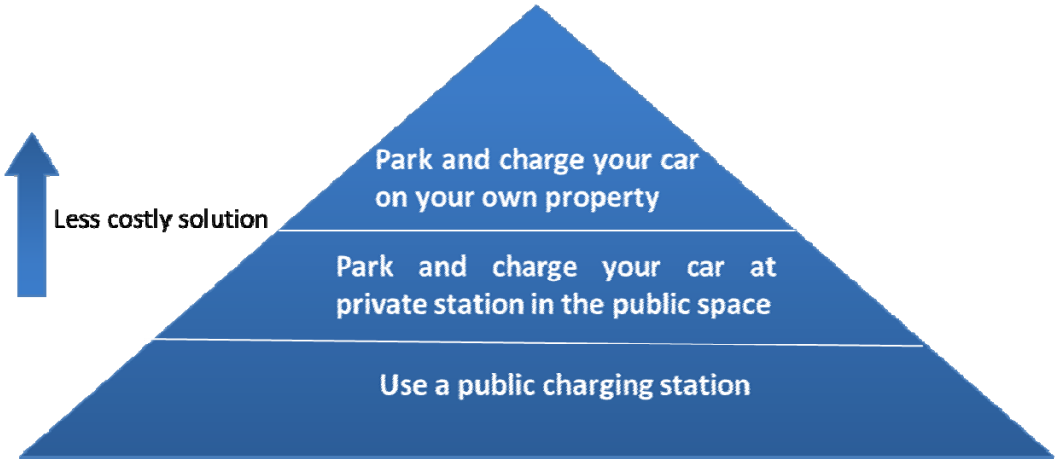

Figure 12: Charging pyramid

4.5 Denmark

Denmark is one of the countries that actively pursue the EV policies and support companies in order to become entirely free of fossil fuels. Nevertheless, despite the fact that the deployment of e-mobility in Denmark is highly supported, the electric charging infrastructure is not fully developed. One of the main Danish stakeholders was Better Place, a company that solely concentrated on electric charging stations services. Better Place went bankrupt in 2013 and its electric charging stations around Denmark were closed. However, E.ON, one of the biggest electric utility service companies decided to purchase the stations and to enter the Danish e-mobility market.[160] In addition to that, E.ON in cooperation with Tesla Motors plans to launch more electric charging stations strategically placed on the core road of Denmark in autumn 2014 (figure 13).[161]

[159] [NL Agency, 2013]
[160] [Ministry of Foreign Affairs of Denmark, 2013]
[161] [Vejdirektoratet, 2014]

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Figure 13: Placement of the electric charging stations provided by E.ON and Tesla Motors[162]

Another interesting and innovative project is the Move About concept, which provides complex public and corporate car-sharing services in Denmark, Norway, Sweden and Germany. In contrast to other car sharing providers, Move About solely focuses on electric vehicles.[163]

4.6 The United Kingdom

One of the most considerable initiatives, regarding the electric charging infrastructure is the Plugged-In-Places programme funded by the Government of the United Kingdom. The initiative strives to establish a thoroughly integrated infrastructure in order to support everyday use of electric vehicles. However, the Plugged-In-Places programme operates on regional level and each of the involved regions has its own individual project or institution that is in charge of covering the electric charging

[162] [Vejdirektoratet, 2014]
[163] [Move About, 2014]

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network. Because of that the interoperability of the networks widely depends on cooperation amongst the regions. Nevertheless, as seen in figure 14, the Plugged-In Places programme coverage is limited and therefore does not provide an integrated electric charging network on a national level.

Figure 14: Plugged-In-Places programme regions[164]

Electric vehicle charging station company Elektromotive is another significant stakeholder of the British market and is also involved in the Plugged-In-Places programme. In 2012 Elektromotive went into the joint venture with Charge Your Car Ltd that was launched in 2010 as an electric charging network operator for the North East region. The aim of the joint venture is to develop and deploy a charging system compatible with all OCPP[165] stations and thus create a fully interoperable electric charging network in the United Kingdom.[166][167] Elektromotive also formed the "Partnership for Zero-

[164] [The Charging Point, 2014]
[165] Open charge point protocol
[166] [Charge Your Car, 2014]

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Emission-Mobility" with the Renault-Nissan alliance to speed up the deployment of electric charging station in cities.[168]

4.7 Norway

The deployment of the electric vehicles in Norway is considered as well developed, however the infrastructure is not fully integrated. With more than 35.000 electric vehicles registered in Norway, the need for a well-developed charging system is also present. One of the more complex e-mobility initiatives, which targets the most important aspects of e-mobility concurrently, including infrastructure, is called Grønn Bil (figure 15).[169]

Figure 15: Grønn Bil initiative[170]

Additionally, as well as in Denmark, the Move About car-sharing concept plays an important role as it provides electric vehicles and charging stations for several Norwegian cities. Moreover, as mentioned in section 3.3, Norway strives to foster the Green Highway project that aims to develop a fossil fuel free highway leading through Norway and Sweden.

4.8 Belgium

The electric charging infrastructure in Belgium functions on regional level, as in the United Kingdom and Germany. One of the significant programmes on the regional level is called the Living Labs Electric Vehicles, which concentrates on Flemish regions. The programme is funded by the Flemish government and five different platforms operate within the programme.[171] Additionally, there existed a

[167] [Elektromotive, 2014]
[168] [Nissan Motor Corporation, 2008]
[169] [EV Norway, 2014]
[170] [EV Norway, 2014]
[171] [Living Lab 2014]

platform that operated on federal level. In addition to that the Belgian Platform on Electric Vehicles was established in order to unify relevant stakeholders of the electric charging market on the federal level.[172] Furthermore, as mentioned in section 3.4, Blue Corner electric mobility service provider, cooperates with Ladenetz and E-laad in order to establish an electric charging station network on international level. In addition to that, as well as Denmark and Norway, Belgium has also supported a car-sharing scheme created by a partnership between Zen Car and the Société Régionale d'Investissement de Bruxelles.[173]

[172] [IA-HEV (1), 2014]
[173] [Sustainable Mobility, 2011]

5. Integration of infrastructure projects with the Transport & Logistics Industry

This part concerns the integration of infrastructure projects with the transport and logistics industry by reflecting on current projects, relevant for the deployment and development of the charging infrastructure.

Based on the analysis provided in chapter 3 it can be stated that the integration and communication with the transport and logistics industry is fairly developed on urban and regional level. However, only few initiatives[174] function on the national and international level. This precludes the further deployment of the electric charging infrastructure and impedes the unification of the international standards.

Secondly, the integration of the private sector could be higher. This is of a great importance as private funding could help address some of the substantial barriers, but currently most of the projects in the NSR countries are funded and supported mainly by governmental institutions. Thus, in order to support mass deployment of the electric charging infrastructure it is necessary to involve the private sector more. The reason for that could be seen in the behaviour of some firms that rather leave the market or do not enter it at all, due to the low market development and thus uncertainty about benefits and costs. So, the governmental institution could cover the initial market development, but for the following market development the degree of participation can be essential in order to allure other stakeholders.

Furthermore, in order to enhance the integration and communication with the transport and logistics industry, it is important for the EC, the Member States and the local governments to not only focus on public and private transportation, but as well as on commercial freight transport. In this regard, each Member State could e.g. support projects that concern the deployment of electric charging infrastructures on major highways, which would create more possibilities for integrating electric vehicles into the transport and logistics industry.

[174] Only concerns projects implemented in the NSR countries

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6. Future perspectives on the use of charging fuel infrastructure

In order to reflect upon this matter it is of a considerable relevance to summarize the principal positive and negative aspects that are related to the deployment of electric charging infrastructure in the NSR countries with focus on the urban areas.

One of the main positive aspects is that the deployment of the charging infrastructure is generally supported on national as well as on the European level. In addition to that, the support is also often reflected in tax exemptions that are linked with the use of electric vehicles. Another positive attribute is the fact that the electricity grid is already well-developed, thus the problem is the integration of charging stations into the already existing electrical network.

On the other hand there are several negatives constraining the deployment, like for example the vicious cycle of standardization, as it is hard to create international standards because of the different level of infrastructure in the NSR countries, which is caused by the absence of standardization in the first place. This precludes the economies of scale and so the prices are still higher compared to the prices on the fossil fuel market. Consequently, the deployment is slowed down by the unawareness of the consumers. This is of a great importance as a relatively low customer acceptance for the use of electric vehicles can create uncertainty in the future market demand and thus unwillingness to invest in this area.

Based of the above, the future perspectives are directly dependent on one hand on the improving and enhancing the positive aspects and on the other hand on amending the negative aspects of the current situation on the charging infrastructure market. Therefore, pursuant to the above-mentioned positive aspects of charging infrastructure there are several future perspectives considered. First and the most rudimental prospect evocated by the greater use of charging infrastructure in the urban areas is seen in reaching the demarcated environmental objectives in the European Union, including the NSR countries. Because a well-developed and functioning charging infrastructure and thus an increased use of most electric vehicles would considerably help to lower the greenhouse gas emissions and in addition to that it would also enable greater transport coverage in low-emission and zero-emissions zones[175]. Another perspective for the future caused by better charging infrastructure coverage in the urban areas lies in incrementing of both, public and private use of electric vehicles. Because of that it would be easier and more economically feasible to enhance rental possibilities or car sharing service in relation to electric vehicles, as this area have not fulfilled its potential. Moreover, this opportunity (rentals, car sharing) can also be more attractive for the final customers as the cost of the electric vehicle can be considered as the major impediment.

[175] *"Low Emissions Zones (LEZs) are areas or roads where the most polluting vehicles are restricted from entering."* [Urban Access Regulations, 2014]

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7. Recommendations for the alternative fuel charging infrastructure

This part of the report offers recommendations for the alternative fuel charging infrastructure based on the analysis presented.

One of the first points fundamental for a successful deployment of the alternative fuel charging infrastructure is to actively support changing regulations and policies on national level in order to encourage purchases of new alternative vehicles and attract investment on R&D as well as building up infrastructures. This is based on the analysis provided in chapter 2, which emphasizes that each Member State should ensure a sufficient coverage of charging stations. However, based on the above research, it is clear that the development level of alternative fuel charging infrastructure is unequal and it is necessary to enforce the implementation of harmonised standards.

The enforcement of the changing regulations and policies by each Member State is closely interconnected with another recommendation – to increase the cooperation between the neighbour countries. There should be exchange of knowledge and information between the Member States to minimize the unequal development of alternative fuels and vehicles as well as their infrastructure. The reason for it is that the charging infrastructure on the international level cannot operate properly if only few Member States endeavour in the deployment of e-mobility. Secondly, the European neighbourhood communication is a crucial aspect for a successful international cooperation. Thus, as stated in chapter 5 it is essential to increase the cooperation amongst the involved private stakeholders.

As regards to the communication it is equally important to raise the cooperation between stakeholders and consumers in order to increase the public awareness related to the use of electric vehicles in the passenger transportation as the customers´ acceptance is a fundamental milestone for the market. In addition to that, opportunities for users to participate in the development and deployment of alternative fuels should be made.

In consequence of that it is recommended to maximize the involvement of the private sector in the whole process of development of alternative fuels as private financing could significantly help the deployment. Thus, it is of great importance to intensify the communication with the private sector players and to attract them because there still exist disincentives that slow down the involvement of the private investors.

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8. Special recommendations for the upcoming NSR programme 2014 – 2020

Based on the above analysis this chapter provides recommendations for the NSR programme 2014 – 2020, aside from the general recommendations provided in chapter 7 that are more or less concentrating on fixing the current situation in the charging infrastructure market. One specific advice is to follow specific market models that concentrate on the relationship and cooperation between the electricity and e-mobility market. In this matter, the most important issue is to ensure smooth cooperation between the electric charging stations providers and manufacturers in order to enhance the standardization of electric plugs and therefore create an interoperable market. Secondly, it is advised to put focus on developing linkages amongst public and private sectors, as for instance the Dutch platform Formula E-team. Another suggestion is to support the deployment of electric charging infrastructure not only in the urban areas, but as well between the cities as for example applied in Norway and Sweden by implementing projects similar to the Green highway project.

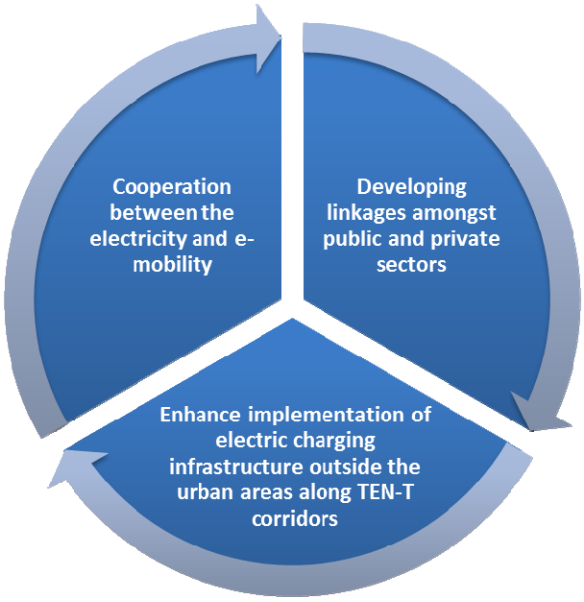

Figure 16: Specific recommendations for the upcoming NSR programme

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NORTH SEA REGION ELECTRIC MOBILITY NETWORK
e-mobility NSR

About E-Mobility NSR

The Interreg North Sea Region project North Sea Electric Mobility Network (E-Mobility NSR) will help to create favorable conditions to promote the common development of e-mobility in the North Sea Region. Transnational support structures in the shape of a network and virtual routes are envisaged as part of the project, striving towards improving accessibility and the wider use of e-mobility in the North Sea Region countries.

www.e-mobility-nsr.eu

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