European Commission

Alternative fuels and infrastructure in seven non-EU markets - Final report

Final Report
Contract: MOVE/C1/SER/2014-268
21 January 2016

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Abstract

In Europe transport is responsible for a quarter of the greenhouse gas emissions, but in countries like the USA and Brazil this is more than 30% and 40% respectively. While in other sectors the emissions go down, transport emissions continue to increase.

Alternative fuels have prominent advantages for reducing emissions of greenhouse gases and pollutants. Furthermore they help alleviating the dependence on fossil fuel consumption in the transport sector. However, the switch from current fuels to the alternative fuels requires a fuel infrastructure change, since most of the alternative fuels are not drop-in fuels (e.g. electricity, CNG, LNG, ethanol, hydrogen).

This study examines how alternative transport fuels and infrastructure, which are expected to play a crucial role in the transport sector's future, develop in other world regions. It aims to contribute to the development and implementation of a European transport strategy effectively promoting alternative modes of transportation and safeguarding the EU's transport industry's leading position.

The report contains concise case studies to illustrate the discussion with practical examples and to further discuss implications for the EU's alternative transportation strategy.

List of Abbreviations

AC	Alternating Current, the electric current flow periodically reverses direction, typically used in power transmission
ASTM	American Society for Testing and Materials
bbl	Barrel: 42 gallons or 159 litre, typically used volume as reference for oil price
BEV	Battery Electric Vehicle
CAAFI	Commercial Aviation Alternative Fuels Initiative
CNG	Compressed Natural Gas
CTL	Coal-To-Liquid
DC	Direct Current, electric current flows in constant direction, e.g. to charge batteries
DOE	United States Department of Energy
ECA	Emission Control Area
ETS	Emissions Trading Scheme
EU	European Union
EV	Electric Vehicle
FAME	Fatty Acid Methyl Esters, biofuel produced from vegetable oils, animal fats or waste cooking oils
FCEV	Fuel Cell Electric Vehicle
GERD	Gross domestic Expenditure on R&D
GTL	Gas-To-Liquid
HDV	Heavy Duty Vehicle
HRS	Hydrogen Refuelling Station
HVO	Hydrotreated Vegetable Oil
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
IEA	International Energy Agency
IMO	International Maritime Organization
LEV	Low Emission Vehicle
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas, also known as autogas
METI	Japanese Ministry of Economy, Trade and Industry
PHEV	Plug-in Hybrid Electric Vehicle
SSE	Shore Side Electricity
US	United States
USD	United States Dollar
ZEV	Zero Emission Vehicle

Executive Summary

Transport is central to society, as mobility enables economic activity and improves the quality of life of citizens. The demand for all forms of transport continues to increase. However, the current practice has a significant environmental burden, especially through emissions contributing to air pollution and climate change, and through the exploration of oil and gas for fuels, frequently involving environmental damage.

Transport is responsible for 27% of the global energy use and 23% of the global greenhouse gas emissions. The fraction of renewable energy in transport is still low, about 3% of the road transport fuels are biofuels. In Europe transport is responsible for a quarter of the greenhouse gas emissions, but in countries like the USA and Brazil this is more than 30% and 40% respectively. While in other sectors the emissions go down, transport emissions continue to increase.

Alternative mobility solutions improve the security of fuel supply and at the same time open routes for improving sustainability. Alternative fuels have prominent advantages for reducing emissions of greenhouse gases and pollutants. Furthermore they help alleviating the dependence on fossil fuel consumption in the transport sector. However, the switch from current fuels to the alternative fuels requires a fuel infrastructure change, since most of the alternative fuels are not drop-in fuels (e.g. electricity, CNG, LNG, ethanol, hydrogen).

In 2010 5% of the global vehicle fleet of around 1 billion vehicles could use high blends of alternative fuels (or electricity). In 2015 this was 8% of 1.2 billion vehicles. The total number of alternative energy vehicles doubled from 50 million. The majority are ethanol flex fuel and dedicated ethanol vehicles: 4% (this number includes 4 million flexi fuel motorcycles which were introduced in Brazil since 2009), natural gas vehicles: 2% (CNG and LNG) and vehicles that can run on LPG: 2%. The amount of electric vehicles (PHEV and BEV) is 0.1% (1 million) at the end of 2015 and growing rapidly. Since most vehicles also use conventional fuel, the alternative fuel use as a percentage of total fuel consumption is lower for these vehicles. For instance less than 1% for natural gas. Ethanol and biodiesel blended with conventional fuels in low blends increases the total alternative fuel use. Many countries have set targets for alternative fuel use and electric vehicle development in recent years and have employed a number of policies to achieve environmental objectives and improve energy security.

Many different alternative fuel solutions are being developed, with different focus areas per country. The driver for the alternative fuel typically is job creation, energy independence, the reduced tailpipe emissions and lower CO_2 emissions, or a combination. For the USA energy independence is very important and for instance for South Korea the local air quality is most important.

In Europe most alternative fuel (mainly biodiesel: about 75%) is blended with conventional fuels in low blends. The average share of renewable energy sources in transport fuel consumption across the EU-28 was 5.4% in 2013, ranging from 16.7% in Sweden to less than 1.0% in Portugal, Spain and Estonia.

With the right focus the European industry can be very competitive, providing global leadership for alternative fuel use and standards, so as to promote economic growth and employment in the EU. For most of the alternative fuels studied we see that Europe is currently lagging behind. We believe that this study can draw important lessons from developments in major non-EU countries, for the EU market. We hope that it will inspire both industry and governments to make new important steps towards alternative mobility options.

Both policies and incentives that support alternative fuel vehicle uptake and alternative fuel infrastructure development are needed to develop a mature market for alternative fuels. Furthermore research and development (R&D) support for required improvements in enabling technologies like batteries is helpful. China, Japan and the USA all have such programmes in place. This is not common in Europe. Europe has the lowest investments in R&D/GDP compared to these countries.

Alternative fuel market developments are the result of strongly differentiated dynamics in the countries of study. While policy lessons and experience from foreign markets can be inspiring the results are not entirely reproducible.

In Russia, Japan and South Korea market entrance is difficult and requires very good preparation. A good model is to look for technology partnerships (example: with OEMs in South Korea and Japan) or to invest in local OEMs (example: Daimler in Russia and Renault in Japan). In this way Daimler has successfully invested in Kamaz and Renault in Nissan. Market entrance in China, India, Brazil and the USA is generally easier, although attention should be paid to specific (more stringent) emission standards in different national regulations.

<u>Costs of alternative fuel components</u>
Most of the alternatives fuels require a higher upfront investment in vehicle technology. For some biofuels though (e.g. ethanol) the additional investments on the vehicle side are marginal, where the required fuels or fuel infrastructure are often more expensive. For electric vehicles the major cost component is battery pack production and development. Of which the costs are going down rapidly. Fuel cells are more expensive and typically the fuel system for CNG, LNG, and LPG vehicles is in-between the cost of the fuel system for biofuels and batteries.

<u>Accounting for complexity and dynamism</u>
Alternative fuel and infrastructure development requires carefully crafted policy packages. These packages need to account for and address the inherent complexity of the alternative transport sector and set well-articulated strategic priorities, continued and ambitious R&D programmes to ensure continued and strategically guided dynamism.

<u>Technology & policy prioritisation</u>
Differentiated technology positioning and prioritisation are important ingredients for countries to achieve market and innovation leadership. The countries where alternative fuels proved to be successful typically concentrated on only a few options. The EU does not have a strong position with the production of alternative fuels (LNG imports, no synthetic production facilities, etc.), but does have a strong position in the production of renewable electricity.

R&D programmes

The development of alternative fuel markets and infrastructure must be considered in both the short and long-term. Ambitious R&D strategies and programmes are needed to ensure long-term prospects are supported. A good example is Japan, where there are both investments in R&D, in the development of infrastructure and incentives for vehicle buyers. Public commitment to removing barriers for industry to engage in R&D, and support through demonstration projects to ensure visibility of emerging technologies has proven to be effective in Japan, Brazil and the USA.

Financial incentives

Evidence suggests that direct financial support measures continue to be required to accelerate the uptake of alternative fuels. Direct financial support should be aimed at supporting options temporarily, until market readiness. Complementary policies are required to phase out the financial incentives when technologies become (more) cost-competitive.

Road transport

The road transport sector offers the largest challenge (measured by the amount of energy that it uses) but also the most options for alternative fuel and infrastructure development are available. Integrated strategies are needed to ensure alternative transport technologies are leveraged adequately in the short-, medium- and long-term. The potential and limitations of each alternative fuel must be carefully considered on relevant timescales.

Waterborne transport

The shipping sector is a global sector that is difficult to regulate (the rules at sea are developed in an international context and many countries need to accept new rules). Still there is potential on a local level for alternative fuel (e.g. methanol and LNG) support in short sea shipping and ferries. The potential and limitations of each alternative fuel must be carefully considered.

Airborne transport

The air transport sector is expected to continue to rapidly grow to 2050. A significant uptake of alternative fuels with a high greenhouse gas saving potential (e.g. bio jet fuels) will be required to meet decarbonisation targets in the sector. Bio jet fuels are seen as an important solution by IATA and several major airlines. Bio jet fuels are expensive compared to current fossil jet fuels. The EU could continue to support the development of biofuels in the aviation sector for increased investments by industry in the bio jet fuel value-chain.

Electricity

Electricity should be a high priority for the EU, as it offers significant potential in terms of its climate change mitigation potential (especially with future emission factor for average electricity), opportunity for European industry, and strong coherence with European mobility requirements and energy infrastructure. Urban environments further offer fertile grounds for the design and implementation of consumer-oriented and context-specific policy packages to promote electric mobility. Non-financial incentives can be envisaged in the form of preferential parking measures, access to priority lanes or regulatory action to remove barriers to the development of electric mobility infrastructure. Public demonstration programmes and public-private infrastructure partnerships are also a likely effective way of driving electric mobility forward in urban environments.

Hydrogen

Hydrogen is still regarded as a long-term option. The absence of a business case for hydrogen vehicles and exploitation of fuelling infrastructure in the short term requires strong financial commitment by public authorities and financial institutions. Partnerships between European and foreign manufacturers have been established in recent years and should be supported. Further, R&D support policies and public demonstration programmes should continue to be on the agenda to support developments by the private sector.

Biofuels

Biofuels are high on policy agendas worldwide and hold significant promise for road, airborne and waterborne transportation. However, concerns about the environmental performance have impacted the political and public acceptance. Biofuels should therefore be jointly approached by governments and industry especially to increase sustainable feedstock production.

Natural gas & bio-methane

Bio-methane production and use in the transport sector is high on the agenda in some European Countries but not in the other countries under study. Bio-methane should be jointly approached by governments and industry to strengthen production routes. EU Member States need to align their policies in order to stimulate a technology neutral use of bio-methane in transport.

LPG

LPG is losing momentum in the EU, USA and Japan, because, in comparison to electric mobility, and even CNG, the environmental benefits over conventional fuels are limited. Consequently, governments reduce the support. LPG is still promising in developing markets in China, India and Russia. The EU industry could try to get a position there, as long as the support for LPG exists or when bio-LPG becomes available.

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1 Introduction

1.1 Context of the study

Transport is central to society, as mobility enables economic activity and improves the quality of life of citizens. Demand for transport, in all forms, continuous to increase. Also, the EU's transport industry plays a major role in terms of economic growth, trade, employment and innovation.

The EU's transport sector is confronted with three major challenges: dependence on imported oil, increasing greenhouse gas emissions and increasing congestion. Alternative fuel options offer promising solutions to tackle the first two challenges and for this reason the EU is developing a strategy to promote the development of alternative transport modes. The 2011 White Paper on Transport (EC, 2011), outlining a roadmap to a competitive and resource-efficient transport sector, and the "Clean Power for Transport Package", released on 24 January 2013 and including a Directive[1] proposal establishing binding targets for alternative fuels infrastructure provision, are important components of this strategy. Transport will also play an important role in the EU's efforts to combat climate change and therefore a 60% emission reduction target by 2050 is envisaged for the EU's transport sector.

In this context, continued research is needed to support ongoing developments with alternative fuels and infrastructure. Monitoring and evaluation of international markets, policy developments and standards is key in understanding the position, threats and opportunities for the EU's transport industry and to informing policies required for the EU to implement a coherent and effective strategy.

1.2 Purpose of the study

This study examines how alternative transport fuels and infrastructure, which are expected to play a crucial role in the transport sector's future, develop in other world regions. It aims to contribute to the development and implementation of a European transport strategy effectively promoting alternative modes of transportation and safeguarding the EU's transport industry's leading position.

More specifically, the study has three core objectives:

1. To assess key alternative fuels and infrastructure developments in major non-EU markets, and give context to these developments, with respect to markets, standards and policies;
2. To provide policy recommendations to the EU, on how to promote the development of alternative fuels and infrastructure, drawing lessons from the countries of study: developments in major non-EU markets may pose risks for European competitiveness, security of energy supply and for the achievement of greenhouse gas emission reduction goals. Understanding these risks is pivotal to providing a rigorous assessment of barriers for the EU industry and strategic policy recommendations to the EU;
3. To assess opportunities and market entry barriers for the EU industry in the examined foreign markets.

[1] The proposal was adopted as Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure, OJ L 307, p. 1 of 28 October 2014.

In order to meet these objectives, the study's scope is delineated by the following three dimensions:

- **Geography**. The focus is on six major non-EU markets: Brazil, China, Japan, Russia, South Korea and the USA. Additionally data for India was collected when readily available;
- **Technologies**. We examine the following forms of alternative energy for transport: electricity, hydrogen, biofuels, natural gas, liquefied petroleum gas, and synthetic fuels;
- **Transport modes**. The study's principle focus is road transport. Airborne and waterborne transport is considered with less detail.

1.3 Structure of the report

For ease of reading, the main body of this report focuses on discussing key developments, barriers and impacts, illustrating these with practical case studies and drawing conclusions and recommendations for the EU. It therefore addresses core objectives 2 and 3 above. More extensive findings from data collection and analysis are provided in the annexes to the report, which address core objective 1.

More specifically, the report structure reflects five key steps in the research process. Information on these steps can be found in different sections as follows:

- **Data collection, see Annexes B, C and D.** In order to develop the analysis on alternative fuel developments outside the EU an extensive amount of data was collected. In Annex B we include data tables for a selection of data. References and an extended bibliography can be found in Annex C. Lastly, in Annex D, we provide factsheets for the countries of study, which cover practical information focusing on the policies and standards in the countries of study.
- **Data analysis, see Annex A.** Based on the data we have collected, Annex A presents a review of market developments in the countries of study, as well as specific insights into policies, standards, technological developments, costs and public perception aspects of alternative transport. Most of the data was collected in 2014, and updated with the latest figures over 2014 where possible.
- **Discussion of drivers, barriers developments and impacts, main body of the report.** We present a discussion based on data collection and analysis, which includes an overview of the countries of study, insights into trends and forecasts for the alternative transport sector, a review of key barriers and impacts of these developments and key considerations pertaining to the mitigation potential from alternative fuels.
- **Case studies, main body of the report.** Building on the literature review, data collection and interviews, we then present concise case studies to illustrate the discussion with practical examples and further discuss implications for the EU's alternative transportation strategy.
- **Conclusions and recommendations, main body of the report.** Lastly, we present a concise overview of key conclusions and recommendations drawing from the data analysis, discussion and case studies.

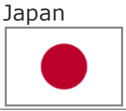
2 Discussion: drivers, barriers, developments & impacts

The transport sector is highly international and dynamic, and alternative fuels and infrastructure are witnessing major developments worldwide. These developments depend on a wide array of societal barriers and drivers, which, in turn, have significant impacts on society. In the European context, alternative transport (modes, powertrains and fuels) has the potential to tackle various challenges related to energy security, greenhouse gas emissions and congestion. Socio-economic considerations, for example related to employment and competitiveness, are also important. In this section, building on the data collection and analysis presented in the annexes, we discuss key elements related to the development of alternative transport fuels and infrastructure worldwide.

2.1 Relevance of the countries of study

Six countries outside of the EU, namely Brazil, China, Japan, Russia, South Korea and the USA, were selected because of their importance for EU exports and because of their leadership in alternative fuel vehicles, fuel and infrastructure for the fuels under study. Additionally, India was included in this study, because of its fast growing transport sector and increasing challenges related to fuel security and polluting emissions. The following table provides an overview of key features and the context of alternative transport fuels in these countries.

Table 1: Overview of key features of the countries of study

Country	Importance of transport fuel use in 2012 (source: IEA statistics)	Driver for fuel choice
Brazil 	45% of energy related CO_2 emissions stem from transport. The majority of transport related CO_2 emissions (90%) stem from road transport.	Brazil supports the use of alternative fuels because of job creation, energy independence, the cleaner exhaust gas and lower CO_2 emissions.
China 	9% of energy related CO_2 emissions stem from transport. The majority of transport related CO_2 emissions (80%) stem from road transport.	Because natural gas vehicles produce less harmful emissions and help to change the fuel mix, their development is supported by the government. Because EVs do not emit harmful emissions their development is supported by the government.
India 	11% of energy related CO_2 emissions stem from transport. The majority of transport related CO_2 emissions (93%) stem from road transport.	With discovery of large new gas reserves, the Indian government has started building supply/re-fuelling infrastructure for the growth of LPG / CNG vehicles. Environment is a driver for, especially in congested cities.
Japan 	18% of energy related CO_2 emissions stem from transport. The majority of transport related CO_2 emissions (90%) stem from road transport.	There are three reasons behind the governmental support for fuel cells: change energy mix, reduce greenhouse gas emissions and industry support.
Russia 	14% of energy related CO_2 emissions stem from transport. The majority of transport related CO_2 emissions (60%) stem from road transport.	Autogas is stimulated since the 1970s because it is abundantly available and cheap and is a co-product of the production of fossil fuels (oil and gas). Natural gas is stimulated recently as a transport fuel in search for a new growth market.
S. Korea 	15% of energy related CO_2 emissions stem from transport. The majority of transport related CO_2 emissions (94%) stem from road transport.	Improving the local air quality is the main driver for supporting alternative fuels over diesel.
USA 	33% of energy related CO_2 emissions stem from transport. The majority of transport related CO_2 emissions (85%) stem from road transport.	The main reason for the USA to support alternative fuels is to decrease dependence on foreign oil. Since the discovery of shale gas, also the use of natural gas in cars is promoted.

2.2 Key considerations, drivers and barriers for alternative transportation

The development of alternative fuel markets depends on a wide array of factors. Here we discuss key considerations, including the mitigation of negative externalities such as greenhouse gas and harmful tailpipe emissions, technology, economy, public perception and policy aspects of alternative transportation.

2.2.1 Emissions

The transport sector is estimated to account for 23% of global anthropogenic (having its origin in the influence of human activity) greenhouse gas emissions (ICCT, 2014b) and 25% of the EU's greenhouse gas emissions. Decarbonising this sector is an important aspect of the EU's strategy for the transport sector and it is pivotal to account for the mitigation potential from different technologies.

Quantifying the emissions mitigation potential of alternative fuels typically requires life-cycle analysis to account for emissions from production through to consumption. As such, the mitigation potential depends on a wide array of parameters and research continues to quantify the emissions mitigation potential of different alternative transport technologies in different transport modes. The following figure provides a representative estimate of relative life-cycle – or 'well-to-wheel' – greenhouse gas emissions for a selection of alternative fuels, relative to diesel and gasoline. It shows that all alternative fuels examined in this study hold greenhouse gas emission reduction potential (without looking at Indirect Land Use Change: ILUC) relative to diesel and gasoline (with the exception of LPG for which greenhouse gas emissions are estimated to be marginally higher than diesel).

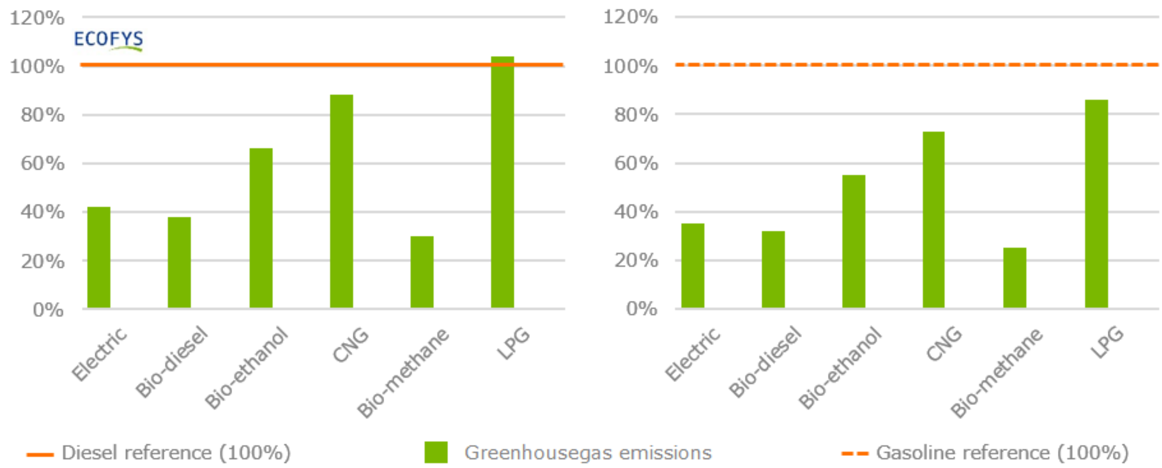


Figure 1: Well to Wheel greenhouse gas emissions for different fuel types for passenger cars relative to diesel (left) and gasoline (right), using current average emission factors (source: www.fuelswitch.nl compiled from many sources from 2002-2011)

Electric vehicles offer mitigation potential due to their energy efficiency and especially when their energy is produced from low carbon sources. Electric mobility is expected to play a major role in decarbonising the transport sector. For example, the IEA estimates that three-quarters of all vehicle sales by 2050 would need to be electric in order to meet the transport sector's 21% share of energy-related emissions reduction needed to bridge its scenario in which the average global temperature increase is limited to 2°C (IEA/EVI, 2013). Electric vehicles convert about 59%–62% of the electrical energy from the grid to power at the wheels—conventional gasoline vehicles only convert about 17%–21% of the energy stored in gasoline to power at the wheels[2].

Hydrogen is most sustainable when produced from renewable electricity. The technology benefits from higher energy efficiency compared to conventional internal combustion engines. The energy efficiency of a fuel cell is generally between 40–60%. Its mitigation potential is generally considered to be significant but depends on the production of hydrogen fuel and other vehicle manufacturing considerations. In light of its relative immaturity, this technology however only holds long-term potential.

The potential mitigation impact of **biofuels** must be evaluated by comparison with other energy systems using Life-Cycle Analysis methodologies (LCA). While the renewable nature of biofuel feedstock implies potential greenhouse gas emission savings, other aspects must be accounted for such as land-use changes. The climate change mitigation potential can be optimised by setting strict requirements (cf. the greenhouse gas emission reduction threshold required by the EU Renewable Energy Directive). In its recent technology roadmap (IEA, 2011), the IEA suggests savings of the order of 20-80% when displacing natural gas and diesel, and an even greater range when displacing gasoline. In its ETP BLUE Map Scenario, which sets a target of 50% reduction in energy-related CO_2 emissions by 2050 relative to 2005, the IEA estimates that biofuels would account for 2.1 Gt of the total of 9 Gt emissions reduction in the transport sector.

Natural gas offers some mitigation potential relative to traditional fuels such as gasoline and diesel. For example, the IEA estimates an average reduction in CO_2 emissions of 25% for light duty vehicles for the displacement of gasoline by CNG (IEA, 2010). Nonetheless, to achieve ambitious decarbonisation of the transport sector, the IEA notes that a commitment to sources such as bio-methane or bio-synthetic gas would be required.

LPG, lastly, may offer some emission mitigation potential relative to gasoline and diesel as it has a lower carbon content compared to gasoline. However, this is partly offset by higher fuel consumption. An important factor in determining its mitigation potential is the source of the LPG; the well-to-wheel greenhouse gas emission increases sharply with international transportation. Bio-LPG is expected to enter the market only from the end of 2016[3].

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[2] http://www.fueleconomy.gov/feg/evtech.shtml
[3] https://www.neste.com/en/neste-breaks-ground-worlds-first-bio-lpg-facility-rotterdam

2.2.2 Technological developments & standards

There are various road fuel **technologies** available with many different applications (e.g. bus, passenger car, truck) in the short- medium- or long term. The large variety of technologies at stake can however result in the fragmentation of the market. For example, the emergence of new technologies on the market can result in the development and adoption of a wide range of **standards**, which is a barrier for the creation of economies of scale.

Important markets such as Japan, China and the USA have produced domestic standards for electric charging (charging system and equipment), making it difficult to produce vehicles which fulfil all the requirements of these standards. Japan and USA for instance use the same standard for conductive charging, while in the EU and South Korea international IEC standards apply. Currently there is one official EV AC charging standard (type 2) and two official EV DC fast charging standards (CHAdeMO & SAE combo charging standard: CCS). Additionally, Tesla has proprietary technology regarding their superchargers and other standards exist in China and Europe.

Only Korea (CNG) and Japan (LNG) have used international standards for the use of natural gas in transport, and have not introduced barriers to foreign car manufacturers. European countries support the development of international standards within ISO for refuelling stations and LNG equipment.

Only for hydrogen refuelling there is a global standard (SAE J2601), which is also used everywhere. Most other standards for hydrogen are also global, because they are all ISO standards. Hydrogen is flammable and must be handled with care. Stringent safety requirements, embedded in local/national legislation, are in place to ensure the risks of incidents are minimised. A balance should be found between safety and the additional costs that come with increased stringency of the safety requirements to ensure that hydrogen becomes an affordable and safe alternative fuel option in the future[4].

Obviously international standards provide a level playing field for the introduction of new technology. When industry in some counties develops new technologies faster than others they introduce local standards to speed up the introduction of the technology, because it helps to get new technology accepted by markets. This can hamper the introduction of other technology in that market.

2.2.3 Costs, competitiveness and economic considerations

The emergence and mainstreaming of alternative transport technologies in global markets is evidently dependent on cost, competitiveness and other economic considerations.

Fossil fuel prices, for example, are an important benchmark for the uptake of alternative energy, including alternative fuels, since the business case for alternatives will be weaker when the fossil fuel prices are lower (Interview: Peter Harris, 2015). For some biofuels though, higher fuel prices also have an effect on fertiliser and other agricultural costs. Therefore, the business case for some biofuels (e.g. cane ethanol) is less sensitive to the crude oil price developments. Mainly due to the current low oil prices the number of hybrid vehicles sold in the USA in 2015 is only 2.2%, where 7% was anticipated in 2008[5].

[4] The Asahi Shimbun 2015 EDITORIAL: Promote hydrogen as a major energy source for Japan's future [available at: http://ajw.asahi.com/article/views/editorial/AJ201501130050] (Accessed 05/06/2015)
[5] http://time.com/money/3654905/toyota-prius-hybrids-sales-decline/

Our analysis shows that further cost decline is expected for most alternative fuels until 2030. Hydrogen fuel, in particular, is expected to witness significant cost declines as technology maturity progresses. Fossil-based natural gas and coal- and natural gas-derived synthetic fuels are most cost-competitive with gasoline. Sugarcane ethanol, a relatively mature technology, is also cost-competitive, even with relatively low crude oil prices. Electricity, in particular has significantly lower driving costs than gasoline and for all energy sources. Biofuels, natural gas and synthetic fuels can also become cost-competitive. Hydrogen, however, is only expected to become competitive when the technology is mature in light of high fuel prices.

Most of the alternatives require a higher **upfront investment in vehicle technology.** For some biofuels though (e.g. ethanol) the investments on the vehicle side are marginal, where the required fuels or fuel infrastructure are often more expensive. Still, for several reasons these investments are stimulated by governments. Important drivers are employment, air quality, security of supply or provision of an outlet for otherwise unused fuels (e.g. natural gas or LPG). For electric vehicles the major cost component is battery pack production and development, which currently doubles the production costs compared to conventional vehicles. The costs are going down rapidly as well. While most European OEMs are dependent on battery production from China, Tesla is taking another approach for producing batteries in the USA, supported by Panasonic. Fuel cells are even more expensive and typically the fuel system for CNG, LNG and LPG vehicles is in-between biofuels and batteries.

Infrastructure costs for the fuels are normally translated in a certain part of the price for the fuel supplied. Therefore a “very expensive” refuelling station does not necessarily translate in a high energy price. For instance Tesla offers their kWh via Superchargers for free, knowing that 90% of the electricity will be supplied from home chargers and their main business is to sell cars. On the other hand FastNed (interview: Langezaal, 2015) wants to have a premium price at their fast chargers at the highway, which is their main business model.

It is regarded as typical that companies have to pay for upstream investments in electric connection for EV charging (interview: Harris, 2015) or Shore Side Electricity, while for other fuels and for consumers this is not the case.

The changing financial situation of countries has a clear impact on the **uptake** of alternative fuels. For instance in Brazil where gasoline is a preferred fuel (via government intervention) over ethanol in 2015, in order to battle the inflation. Russia is seeing similar problems due to reduced income from lower value energy exports and sanctions from the West.

2.2.4 Consumers and public perception

Transportation serves society at large, from industry to individual consumers. Being a pivotal aspect of every-day life, transport is under severe scrutiny from the general public and the development of alternative fuels is closely monitored. The positioning of consumers and public perception considerations is therefore highly important to consider understanding alternative fuels market developments. For example, the introduction of E10 (10% ethanol in gasoline) in Germany in 2011 created confusion on the German market, because consumers had concerns about damage to their vehicles: a poor start, whereas the introduction of the same fuel blend in France was much smoother. In 2014 the share of E10 now stands at 17% of gasoline sales in Germany, still less than in France.

The main concern for the public with vehicles using gaseous fuels is safety. General worries are relate d to the safety and reliability of hydrogen, CNG and LPG as a fuel. Safety concerns include the pressurised storage of hydrogen, CNG and LPG on-board vehicles.

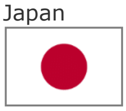
When there is a financial benefit for the consumers the public is more willing to adopt the new technology. The public in the USA is willing to pay only slightly more per gallon of fuel for biofuels instead of gasoline. Support for advanced "cellulosic" biofuels has remained relatively high. The cost of purchasing an electric car is the main barrier to its acquisition in the USA. LNG and CNG fuels are relatively cheap. Natural gas in China is both perceived as clean and cheap. Positive perception in Brazil regarding biofuels is: good for the environment and good for the economy. In Japan most consumers are in favour of EVs. In China the public is very receptive for electric driving from the experience with electric bicycles: clean and fast.

2.2.5 Uptake and policy support

Alternative fuel markets are relatively new and small and compete against well-established fossil-based technologies. In light of this and of the considerations presented above, policy efforts are required to promote their continued development and many countries are designing and implementing policies to promote alternative transport technologies on regional, national or local markets.

The USA have policies in place aimed at all the fuels under study. Besides incentives market uptake policies are important. Brazil focusses on biofuels (mainly ethanol) and natural gas, mainly via incentives and demand management. China has targeted electric driving via their policies as the dominant "fuel", whereas South Korea choose biofuels, both via innovation support, incentives, market uptake and demand management.

Table 2: Overview of key policies and incentive measures responsible for the large uptake of alternative fuels

Country	Importance policies	Important incentives
Brazil 	Proálcool programme: Gas stations obliged to sell ethanol	Proálcool programme: Ethanol price lower than gasoline's; Guaranteed remuneration of the producer; Financing to producers –increasing of production's capacity. Reduction of taxes for vehicles using hydrous ethanol
China 	Government purchase of EVs Traffic restrictions Vehicle lottery (limited sales of conventional vehicles)	EV buyers gain subsidy, are not part of a vehicle lottery and have no traffic restrictions (lane use, licence plate based or other) Incentives for EV buyers in some cities for selected EVs
Japan 	R&D programmes for lithium-ion battery and fuel cell development Government purchase of Hydrogen Fuelled vehicles	Incentives for fuel cell vehicle buyers and HRS infrastructure
Russia 	Innovation support for biofuel production	Incentives for the development of CNG and LNG refuelling infrastructure and pilots with natural gas vehicles
South Korea 	Market uptake and demand management: biodiesel blend mandate, promotion of natural gas for buses	Innovation support and incentives for natural gas vehicles (subsidies and low priced natural gas for public buses)
USA 	Energy Independence and Security Act of 2007: loans for automobile manufacturers to develop EVs Next generation electric vehicle: provided funding for the production of batteries and their components Energy Policy Act: pilot projects for advanced vehicles	Energy Improvement and Extension Act of 2008: federal tax credit for PHEV buyers Clean vehicle rebate Project: rebates for zero emission vehicles and PHEVs State level incentives: tax reduction or exemptions and rebates for both EVs and PHEVs, and the non-fiscal incentives included free access to high occupancy vehicle lanes California has supported the production and sales of low emission vehicles (LEVs) or zero emission vehicles (ZEVs) through imposing civil penalties on the manufacturers for non-compliance with the targets and credits for others

Both policies and incentives that support alternative fuel vehicle uptake and alternative fuel infrastructure development are needed to develop a mature market for alternative fuels. Furthermore R&D support for required improvements in enabling technologies like batteries is helpful. China, Japan and the USA all have such programmes in place. This is not typically done within Europe. One example where it does take place is the German Federal Ministry of Education and Research (BMBF) sponsoring the Lithium-ion Battery Alliance (LIB 2015) with €60 million for R&D[6].

The market uptake policies are typically introduced years before the vehicles reach the market. This is different from the EU policies that support the sales of low CO_2 vehicle sales as the main driver. In China the government was an important buyer of electric buses and taxis in the early days of electric vehicle deployment in 2008.

[6] www.lib2015.de

China does not reward manufacturers for the sales of EVs. The Japanese government is currently an important customer for fuel cell vehicles[7].

2.2.6 Research and innovation policies

Since the alternative fuel technologies need to be improved in order to be competitive with the conventional technology that is already more than 100 years available and continuously improved, governments often stimulate the development via R&D programmes. China is very strong in R&D spending. In 2012, its gross domestic expenditure on R&D (GERD) topped €144 billion in 2015. Measured by purchasing power parity, China's GERD reached €259 billion, behind the United States' €400 billion and the European Union's €300 billion but ahead of Japan's €134 billion.

China's GERD as a percentage of gross domestic product (GERD/GDP) reached 1.98%; it more than tripled since 1995, surpassing the 28 EU Member States , which together managed 1.96%[8]. South Korea spends 4.36% of GDP on research and development and Japan 3.35%[9].

An important example is the US Department of Energy programme "EV Everywhere Grand Challenge" in 2012, still in place today, for R&D, testing, modelling of EVs across the country to improve performance of vehicle components. In the USA, Commercial Aviation Alternative Fuels Initiative (CAAFI) is actively studying and supporting the deployment of alternative jet-fuels for commercial flights. Furthermore the US Environmental Protection Agency is actively developing new vehicle technology in order to further improve the energy efficiency of road vehicles.

The Chinese government started several projects to be able to show fuel cell buses, electric buses and hybrid vehicles (taxi's) at the Beijing Olympics in 2008, in total 500 alternative fuelled vehicles were delivered. This is considered to be the start of Chinese industry in this area. The Chinese electric car manufacturers SAIC and BYD have further invested in R&D programmes for continuous improvements in EV technology in China.

Petrobras in Brazil is currently carrying out and financing technical and commercial feasibility studies for the production of advanced biofuels (from cellulose crops and residues). Local CNG programmes have been tested and analysed in Brazil to further investigate national vehicle deployment. The Ministry of Mines and Energy is working in partnership with other national institutions in Brazil to provide substantial technological and financial support to R&D projects for production, transportation, storage and distribution of hydrogen.

In Russia all fuels are in the development stage and at the moment the policies are aimed at innovation support. The first Russian EVs have been tested in regional pilot programmes. Gazprom is currently investing in R&D on improvements in natural gas refuelling and storage infrastructure, constructing filling stations and financing demonstration projects of vehicle deployment in Russia.

[7] 60 percent of the first month 1,500 Mirai orders came from government offices and corporate fleets (opposed to the target set by Toyota to sell 400 cars in 2015).
[8] http://www.sciencemag.org/content/345/6200/1006.short
[9] http://www.universityworldnews.com/article.php?story=20141114112226407

2.3 Developments, trends and forecasts in different transport modes

The transport sector is highly dynamic and its complexity can result in rapid changes making it difficult to accurately predict developments.

Various organisations have attempted to model or forecast the development of energy use in the transport sector. The IEA, for example released the ETP 2010 BLUE Map Scenario in 2010, setting a target for 50% reduction in energy-related emissions by 2050. To meet this target, the model proposed the fuel mix presented in Figure 2. Among the alternative fuel technologies examined in this study, the BLUE Map Scenario awards the greatest share to biofuels, forecast to account for 27% of the total estimated energy consumption for transportation by 2050, predominantly for road transportation, but also for aviation and shipping.

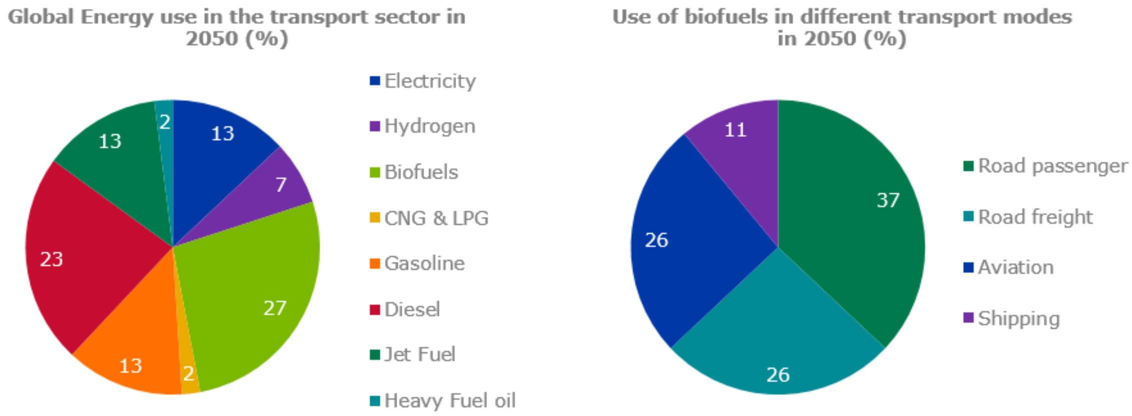


Figure 2: Global energy use in transportation (left) and use of biofuels in different modes (right) according to the BLUE map energy Scenario (Source: IEA, 2010b)

Developing such forecasts requires the consideration of a large number of economic, demographic policy or technology variables. In its latest Global Transportation Energy and Climate Roadmap, the ICCT examines the impact of transport policies on greenhouse gas emissions and the models generated include forecasts on vehicle stocks. Figure 3 provides insights into expected developments in the countries of study, including forecasts on different vehicle stocks to 2030 (ICCT, 2012). This provides valuable insights into the potential opportunities for the EU industry in the countries of study.

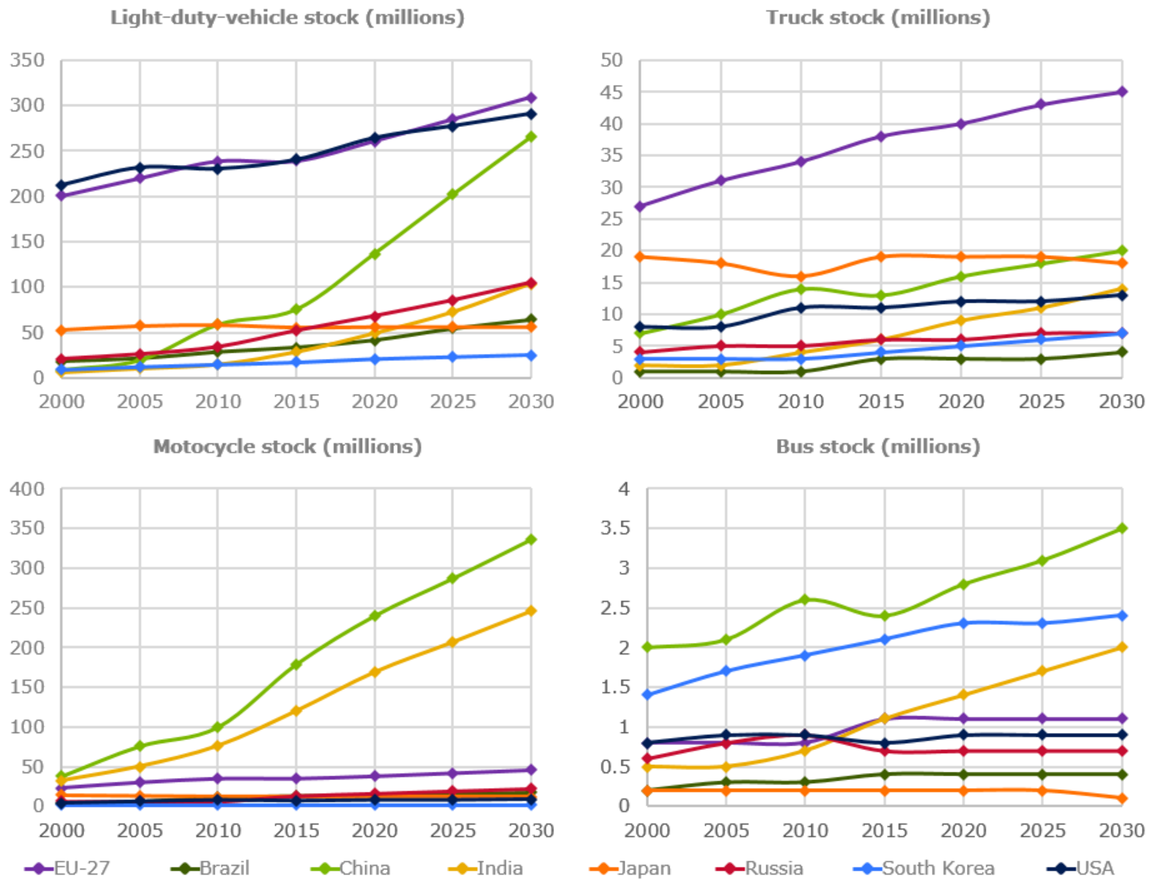


Figure 3: Expected developments in the countries of study, including forecasts on different vehicle stocks to 2030 (Source: ICCT, 2012)

The examples presented above illustrate both the dynamic nature and complexity of alternative transportation sector. In the following sub-sections we present some key practical observations on major developments and trends in land-based, airborne and waterborne transportation, building on data collection and analysis presented in the annexes.

2.3.1 Land transport

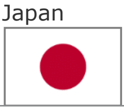
Land transportation forms the principal focus of the study. Table 3 provides an overview of alternative fuel markets in the countries of study based on key indicators we have selected for each of the technologies under study. When a certain fuel is more important over another typically the number of vehicles, fuelling stations and fuel consumed are higher. Here we highlighted only one indicator per fuel type, in order to highlight the dominant markets. Further insight into our data, by country and technology are presented thereafter.

Table 3: Key indicators for different alternative fuels in the countries of study (leading markets are highlighted from dark to light blue)

Country	Electricity (total number of Electric Vehicles sold, 2012)	Hydrogen (number of fuelling stations in service, 2014)	Biofuels (total biodiesel consumption, Mtonne, 2012)	Biofuels (total bioethanol consumption, Mtonne, 2012)	Natural Gas (natural gas vehicles in circulation, latest available, thousands)	LPG (LPG consumption, Mtonne, 2013)
EU	30,000+	72	11.41	5.23	1,099	5.42
Brazil	~0	1	2.51	16.45	1,744	0
China	9,934	2	0.82	1.98	1,577	0.73
India	~0	3	0.06	0.24	1,500	0.32
Japan	22,465	22	0.01	0.04	43	0.98
Russia	~0	0	0.00	0.00	90	2.85
S. Korea	548	12	0.33	0.01	36	3.99
USA	53,177	58	3.13	38.44	250	0.41

By country:
Especially Brazil, China, Russia and the USA are important export markets for EU car/truck manufacturers. The EU automotive industry is strong in diesel technology (Groupe ALPHA, 2007), but weak in electrified powertrains (e.g. pure electric, hybrid and plug-in hybrid). Regarding natural gas Fiat is an important global player (Frost&Sullivan, 2010).

Table 4: Overview of likely position of countries in the future regarding alternative fuels

Country	What remains important fuel/technology	New developments
Brazil 	Biofuels (mainly ethanol) Natural gas for passenger cars	Natural gas for trucks is getting attention and this market is expected to develop.
China 	Electric vehicles Natural gas for passenger cars (CNG) and trucks (LNG)	Plan for 5 million electric vehicles in 2020. Much of the growth in China's NGV fleet counts will be in LNG vehicles (6% of the fleet in 2020). Total number of NGVs is expected to be around 3.0 million by 2020.
India 	LPG and natural gas. All public busses are required to use CNG	Is forecast to become the world's largest natural gas vehicle market. Application of natural gas in locomotives is under investigation.
Japan 	Electric and fuel cell vehicles	Hydrogen Refuelling Stations see a fivefold increase in 2016 compared to 2014: 100 in total. Also hydrogen fuelled fuel cell vehicles will be subsidised. Japan will then have more HRS than Europe.
Russia 	LPG	Natural gas and biofuels are new in the market. LPG use will increase. Gazprom invests in natural gas refuelling infrastructure and provides incentives, expects by 2020 that 50% of public transport and municipal vehicles will be powered by natural gas. Furthermore Gazprom expects 30% of long distance trucks to use LNG. Billions of euro investments planned for the production of biofuels.
S. Korea 	South Korea has the largest LPG market	LPG incentives are reduced, taxis are not obliged to use LPG anymore.
USA 	All except LPG	Fuel cell vehicles are on the agenda, around 10,800 vehicles are expected by 2025 in eight states that invest in the vehicle and /or infrastructure technology. Electric vehicles costs will decrease considerably, making them competitive on an economic level against the conventional fuelled cars around 2025. Alternative fuels (other than electricity) in cars in California is stimulated less, since in 2050 87% of the cars on the road need to be full zero Emission Vehicles.

For Brazil, biofuels remain important and the market for natural gas vehicles is still developing. The market for natural gas vehicles contains only passenger vehicles at the moment. The government stimulated EVs but only in limited numbers, in Rio de Janeiro only about ten electric vehicles were on the road in 2015 and there are a limited number of hybrid vehicles (interview: Roberto Schaeffer, 2015). The high import taxes also make it impossible for consumers to earn back the higher investment.

In China both electric vehicles and natural gas vehicles are an important market, while other fuels are on the agenda but only represent a small market. For the truck sector LNG is an important fuel that is also cheaper to operate than diesel. The most important Chinese truck manufacturers have LNG trucks available. The LNG option is relatively expensive, since in China still low budget trucks are available for the price of €22,000 to €25,000. MAN expects a shift from these low-cost trucks to budget trucks, with lower fuel consumption and better reliability, which have a better return of investment in the end. The additional price for alternative fuelled trucks therefore becomes less.

In Russia LPG is currently more important than natural gas, while electricity and hydrogen as a vehicle fuel are not on the agenda (besides a few pilot projects). Biofuels remain small in Russia; however, Russia has recently taken up on the construction of its first ethanol plant and a biodiesel pilot plant. Developments regarding natural gas are promising.

In the USA the market for LPG is decreasing, while the other alternative fuels show a strong growth trend. For LPG vehicles the best case breakeven distance is 200,000 km because of low federal and state taxes on all automotive fuels. Therefore, at present, LPG is not competitive in the USA according to WLPGA (2014).

By technology:
In terms of numbers of vehicles sold, the USA, Japan and China were leading markets in 2012, 2013 and 2014 for **electric** vehicles and the European Union represented the bulk of the remaining electric vehicle sales. Especially electrified and alternative fuel powertrains are showing a growth trend in the markets under study.

As of mid-2014, 186 **hydrogen** fuelling stations were in service worldwide, including 72 in Europe, 58 in the USA, 22 in Japan and 12 in South Korea[10]. These stations support a fleet of buses and passenger cars (mainly in pilot projects). There is a rather slow growth of hydrogen stations in operation in recent years. This might change with the launch of the commercially available fuel cell vehicle Mirai from Toyota. According to (interview: Eelen, 2015), the hydrogen vehicles market will not necessarily compete with electric vehicles, but most likely respond to a different purpose. Indeed, electric vehicles currently still have range limitations, with the exception of Tesla, and additional weight. Oppositely, hydrogen proved best in these categories. Thus Toyota soon expects to transfer the hydrogen fuel cell technology to trucks and buses, together with passenger cars.

Biodiesel is brought to the market mainly via blending with conventional diesel. The largest market is the EU by far and the USA and Brazil are next. Biodiesel does not reduce the NO_x emissions from vehicles, which is more and more an area of attention for cities.

[10] http://www.netinform.net/H2/H2Stations/Default.aspx

Ethanol consumption is strongly concentrated in the USA and Brazil. In Brazil via high blends (E25 and E100) and in the USA mainly via low blends in regular gasoline (E10). The EU's consumption (also mainly via central blending with low blends), having steadily increased since the mid-2000s now represents 6.6% of global consumption.

Natural gas, either in the form of Compressed Natural Gas (CNG) or Liquefied Natural Gas (LNG) is used in both road transport and waterborne transport, accounting for less than 1% of fuel consumption for road transportation and less than 1% of total natural gas consumption. India and China have witnessed rapid growth in recent years and India, in particular, is forecast to become the world's largest natural gas vehicle market (IEA, 2010). Bio-methane is rarely used in the countries outside EU under study.

LPG (Autogas) is currently the most adopted alternative fuel in road transport in terms of number of vehicles. The LPG market is dominated, in terms of vehicles, by 5 countries, which together account for almost half of global consumption: Turkey (4 million vehicles), Russia (3 million), Poland (2.8 million), Korea (2.4 million) and Italy (2 million)[11].

Synthetic drop-in fuels production remains still relatively small today (in China currently 2.4% of the daily oil consumption of China could be replaced by nationally produced synthetic drop-in fuels). There is a strong growth trend however. Synthetic fuel production is mostly concentrated in South Africa, Qatar, China and the USA. Gas-to-Liquid and Coal-to-Liquid production is limited to a few plants in South Africa, Malaysia and Qatar. Since synthetic fuels are mainly produced as drop-in fuels, there is no particular attention for the EU OEMs (Original Equipment Manufacturers, i.e. the car producers).

The 20 biggest **truck engine** manufacturers produce 88% of the global truck engine market (AW Megatrends, 2014) among which four from the EU; Cummins, including its Asian joint ventures, dominates global engine supply in medium and heavy trucks. An important trend according to (AW Megatrends, 2014) is the adoption of natural gas engines. Global natural gas engine production is expected to double as regions – Europe, Asia and Eurasia – develop appropriate infrastructure. By 2020, the global truck market will total 6.25 million units, compared with 3.7 million in 2009 according to (AW Megatrends, 2014). China's truck production share will decline from 42% today to 39% by 2020, because of a shift to larger but fewer trucks as labour cost and congestion increases.

2.3.2 Shipping

Several policies now aim to reduce greenhouse gas emissions from shipping by improving energy efficiency. By lack of support in the area of alternative fuels from many stakeholders, the use of alternative fuels (e.g. methanol, HVO, bio-methanol, and LNG) in shipping remains to be a niche activity for ferries, short sea shipping and LNG cargo carriers that run their engines on boil-off gas. Besides the lack of policy support also a split incentive and long life-cycle are not favourable for the introduction of new technologies. LNG is mainly used in Norway (interview: Laffineur, 2015). Currently (May 2015) about 60 vessels are using LNG as fuel, with the early adopters being Norwegian car/passenger ferry and offshore operators. Furthermore there are 78 confirmed LNG fuelled new builds.[12]

[11] http://www.wlpga.org/wp-content/uploads/2015/09/autogas_incentive_policies_2014.pdf

[12] DNV-GL and PwC for the European Commission (2015) Study on the completion of an EU framework on LNG-fuelled ships and its relevant fuel provision infrastructure; LOT 1: Analysis and evaluation of identified gaps and of the remaining aspects for completing an EU-wide framework for marine LNG distribution, bunkering and use

One of the fuels that can be easily implemented, also in existing ships is methanol. Stena Line already uses the fuel successfully. Methanol is at least in the same development stage as LNG if you leave out Norway and LNG cargo carriers (interview: Tanneberger, 2015). Methanol has been recommended by the Community of European Shipyards Associations and bio-methanol is foreseen to be the most energy-efficient fuel pathway by 2050. Methanol is particularly promising for marine transportation in light of its relatively simple storage requirements, both in tankers and on-board ships. Some simple policy changes could further support biofuels in shipping. **The Renewable Energy Directive supports biofuels in all forms of transport, but Member States did not include maritime shipping in their policies. Even an opt-in would give fuel suppliers the possibility to bring cheaper biofuels to the market. The quality required for shipping is lower than for road or aviation.**

In the field of alternative fuels technology in shipping Europe could play a large role, though European countries are nowadays only minor ship building countries. Japan had been the dominant ship building country from the 1960s through to the end of 1990s but gradually lost its competitive advantage to the emerging industry in South Korea which had the advantages of much cheaper wages, strong government backing and a cheaper currency. South Korean production overtook Japan's in 2003 and Japanese market share has since fallen sharply. By the end of 2014 South Korea overtook China as the world's largest shipbuilding country with a global market share of about 30%. The production of LNG cargo carriers is dominated by Korean shipyards. Of the 134 liquefied natural gas (LNG) tankers built worldwide since 2009, 133 were built in Asia: 100 in South Korea, 20 in China and 13 in Japan[13]. **The engine technology, however, is often supplied by European companies like Wärtsilä, Rolls-Royce or MAN. European companies like Siemens and Schneider-Electric are installing onshore power supply, another technology under development.**

2.3.3 Aviation

In the USA and Brazil the use of biofuels in aviation is starting to take off. So far, three production routes have been approved for the production of aviation biofuels and another four are currently under scrutiny by ASTM. None of the other alternative fuels have been found in serious quantities in aviation. Full electric planes are being developed[14] and planes using LNG as a fuel are considered again[15], these are however not (yet) used by commercial airlines. Alternative fuel needs to comply with the ASTM standards for jet fuel, in order to be used as a drop-in jet fuel.

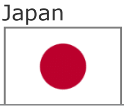
The EU Renewable Energy Directive requires Member States to implement a certain amount of biofuels in transport. Only the Netherlands has implemented the RED in a way that more modalities than only road transport are included. Biofuels in aviation account towards the national target via an opt-in. **If more Member States than only the Netherlands would have an opt-in or similar implementation of the RED, there would be more support in the whole of Europe for biofuels in aviation.**

[13] http://www.citigroup.com/transactionservices/home/trade_svcs/docs/asian_shipbuilding.pdf
[14] http://www.aircraft-certification.de/index.php/home.html
[15] http://www.eenews.net/stories/1059986357

3 Case studies and implications for the EU's alternative transportation strategy

The implications for the EU of alternative fuel developments worldwide are twofold. First, the lessons learned from the successful policy behind the uptake of alternative fuels could be translated to European Policy. Second, the EU industry could embrace the opportunities abroad in order to strengthen their position in the global market. A summary of the opportunities and barriers for EU industry in the countries of study is presented below.

Table 5: Overview of opportunities and barriers for EU industry to access foreign markets

Country	Opportunities	Barriers
Brazil 	Vehicles need to be locally manufactured because of high import taxes. Typically OEMs from outside Brazil started local production in Brazil and this could also be interesting for OEMs from the EU not yet present on the Brazilian market.	The governmental support for ethanol or natural gas in favour of gasoline is unclear. Other fuels and electric driving are not expected to be supported in the near term.
China 	The large growth in LNG vehicles is an opportunity for EU Industry. Several EU manufactures are already involved in LNG/CNG engines production and they offer a good range of products. Foreign automakers are required to set up joint ventures with Chinese partners to produce and sell cars in the domestic market.	EV incentives are restricted to a selection of 10 vehicles. Chevrolet Volt and Nissan Leaf, very successful in USA and Europe did not get any subsidy. Electric vehicle charging infrastructure is monopolised by the State Grid Corporation of China (SGCC) or the China Southern Power Grid (CSPG). SGCC is not only the manager, but also the supplier. EU industry will not face major barriers for entering the LNG truck market in China. The only issue could be related to any specific emission standard rule which could be defined at regional or even municipal level.
India 	CNG vehicle fleet expected to grow due to development of CNG refuelling infrastructure. Partnerships and local production of foreign models is common. Several European manufacturers (Renault, Mercedes-Benz (cars, buses and trucks), BMW, Mini, Jaguar Land Rover, Audi, Volkswagen, Skoda, Fiat, Scania, Volvo Trucks) already produce cars in India, using many locally produced components.	No big barriers exist. Since the vehicles in India have much smaller engines compared to similar vehicles in China, the USA and Europe, dedicated vehicles need to be developed for this market.
Japan 	Investing in Japanese companies, like Renault did with Nissan (initial transaction value: about USD 3 billion) was successful and opens doors for others.	Market entry is difficult because of a network of regulations, permissions, certifications and procedures.
Russia 	All alternative fuels are in an early stage of development. The CNG and LNG market could be the first to reach significant volume. OEMs from outside Russia invested in Russian companies, like for example Daimler in Kamaz.	Market entry is difficult because of limited acceptance of foreign companies. There is a tight control of the suppliers and import of products and components.
South Korea 	OEMs from outside S. Korea started technology partnerships with and even own S. Korean OEMs. This could also be interesting for OEMs from the EU.	Koreans buy Korean cars (only <1% are imports), making it difficult to sell other brands.
USA 	Incentives for car buyers are aimed at specific vehicle technologies and do not have restrictions on the manufacture origin. EU Industry should rethink franchise organisations, service, resale value, free charging etc. like Tesla	Automotive R&D programmes target local manufacturers. The U.S. Navy has a leading (international) position regarding algae fuels in shipping.

Building on the earlier discussion, we evaluate ten case studies that cover the major alternative fuel markets and modalities. From these, we elaborate potential policy pathways for the EU, as well as risks and opportunities for the EU industry. The concise case studies are split into two sub-sections accordingly. More information on policies, measures, standards, technological developments & costs are available in Annex A.

3.1 Policy lessons from the foreign markets

CASE 1 - Electric vehicles in urban environments: some examples
Urban transportation is particularly suitable to electric mobility in light of relatively short commutes and the advantages of zero-emissions technologies for urban air quality. The 'EV City Casebook' (IEA, 2012), provides an overview of developments in 16 urban areas, including in the countries of study, and presents interesting insights into policy options.

In China, Shanghai was one of the selected cities for piloting electric mobility policies. The city doubled the financial subsidies provided by the national government (RMB 50,000 (€7,200) for hybrid electric vehicles and RMB 60,000 (€8,600) for pure electric vehicles) to about RMB 100,000 (€14,400) and provides support to the development of charging infrastructure. The subsidies are large enough to provide a business case for the buyers of these electric vehicles (mainly pure electric). Professional driving demonstrations and fixed electric bus routes have also been implemented to increase the visibility of electric mobility in the city. With these policies, Shanghai increased the number of vehicles from less than two thousand in 2011 to about 22,000 by mid-2015. BMW has built a pilot charging network for its i8 and i3 electric vehicles in Shanghai. The support to the development of charging infrastructure is needed for improving the capacity of local grids[16].

In Japan, the Nagasaki prefecture established a consortium composed of industry, academia and government to promote electric vehicles throughout Nagasaki and the Goto Islands. Key goals were to create "driving tours of the future", promote electric mobility in tourism, create Nagasaki-originated global standards and a regional business model. Efforts resulted in various successes, for example with over 35 thousand people experiencing electric vehicle rentals from April 2010 to January 2012. In Kanagawa, where many automobile and battery production companies are situated, an EV Promotion Council was established, including government, the Kanagawa prefecture and academia. A system of subsidies and tax breaks was put in place to promote rapid growth in electric mobility, the national government providing a subsidy covering half of the price difference between electric and traditional gasoline vehicles, and the prefecture providing additional tax relief. Further, a public charging infrastructure plan was developed to install 100 DC quick chargers.

In the USA, subsidies are provided at a national level for plug-in electric vehicles (up to USD 7,500 on purchases) and the EV city Casebook presents several cases of cities complementing this national policy at a municipal level with financial and no-financial policies. In New York, the Long Island Power authority offers a complementary USD 500 rebate for the purchasers of electric vehicles, while municipal authorities are taking steps toward the electrification of the municipal fleet. The complementary rebate is helpful, but a small amount when compared to other subsidies or the additional costs of the electric vehicles.

[16] http://www.shanghaidaily.com/metro/public-services/New-policy-aims-to-help-owners-of-electric-cars/shdaily.shtml

In Los Angeles, e-bus routes were announced for the airport and the port purchased 25 heavy-duty all-electric trucks in 2009. In Portland, the *EV Project* realised its goal to deploy thousand residential charging units by 2013. Lastly, in the Research Triangle Region, North Carolina, the city of Raleigh adapted building and electrical codes (municipal codes) to remove barriers for the development of plug-in electric vehicles. Furthermore, the U.S. Department of Energy (DOE) is collaborating with its partners in the public and private sectors to research, develop, and deploy technologies that enhance the performance of electric drive vehicles, including hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and all-electric vehicles (EVs)[17].

Policy pathways:
Urban environments offer fertile grounds for policy testing at local levels with highly customer-oriented focus and the possibility of effectively involving public, private and academic actors. Europe has a long history with complex urban infrastructure, which is an advantage for the development of successful policies and an advantage to EU industry. The EV City Casebook in fact presents numerous European examples that demonstrate Europe's leading position in this field (Amsterdam, Barcelona, Berlin, BrabantStad (five cities in the South of the Netherlands), Hamburg, Helsinki, Northeast England, Rotterdam, Stockholm, etc.). These initiatives might however be too scattered to form a congruent market, posing a risk to fall behind. In each of the areas, because of governmental support different types of vehicles are targeted. A congruent market is needed to be able to produce EVs in large quantities and at reasonable costs.

When considering electric mobility, it is important to examine a range of policy options, as is further explained below. **Financial incentives** are often needed and national policies can be combined with regional or municipal measures to boost local markets. They can be provided through rebates, tax credits, exemptions to registration fees, toll and parking discounts, etc. These measures can also be effectively complemented by **non-financial incentives**, which may include preferential parking measures, access to priority lanes or regulatory action to remove barriers to the development of electric mobility infrastructure. **Public demonstrations and examples**, lastly, can also have impact of the visibility and credibility of electric mobility. The provision of public charging spots, implementation of public fleet strategies, piloting of public transport programmes, or support to local community programmes are amongst the options available to public authorities.

EU Industry opportunity
Electricity offers a strong growth potential in Europe and various European manufacturers have released electric vehicles in recent years, which have penetrated foreign markets (e.g. BMW i3 and i8, Smart ED, Renault Fluence, Fiat 500e). Effective harmonisation at EU level is needed to ensure EU standards are influential in guiding the adoption of standards suitable to European manufacturers by the market.

Projected growth and R&D programmes:
In the USA, like in most national markets, any forecast toward 2030-2050 about the EV deployment and costs depends on the diffusion of such standards, because of economies of scale and network externalities. We have to consider that the price of electric vehicles is related to the price of batteries. Relevant players in the market are trying to lower such costs by extensively investing in bigger production lines, in order to increase the efficiency of manufacturing procedures.

[17] From the Alternative Fuel Data Center website, accessed on May 20, 2015, available at http://www.afdc.energy.gov/fuels/electricity_research.html

The U.S. Department of Energy (DOE) is collaborating with its partners in the public and private sectors to research, develop, and deploy technologies that enhance the performance of electric drive vehicles, including hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and all-electric vehicles (EVs).[18] Research and Development activities are seeking some relevant solution regarding the cost, volume, weight, performance and efficiency of the batteries. A particular focus is given to the improvement of materials, since they are a key factor for achieving a technological enhancement.

Furthermore, in March 2012, President Obama launched a ten years initiative (EV Everywhere Challenge[19]), which aims at reducing electric vehicles prices, putting them in line with conventional vehicles and making affordable products for the widespread adoption. As confirmed by a market player the goals set by the EV Everywhere Challenge are likely to be achieved in 10 years: vehicles costs will decrease considerably, making such products competitive on an economic level against the conventional ones. On the other hand, in terms of competition, the only doubt could be related to the autonomy range and the availability of recharging stations.

Japan aims at electric vehicle sales having a market share of 50% in total vehicle sales by 2020. This was presented in their "Next-generation vehicle strategy" from 2010. China's "Energy saving and energy automobile industry planning" from 2012 talks about 5 million electric vehicles in 2020. Both countries depend on high investments in R&D to reach the goals.

[18] From the Alternative Fuel Data Center website, accessed on May 20, 2015, available at http://www.afdc.energy.gov/fuels/electricity_research.html

[19] From the Office of Energy Efficiency and Renewable Energy (EERE) website, accessed on 26/06/2015, available at: http://energy.gov/eere/vehicles/ev-everywhere-grand-challenge-does-10-year-vision-plug-electric-vehicles

CASE 2 – Fiscal incentive policies for electric vehicles
A recent study by the International Council of Clean Transportation (ICCT, 2014) provides further insight into the impact of fiscal policy on the uptake of electric vehicles. It evaluates market response to fiscal incentives in 2013, based on a synthesis of sales data, fiscal taxation policy and subsidies, focusing on two representative models (Renault Zoe BEV and Volvo V60 PHEV).

The study includes a review of policies in China, Japan and the USA. Table 6 provides a summary of the taxation schemes, subsidies and market trend of EVs in these countries. The study also reports several EU and other European cases (Austria, Denmark, France, Germany, Netherlands, Sweden, UK & Norway), highlighting the Dutch and Norwegian cases where subsidies respectively covering about 75% and 55% of the vehicle base price, resulted in market growths of 1,900% (mainly PHEVs) and 90% (mainly EVs).

In the Netherlands this overcompensation was abandoned from January 2015. The Dutch government did not expect the compensation to be so successful. Furthermore the compensation was influencing the market too much. In total about €500 million subsidy was provided in 2013 for mainly PHEVs. Almost all of the Mitsubishi Outlander PHEVs produced came to the Netherlands. Another aspect in the discussion was that the PHEVs were not charged as often as expected, and therefore their environmental benefit was much smaller. The support has been scaled down to a promotion of only EVs from 2017.

Table 6: Overview of 2013 vehicle taxation schemes, subsidies and EV market trend – (source: adapted from ICCT, 2014)

Country	Taxation scheme	EV subsidies	EV market trend
China	*VAT*: 17% *One-time*: Acquisition tax (10%); excise tax based on vehicle engine displacement and price. *Annual*: Vehicle and vessels fee based on engine displacement and price. EVs are exempted.	Up to € 7,200 for EVs	EV market share of 1.1% in 2014, up more than 10 times from 2013.
Japan	VAT: 5% One-time: Acquisition tax based on engine displacement and vehicle price. EVs are exempted. Annual: Tonnage tax based on vehicle weight. EVs are exempted; automobile tax based on engine displacement. EVs are exempted 50%.	Up to about € 6,500 based on price difference for EVs.	EV market share of 0.7% in 2014, up 20% since 2013.
USA	VAT: 7.3% (sales-weighted average of state taxes) One-time: Registration fee around 33 EUR; gas-guzzler tax for very fuel-inefficient vehicles	Federally, up to about € 5,500 based on battery capacity (federal); in California about € 1,800 for BEVs and € 1,100 for PHEVs	EV market share of 1.5% in 2014, up nearly 100% since 2012 (4% market share and nearly 120% growth for California alone).

Effectiveness of ZEVs policies:

Alternative fuelled vehicle uptake is influenced mainly by financial incentives and available charging points or refuelling infrastructure (Ecofys, 2010).

Up to 2013, the uptake of EVs in China was not as successful as in some of the other countries. In China, the fiscal incentives were limited to 10 vehicle types and therefore hampering the market uptake. The School of Economics and Management (Xingping Zhang, 2014) for instance suggested "China to open its arms and welcome good models to spur the desire of people to purchase EVs". In 2014 the EV market share increased more than 10 times.

The success is probably partly the result of the elimination of the vehicle tax (10%) on electric vehicles and the exemption of limitation of vehicle registrations for EVs in Beijing[20].

In Japan the main focus is on improving the technology through R&D programmes and thereby reducing the cost of the vehicles.

Relevant stakeholders in the USA market suggested that the policies proposed by the government have already proven useful to stimulate initial market growth and to generate a positive impact, mostly for economic or small cars. Although these are good policies bringing positive effects, it would be better not to count only on them for the long term. A regulatory framework is needed which allows the widespread deployment of such products in everyday use.

Policy pathways:
It can be concluded that **fiscal incentive policies are an important factor influencing recent electric vehicle markets, but that they are not the only determining factor**, pointing as an example to the UK, where relatively high fiscal incentives did not result in expected market growth. It emerges that, while financial support does appear effective, it is also important to understand the limitations and pitfalls of such policies. **Since electric vehicle performance (range, charging requirements) is different from conventional vehicles other policy mechanisms are needed to ensure sustained and effective growth of electric vehicle markets**.

EU Industry opportunity
For the industry it is very difficult to produce vehicles that fall under a favourable regime in a few countries. EU industry would benefit more if the incentive programmes would be harmonised more (especially in Europe) so the vehicle development can be adjusted accordingly.

Projected growth
Subsidies have proven to be highly important and effective for electric vehicles, as illustrated in the Netherlands and Norway, where spectacular uptake occurred as a result of very favourable subsidy regimes, and where the markets, once developed cannot yet exist in absence of such subsidies. The growth in number of vehicles on the road is therefore dependant on the targets that the governments set for themselves.

[20] http://fortune.com/2015/02/19/chinas-electric-car-boom-should-tesla-motors-worry/

CASE 3 - Incentive policies for LPG

The past uptake of LPG provides insights into the impacts of fuel incentive policies on market uptake. Gasoline vehicles can be converted to run on LPG, which typically presents environmental advantages that are attractive to governments. Despite the up-front costs of the conversion, consumers can benefit financially if LPG fuel prices are lower (often trough a favourable tax) than traditional fuel prices. The World LP Gas Association has carried out a review of LPG incentive policies in key markets covering approximately 84% of the global LPG market (WLPGA, 2012).

The WLPGA study highlights that providing a favourable fuel-tax regime relative to gasoline and diesel is the most occurring measure making LPG attractive. Such regime indeed directly affects the fuel cost savings of LPG relative to other fuels and impacts the break-even point (expressed in distance travelled) at which conversion costs are offset. Other financial incentives are also possible and have proven to be effective, such as the provision of tax rebates or direct subsidies on conversion costs.

Similarly to the case of fiscal incentives for EVs, financial incentives are however not the only important parameter determining LPG market growth and the study lists the following considerations:

- The need for stable and strong policy commitment;
- Non-financial policies and measures, in particular targeting public awareness and education (e.g.: on LPG safety) and 'leading-by-example' policies with public fleet mandates, conversion programmes;
- Restrictive policies on competing fuels such as diesel;
- Availability of refuelling infrastructure and conversion services.

Policy pathways:

The case of **LPG provides additional evidence on the importance of financial incentives supporting the competitiveness of alternative fuels relative to conventional road-transport fuels**. It also highlights the importance of other factors and the inertia of policies, as shown in the continued dynamics of the Korean market despite reduced fiscal support. Lastly, LPG provides a concrete example of the importance of differentiating between different user/consumer groups. Commercial and non-commercial vehicles typically have different mileage profiles, which is an important determinant in implementing targeted and effective policies.

EU Industry opportunity

The LPG market remains a market (similar in global natural gas vehicle fleet size) that is successful in a few countries: Korea, Turkey, Russia, Italy, Japan and Australia are responsible for 60% of the volume that is consumed globally in transport. Therefore the market is typically a niche market for the conversion of existing vehicles to the use of LPG in these countries, an opportunity for fuel system suppliers. In the EU Poland is the largest LPG market with 2.6 million vehicles in 2015.

Projected growth

South Korea is the largest LPG market globally and was among the pioneers promoting widespread use of LPG. Large tax incentives provided in the early 1990s resulted in a demand surge driven by high-mileage vehicles such as taxis, as well as by public buses. This policy was complemented by restrictive policies on diesel, driven by environmental considerations. In recent years, however, the improved performance of diesel and gasoline fuels has led to a progressive decrease of LPG fuel tax incentives and to slower growth of the Korean LPG market.

The South Korean LPG market nonetheless remains dynamic and accounted for 14% of total road-transport fuel consumption in South Korea in 2013[21].

The sales of LPG vehicles in South Korea are falling and cars that were introduced into the market (between 1999 and 2002) are now phased out and not replaced by LPG vehicles[22]. The taxi market, responsible for 40% of total LPG consumption is reconsidering the use of LPG (in 2013, because of an obligation, 95% of the fleet was using LPG). As of September 2015, taxis will be allowed to use diesel cars that meet Euro-6 standards.

[21] www.auto-gas.net/korea
[22] http://www.wlpga.org/mediaroom/290/57/Strategies-for-growing-the-Autogas-market-in-Korea

CASE 4 - The LNG strategy in China: a case study of developments for trucks

The recent Chinese economic growth has brought some major consequences and the most important among them is the worsening of air pollution. In order to reduce this phenomenon, during the last 15 years, the Chinese government enforced several policies, the last of which was the 12th Five Year Plan (2011), approved by the National People's Congress (NPC).

Among the different targets, this regulatory framework was also aimed at increasing the LNG consumption of final users and at reducing carbon dioxide (CO_2) emissions. For decreasing energy intensity, a binding target was set up to 16% less CO_2 per unit of GDP by 2015. This policy has important consequences on the transportation sector, which accounts for more than 40 percent of China's oil consumption. That is why the president Hu Jintao promoted the development of vehicles, which generate lower emissions compared to traditional vehicles.

In this regard, Natural Gas Vehicles (NGVs) were chosen as the best technological solution for achieving these ambitious targets; in particular the heavy trucks and transit buses with liquefied natural gas (LNG) engines became the trend of the Chinese transportation industry in the recent past. Therefore, the natural gas is expected to become the primary fuel for transportation in China in the next few years. For the time being, the NGV adoption is mostly related to the commercial and public sectors. Since 2012, China is the most important LNG heavy vehicles market[23].

The Ministry of Environmental Protection (MEP) enforcement is related to the compliance of new vehicle type approval and Conformity of Production (COP) testing. The responsible authority for implementing the natural gas programme is the Vehicle Emission Control Center, which is a part of the MEP.

Vehicle emission and control rules are defined by the Air Pollution Prevention and Control Law, including compliance programmes. Manufactures cannot exceed the emissions levels prescribed by the law for designing their motor vehicles and vessels; only compliant products can be sold or imported in the Country[24]. Since 1999 the Chinese government has set relevant targets for the deployment of cleaner vehicles; four main policies were enforced: offering preferential gas price policies; developing the infrastructures for refilling stations; defining the most important Chinese cities as model zones (for example Beijing, Shanghai, Tianjin, and Chongqing); accelerating the research and development of new technologies.

China aims at increasing the final consumptions of natural gas in several sectors. According to the country's national plan, China's natural gas vehicle ownership would be 1.0 million in 2012, 1.5 million in 2015 and 3.0 million in 2020[25]. The main challenge to achieve such ambitious goals are: increasing gas supply; building and improving the gas infrastructure; defining an effective framework to incentives the gas market, from upstream, import infrastructure to midstream (pipelines and storage). At local level, there are some examples of NGV subsidies or policy support.

[23] From the Heavy Duty Manufacturers Association website, accessed on 05/06/2015, available at: http://www.hdma.org/Main-Menu/HDMA-Publications/Diesel-Download/January-14- 2014/Nearly-1-Million-CNGLNG-Trucks-and-Buses-Will-Be-Sold-from-2012-to-2019.html

[24] From the Diesel Net website, accessed on 05/06/2015, available at: https://www.dieselnet.com/standards/cn/hd.php

[25] From Forbes website, Natural Gas Vehicles In China, accessed on 05/06/2015, available at: http://www.forbes.com/sites/jackperkowski/2012/04/13/natural-gas-vehicles-in-china/

In February 2015, the Shenzhen Municipality published a scheme to subsidise the purchase of medium-sized LNG vehicles[26]: 20,000 RMB (€2,880) subsidy is given per vehicle, for a maximum of 15,000 vehicles. Further to this, the Shanxi Province offers financial support for NVGs and the Shandong Province offers state aids to NGVs buyers.

As a pilot programme, China LNG Group and Sinopec intend to select two highways — Ningbo Expressway (G60) (connecting Shanghai and Hangzhou – 151 km) and Pu-Hangzhou Expressway (G15) (connecting Pudong and Hangzhou – 112 km)[27], for the addition of LNG facilities to existing filling stations. Following successful implementation of such stations, Sinopec will increase the number of LNG fuel stations based on the demand and development of the company's LNG businesses.

China LNG Group is responsible for actively expanding the liquefied natural gas vehicle market, providing its customers with funding for conversion of heavy-duty trucks and establishing financial lease services for those customers wanting to purchase new LNG heavy-duty trucks. China LNG Group has expressed intent for direct investment in a minimum 100,000 LNG-fuelled trucks and indirect-investment in 200,000 LNG-fuelled trucks by 2020[28]. Global LNG handling producer Chart supports Petrochina (the main supplier of LNG for trucks) with the supply of LNG Station Modules, storage tanks, and vehicle tanks[29].

In December 2014[30], the Asian Development Bank (ADB) granted a loan of USD 450 million for further spreading the use of natural gas in China. The investment is aimed at building 600 Compressed Natural Gas (CNG) and 200 LNG stations throughout the Country by 2018, with particular attention to the main transportation highways, which link together the entire Chinese territory.

In 2013 the International Finance Corporation (IFC, part of the World Bank Group) granted a funding of USD 150 million to finance a private company (ENN Energy Holdings Limited) for constructing a fuelling network in China. Currently, ENN manages more than 200 Natural Gas Vehicle refuelling stations in China[31].

The LNG trucks are locally produced, for instance by China Yuchai International Limited, FAW Jiefang, Sinotruk (joint venture with Volvo), Auman Truck, SAIC-IVECO Hongyan and others. Volvo Group explained (interview: Klintbom, 2015) that the LNG trucks in China are less efficient than conventional diesel, since they use Otto engines. These engines are 20% cheaper than diesel engines, which helps to bring the initial cost of the vehicle down. The LNG storage is bought on the international market and the price for that is similar around the globe.

[26] From Transport Commission of Shenzhen Municipality, accessed on 24/06/2015, available at: http://www.sztb.gov.cn/jtzx/tzgg/201502/t20150215_49771.html
[27] From the Heavy Duty Manufactures Association website, accessed on 05/06/2015, available at: http://www.hdma.org/Main-Menu/HDMA-Publications/Diesel-Download-2013-Archive/Diesel-Download-2013-Archive/December-1-2014/China-LNG-Sinopec-to-Develop-Small-Scale-LNG-Fueling-Stations-for-HD-Truck.html
[28] http://www.ngvglobal.com/sinopec-china-lng-agree-to-develop-hd-truck-lng-fuel-market-1128
[29] http://www.ngvglobal.com/blog/chart-industries-wins-40-million-contract-to-supply-lng-station-modules-to-petrochina-0303#more-25866
[30] From the Ship Banker website, accessed on 05/06/2015, available at: http://shipandbunker.com/news/apac/143595-asian-development-bank-announces-450m-loan-for-lng-cng-fuel-infrastructure-in-prc
[31] From The Energy Collective website, accessed on 05/06/2015, available at: http://theenergycollective.com/coley-girouard/2227136/advanced-energy-now-fueling-stations-get-boost-low-priced-gas

The Chinese standards for LNG engines are in line with the European ones; in this regard, a European manufacturer should not face any relevant barriers for exporting its products into the Chinese market. However, some issues could be found at regional or municipal level when local specific emission requirements are present. In some cases cities or regions implement a stricter standard before the national standard has been released. Large metropolitan areas, including Beijing and Shanghai, Guangzhou, and some other cities have adopted more stringent regulations on an accelerated schedule, ahead of the rest of the country.

Policy pathways for EU:
Working both on the development of infrastructure and vehicles at the same time would help to develop the market. In the EU the development of LNG infrastructure is supported, but governments do not take the lead in the realisation the new infrastructure. The risk for the EU industry is that they might not able to keep up with the pace in which LNG is developing in China, in terms of standard setting and large volume/low cost production. There is a lot of LNG experience in the EU regarding the deployment of LNG infrastructure/vehicle upgrades in e.g. Sweden, Czech Republic, UK, Spain and the Netherlands, which could be promoted more.

EU Industry opportunity:
At present we can assume that the EU industry will not face major barriers for entering the LNG truck market in China. Several EU manufactures are already involved in LNG/CNG engines production and they offer a good range of products. In terms of technological level, no barriers were found for the Chinese market. The only issue could be related to any specific emission standard rule which could be defined at regional or even municipal level. In some cases requirements are not in line with the European emission standards[32] (i.e. for instance an emission standard in between Euro IV and Euro V). Since emissions standards can diverge unpredictably at local level, there is no certainty for automotive investments which are supposed to be recovered in the medium long term. Furthermore, emissions standards not aligned with the European ones can discourage the market entry by new players: a vehicle compliant with Euro V emission standard might be too expensive to compete in a local market where the required emission standard is set in between Euro IV and Euro V.

From an infrastructure point of view, the Chinese companies are able to achieve better economies of scale regarding the refuelling stations than the EU industry.

Projected growth and R&D programmes:
In May 2014 there were already 1,800 LNG fuelling stations in China (compared to for instance 93 in the USA)[33]. Because China's natural gas pipeline infrastructure is not well developed in many areas, analysts project that much of the growth in China's NGV fleet counts will be in LNG vehicles. By the end of 2015, 220,000 heavy trucks and 40,000 buses in China are expected to run on LNG[34]. Sanford Bernstein, has projected that the number of LNG vehicles in China will grow tenfold between 2014 and 2020, to a total fleet of 800,000. This is about 6.5% of the total fleet of 12 million.

[32] Direct interview with Chinese automotive player, 18 Feb 2015
[33] http://ngvtoday.org/2014/05/27/special-report-chinas-burgeoning-ngv-market-draws-on-north-american-knowhow-and-technology-made-in-china/
[34] From Bloomberg New Energy Finance, accessed on 05/06/2015, available at: http://www.bloomberg.com/news/articles/2014-07-04/choking-smog-puts-chinese-driver-in-natural-gas-fast-lane

Until now, at least nine provinces or municipalities have launched plans for buying NGVs or building refuelling infrastructure. On the other hand, Beijing is planning to add more than 3,000 buses to its transit fleet in 2015. According to the International Centre for Natural Gas Information[35], China will represent almost half of the world market for the use of LNG trucks.

In general, the need for specific parts for assembling an LNG engine makes the final product more expensive; higher production volumes could considerably tackle this barrier. It is extremely hard to estimate any further forecast about the vehicles prices towards 2030 and 2050.

[35] From the Bloomberg website, accessed on 05/06/2015, available at: http://www.bloomberg.com/news/articles/2014-09-28/lng-trucks-to-boost-transport-market-share-by-2035-cedigaz-says

CASE 5 - Biofuel policies in Brazil: lessons learnt from global developments
In response to the 1973 oil crisis, Brazil wanted to reduce its dependence on foreign fuels (more than 80% of the fossil fuel import was gasoline imports). Because also internationally the price for sugar was low, the government searched for another outlet for sugar producers. They also looked for jobs (currently about 1 million in total for the ethanol industry). Also CO_2 (since 1990) and local emissions became important drivers to further stimulate ethanol use as a vehicle fuel.

The National Alcohol (Pró-Álcool) Program, launched in 1975, was a nationwide programme financed by the government to phase out automobile fuels derived from fossil fuels, in favour of ethanol produced from sugarcane.

By the late 1980s, there were more than four million cars and light trucks, representing one third of the country's motor vehicle fleet, running on pure ethanol.

International sugar prices increased sharply at the end of 1988 and the government did not set the sugar export quotas. Consequently, production shifted heavily towards sugar. This resulted in an ethanol supply shortage as the real oil price parity cost of ethanol production was around USD 45 per barrel. As a result the consumers began selling their vehicles or converting them back to gasoline. The introduction of flexi fuel vehicles in 2003 restored confidence (Garth, 2009). Since 2007 millions of flexi fuel vehicles were sold annually. Nearly 75% of the vehicle sales (88% of the passenger car sales) from 2010-2015 were flexi fuels, thereby changing the fleet into flexi fuel rapidly[36]. Mid-2015 there were around 30 million vehicles in Brazil that could drive on high blends of ethanol.

Although there are no sustainability criteria for the production of ethanol in Brazil, there are environmental laws for the prevention of environmental degradation. Overall ethanol production from sugarcane (the main source in Brazil) is regarded as relatively good on sustainability criteria. Brazil is interested in setting up a bi-lateral agreement with the EU regarding sustainability criteria for biofuels production (Ecofys, 2014).

Policy pathways for EU:
The Brazilian government provided several financial drivers to support the uptake of ethanol as a vehicle fuel, which provided both long term perspectives for the ethanol producers (guaranteed purchases) as well as for the consumers (fixed financial advantage over gasoline). This resulted in a large market for ethanol (high blends) and could inspire the EU to also make a clear decision and fully dedicate the policy around a preferred fuel in order to achieve serious uptake. Since the EU normally advocates technology neutrality this would require a paradigm shift.

Opportunities for EU industry:
Vehicles need to be locally manufactured because of high import taxes. From around 150.000 of cars produced annually the initial investment can be earned back. Since Brazil is a huge market, of around 4 million new vehicles sold annually many OEMs are interested. Typically OEMs from outside Brazil follow this approach and this could also be interesting for all OEMs from the EU (FIAT and Volkswagen already have a large market share).

[36] http://www.virapagina.com.br/anfavea2014/files/assets/common/downloads/publication.pdf

Projected growth:
In the period 2011-2012 there was a peak for ethanol production in Brazil. The future is now unclear (interview: Roberto Schaeffer, 2015). The growth of the (already huge) ethanol market is at this moment difficult to judge. The government influences the financial benefit for the consumers by controlling the gasoline prices at refinery & tax-for ethanol. The price for gasoline at the pump was kept artificially low (in order to fight inflation). In early 2015 ethanol lost competitiveness because the prices at the pump were passing the tipping point. Most people are going back to gasoline, so now Brazil has to import gasoline again.

Because of the blend obligation of ethanol in gasoline there still remains a big market for ethanol. The government is considering to bring the price of gasoline back to international level. This would further stimulate the ethanol market, because ethanol would be cheaper again per km compared to gasoline.

CASE 6 - Biofuel policies in USA: lessons learnt from global developments
The first fuel ethanol plant in the USA was built in Nebraska by the US Army in the 1940s. The ethanol was used as fuel by the Army and for regional blending but essentially none was sold commercially until the late 1970s when blends containing up to 10% ethanol came into increasing use as the government responded to the agricultural lobby to subsidize fuel ethanol production using several different fiscal measures.

Demand for ethanol fuel produced from corn (maize) was spurred by the banning of MTBE as a gasoline octane enhancer in about 20 states by 2006 and a 2005 decision refusing legal protection for MTBE producers opened a new market for ethanol fuel as its primary substitute. Corn growers responded rapidly and by 2006 about 50% of the gasoline used in the USA and more than 85% of Hawaii's gasoline contained ethanol in different proportions. The Biomass Crops Assistance Program currently provides incentives in the agricultural sector for production of biofuels (until 2018).

In the USA still many environmental schemes continue to be voluntary and are therefore not safeguarding all biofuel crop production. The support systems for biofuels that are available stimulate the application of better performing advanced biofuels. The USA is interested in setting up a bi-lateral agreement with the EU regarding sustainability criteria for biofuels production (Ecofys, 2014).

In the USA, Commercial Aviation Alternative Fuels Initiative (CAAFI) is actively studying and supporting the deployment of alternative jet-fuels for commercial flights. But the most important alternative fuel market is passenger cars.

The number of ethanol compatible road vehicles capable of using E10 (and even E15) has grown rapidly. E15 is almost not offered to the public, whereas E10, which is also compatible with vehicle from before 2001 and boats and motorcycles are. Most cars on the road today in the USA (E15 is an approved ethanol blend for model year vehicles 2001 and newer) can operate on blends up to E10.

There were 2,622 E85 refuelling stations (excluding private stations) and 17.4 million flexible-fuel vehicles (FFVs), capable of using any combination of ethanol and gasoline from 0 to 100%, in service by mid-2015 (more than double the amount of vehicles in 2008). Seventy-two flex-fuel vehicle models were offered in model year 2014. Flexi fuel vehicles made up only 3 to 6 percent of the total U.S. light vehicle fleet of about 250 million vehicles in 2014, compared to 50 percent of the vehicles in Brazil. E85 has captured less than 1 percent of the U.S. gasoline fuel market, and the Energy Information Administration estimates that in 2011, only 1 million of the approximately 10 million ethanol-flex fuel vehicles in the U.S. actually used E85[37].

The cost related to the E10 flexi fuel system are in the order of USD 100 per vehicle compared to 100% gasoline, and USD 25 more for a E85 flexi fuel compared to a E10. Conversion kits for conversion from gasoline to E85 are available from a few hundred euros. The price of ethanol fuel at the pump fluctuates but is usually similar to the price of gasoline. E85 is usually priced lower to compensate for the lower energy content. For more info on costs see the last part of Annex A.

The only support for diesel fuel blends containing a minimum of 20% of biodiesel in the USA was a federal tax credit until 2014 which supported fuelling equipment.

[37] http://www.bioenergyconnection.org/article/flex-fuel-vehicles-united-states-why-are-we-lagging-behind-brazil

Important drivers for reducing fuel consumption for California are greenhouse gas emission reductions, reducing oil dependence, create local jobs. The path included reduction of miles travelled, more efficient vehicles and doubling the use of biofuels in 2030 compared to 2015. California has had 10 percent ethanol in its gasoline since the beginning of 2010. California Reformulated Gasoline (CaRFG3) regulations do not require the use of ethanol. However, ethanol is an oxygenate, and there is an oxygen content requirement.

Diesel-powered vehicles only account for about 4 percent of California motor vehicles. In 2014 there were about 50 biodiesel stations in California with some limited availability for general public use[38].

Policy pathways for the EU

The USA government provided several financial drivers to support the uptake of ethanol as a vehicle fuel, which provided both **long term perspectives for the ethanol producers** (a series of mandates from federal, state and city governments) **as well as for the consumers** (a number of fiscal incentives). This resulted in a large market for ethanol (mainly via **low blends**) and could inspire the EU to also make a clear decision and fully dedicate the policy around a preferred fuel in order to achieve serious uptake. Since the EU normally advocates technology neutrality this would require a paradigm shift.

Opportunities for EU industry

Vehicles sold in the USA need to be produced according to US specific safety and emission standards. Toyota and Volkswagen (recently since 2011: US-spec Volkswagen Passat) for example have production facilities for engines, and assembly plants for vehicles available in the USA. Typically OEMs from outside USA follow this approach and this is therefore also a good solution for OEMs from the EU.

Projected growth

U.S. Congress passed the Energy Independence and Security Act (2007), which mandates an increase in the use of biofuels, including ethanol, through the year 2022, in a new Renewable Fuel Standard (RFS).

Biofuels in cars in California is less stimulated than some other options, since in 2050 87% of the cars on the road need to be full Zero Emission Vehicles.

The major cost component is feedstock: 90% for biodiesel, 60-80% for ethanol and 30-45% for advanced biofuels. Ethanol is already a mature and competitive market in Brazil and the USA. Advanced biofuels are just scaling up and are less dependent on feedstock prices, which means that it is more likely that production costs could fall to competitive levels.

[38] http://www.driveclean.ca.gov/Search_and_Explore/Technologies_and_Fuel_Types/Biodiesel.php

3.2 Industrial strategies & insights from foreign markets

CASE 7 - Tesla: breaking ground with electric vehicles and challenging industry models

Tesla's has been successful in developing innovative electric cars and the ability to attract investors. The idea from Tesla, which was different from other EV car manufacturers in the US, was to develop an electric car similar to fossil fuelled cars, that could be used in everyday life. This strategy copes with high vehicle prices (in line with the premium segment of the automotive sector) during the inception phase.

The Tesla Motors history in short:

- Tesla Motors was founded in 2003[39]. They wanted to produce electric vehicles using AC Propulsion technology from the T-ZERO (in licence) in a high performance, lightweight sports car. Tesla could buy all the parts they needed, without having to engineer them since all the big car manufacturers outsourced almost everything except internal combustion engines, final assembly and sales & marketing. Tesla would start with using a lotus chassis to build their first car, almost completely at the lotus factory in the UK. In 2004 Elon Musk lent the company USD 7.5 million and became chairman;
- By November 2004 they build their first "mule" on the basis of a Lotus Elise and they secured USD 13 million more in funding. The roadster was presented in 2006. Because of a lot of changes compared to the Lotus cars, Tesla ended up being involved in the production of the vehicle for a lot more components and sub-assemblies than initially thought;
- By October 2008 Elon Musk invested USD 55 million in Tesla and got more involved in running the company;
- The Roadster was shipped from 2008 until 2012, 2500 units were produced using Lotus Gliders. The body panels come from French supplier Sotira. Brakes and airbags were made by Siemens in Germany. The roadster used Lithium-ion batteries (6831 cells, 53kWh, 450kg), had a range of 400km on a single charge and was relatively expensive at €100,000;
- In 2010 Tesla raised USD 100 million. Also Daimler bought a sizable stake in the firm, and Toyota signed a deal with Tesla (worth a total of USD 50 million);
- On June 29, 2010, Tesla Motors launched its initial public offering on NASDAQ. 13,300,000 shares of common stock were issued to the public at a price of USD 17.00 per share. The IPO raised USD 226 million for the company. It was the first American car maker to go public since the Ford Motor Company had its IPO in 1956[40];
- Tesla manufactures the Model S at the Tesla Factory in Fremont, California. Production in 2015 is about 1,000 vehicles per week. For the European market, Tesla assembles and distributes from its European Distribution Centre in Tilburg, the Netherlands. On April 8, 2015, Tesla introduced the Model S 70D as its new USD 75,000 entry-level car, with all-wheel drive and an improved range of 240 miles (385 km) from its 70 kWh battery. All models support supercharging. Global cumulative sales passed 75,000 units in June 2015. The Model S has double the range of the Roadster at a lower price for the final customer;

[39] http://uk.businessinsider.com/tesla-the-origin-story-2014-10?r=US
[40] http://www.marketwatch.com/story/tesla-motors-revs-up-244-million-ipo-2010-06-28

- For several reasons Tesla decided to sell and service their vehicles without franchise dealerships. Tesla offers a high resale guarantee via Tesla financing[41], Tesla offers free electricity at their fast chargers (Superchargers);
- In early 2015 Tesla presented the Roadster 3.0 upgrade: new battery, new aerodynamics, new tires and bearings, which increases the driving range from 400 km to 640 km. The battery fits in the original battery space;
- In April 2015 Tesla presented the Powerwall, a modular home battery (available in 7 and 10kWh versions), that can also be installed as multiple batteries. The battery can typically be installed in houses with solar panels where is stores surplus energy for later use. The bigger battery called Powerpack, that can store 100kWh of electricity, is available for industrial consumers, reaching a price point of USD 250/kWh. Both models are already sold out until mid-2016, at combined orders of USD 800 million[42];
- From October 2015 the Tesla S vehicles produces since September 2014 (60,000 out of 90,000 produced) received a software update to introduce automated driving. The main features are: auto steer, auto lane change and auto park[43];
- As of November 3 December 2015, there are ***557 Tesla Supercharger stations operating globally***, 239 of them are located in the USA, 15 in Canada, 7 in Australia 203 in Europe, and 93 in the Asia/Pacific region[44].

Public Enforcement in R&D:
The Department of Energy lent the company USD 465 million to help build the Model S sedan[45]. The U.S. government has invested into the auto and new energy industries to foster R&D and innovation. In 2010, as part of the Advanced Technology Vehicle Manufacturing programme, the DOE awarded Tesla Motors with a milestone-based loan (USD 465 million), requiring matching private capital obtained via public offering. By interventions like this, the government almost acts like a venture capitalist, since it makes new energy companies viable when private investment are not sufficient. In 2013 (nine years ahead of schedule), Tesla repaid the loan facility with interest. Through this success case, the USA government is pushing competitors to accelerate their effort and investments in new energy.

Relevant stakeholders in the USA market suggested that R&D incentives do not represent a significant factor in terms of industrial strategies. They are useful to help the technological development definitely, but with respect to the customers' perspective toward the EVs, they are not so effective as the economic rebates or the incentive policies (High-occupancy vehicle (HOV) lane allowance, parking reservation for charging) for stimulating the uptake of new standard among the final consumers.

Risks for EU industry:
Tesla's innovative thinking has given it a leading industrial position with battery electric vehicles. This position has enabled the USA manufacturer to not only commercialise electric vehicles, but also to pioneer infrastructure developments, including outside of the USA. This position poses a risk to European manufacturers and industry with the future development of electric mobility, outside, but also inside of European borders.

[41] http://www.teslamotors.com/de_AT/blog/tesla-improves-financing-product-best-resale-value-guarantee-and-lower-monthly-
[42] http://www.bloomberg.com/news/articles/2015-05-08/tesla-s-battery-grabbed-800-million-in-its-first-week#r=read
[43] http://www.usatoday.com/story/tech/2015/10/14/teslas-new-software-helps-model-s-drive-itself/73942116/
[44] http://www.teslamotors.com/supercharger
[45] http://www.wired.com/2010/06/tesla-ipo-raises-226-1-million/

EU Industry opportunity:
At present, comparing the EU and US current status regarding the EVs technologies, we can assume that the EU automakers will not incur in any major barrier for entering the US market. European manufactures are already selling their EVs products in US. Furthermore Tesla's strategy has shown **that funding and industrial partnerships** can be effective to support and accelerate the development of e-mobility. The partnerships with a European car-manufacturer (Lotus), technology-provider and huge funding offered an attractive opportunity to create a competitive position in this field. This approach is not necessarily an opportunity for the established OEMs in Europe, but could be more appealing for the Googles and Apples of this world. **EU OEMs could try to build upon Tesla's success and rethink franchise organisations, service, resale value, free charging etc.**

Furthermore, a lot of work has still to be done in R&D for improving vehicles performances and solve the main issue, which is the battery range. Relevant investments in the field could allow the European automotive industry to enhance its products and become a leading reference for technological innovation.

Projected growth
The Model X crossover will be available in late 2015 from USD 80,000. The low cost Tesla 3 is set for reveal in March of 2016, with deliveries beginning in 2017; the Model 3 is projected to cost USD 35,000 and will have a 320km range. For achieving the cost goal for the batteries, Tesla enhanced the production efficiency, mainly by increasing the volumes and by reducing the production costs;

In 2017 the Tesla Gigafactory (in cooperation with Panasonic) will be operational and ready to produce the Model 3 batteries. After ramp up the factory should be able to produce enough batteries for 500,000 Tesla vehicles annually.

Figure 4: Artist impression of Tesla/Panasonic Gigafactory, Reno, Nevada

Any forecast toward 2030-2050 about the vehicles costs depends on economies of scales and network externalities. We have to consider that the price of electrical vehicles is related to the price of batteries. The average price of a new car in the USA is just over USD 25,000 (not including light trucks)[46]. The USD 10,000 premium for the Tesla 3 can therefore be earned back from lower operating costs. For more info on costs see the last part of Annex A.

[46] http://cta.ornl.gov/vtmarketreport/pdf/2014_vtmarketreport_full_doc.pdf

CASE 8 - Toyota’s strategy with hydrogen technology

Toyota announced the commercialisation of its first mass-produced hydrogen fuel-cell vehicle, the Mirai, in late 2014, with commercialisation due to follow in Europe and the USA later in 2015. In doing so, Toyota became the first manufacturer to launch a hydrogen vehicle. Key milestones (largely based on press releases) in this industrial venture include:

- Toyota started its R&D projects for alternative fuel vehicles back in the 90s, to differentiate from competitors;
- In December 2002[47], Toyota announced the delivery of the world’s first ‘market-ready’ fuel cell vehicle, offering 250 km range, for trial by government departments in Japan. Produced at high costs, it was forecasted that it would be at least ten years before mass-marketing of such vehicle could be possible;
- By October 2007[48], Toyota announced range improvements enabling an improved FCHV to travel 560km between Osaka and Tokyo without refuelling and, in June 2008[49], Toyota announced an 830km range for the advanced version of its hydrogen fuelled vehicle (the Toyota FCHV-adv). Later that year, in September 2008[50], the firm announced the start of a leasing plan for Japan’s Ministry of the Environment;
- In November 2013[51], at the Tokyo motor show, Toyota unveiled the FCV (Fuel Cell Vehicle) Concept, set to become the world’s first mass-produced hydrogen-powered car, with a range of 500km and refuelled in as little as three minutes. Its expected cost was announced to be below 10 million Yen (or about USD 108,000);[52]
- In June 2014[53] Toyota revealed the exterior design of its first fuel cell sedan, to go on sale in Japan for approximately 7 million Yen (just over USD 73,000). Sales in Japan began on 15 December 2014. In September 2015 the Mirai is introduced to selected European markets (UK, Germany and Denmark)[54]. Finally, staring from October 2015[55], the first 300 Mirai are delivered to USA customers.

Figure 5: Toyota's 4-door hydrogen fuel cell-powered Mirai. Credit: Toyota

[47] https://www.pressroom.com.au/press_release_detail.asp?clientID=2&prID=780&navSectionID=
[48] https://www.pressroom.com.au/press_release_detail.asp?clientID=2&prID=3404&navSectionID=
[49] https://www.pressroom.com.au/press_release_detail.asp?clientID=2&prID=3618&navSectionID=
[50] https://www.pressroom.com.au/press_release_detail.asp?clientID=2&prID=3688&navSectionID=
[51] https://www.pressroom.com.au/press_release_detail.asp?clientID=2&prID=5173&navSectionID=
[52] https://www.pressroom.com.au/press_release_detail.asp?clientID=2&prID=5173&navSectionID=
[53] https://www.pressroom.com.au/press_release_detail.asp?clientID=2&prID=7322&navSectionID=
[54] https://www.toyota-europe.com/world-of-toyota/articles-news-events/2014/the-toyota-mirai.json
[55] http://pressroom.toyota.com/releases/toyota+mirai+owners+jump+future.htm

- The midsized Mirai will have a base price (without incentives) of USD 57,500 (€52,000) in the USA. Toyota said it is providing three years' worth of free hydrogen for the initial buyers of the Mirai[56].
- In October 2015 Transport of London announced that they will be the first customer in the UK for the Mirai. The initial 4 vehicles will be followed by eight others from 'greentomatocars' and ITM Power[57].
- **The fuel cell car is based on the Prius+ chassis and suspension. Additionally, many Prius hybrid components were used extensively in the fuel cell powertrain, including the electric motor, power control and main battery.**

These milestones demonstrate Toyota's long-term strategic commitment to hydrogen technology and the complexity of such an industrial programme. Toyota's first vehicles were delivered and then leased to the Government of Japan, demonstrating the firm's willingness to engage with public authorities in the process. Toyota also engaged in a number of industrial partnerships, including:

- Partnerships in the USA to boost hydrogen infrastructure and facilitate demonstrations, such as for the construction of the first hydrogen station fed directly by pipeline and developed on Toyota grounds in partnership with Shell[58];
- The signature of an agreement among Japanese manufacturers and energy companies to popularise FCEV mobility and join forces to build a network of up to 100 refuelling stations in a selection of major urban areas (Fuel Cell Today, 2013); and
- The announcement in January 2013 of a technology sharing partnership with BMW, covering fuel cell system, hydrogen tank, electric motor and supporting battery system (Fuel Cell Today, 2013).

The major cost component is transportation of hydrogen (under high pressure or very low temperatures) and platinum in fuel cells and water splitting cathodes. The costs in storage and refuelling infrastructure are high. Hydrogen is only expected to become competitive in a mature technology scenario in light of high fuel prices. For more info on costs see the last part of Annex A.

The **Japanese government is providing subsidies** up to 50% for the construction of Hydrogen Refuelling Stations (HRS) (allocating 7.2 billion yen – approximately €55 million – in 2014), which currently total 42 across the country and will reach 100 by the end of March 2016[59]. At the current technology level, the construction of hydrogen stations is about five times more expensive than conventional gas stations (mainly due to high safety requirements).

[56] http://www.computerworld.com/article/2850882/flurry-of-hydrogen-fuel-cell-cars-challenge-all-electric-vehicles.html
[57] http://fleetworld.co.uk/news/2015/Oct/Transport-for-London-to-take-first-Toyota-Mirai-fuel-cell-electric-vehicles/0434021998
[58] https://www.pressroom.com.au/press_release_detail.asp?clientID=2&prID=4379&navSectionID=
[59] Shinka Y. (NEDO) 2014 Hydrogen and Fuel cell utilization in Japan and NEDO's R&D activity for Hydrogen and Fuel cell technology [available at: http://www.iphe.net/docs/Meetings/SC22/Workshop/5th%20H2iger%20Educational%20Rounds%20Presentations/2_Shinka_NEDO_IPHE_1-12-2014.pdf] (Accessed 05/06/2015)
Watanabe S. (NEDO) 2014 Hydrogen Infrastructure in Japan [available at: http://www.hydrogen.energy.gov/pdfs/review14/h2in_watanabe_2014_o.pdf] (Accessed 05/06/2015)
Iwata M. 2014 Construction of Japanese Hydrogen Refueling Station Begins [available at: http://www.wsj.com/articles/construction-of-japanese-hydrogen-refueling-station-begins-1409570814] (Accessed 05/06/2015)

While the government subsidises HRSs to support the popularisation of the hydrogen technology, it also provides support to early adopters of the new cars (i.e. Toyota Mirai and, in the next future, Honda FCV Concept) with 3 million yen (€22,000) grant per car (approximately 45% the sale cost of the vehicle), which is more than triple the incentive the government gave to purchasers of i.e. the electric i-MiEV car (950,000 yen - €6,800).

Additionally, the support from the government was that 60 percent of the first month 1,500 Mirai orders came from government offices and corporate fleets (opposed to the target set by Toyota to sell 400 cars in 2015).

Effectiveness of H_2 policies:
The Japanese government is supporting the H_2 programme by a thorough and stable policy framework, which aims at developing Hydrogen Refuelling Stations (HRS) starting from major cities. The strategy follows a "centre of gravity" approach, which aims to benefit from the highest demand of potential consumers, by concentrating initial investments in those areas. In order for the technology to be timely aligned with the automotive industry, the deployment of the refuelling infrastructure anticipates the commercial sales of Hydrogen cars, with approximately 100 HRS concentrated in Tokyo, Osaka, Nagoya and Fukuoka.

Public Enforcement in R&D:
Performing the extensive desk research and the stakeholder consultation, no evidence was found in respect to the relationship between R&D incentive at governmental level and any potential benefit regarding the deployment of hydrogen as an alternative fuel. As previously mentioned, Toyota has been developing R&D programme in the field since the 90s, following a precise and well-defined industrial strategy; Toyota considered this standard as a possible solution for both the sustainability and the energy supply issues in Japan. Stakeholders did not highlight any other relevant public enforcement in the field.

Risks for EU industry:
Toyota's engagement with hydrogen technology has given it a leading industrial position with this technology. In combination with the use of a mass produced (hybrid) electric vehicle platform, this position has enabled the Japanese manufacturer to not only commercialise the first hydrogen fuelled vehicle, but also to pioneer infrastructure developments, including outside of Japan. As a first mover, Toyota also sets the standards. In this regard, the strategies on hydrogen vehicles are driven by the need of the first mover to consolidate its technology as a baseline and, even more, to create a critical mass for the hydrogen transport market to have its infrastructure developed.

This position poses a risk to European manufacturers and industry with the future development of hydrogen mobility, outside, but also inside of European borders. For European manufacturers it is both difficult to get access to advanced fuel cell technology, but also to mass produced electric traction and batteries.

As reported by a relevant stakeholder in the market[60], what appears as the main element differentiating the Japanese case from the smaller-scale H_2 projects in Europe is a centralised and committed source of investments in the long-run.

[60] Direct interview with Mr. Eelen performed on 25/06/2015

EU Industry opportunity:
Toyota's strategy has shown that industrial partnerships are required to support and accelerate the development of complex technologies such as hydrogen-fuelled mobility. Partnerships with European manufacturers, technology-sharing and joint development of refuelling infrastructure with industry and public authorities offer attractive opportunities for EU industry to maintain a competitive position in this field.

Toyota incentivises other manufacturers to invest in hydrogen, in particular at international level. With this aim, approximately 6,000 patents are going to be shared free of royalties from Toyota[61,62], including those related to fuel cell stacks, high-pressure hydrogen tanks, software control systems and the industrial processes involved in generating and supplying the H_2.

Further, to increase the reach of the hydrogen technology, Toyota agreed a partnership with BMW, where technology exchanges were at focus. While the German manufacturer shares its diesel technology with Toyota, they share their Hydrogen technology with BMW. This leads to several components and production activities from the Mirai to be applied for BMW models. Similarly, Honda and General Motors are collaborating on hydrogen fuel cell technology. However, it should be considered that in light of the expansion strategy of Japanese manufacturers, the EU industry may benefit from the mentioned partnerships and agreements, allowing e.g. Toyota and Honda to enter the European market but at the same time sharing the potential benefits from H_2 technology market development.

Projected growth:
Our stakeholder consultation suggested that the hydrogen vehicles market will not necessarily compete with electric vehicles, but most likely respond to a different purpose. Indeed electric vehicles, with the exception of Tesla, still currently suffer from range limitations. Oppositely, hydrogen was considered best in these categories. Thus, Toyota soon expects to transfer the hydrogen fuel cell technology to trucks and buses, together with passenger cars.

Toyota has set goals that are in line with the niche market that hydrogen vehicles are[63]. Total sales are expected to top just 3,000 units by the end of 2017. By 2025, there are predicted to be about 10,800 hydrogen vehicles in general across the Northeast of the USA[64].

[61] Ayre J. 2015 Toyota Making 5,600 Hydrogen Fuel Cell Patents Free To Use *Clean Technica* [available at: http://cleantechnica.com/2015/01/08/toyota-making-5600-hydrogen-fuel-cell-patents-free-use-industry-companies/] (Accessed 05/06/2015)
[62] Direct interview with Mr. Eelen performed on 25/06/2015
[63] Direct interview with Mr. Eelen performed on 25/06/2015
[64] http://www.autoblog.com/2015/03/01/10000-hydrogen-car-plan-us-northeast/

CASE 9 – Shipping
Marine liquid fuel consumption represents close to 10% of the world's total liquid fuel supply and is dominated by low-quality and low-price residual fuel (heavy fuel oil – HFO), often with a high sulphur content.

Emissions Control Areas (ECAs) are in force or expected in the future, mostly near European, North American and Japanese shores. These impose strict requirements on the shipping industry. These new regulatory regimes have brought alternative fuels to the forefront as means for shipping companies to achieve compliance in a cost-efficient manner and could support biofuels as well. The LNG (as a shipping fuel) largest market consists of LNG for short seas shipping in Norway (45 ships in 2015), because of the stimulation of low NO_x via the Norwegian NO_x fund. Currently, the most used solution in ECAs is low-sulphur (fossil) fuel.

A range of alternative fuels are however envisaged as part of the marine transportation's future fuel mix. An important distinction is that between drop-in fuels, which can be distributed through existing channels and non-drop-in fuels, which require a completely new infrastructure.

Maritime shipping prefers drop in fuels like (algae-)HVO. The U.S. NAVY tested 76,000 litre of algae based biodiesel as a drop-in fuel on a decommissioned destroyer (fast manoeuvrable long-endurance warship) in 2011[65]. Development of alternative fuels closer to operations shortens and diversifies supply lines. It can also reduce greenhouse gas emissions, and foster "good neighbour" cooperation among nations, according to the U.S. Department of Defence[66]. The U.S. Navy plans for biofuels to comprise up to 50 percent of the fuel used by deploying ships and aircraft throughout the fleet in calendar year 2016.

An important step for methanol as a fuel was the conversion (EU funded: 'Motorways of the Sea') of the Stena-owned *Germanica* ferry to dual-fuel Wärtsilä engines. The engines are fitted with new dual-fuel injection nozzles which are able to inject both methanol and diesel fuel. Before the conversion it only used diesel. Each engine is supplied by its own high-pressure methanol pump with a working pressure of 600 bar[67]. At the moment only one engine runs on methanol and the others will be converted if the test is successful. Furthermore, methanol is developed in MethaShip, launched by the project's three key partners, the German shipyard Meyer Werft, Lloyd's Register and the German shipbuilder Flensburger Schiffbau-Gesellschaft (FSG). The project is funded by the German government. Lloyd's Register has already published Rules and Regulations (interview Timothy Wilson, 2015) to facilitate the use of methanol-as-a-fuel.

The fuel production costs shows that crude oil prices are an important factor affecting the competitiveness of alternative transport fuels. It also shows that further cost decline is expected for most alternative fuels. In a current technology scenario, fossil-based natural gas and coal- and natural gas-derived synthetic fuels are most cost-competitive with gasoline, however still more expensive than heavy fuel oil that is commonly used in shipping. Because low quality fuels are acceptable in shipping, cheaper biofuels could be introduced here, where nowadays usually biofuels for road transport and aviation are stimulated. For more info on costs see the last part of Annex A.

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[65] http://cleantechnica.com/2011/11/29/u-s-navy-conducts-its-largest-algae-biofuel-test-ever/
[66] http://www.navy.mil/submit/display.asp?story_id=82044
[67] http://www.lr.org/en/_images/213-48700_LR_Horizons_January_2015_spreads.pdf

Risks for EU industry:
The U.S. Navy's engagement with algae technology has given it a leading industrial position with this technology. This position has enabled the U.S. Navy to not only perform large pilot projects, but also to pioneer infrastructure developments, including outside of the USA. This position poses a risk to European manufacturers and industry with the future development of algae-HVO, outside, but also inside of European borders.

Industry opportunity:
The realisation of methanol powered ships (sponsored by the German government in 'Methaship' and the EU 'Motorways of the Sea' for the Stena Germanica: 50% of €22 million) has shown that **industrial partnerships can be effective to support and accelerate the development of complex technologies** such as alternative fuels infrastructure and its use on-board ships. Partnerships with European manufacturers, technology-sharing and joint development of refuelling infrastructure with industry and public authorities offer attractive opportunities for EU industry to maintain a competitive position in this field.

Projected growth:
Alternative fuels such as biofuels and natural gas have limited development prospects in the short and medium-term. They are now used in niche markets where the application is supported by policy measures and/or commercial premiums. IEA-AMF expects that fossil fuels will continue to be dominant (IEA-Advanced Motor Fuels Implementing Agreement, 2013). The prospects for LNG and methanol are more favourable, particularly in ECAs and for small ships and ferries. Methanol is particularly promising for marine transportation in light of its relatively simple storage requirements. The infrastructure requirements and costs of ship construction or retrofit limit its short- and medium-term potential for large cargo ships.

CASE 10 – Aviation

The global aviation sector is growing rapidly, with projected growth of 4.5% annually up to 2050. Such growth could have tremendous environmental impact if no action is taken to mitigate emissions. In this context, in 2012, the Air Transport Action Group (ATAG) presented various options available to meet ambitious decarbonisation objectives by 2020. More information is available in Annex A on airborne transport.

As shown there, economic measures will play an important role in achieving carbon neutral growth by 2020. The International Civil Aviation Organisation (ICAO) has announced its ambition for the development of a market based mechanism (MBM) to cap emissions at 2020 levels. In a study, which models the impacts of the adoption of such an MBM to 2036, ICAO estimates a mitigation potential of 464 Mt CO_2 by 2036, relative to the baseline scenario, of which 12 Mt would be in-sector (reduction of the traffic demand), and 452 Mt would result from capping emissions at 2020 levels (ICAO, 2013).

Technology-based measures will be required to enable efficiency gains. Further, biofuels are expected to play a major role after 2030, despite the fact that the use of bio-jet-fuels in aviation faces many challenges (technical, sustainability, economic and political challenges). To overcome these challenges, the development and approval of bio-jet-fuel from different production routes is required. So far, three production routes have been approved by the ASTM for the use of biofuels in aircrafts:

- Fischer-Tropsch (FT) up to 50% blending maximum with fossil jet-fuel in 2009, which uses woody biomass as feedstock and is mainly used as an aviation fuel by Solena, headquartered in the USA;
- Hydroprocessed Esters and Fatty Acids (HEFA) up to 50% blending maximum with fossil jet-fuel in 2011, which is important for Neste Oil who operate large production facilities in Rotterdam, Singapore and Finland; and
- Farnesane up to 10% blending maximum with fossil jet-fuel in 2014. Farnesane is a sugarcane biofuel, and therefore important for major sugar producer Brazil.

These production routes are pivotal to enabling scale-up in the availability of biofuels for aviation. The up-take by the aviation industry further requires the participation of aircraft manufacturers and airlines. Since 2008 when Virgin Atlantic became the first commercial airliner to perform a test flight, many airlines have been performing test flights or operating commercial flights using biofuels. As of June 2012, more than 18 airlines had performed over 1,500 commercial flights (IATA, 2013). These include European airlines such as Air France and KLM, which were the first airlines to perform test flights with passengers on board in 2009, and Lufthansa, which was the first airline to perform a series of commercial flights using biofuels in 2011.

Economically, biofuels still suffer from an important price-gap with conventional jet fuel (typically 2-4 times the price of conventional fuels) and from an un-level playing field with the road transportation sector: there are no mandatory targets in the airborne sector for the use of biofuels. The combination of upward trending conventional fuel prices and downward trending biofuel prices is expected to lead to price-competitiveness in the medium term. Overall the diesel-like fuels required for aviation remain more expensive than gasoline equivalents like ethanol from sugarcane or corn. For more info on costs see the last part of Annex A.

Risks for EU industry:
The **development and ASTM certification of new production routes for bio jet fuel could open new opportunities for European players**. Current bio jet fuel production in Europe takes place via the HEFA route and Europe is one of the leaders in this field, whereas the US is leading on Fisher Tropsch and Brazil on the Farnesane route. There is a risk for European stakeholders that HEFA produced bio jet fuel might in the end not be the most successful route and that non-European stakeholders have established a competitive advantage. Furthermore, the a dependence on bio jet fuel production facilities outside the EU could also have implications in terms of energy security and on the continued dependence on imported fuels.

Industry opportunity:
Efforts to decarbonise the aviation sector, expected to combine economic mechanisms, technology-based solutions and biofuels represents a major opportunity for the EU industry. The EU benefits from extensive experience with Market Based Measures through the EU ETS, which includes the aviation sector since 2012. Additionally, the Renewable Energy Directive requires that EU Member States ensure the use of 10% renewable energy in transport in 2020. The Netherlands allows biofuels delivered to aviation to also count towards the obligation for the fuel suppliers, which is not the case in other Member States. Lastly, European aircraft manufacturers, in particular Airbus, are leading global players with the development of new aircraft technologies. These considerations provide **the EU industry with essential assets to play a leading role in driving the aviation sector's decarbonisation, particularly with regard to the increased use of biofuels.**

Projected growth:
Projections to 2020 and 2050 vary significantly. In 2011 the "European Advanced Biofuels Flight Path Initiative" outlined the aim to replace 2 million tonnes of conventional jet fuel with biofuels in 2020, 1% of all jet fuels. The 2012 report by the IEA shows estimates ranging from a 10% to a 100% share by 2050 and concludes that, assuming a growth of aviation fuel consumption to 368 to 575 Mtonne by 2050 and a 10% share for biofuels, biofuel consumption could be of the order of 36.8 to 57.5 Mtonne by 2050.

4 Conclusions & recommendations

4.1 Key alternative fuel markets and context

We evaluated the context of seven alternative fuels in seven countries and compared that to EU-28. The following table shows how each of these countries focusses on a limited set of fuels. Strong growth of an option is often the result of high attention (and dedicated policies) on a national level. Options that receive less attention show no growth. It is furthermore remarkable that hardly any option shows a downward trend, except for LPG in Japan and the USA.

Table 7: Summary of alternative transport fuel developments in the countries of study

Country	Electricity	Hydrogen	Biodiesel	Ethanol	Natural gas	Bio-methane	LPG
Brazil	◆ (blue, small)	◆ (blue, small)	◆ (blue, small)	⬆ (green, medium)	▲ (green, large)	◆ (yellow, small)	◆ (yellow, small)
China	⬆ (green, medium)	▲ (blue, small)	▲ (blue, small)	▲ (blue, small)	⬆ (green, medium)	◆ (yellow, small)	▲ (blue, medium)
India	◆ (blue, small)	▲ (blue, small)	◆ (yellow, small)	▲ (yellow, small)	⬆ (green, medium)	◆ (yellow, small)	▲ (yellow, medium)
Japan	⬆ (green, medium)	▲ (blue, medium)	◆ (yellow, small)	◆ (yellow, small)	◆ (yellow, small)	◆ (yellow, small)	⬇ (yellow, small)
Russia	◆ (yellow, small)	◆ (yellow, small)	◆ (yellow, small)	◆ (yellow, small)	◆ (blue, medium)	◆ (yellow, small)	⬆ (green, medium)
South Korea	▲ (blue, small)	◆ (blue, medium)	▲ (blue, small)	◆ (yellow, small)	◆ (yellow, small)	◆ (yellow, small)	▲ (green, large)
USA	⬆ (green, medium)	⬆ (blue, large)	⬆ (blue, small)	⬆ (green, medium)	▲ (blue, medium)	◆ (yellow, small)	⬇ (yellow, small)
EU-28	⬆ (green, medium)	⬆ (yellow, large)	⬆ (yellow, large)	⬆ (green, small)	▲ (green, large)	▲ (green, small)	◆ (blue, large)

National status (colour)
● (green): *high attention*
● (blue): *on the agenda*
● (yellow): *minimal consideration*

International status (size)
● (large): *leading market*
● (medium): *medium market*
● (small): *small market*

Trend (shape)
⬆: *strong/consistent growth*
▲: *growth trend*
◆: *stable market or inconsistent trend*
⬇: *decreasing market*

The introduction and market uptake of a specific technology in the transport sector is heavily dependent on policies and measures implemented by countries, or initiated by private companies or (international) organisations. We found that the key policies and measures are mostly focused on road transportation for all countries.

The USA and has the most policies in place aimed at all the fuels under study. Brazil focusses on biofuels and natural gas. China has targeted electric driving via their policies as the dominant "fuel", whereas South Korea choose biofuels, both via innovation support, incentives, market uptake and demand management. In Russia, all fuels are in the development stage at the moment.

4.2 Risks, opportunities and policy options for the EU

Context-specificity

Alternative fuel market developments are the result of strongly differentiated dynamics in the countries of study. It is clear that a large number of factors, drivers and barriers must be considered and that each market displays unique characteristics. In some cases, alternative fuel development policies are the result of clear economic or geographical characteristics, as was the case with the development of the bioethanol industry in Brazil that resulted from a long history of sugar cane production connected to a new strong industrial potential. In other cases, however, alternative fuel choices appear connected to more complex policy processes and strategies that are not strictly context-dependent, as was the case with the development of South Korea's LPG market. Such observations indicate that the EU needs to develop a sound alternative transport strategy that fits its physical and practical context while accounting for political drivers. **While policy lessons and experience from foreign markets can be inspiring, it is also important to stress that the dynamics of those foreign markets are not the same as in the European context and therefore, the results are not entirely reproducible.**

Accounting for complexity, dynamism and competitiveness

It is evident that alternative fuel and infrastructure development is complex, dynamic and provides opportunities for a competitive advantage. Alternative fuel development is complex and generally relies on a broad portfolio of solutions, implemented at different levels. There are a large number of technologies and applications, each offering solutions as well as challenges. Transportation is important to socio-economic structures and depending on a wide range of stakeholders from consumers, to industry and to policy-makers. The case of hydrogen, and the industrial saga (see Case study 8 in Chapter 3) that led to the release of the first commercial passenger vehicle by Toyota, is illustrative of this complexity. Its development was made possible by a combination of ambitious and long-term R&D programmes, industrial commitment and public support, ultimately offering potential to disrupt consumer markets. The road transport sector has also proven to be highly dynamic, with many rapid developments having taken place in recent years. Electric mobility is a particularly striking example in this respect, and the deployment of electric vehicles has shown rapid acceleration within only a few years. Tesla, and its model S and roadster, is a high-profile front-runner of this dynamism, which not only promises to disrupt the passenger vehicle market, but also poses risks to the EU industry positioning through its leading role with vehicle but also infrastructure development worldwide. Lastly, competitiveness is clearly a defining feature of the alternative transport sector. Competitiveness can be examined in terms of industrial competitiveness between vehicle manufacturers, but also in terms of the competition between alternative (and traditional) technologies. Alternative transport technologies and companies must indeed displace other technologies and compete within markets to secure sustainable growth. **The development of alternative transport requires carefully crafted policy packages. These packages need to account for and address the inherent complexity of the alternative transport sector and set well-articulated strategic priorities, continued and ambitious R&D programmes to ensure continued and strategically guided dynamism (management of simultaneous actions).**

Technology & policy prioritisation

Differentiated technology positioning and prioritisation are important ingredients for countries to achieve market and innovation leadership. We have seen that countries prefer certain fuels over others and focus helps to create a big market. As an example, strong policy support to bioethanol and natural gas in Brazil have enabled its leading position in these markets. While evidence shows growth across most alternative technologies in the EU and a rather strong market position with many technologies, it is clear that sustained growth with all technologies will require considerable commitment and pose many challenges to the EU and its industry. **EU policy should be closely aligned with thoroughly supported development patterns/trends for alternative fuels. Opportunities for EU industry lie particularly in electricity and/or electricity derived fuels, as other regions have established strong positions on other alternative fuels (e.g. the EU is an importer of biofuels and LNG, limited synthetic fuel production capacity is available in the EU, etc.).**

R&D programmes

The development of alternative fuel markets and infrastructure must be considered in both the short and long-term. Some alternative transport technologies are proven and cost competitive in many contexts. LPG, for example, can offer various quick benefits pertaining to the use of available fossil energy (the use of otherwise flared propane gas in refineries), improved air quality and some climate change mitigation potential and can be deployed cost-effectively. Electric vehicles, although still benefiting from subsidies in most countries, are also understood to have (almost) reached cost-parity. Other alternative transport technologies, however offer more long-term potential. Hydrogen, for example, holds considerable climate change mitigation potential but its widespread adoption across markets remains a distant prospect that will require continued industrial and political commitment. Hydraulic hybrids (like the one Peugeot has been working on) have the potential to be produced at low cost compared to electric hybrids, as the material costs are lower than for electric hybrids. Furthermore, European industry has a strong position in hydraulics. Peugeot, who considered developing the technology further, have shelved the plan as investments costs were deemed too high for the company to invest without additional support. In the aviation sector, the development, piloting and scale-up of new bio-jet-fuel production routes, which also holds important promise in terms of climate change mitigation, has also proven to be a long and demanding R&D process. **Ambitious R&D strategies and programmes are needed to ensure long-term prospects are supported. Public commitment to removing barriers for industry to engage in R&D, and support through demonstration projects to ensure visibility of emerging technologies has proven to be effective. Governments might even act like a "venture capitalist, see case study 7, Tesla.**

Financial incentives

Evidence suggests that financial incentives continue to be required. The impact and need for financial incentives is indeed evident with different technologies. For example, the deployment of LPG has not been possible without favourable tax and/or subsidy regimes, to ensure amortisation of the conversion costs, and abandonment of existing schemes now leads to stagnating and even decreasing application. Subsidies have also proven to be highly important and effective for electric vehicles, as illustrated in the Netherlands and Norway, where spectacular uptake occurred as a result of very favourable subsidy regimes, and where the markets, once developed cannot yet exist in absence of such subsidies (see case study 2). **Financial incentives therefore pose risks in terms of the sustainability of alternative transport technology growth models. Complementary policies are required to phase out the financial incentives when technologies become (more) cost-competitive.**

Road transport

The road transport sector offers the largest challenge (measured by the amount of energy that it uses) but also the most options for alternative fuel and infrastructure development are available. Integrated strategies are needed to ensure alternative transport technologies are leveraged adequately in the short-, medium- and long-term. Natural gas and LPG offer some advantages and short-term potential, but commitment to ambitious decarbonisation of the transport sector will require a shift away from fossil fuels. Therefore, these fuels should only be considered as transition fuels or used on a resource availability basis (e.g.: using propane gas that would otherwise be flared). Natural gas, in particular, could form part of a transition from fossil-based gas to biogas or bio-synthetic-gas, which offer more climate change mitigation potential. Electric mobility and electricity-based fuels such as hydrogen require extensive infrastructure development. Their widespread adoption is only likely in the medium- to long-term, and performance improves once electricity and hydrogen are produced from renewable sources. Collaboration among actors from different Member States (and regions within) is needed to develop alternative fuel infrastructure (i.e. standards are to be defined, concession agreements need to be aligned, etc.). **The potential and limitations of each alternative fuel must be carefully considered and examined in terms of the displacement of less favourable options, and on relevant timescales**.

Waterborne transport

The shipping sector is a global sector and difficult to regulate (the rules at sea are developed in an international context and many countries need to accept the new rules). Still there is potential on local level for alternative fuels support in short sea shipping and ferries (e.g. natural gas in the form of LNG and methanol). Because of the restrictions in Environmentally Controlled Areas means industry has a real interest in engaging on this front. Lastly, various ports are engaging in infrastructure development (shore side electricity, LNG terminals, etc.). SSE development is still in an early stage and could be beneficial for reducing greenhouse gas and harmful emissions, and for European electric infrastructure industry (e.g. Siemens and ABB). **The potential and limitations of each alternative fuel must be carefully considered and examined in terms of the displacement of less favourable options, and on relevant timescales**.

Airborne transport

The air transport sector is expected to continue rapid growth to 2050 and significant uptake of alternative fuels with a high greenhouse gas saving potential (e.g. bio jet fuel) will be required to meet decarbonisation targets in the sector. In Europe, experience with the EU ETS and the inclusion of the aviation sector since 2012, the EU Renewable Energy Directive and the engagement of European airlines in testing biofuels mean that the EU industry is in a good position to take a leading role. If more Member States, than only the Netherlands would have an opt in or similar implementation of the RED, there would be more support in the whole of Europe for biofuels in aviation. Continued growth in biofuel consumption in aviation will however require the approval of new production routes and the scale-up of production facilities. **Bio jet fuels are seen as an important solution by IATA and several major airlines. Bio jet fuels are expensive compared to current, fossil jet fuels. The EU could continue to support the development of biofuels in the aviation sector for increased investments by industry in the bio jet fuel value-chain.**

Electricity

Electricity should be a high priority for the EU, as it offers significant potential in terms of its climate change mitigation potential, opportunity for European industry, and strong coherence with European mobility requirements and energy infrastructure. Electricity offers a strong growth potential in Europe and various European manufacturers have released electric vehicles in recent years, which have penetrated foreign markets (e.g. BMW i3 and i8, Smart ED, Renault Fluence, Fiat 500e). International developments however pose significant risks to the continued growth of European industry players. Tesla, firstly, has demonstrated its ability to conquer the market and imposed itself as a high-profile leader on both vehicle and infrastructure markets, even deploying its own charging stations is Europe. Further, the emergence of fragmented standards in different countries represents an important barrier to vehicle manufacturers and effective harmonisation at EU level is needed to ensure EU standards are influential in guiding the adoption of standards suitable to European manufacturers by the market. **Urban environments further offer fertile grounds for the design and implementation of consumer-oriented and context-specific, policy packages to promote electric mobility. Non-financial incentives can be envisaged in the form of preferential parking measures, access to priority lanes or regulatory action to remove barriers to the development of electric mobility infrastructure. Public demonstration programmes and public-private infrastructure partnerships are also a likely effective way of driving mobility forward in urban environments.**

Hydrogen

Hydrogen is still regarded as a long-term option, which hinders strong financial commitment by public authorities in the short term, but that requires commitment to removing barriers for industry in the area of alternative fuel infrastructure. What appears to be required is the reach of a minimum infrastructural level to meet initial demand, which would then be supported by the industry itself[68]. Europe holds a favourable position with significant refuelling infrastructure and public demonstration programmes. Japan, and Toyota in particular, however hold leadership with the commercialisation of passenger vehicles and with the development of long-term industrial partnerships involving private and public entities. This leading position poses both a risk to European manufacturers, which may become dependent on foreign technology, as well as an opportunity for international partnership and collaboration. **Partnerships between European and foreign manufacturers have been established in recent years and should be supported. Further, R&D support policies and public demonstration programmes should continue to be on the agenda to support developments by the private sector.**

Biofuels

Biofuels are high on policy agendas worldwide and hold significant promise for road, airborne and waterborne transportation. However, concerns about the environmental performance have impacted the political and public acceptance. In all transport modes, the potential for biofuels is large. Biofuels sold in the EU must comply with strict sustainability criteria. The increasing consumption of biofuels may lead to a direct or indirect expansion of agriculture worldwide, with potentially negative impacts for biodiversity and carbon sinks. This can limit the carbon benefit on the short term and therefore, policy makers have become hesitant about biofuels. Solutions exist to minimise such indirect impacts.

Biofuel producers have a leading role in demonstrating the improving sustainability and so consolidating the rationale for continued/increased biofuel use, demonstrating that biofuels are a good option to phase out fossil fuels. The European road fuel market especially consumes diesel. In the road transport sector, biodiesel poses some problems for passenger vehicles, with respect to air pollution. Regulation and policies limiting diesel-engine vehicles are expected, particularly for passenger vehicles in urban areas. Biodiesel (and derived fuels) however present significant potential for road-freighting, aviation and maritime, and could still be shifted towards these sectors in significant quantities. **Biofuels should therefore be jointly approached by governments and industry especially to increase sustainable feedstock production.**

[68] Ikeda T. 2012 FCV/ Infrastructure Demonstration Program in Japan [available at: http://www.theicct.org/sites/default/files/HySUT_Report_June5_2012_Rev1.pdf] (Accessed 05/06/2015)

Natural gas & bio-methane

Bio-methane production and use in the transport sector is something that is high on the agenda in some European Countries but not in the other countries under study. Methane is promoted to be used on the road and in the shipping sector, although the benefit for emission reduction remains low. Bio-methane production and use is stimulated, often via the natural gas grid. The direct use of bio-methane in transport in the form of bio-LNG might be a cheaper route than production of bio-methane, injection in the gas grid and then to the transport sector. In order to promote bio-LNG more this should either be stimulated or subsidies for producing bio-LNG should be similar to producing bio-methane for the grid. Accelerating the technology for the whole of Europe would be good for the industry in Europe which is currently working on the required technology. **Bio-methane should therefore be jointly approached by governments and industry to the strengthening of production routes and channelling to the most promising uses**. **Governments need to align their policies in order to stimulate a technology neutral use of bio-methane in transport.**

LPG

LPG is losing momentum in the EU, USA, South Korea and Japan, because, in comparison to other alternative fuels, the environmental benefits over conventional fuels are limited and the technology is mature. Therefore governments reduce their policy support. The fuel has environmental benefits over diesel application, but without the availability of a switch to bio-LPG, this fuel is mainly used to stimulate high-mileage users to choose for LPG instead of diesel, thereby reducing the emissions of NO_x and PM. If the incentives do not help to make the vehicles cheaper to operate than diesel, the use is limited to only the users in-between the breakeven mileages with gasoline and diesel. Accelerating the technology in countries where there is still a problem with harmful emissions from diesel vehicles and enough LPG available this might provide a reasonable alternative. **LPG is still promising in developing markets in China, India and Russia and the EU industry could try to get a position there, as long as the support for LPG exists.**

Annex A: Data collection and analysis

This Annex presents the findings from data collection, which was carried out to support analytical elements of the study presented in the main body of the report. It includes:

- An overview of the relevance and application of alternative fuels to road, airborne and waterborne transport;
- Information on alternative fuel and infrastructure markets for the technologies of study, with a focus on road transport;
- Insights into the application and development of markets for waterborne and airborne transport; and
- Information on important policies, standards, costs, technology development and public perception of alternative transportation.

Additional findings per country are presented in Annex D: Country factsheets.

Methodologically, the study is supported by two key components:

- A desk study to collect relevant and reliable data and information;
- Stakeholder consultation through phone interviews with experts and market players to collect case studies and validate desk research.

The information presented in this annex, focusing on data collection, mostly includes information from the desk study. We have collected data and information from a wide range of sources including:

- High level reports from leading international organisations and institutions (IEA, OECD, EU, etc.);
- Reports, websites and other resources from national governments and state organisations (ministries, state departments, etc.);
- Data and information compiled by industry associations, standardisation bodies and other key national and international organisations active in the transport sector;
- Other web-based resources including commercial databases, highly recognised blogs, media releases, company websites, etc.

Country profiles

The study focuses on major markets, namely Brazil, China, Japan, Russia, South Korea and the USA. We have included information on India wherever possible. Below and in Figure 6, we provide information on the geographic, demographic, economic and energetic profiles of these countries:

- **Brazil** is the fifth largest country by land area and population;
- **China** is the world's most populous country and third largest country by land area. It is the world's second largest economy, second consumer of total primary energy and largest consumer of electricity;
- **India** is the world's second most populous country but retains a low urbanisation rate (X%). It is the tenth largest economy but still suffers from a low level of development and low GDP per capita;
- **Japan** is the tenth most populous country worldwide and is characterised by its high urbanisation rate (>90%), Japan is a very large energy importer;
- **Russia**, the world's largest country in by land area, the world's leading oil producer and second producer of natural gas;

- **South Korea** is characterised by its high population density and high urbanisation rate (>90%);
- **The USA** is the world's third most populous and fourth largest country by land area. It is the world's number one economy and ranks amongst the world's wealthiest countries in terms of GDP per capita (#10). The USA is the world's leading natural gas producer and third oil producer. It is the also the world's largest energy consumer.

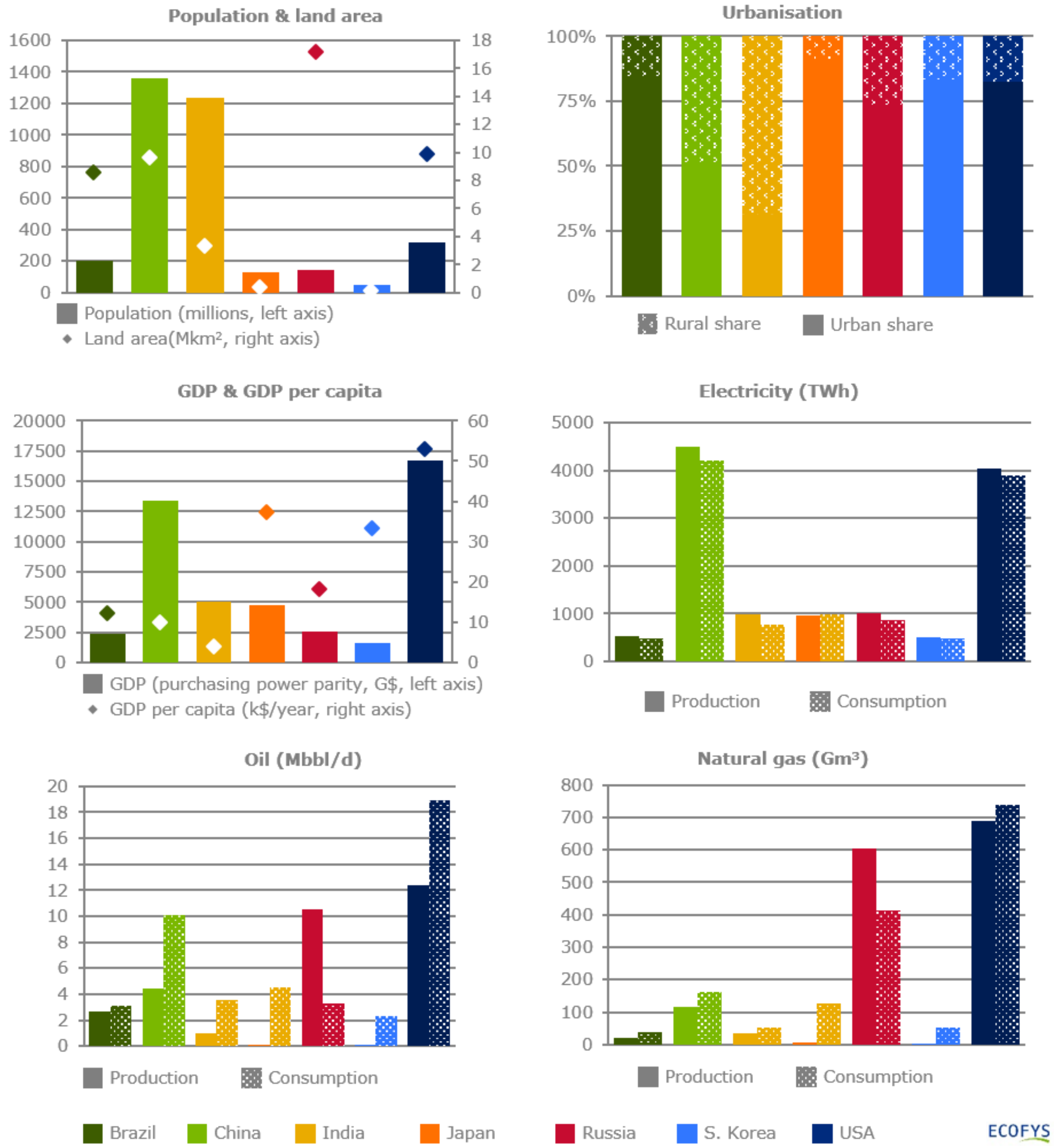

Figure 6: Country profiles: selection of demographic, economic and energy indicators for the countries of study

Overview of alternative transportation applications

The principal focus is road transport, which offers the most applications for alternative transport fuels. We also consider airborne and waterborne transport. Table 8 below provides an overview of the applicability of the technologies of study for these transport modes.

Table 8: Summary of alternative fuels and their relevance to land, airborne and waterborne transport

Segment	Electricity	Hydrogen	Biofuels	Natural gas	LPG	Synthetic fuels
Road transport	●	●	●	●	●	●
Waterborne transport	● (as an alternative power source for ships in ports)		●	●	●	●
Airborne transport	● *(as an alternative power for planes at airport gates)*		●			●

***LEGEND**: ● applicable; ● limited applicability;*

Road transportation: alternative fuel technologies & markets

This study focuses on the most promising and widespread technologies. In this section we present insights into market developments for the following technologies:

- **Electricity**, focusing on two key applications for land transport: fully electric Battery Electric Vehicles (BEVs), and Plug-in Hybrid Electric Vehicles (PHEVs), which combine electric and combustion engines and can be charged from the grid;
- **Hydrogen** and its use in fuel cells, for providing electricity for electric motors in Fuel Cell Electric Vehicles (FCEVs);
- **Biofuels**, including biodiesel, bioethanol and bio-jet-fuels, which are blended in varying percentages with other liquid fuels and used in combustion engines;
- **Natural gas**, including Compressed Natural Gas (CNG), Liquefied Natural Gas (LNG) and bio-methane, is most commonly used for medium and heavy duty trucks and buses;
- **Liquefied Petroleum Gas**[69], which can be used by a wide range of purpose built or modified fleet of vehicles;
- **Synthetic fuels** are drop-in fuels that can be produced via the production of synthesis gas derived from coal, natural gas or biomass.

In this section, we focus mainly on road transport. Information on developments for airborne and waterborne transport are provided in the sections hereafter.

[69] Also commonly referred to as propane, liquefied propane gas or autogas

Electricity

Electric road vehicles have been in use for over 100 years yet electric vehicles have remained marginal until recently. Since the mid-2000s, issues such as volatile oil prices, poor urban air quality and climate change, have led to renewed interest for electric vehicles, the development and commercialisation of new models and rapid growth, particularly since 2008.

Electricity can be used as an alternative power source for transportation in various applications. In this study we focus on its application to passenger vehicles and examine full electric Battery Electric Vehicles (BEV) and Plug-in Hybrid Vehicles (PHEV), which combine electric and combustion engines and can be plugged in.

Figure 7 provides a snapshot of electric vehicle sales in 2014, as reported by the (IEA, 2015). In terms of numbers of vehicles sold, the USA (39.4% of the global market), China (18.2%) and Japan (13.5%) were leading markets. Approximately over 550 electric vehicles were sold in Korea in 2014 (0.2%) and European Union represented the bulk of the remaining 28.7% of the global market. BEVs have a bigger market share in China, where these are equally important in Japan and the USA. Only in the Netherlands and Sweden the PHEVs have acquired a higher market share than BEVs.

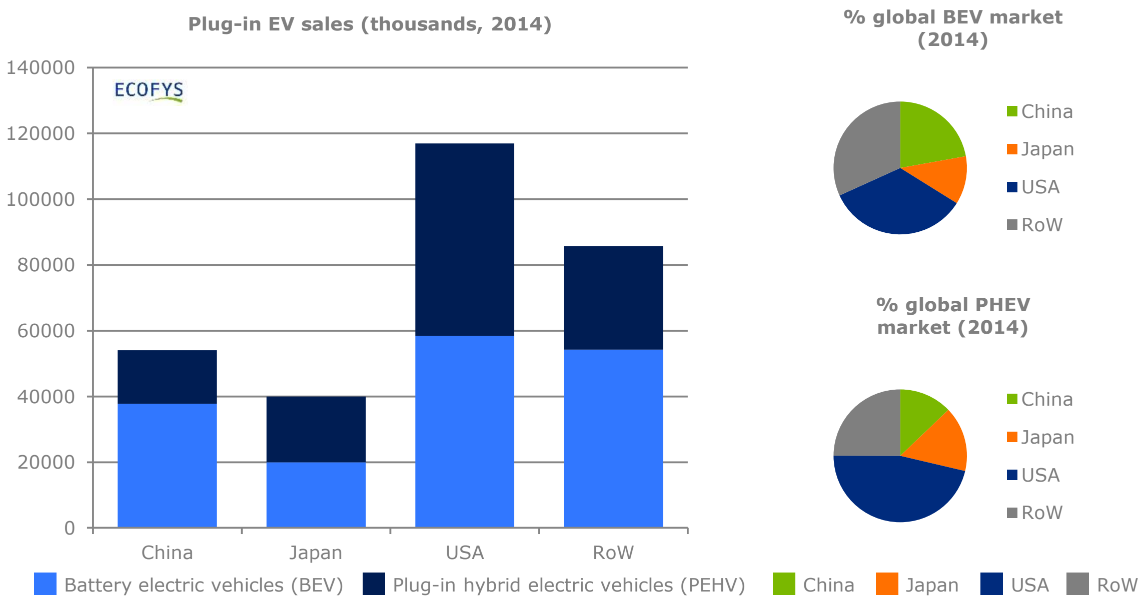

Figure 7: Snapshot of battery electric vehicle sales in 2014 (source: IEA, 2015)

Figures on the total passenger car market share of electric vehicles in the yearly sales are presented in Figure 8. These contrast with absolute figures presented previously and provide an indication on the –still limited- penetration of electric vehicles in leading markets, with the exception of Norway and the Netherlands where electric vehicles represented close to 6% of the passenger vehicle market in 2013. For 2014 the growth in the Netherlands was less, because of less favourable tax incentive for plug-in electric vehicles. In Norway the sales further increased in 2014 to 14% of new registrations. This figure also shows that many European markets are leaders with respect to the relative sale of electric vehicles, for which the USA, China and Japan are respectively relegated to the third, fourth and seventh positions in 2014.

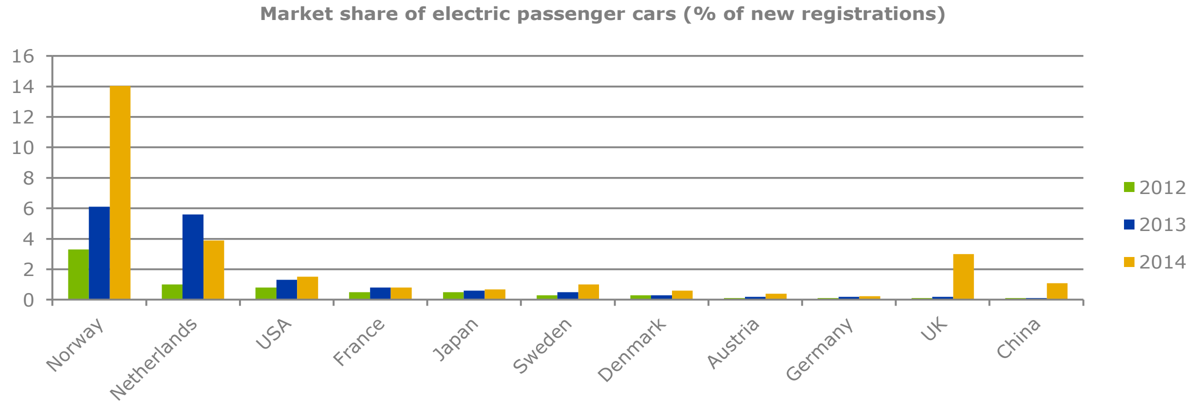

Figure 8: Market share (of new registrations) of electric passenger cars in leading electric vehicles markets, 2012 & 2013 (source: MCT, 2014), 2014 (source: ZSW, 2015). Order based on share in 2013

Lastly, Figure 9 provides a timeline showing the growth of BEVs and PHEVs markets in the countries of study since 2004. It shows rapid growth in sales after 2008 for BEVs and after 2010 for PHEVs.

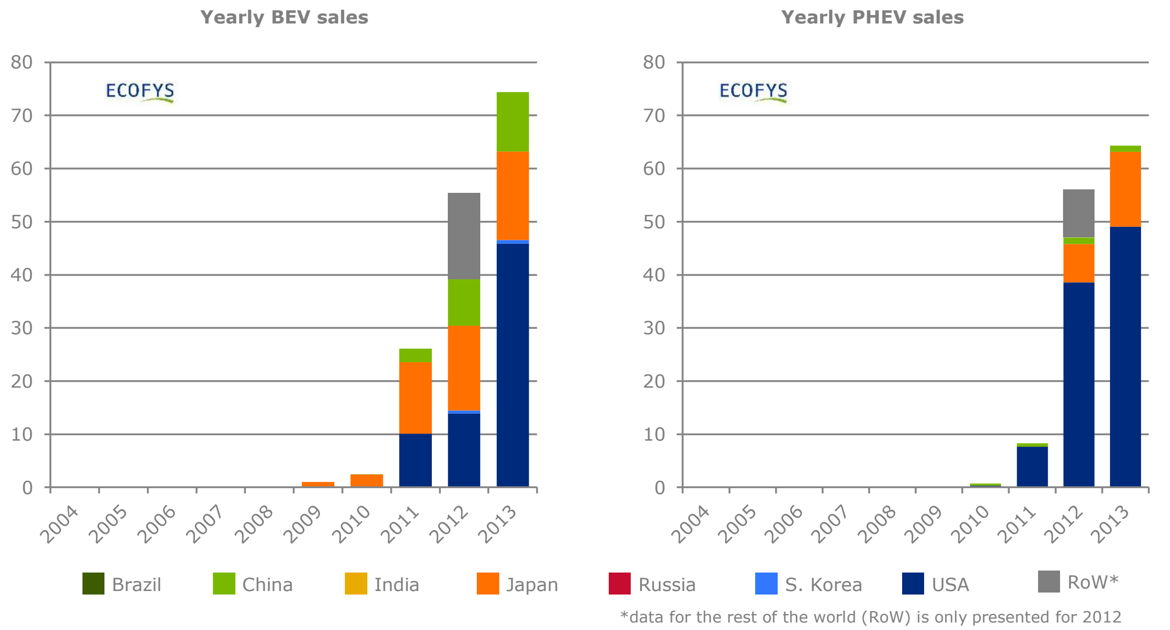

Figure 9: Yearly sales of BEVs (thousands, left) and PHEVs (thousands, right) in the period 2004-2013 (source: MarkLines database)

The numbers for Russia are either zero or not visible. In 2012 the first pilot with 8 electric vehicles and 20 charging stations was started in Moscow with the support of MOESK. The technology was delivered by Ensto, a Finnish based international company[70].

70 http://www.ensto.com/download/21193_Ensto_to_Deliver_Charging_Stations_for_a_Major_Russian_EV_Charging_Pilot.pdf

Hydrogen

Hydrogen, used as a fuel in fuel cell to convert chemical energy into electricity, can be used to power fuel cell electric vehicles. Hydrogen fuel cell technology use for transportation is in development with demonstration vehicles and pilot programmes emerging across the world since the mid- to late- 2000s.

Table 9: Overview of key applications and developments of hydrogen fuelled fuel-cell electric vehicles

Application	Developments
Passenger vehicles	Fuel cell electric vehicles have promising applications for passenger vehicles. Many car manufacturers are engaged in demonstration programmes, or development partnerships but there are currently no models produced on industrial scales. Key developments include: ▪ Toyota has announced the commercial release of a model in select locations in December 2015. ▪ Hyundai plans to produce 1,000 demonstration vehicles between 2013 and 2015 before entering mass production of up to 10,000 vehicles per year; ▪ Three key alliances were formed in 2012 and 2013: BMW-Toyota, Renault-Nissan-Daimler-Ford and GM-Honda.
Buses	The application of hydrogen fuel-cell technology for buses is under development or demonstration in Europe, the USA, China & India. Key developments include: ▪ Since 2010, the Clean Hydrogen in European cities operates, with a goal of integrating 26 hydrogen fuelled buses to transport infrastructure in five cities (including one in Switzerland); ▪ Since 2012, the High V.LO-City programme aims to rapidly deploy fuel cell buses in Brussels (Belgium), Imperia (Italy) and Aberdeen (Scotland); ▪ The US Department of Transportation recently announced the provision of USD 13.6 million to support eight projects to advance the commercialisation of fuel cell buses[71]; ▪ The use of six fuel cell buses in China for the 2008 Olympic games and 2010 World Expo; ▪ The joint development of fuel cell buses by Tata Motors and the Indian Space Research Organisation since 2006.
Other	Other applications for hydrogen fuel cell vehicles include: ▪ Lightweight / light duty passenger vehicles; ▪ Trucks, with demonstration projects under development in Texas following the award of USD 3.4 million by the DoE; ▪ Material handling vehicles.

The development of hydrogen fuel cell transportation is dependent on the availability of refuelling infrastructure. Figure 10 illustrates recent developments with hydrogen fuelling stations worldwide. As of mid-2014 186 fuelling stations were in service worldwide, including 72 in Europe, 58 in the USA, 22 in Japan and 12 in South Korea. These stations form an important part of demonstration projects led by states, public-private partnerships or manufacturers to accelerate the commercialisation of hydrogen electric vehicles. Importantly, changing fuelling standards and limited funding have led to the closure of fuelling stations alongside the realisation of new ones, leading to a rather slow growth of stations in operation in recent years. In some cases the HRS were part of a research/demonstration project and were closed down when the project ended.

[71] For more information: http://www.fta.dot.gov/14617_15670.html

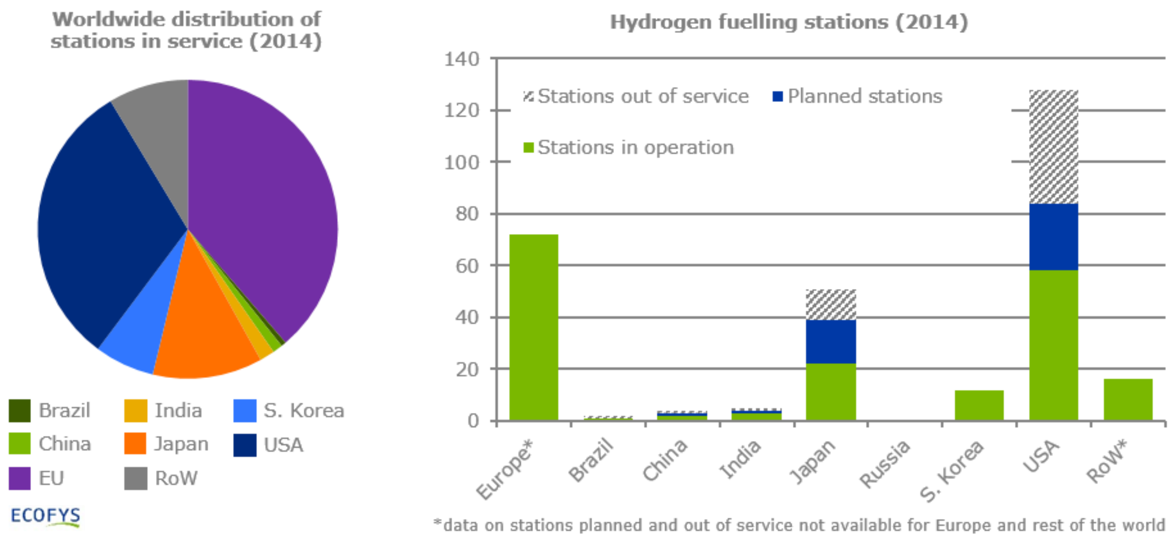

Figure 10: Distribution & recent count of hydrogen fuelling stations worldwide (source: www.h2stations.org)

Biofuels

Biofuels, defined by the IPCC72 as "A fuel produced from organic matter or combustible oils produced by plants", have significant potential to contribute to the decarbonisation of the transport sector by providing a low-carbon alternative to conventional fossil-fuels. Biofuels offer added advantages such as their suitability for distribution through existing infrastructure (in case of low blends directly or via higher blends in similar infrastructure), minimal required changes to the existing vehicle stock, energy security of supply and the creation of new sources of income for rural areas. The widespread use of biofuels in road, airborne and waterborne transportation includes some challenges related to feedstock supply, conversion efficiencies, cost competitiveness and sustainability. Many studies project that the sustainable potential for bioenergy can be very large, if agricultural production is significantly improved, globally.

A wide range of biofuels are currently in use by the transport sector or under development. Their classification, subject to considerable debate, can be based on the feedstock or the conversion processes involved or the technological maturity. Biofuels are commonly classified as 'conventional' or 'advanced':

- Conventional biofuels (also referred to as first generation biofuels) are derived from sugar, starch or vegetable oil from crops. The technology is typically commercially mature and include sugar- and starch-based ethanol, conventional biodiesel produced from raw vegetable oil, and biogas produced form the anaerobic digestion of feedstock.
- Advanced biofuels (also referred to as second and third generation biofuels) are derived from various feedstock, including lignocellulosic biomass, woody crops, waste and residues, algae, etc. Advanced biofuels are typically undergoing research and development, demonstration or in early stages of commercial availability. They include cellulosic ethanol, advanced biodiesel derived through HVO and FT processes, and bio-synthetic gas.

[72] http://www.ipcc.ch/publications_and_data/ar4/wg2/en/annexessglossary-a-d.html

For the purpose of this study, we have focused data collection on biofuels infrastructure and not on the feedstock, in particular the infrastructure for ethanol and biodiesel are analysed, which are the most widespread biofuels. Figure 11 provides a snapshot of biodiesel and ethanol consumption in 2011 in the countries of study. It clearly shows the importance of the USA, Brazil and the EU, which together account for close to 90% of the global biodiesel and ethanol market (49%, 22% and 18% respectively).

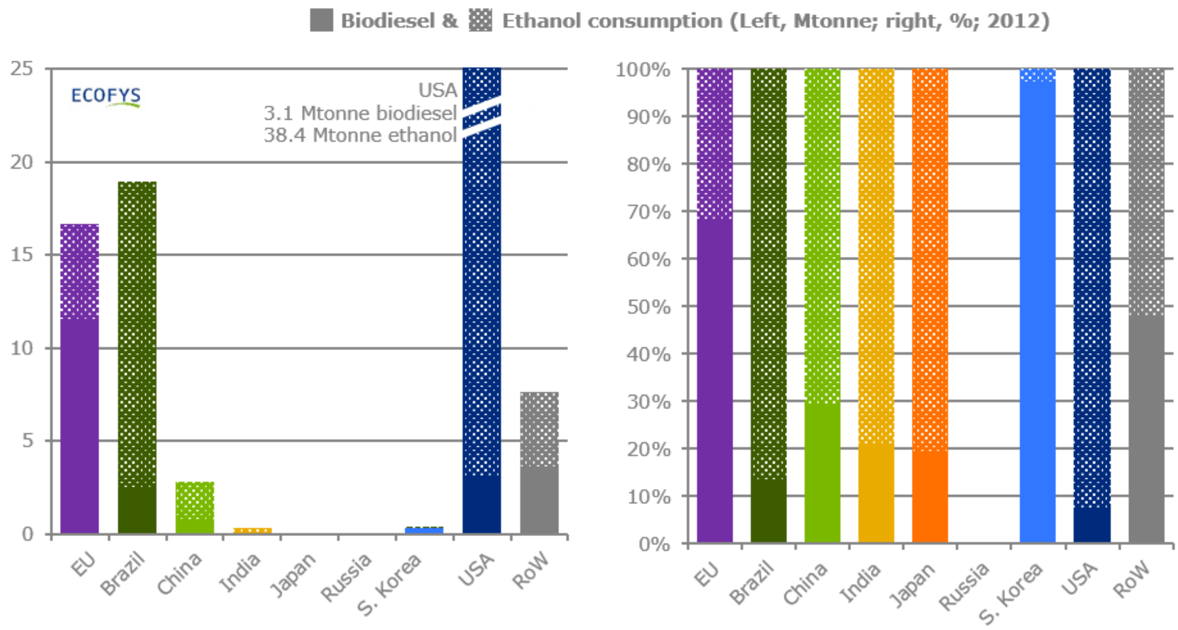

Figure 11: Absolute and relative consumption of biodiesel & bioethanol worldwide in 2011 (source: US EIA, Eurostat)

As shown in Figure 12 and Figure 13, biofuels have witnessed rapid growth since 2000. Biodiesel consumption has grown from less than 1 Mtonne in 2000 to over 21 Mtonne in 2011. Until 2004, the EU accounted for over 90% of global biodiesel consumption. It has since been steadily decreasing and represented close to 57% of the global consumption in 2011, despite consistent volumetric growth. The share of other countries exceeded 10% for the first time in 2005 and has grown steadily to represent approximately 43% in 2011, with the USA and Brazil now consuming 14% and 11% of biodiesel worldwide.

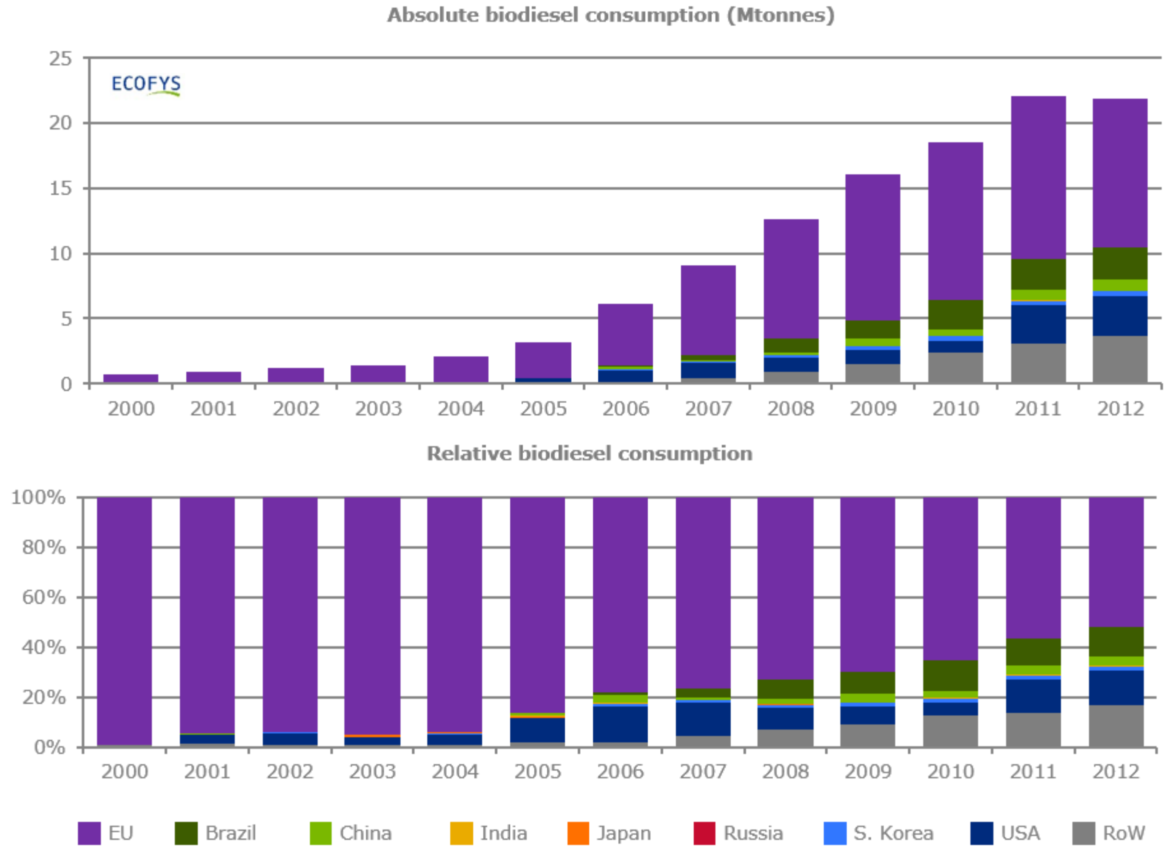

Figure 12: Absolute and relative consumption of biodiesel worldwide 2000-2011 (source: US EIA, Eurostat)

The biofuels can be blended with fossil fuels, as is typically done in Europe. This places no special requirements on the fuel infrastructure and vehicles up to a certain percentage. OEMs guarantee their passenger cars to operate up to 10% bioethanol (E10) and 7% biodiesel (B7). This "E10" is a blend of 10% ethanol / 90% unleaded gasoline and is the most common way ethanol is sold in the USA.

Ethanol consumption is strongly concentrated in the USA and Brazil. In total, ethanol consumption represents over three times the amount of biodiesel consumption (in terms of mass), totalling 69 Mtonne in 2011, which was a slight decrease from 2010. The USA is now the single largest consumer of ethanol, with 59.7% of global consumption, followed by Brazil, with close to 25.8% of global consumption. The EU's consumption, having steadily increased since the mid-2000s now represents 6.6% of global consumption. This is presented in the next figure.

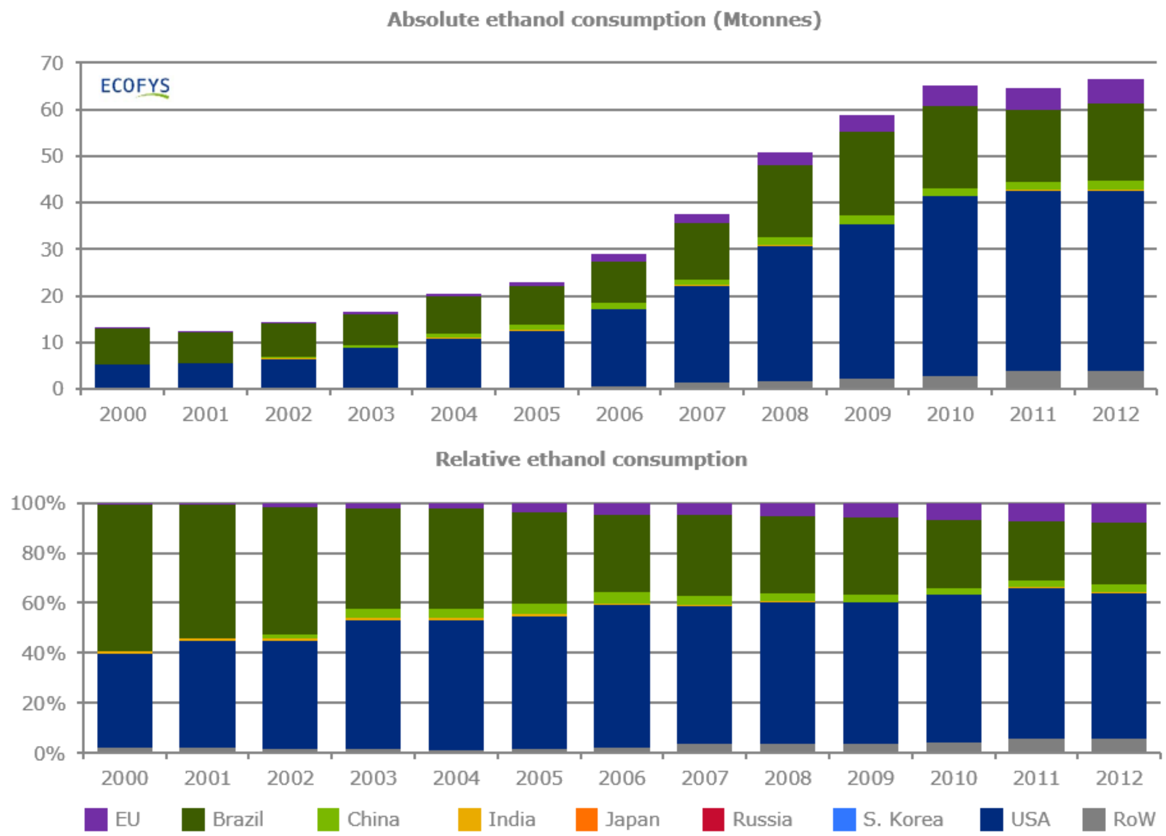

Figure 13: Absolute and relative consumption of bioethanol worldwide 2000-2011 (source: US EIA, Eurostat)

In the USA there were five million vehicles on the road in 2010 that could run on E85. These vehicles are called flexible fuel vehicles or FFV's.

E25 contains maximum 25% ethanol and minimum 75% gasoline. This blend has been widely used in Brazil since the late 1970s. A summary of the main ethanol blends used around the world today is presented in the next figure (see also the section on standards). E5-E25 are used in normal (approved) gasoline vehicles and E85 and E100 require flex fuel vehicles.

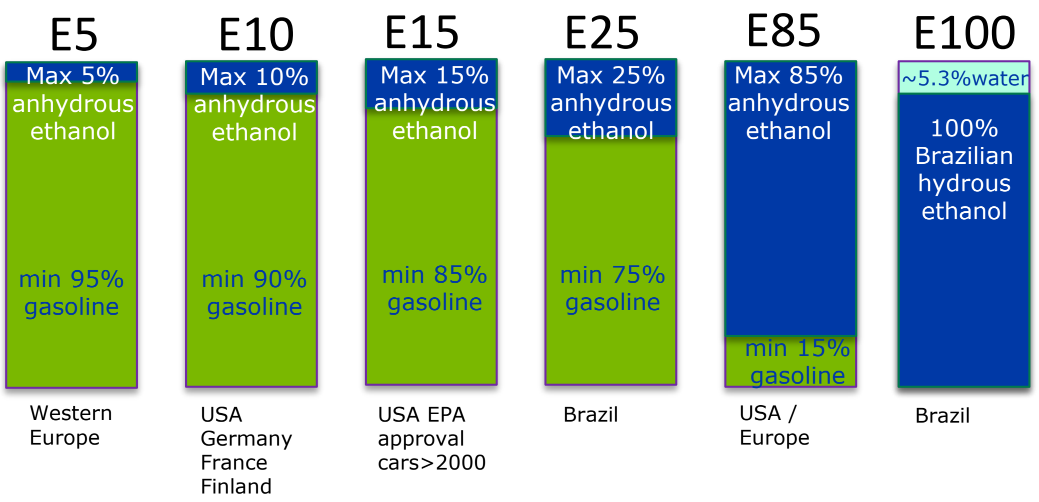

Figure 14: Summary of the main ethanol blends used around the world today (source: Wikipedia)

Natural gas & bio-methane

Natural gas, either in the form of Compressed Natural Gas (CNG) or Liquefied Natural Gas (LNG) is used in both road transport and waterborne transport. For road transport, it is suitable for light duty, medium and heavy duty vehicles. Although vehicles and technologies are readily available and often cost competitive, natural gas transportation remains marginal in all but a few countries, accounting for less than 1% of fuel consumption for road transportation and less than 1% of total natural gas consumption (IEA, 2010). Natural gas combustion being cleaner than that of conventional transport fuels, can play a role in efforts to mitigate pollutant emissions from the transport sector but, in the long-term, a commitment to very low carbon dioxide gas sources would be required (for example by using biogas). Biogas can be produced through anaerobic digestion of various feedstock. Typically used for electricity of heat generation, biogas can also be upgraded to bio-methane by removing carbon dioxide and hydrogen sulphide. After this upgrading process, bio-methane can be injected into the natural gas grid and becomes fully compatible with natural gas vehicles and infrastructure (IEA, 2011).

Internationally, Argentina, Brazil, India, Iran and Pakistan are the countries with the highest levels of market development for natural gas vehicles. Figure 15 and Figure 16 provide information on the number of natural gas vehicles in circulation and what share the vehicles in circulation represents in the countries of study (for India the data is only available for a number of years and not for the share of the total fleet). After having witnessed rapid growth in the 2000s, the growth of the natural gas market in Brazil has slowed, yet it remains the largest market of the countries of study. India and China have witnessed rapid growth in recent years and India, in particular, is forecast to become the world's largest natural gas vehicle market (IEA, 2010). In the USA, increasing policy support may lead to rapid developments in the coming years, which would be enabled by the large vehicle fleet suitable for conversion to natural gas.

Bio-methane is rarely used in the countries under study outside the EU. Specific standards have not been implemented so far, with the exception of the 2015 regulation in Brazil. Nonetheless small-scale projects of bio-methane use for vehicles, mostly buses, have been launched in China, South Korea and the USA. However, in Europe, bio-methane as part of natural gas for road transport is very popular in Iceland (100% via dedicated pipeline), Sweden (60% via dedicated pipelines), Netherlands (50%, injected in natural gas grid), Finland (25%), Switzerland (23%), Germany (20%), Norway (10%), France (3%) and Hungary (2%).[73]

[73] http://www.ngvaeurope.eu/worldwide-ngv-statistics

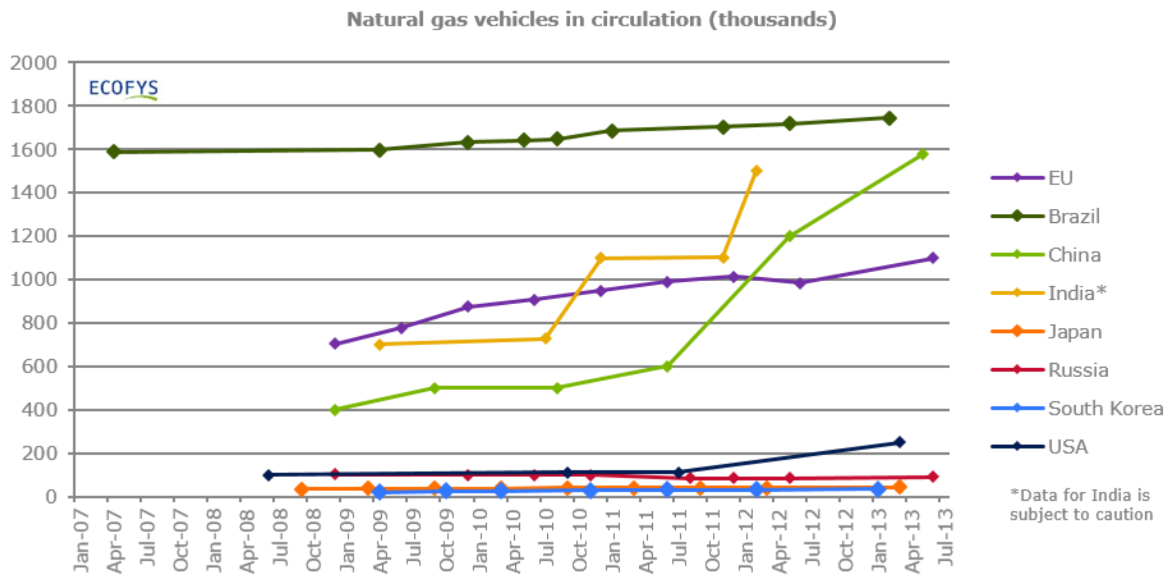

Figure 15: Total number of natural gas vehicles in circulation in the countries of study + India (source: NGVA Europe)

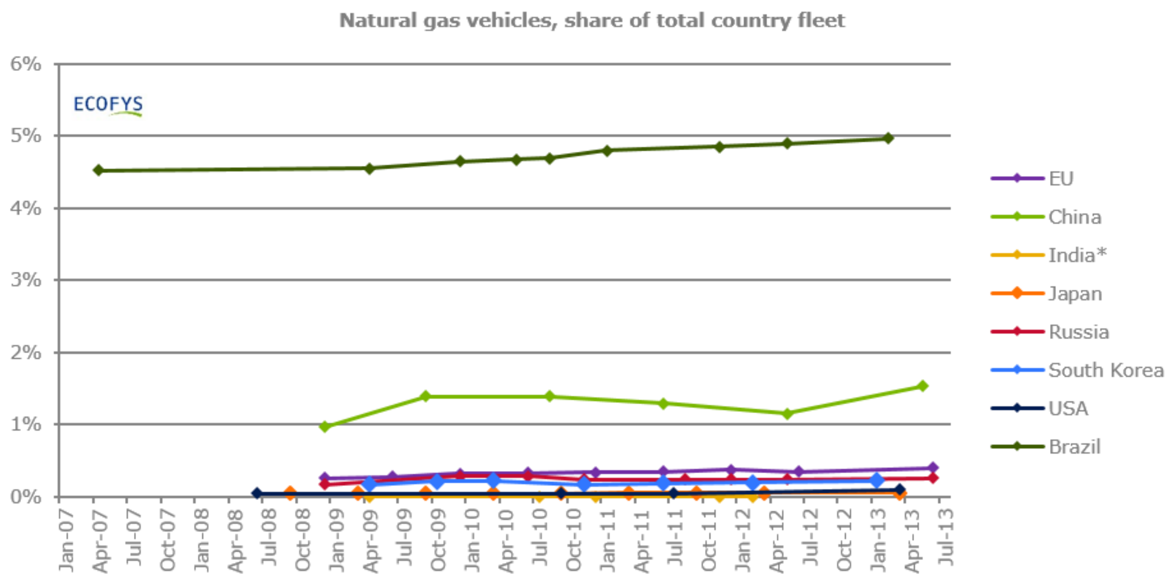

Figure 16: In-country share of natural gas vehicles in the countries of study (source: NGVA Europe)

Figure 17 provides additional information on the different types and number of natural gas fuelling stations in the countries of study. It shows that CNG is by far the most widespread type of natural gas based fuel. With the exception of China, almost all natural gas stations are indeed CNG stations.

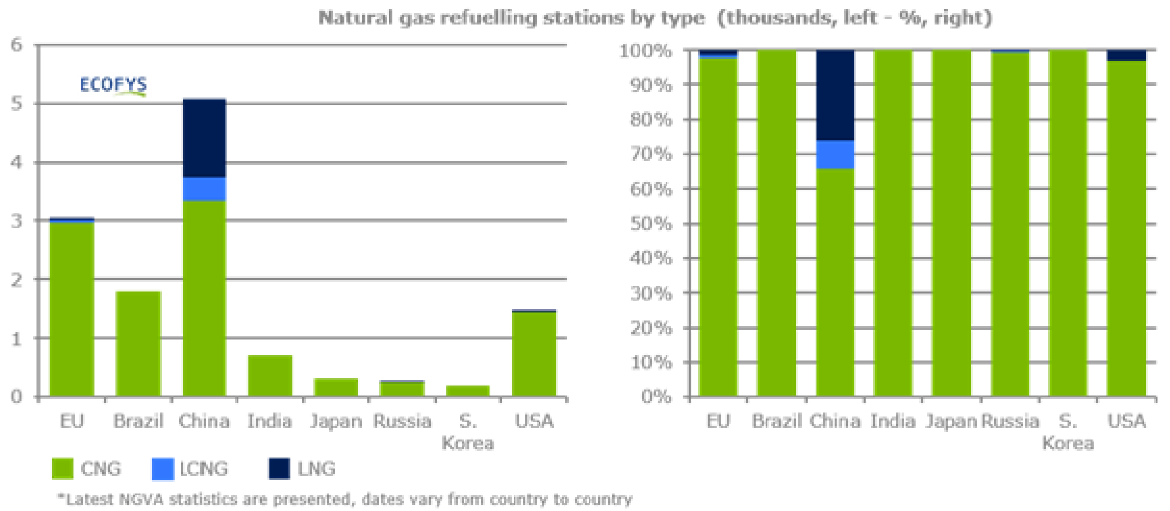

Figure 17: Natural gas refuelling stations by type in the countries of study (source: NGVA Europe)

Figure 18 provides additional information on the respective shares of light-duty vehicles medium and heavy duty buses and trucks. This highlights the different national approaches to the development of natural gas vehicles and infrastructure, as exemplified by the contrasting profiles of Brazil, where almost all the fleet is composed of light duty vehicles, Japan, where over half of vehicles are heavy duty trucks, and South Korea, where almost the entire fleet is composed of buses.

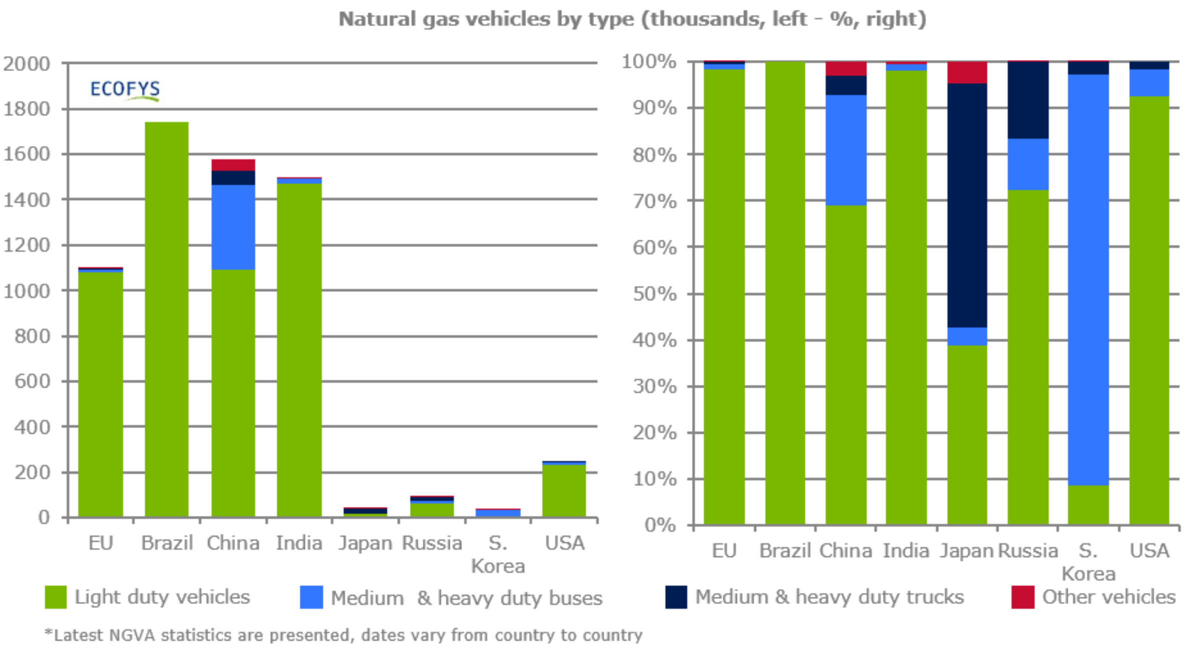

Figure 18: Distribution of natural gas vehicles by type in the countries of study (source: NGVA Europe)

The specific policies and measures that stimulate the natural gas market are presented in more detail in section the section on policies and measures. Typically the incentives create a business case for the users, and are different for each vehicle segment. South Korea promotes natural gas in the public transport sector, while Brazil is considering an approach that also stimulates natural gas in busses and trucks.

Liquefied Petroleum Gas

Liquefied Petroleum Gas (LPG), also commonly referred to as autogas, is an alternative fuel composed of propane and butane gas, which is suitable for use in retrofitted or purpose-built vehicles. It is currently the most widely adopted alternative fuel in road transport – in number of dedicated vehicles - with almost 26 million vehicles in circulation worldwide in 2015. The LPG market dominated, in terms of vehicles, by 5 countries, which together account for almost half of global consumption: Turkey (4 million vehicles), Russia (3 million), Poland (2.8 million), Korea (2.4 million) and Italy (2 million)[74].
Recent developments with biofuel technologies may also offer future opportunities for sustainable and low carbon alternatives to fossil-based LPG. Dimethylether (DME) can be derived from methanol through catalytic dehydration, of from syngas through the gasification of lignocellulosic and other feedstocks. DME can then be used as a substitute for propane in LPG. The production of DME at industrial scales is however still in demonstration and the first plant started production in 2010 in Sweden.

The total global consumption of LPG as a transportation fuel is about 21 Mtonne, whereas biofuel consumption totals 88 Mtonne in 2010, more than 4 times as much.

Figure 19 provides a snapshot of the global LPG market in 2010, in terms of the total consumption of LPG and total number of vehicles in circulation. The EU accounted for 34.2% and 20.9% to LPG vehicles and consumption respectively, South Korea for 13.2% and 36.4% and Russia for 7.3% and 10.1%.

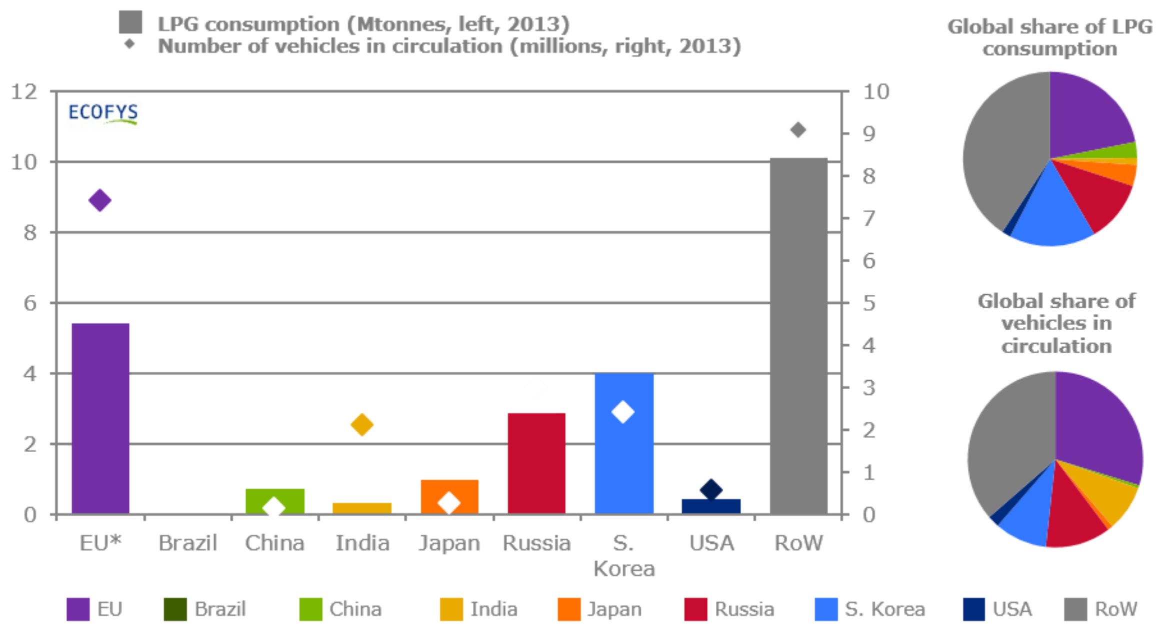

Figure 19: Snapshot of LPG consumption and vehicles in 2013 (source: WLPGA)

Figure 20 and Figure 21 provide additional detail on the growth of LPG consumption and vehicles in circulation since 2000 and clearly show a consistent and steady growth of LPG use worldwide.

[74] http://www.wlpga.org/wp-content/uploads/2015/09/autogas_incentive_policies_2014.pdf

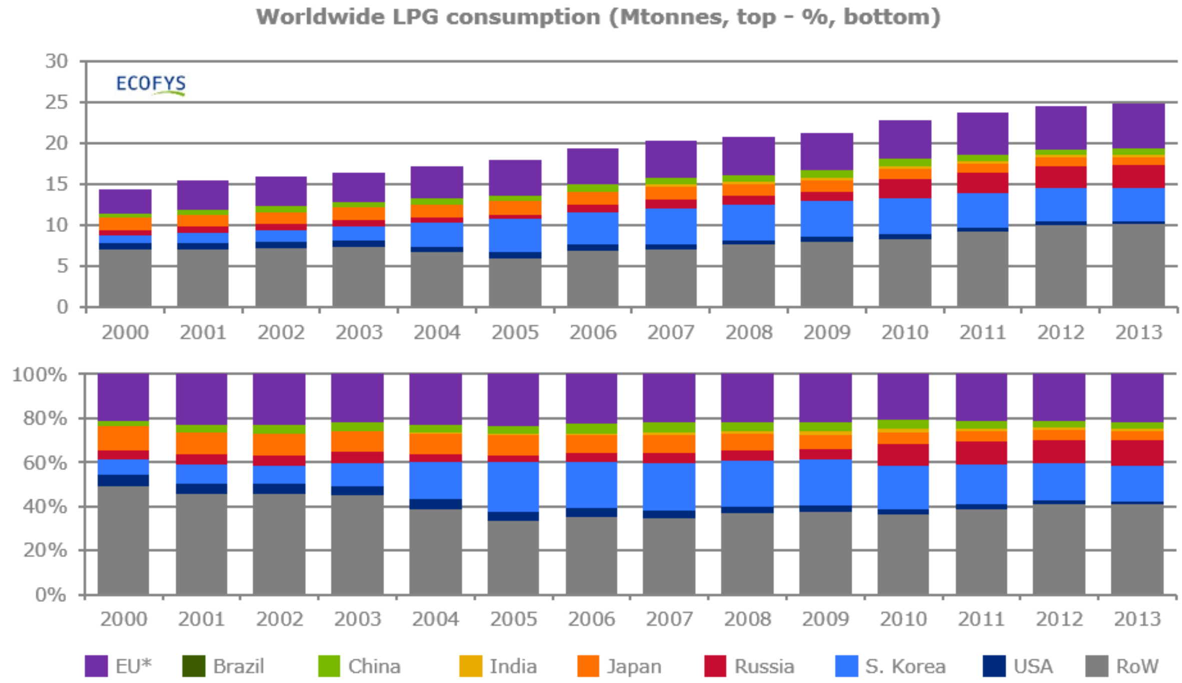

Figure 20: Absolute and relative consumption of LPG worldwide, 2000-2013 (source: WLPGA)

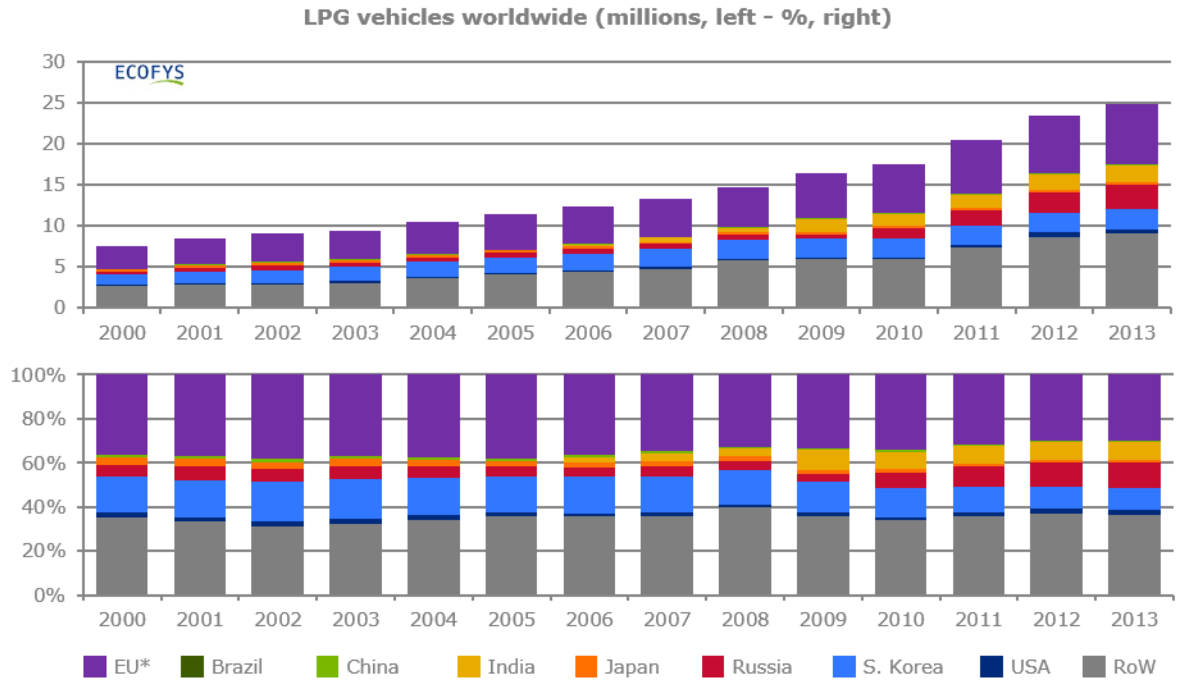

Figure 21: Absolute and relative number of LPG vehicles worldwide, 2000-2013 (source: WLPGA)

Synthetic fuels

Synthetic diesel and gasoline can be produced via the production of synthesis gas (syngas, composed of hydrogen and carbon monoxide) derived from coal or natural gas, as illustrated below. Synthetic gas can also be derived from (solid) biomass following the coal route and biogas following the natural gas route. Bio-synthetic gas however remains at a demonstration stage.

From the syngas several fuel types can be produced. The production processes involved (Fischer Tropsch and Mobil methanol-to-gasoline) are proven and commercial production is feasible. Other production pathways are under development.

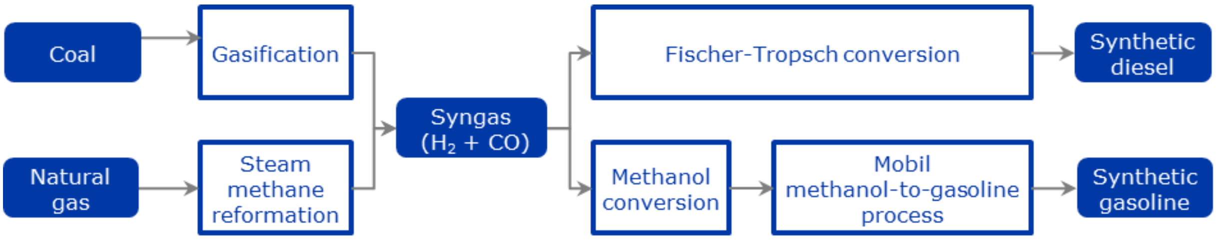

Figure 22: Production of synthetic fuels from solid or gaseous feedstock

Synthetic fuel production is mostly concentrated in South Africa, Qatar, China and the USA. Gas-to-Liquid production is limited to a few plants in South Africa, Malaysia and Qatar including:

- The Bintulu GTL Plant located in Malaysia, started operations in 1993 and has a production capacity of FT liquids of 12,500 bbl/day;
- The Pearl GTL Plant located in Qatar, started operations in 2011 and has a production capacity of FT liquids of 140,000 bbl/day.

Coal-to-Liquid production is concentrated in South Africa, China and the USA. The following table provides a list of operational and planned plants in China and the USA.

Table 10: Overview of operational and planned coal to liquid plants in China and the USA (source: Gasification Technologies council, World Gasification Database – information last retrieved 24/11/14[75])

Country	Coal to liquid plants, year and production capacity
China	**Operational**: ▪ Yitai CTL Plant (2009): FT liquids, 4,000 bbl/d ▪ Jicheng MTG Plant (2009): Methanol, 300,000 mt/a ▪ Yunnan MPG Plant (2013): Methanol, 1,800,000 mt/a ▪ Shanxi Lu'an CTL Plant (2014): FT liquids, 4,000 bbl/d **Planned**: ▪ Shaanxi Future Energy (2015): FT liquids, 30,000 bbl/d ▪ Shanxi Lu-an CTL Plant (2015): FT liquids ▪ Yitai Urumqi CTL Plant (2016): FT liquids, 46,000 bbl/d ▪ Yitai Ordos CTL Plant Phase II (2016): FT liquids, 46,000 bbl/d ▪ Yitai Yili CTL Plant (2016): FT liquids, 30,000 bbl/d ▪ Yinchuan CTL Plant (2017): FT liquids, 100,000 bbl/d
USA	**Planned**: ▪ Medicine bow CTL (2015): Gasoline, 11,600 bbl/d; LPG: 1,259 bbl/d ▪ TransGas Adams Fork MTG plant (2016)

The production may seem huge, but is still relatively small when all the planned plants are in operation: 2.4% compared to the daily consumption of China in 2013 (10.7 million bbl/d[76]). There is a strong growth trend however.

[75] Available at: http://www.gasification.org/
[76] http://www.eia.gov/countries/cab.cfm?fips=ch

Waterborne transport

The global shipping industry currently accounts for approximately 3% of the world's and 4% of the EU's greenhouse gas emissions. Under 'business-as-usual' scenarios these emissions are expected to more than double by 2050. Marine liquid fuel consumption represents close to 10% of the world's total liquid fuel supply and is dominated by low-quality and low-price residual fuel (heavy fuel oil – HFO). In addition to carbon dioxide emissions, marine fuels combustion typically results in high sulphur oxide (SO_x) and nitrogen oxide (NO_x) emissions and the marine shipping industry faces the challenges of reducing these exhaust gases. International regulatory bodies such as the International Maritime Organisation (IMO) and many national and international governments are imposing strict regulatory regimes to curb maritime emissions. Notably, Emissions Control Areas (ECAs) in force or expected in the future, mostly near European, North American and Japanese shores, impose strict requirements on the shipping industry. These new regulatory regimes have brought alternative fuels (e.g. LNG) and scrubbers (to wash out sulphur from the exhaust gasses) to the forefront as means for shipping companies to achieve compliance in a cost-efficient manner.

Currently, the most practical solution is to use low-sulphur (fossil) fuels in ECAs. A range of alternative fuels are however envisaged as part of the marine transportation's future fuel mix. An important distinction is that between drop-in fuels, which can be distributed through existing channels and non-drop-in fuels, which require a completely new infrastructure.

- Various **biofuels** are expected to become available as drop-in fuels: biodiesel[77], bio-methanol and pyrolysis oil. In the European Project METHAPU (2006-2010) bio-methanol was demonstrated in a fuel cell producing auxiliary power.
- Alternative fuel **methanol** received a lot of attention and can be reformed on board to DME (OBATE process[78]), a fuel which can be used in diesel engines. Methanol can also be used in dual fuel diesel engines (both two and four stroke) (Tanneberger, 2015). Methanol has for example been recommended by the Community of European Shipyards Associations and bio-methanol is foreseen to be the most energy-efficient pathway for fuels by 2050. Methanol is particularly promising for marine transportation in light of its relatively simple storage requirements on board tankers and other ships.
- **Natural gas** (LNG and CNG) and Liquefied Petroleum Gas (LPG) hold potential as non-drop-in fuels. LNG powered ships (not including tankers which use of boil-off gas in their engines) are mainly used in Norway (more than ¾ of the global fleet of 60 in 2015) (Laffineur, 2015).
- **Electricity** can be provided from the shore while the ships are at berth. The auxiliary engines that normally produce the electricity on board are then shut down. Because of more efficient and cleaner electricity production on shore there are benefits for all emissions in most areas. Ecofys (Ecofys, 2015) calculated that in 2020 on average 40% of CO_2 emissions are saved when ships in Europe switch from fossil fuel use on board to shore side electricity.

The IEA-AMF's 2013 report on alternative fuels for marine applications proposes a list of drivers and criteria for alternative fuels, which are summarised below.

[77] For instance Fatty Acid Methyl Ester (FAME) or hydrotreated vegetable oils (HVO)
[78] http://www.lngbunkering.org/sites/default/files/2013%20stena%20line%20The_Methonal_Alternative.pdf

Table 11: Overview of key drivers and criteria for alternative fuels for marine applications (source: modified after IEA-AMF, 2013)

Drivers	Criteria
▪ IMO's MARPOL SO_x and NO_x legislation ▪ Volatility of fossil fuel prices ▪ Possible diesel shortages in Europe ▪ Possible scarcity of low-sulphur distillate fuel in 2015 following regulatory changes on sulphur requirements ▪ Current and expected ECS and SECAs ▪ The Renewable Fuel Standard (USA) ▪ IMO MARPOL's Energy Efficiency Design Index (EEDI)	**Relevant to drop-ins and non-drop-ins** ▪ Lower SO_x and NO_x emissions ▪ Competitive pricing ▪ Worldwide availability ▪ Safety and minimal environmental risks **Mostly relevant to drop-ins** ▪ Limited impacts on the engine and shipboard fuel system ▪ No degradation of engine performance ▪ Ability to mix with current fossil fuels

On the basis of these drivers and, alternative fuels such as biofuels and natural gas have limited development prospects in the short and medium-term. They are now used in niche markets where the application is supported by policy measures and/or commercial premiums. IEA-AMF expects that fossil fuels will continue to be dominant (IEA-Advanced Motor Fuels Implementing Agreement, 2013). The prospects for LNG are more favourable, particularly in ECAs and for small ships and ferries. The natural gas infrastructure requirements and costs of ship construction or retrofit limit its short- and medium-term potential for large cargo ships. The following table provides a summary of key issues and prospects for biofuels and natural gas for marine applications.

Table 12: Overview of pros, cons, applications and outlook for biofuels and natural gas for marine applications

Fuel type	Pros & cons	Applications & outlook
Biofuels	**Pros**: diesel engine compatibility, lower SO_x emissions, safety **Cons**: costs	**Applications**: relatively high costs and quality-related issues, limits applications considerably **Outlook**: 1Mt for small ships, ferries etc. and 1Mt for cargo ships without sulphur removal by 2020 (0.5% of marine fuels by fuel weight, IEA-AMF, 2013)
Natural gas (CNG & LNG)	**Pros**: availability, cost, lower SO_x emissions, experience with and availability of ship construction rules and marine gas engines **Cons**: compatibility with existing engines and fuel systems, ship construction / retrofit premium, increased fuel storage space, increased fuelling time, increased safety requirements, limited bunkering infrastructure	**Applications**: due to the limited availability of natural gas bunkering infrastructure & high construction/retrofit costs, natural gas is expected to mostly develop on small ships, ferries etc. operating in ECAs. **Outlook**: 15Mt by 2020 (3.75% of marine fuels by fuel weight) and 66 Mt by 2025 (IEA-AMF, 2013)

Also ethanol (Ecofys, 2012) or LPG (Kjarthansson, 2011) are considered by others as a non-drop-in fuel.

Airborne transport

Global Aviation is projected to grow by 4.5% annually up to 2050, which would result in a six-fold increase of greenhouse gas emissions by that date compared to 2010 under a 'business-as usual' scenario[79]. Many initiatives seek to reduce the environmental impacts of aviation. Notably, in Europe, the Renewable Energy Directive requires that EU Member States ensure the use of 10% renewable energy in transport in 2020 and the aviation sector was included in the EU Emissions Trading Scheme as of 2012. Internationally, following negotiations with the EU on the coverage of the aviation sector in the EU ETS, the International Civil Aviation Organisation (ICAO) general assembly of October 2013 led to an agreement on a roadmap for the development of a global market-based mechanism to tackle aviation emissions by 2016 and to be implemented by 2020. The International Air Transport Association (IATA) is also committed to achieve carbon neutral growth by 2020 and a 50% reduction in greenhouse gas emissions by 2050. In 2012, the Air Transport Action Group (ATAG) presented various options available to meet such objectives, as illustrated below. Biofuels are expected to play a central role.

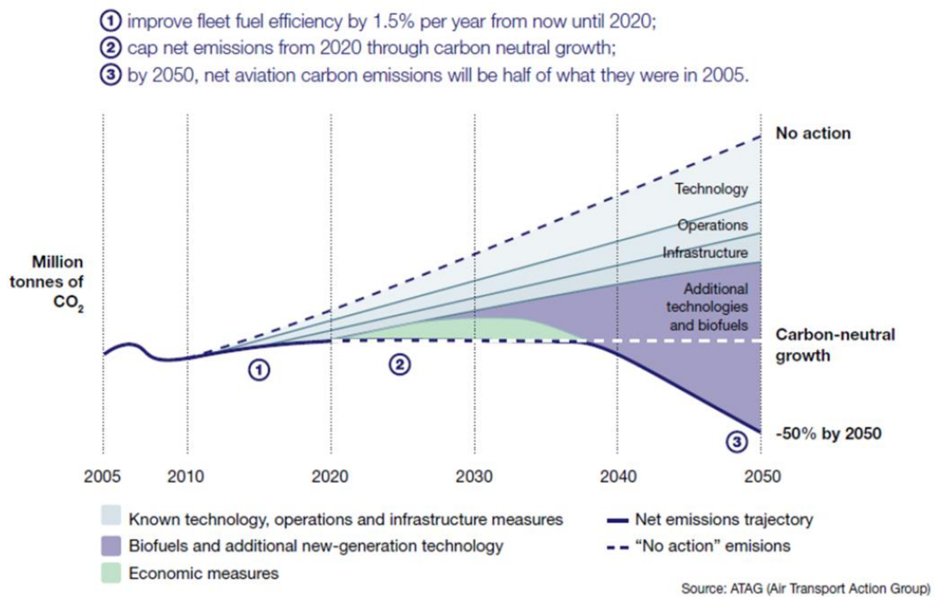

Figure 23: Pathway to 50% reduction in greenhouse gas emissions from the aviation industry by 2050

Many developments in the past few years demonstrate the promising role of biofuels in the future of aviation. These include:

- Many airlines are performing test flights or operating commercial flights using biofuels since 2008. As of June 2012, more than 18 airlines have performed over 1,500 commercial flights (IATA, 2013);
- An increasing number of multi-stakeholder initiatives are being announced, bringing together public and private stakeholders from across the value chain (in in annual report 2013, IATA accounts for a total of 48 initiatives by October 2013, 23 of which were announced since 2012);

[79] http://ec.europa.eu/energy/technology/initiatives/doc/20110622_biofuels_flight_path_technical_paper.pdf

- Three production routes have been approved by the ASTM for the production of biofuels for aviation (Fischer-Tropsch (FT) in 2009 and Hydroprocessed Esters and Fatty Acids (HEFA[80]) in 2011, and Farnesane in Brazil in 2014) and technological developments for other production routes are ongoing; Farnesane is a sugarcane biofuel, and therefore important for major sugar producer Brazil. The HEFA production route is important for Neste Oil who operate large production facilities in Rotterdam, Singapore and Finland. FT uses woody biomass as a feedstock and this process is mainly used as an aviation fuel by Solena, headquartered in the USA;
- Technical and sustainability standards are available and increasingly used internationally.

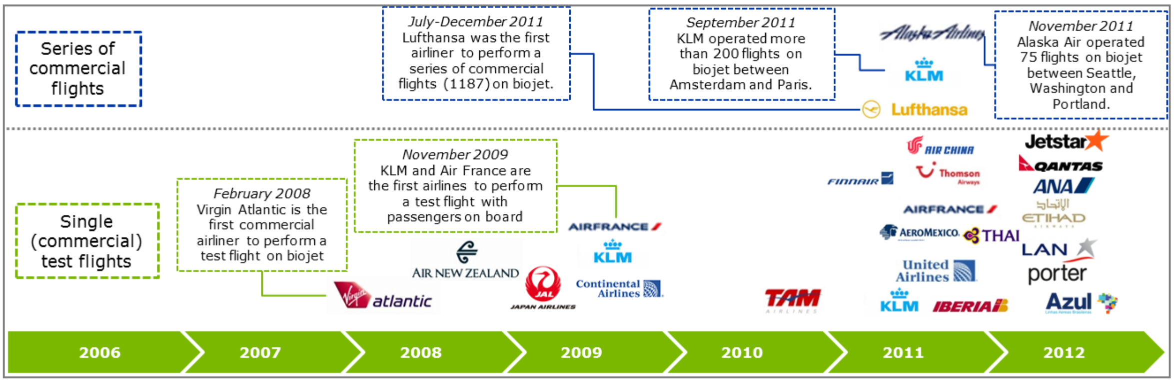

Figure 24: Timeline for the development of biofuels in aviation

The use of biofuels in aviation faces many technical, sustainability, economic and political challenges. Technically, international fuel quality standards mean that the technical requirements and approval of biofuels for aviation are difficult to meet and long to develop. Sustainability criteria extend beyond greenhouse gas emissions considerations to include other aspects such as feedstock sourcing and land-use. Economically, biofuels still suffer from an important price-gap with conventional jet fuel (typically 2-4 times the price of conventional fuels) and from an un-level playing field with the road transportation sector: there are no mandatory targets in the airborne sector for the use of biofuels. The combination of upward trending conventional fuel prices and downward trending biofuel prices is expected to lead to price-competitiveness in the medium term. Politically, the many interests at stake has made the that the setting of targets for biofuels use in aviation or the inclusion of aviation in national and international emissions reduction policies difficult.

Estimates on the current uptake of biofuels in aviation are typically lacking but it is generally acknowledged to represent a marginal fraction of jet fuels. Prospects for growth are driven by growing jet fuel demand, the availability of biofuels, environmental considerations, market developments and international trade considerations. Projections to 2020 and 2050 vary significantly. The 2011 paper entitle "2 million tons per year: A performing biofuel supply chain for EU aviation", published as part of the "European Advanced Biofuels Flight Path Initiative" outlined the aim to replace 2 million tonnes of conventional jet fuel with biofuels in 2020, which should be placed in the perspective of the roughly 200 million tonnes of fossil jet fuel consumed annually. The 2009 "Review of the potential for biofuels in aviation" for the UK Committee on Climate Change E4tech estimated a likely share of 1.6% for biofuels by 2020.

[80] Also known as Hydrogenated Vegetable Oil (HVO)

The 2012 report by the IEA shows estimates ranging from a 10% to a 100% share by 2050 and concludes that, assuming a growth of aviation fuel consumption to 368 to 575 Mtonne by 2050 and a 10% share for biofuels, biofuel consumption could be of the order of 36.8 to 57.5 Mtonne by 2050.

Table 13: Overview of key initiatives for the development of biofuels for airborne transport in the countries of study

Country	Segment	Fuel	Description
Europe	Air	Biofuels	• **European Advanced Biofuels Flight path Initiative** • **The Initiative Towards sustAinable Kerosene for Aviation** (ITAKA)
Brazil	Air	Biofuels	• **Sustainable Aviation Biofuels for Brazil**: "Flightpath to Aviation Biofuels in Brazil: Action Plan" • **Brazilian Alliance for Aviation Biofuels** (ABRABA)
USA	Air	Biofuels	• **Defence Logistics Agency**: initiatives supporting certification and commercialization of alternative aviation fuels • **Midwest Aviation Sustainable Biofuels Initiative** (MASBI) • **The Commercial Aviation Alternative Fuels Initiative** (CAAFI) • **The Sustainable Aviation Fuels Northwest** (SAFN)

For the countries Japan, South-Korea and Russia there were no key initiatives regarding biofuels in aviation found.

Specific findings

The analysis of important lessons for the EU starts with an analysis of the policies and measures in place in the countries of study. All relevant policies and measures that say something about alternative fuels are presented and further analysed for the most successful fuels.

Policies and measures

The introduction and market uptake of a specific technology in the transport sector heavily depend on policies and measures implemented by countries, or initiated by private companies or (international) organisations. The following tables provide an overview of the most relevant policies in every country including their objective, impacts and competent authority. The majority of these measures are related to road transport. Additionally information is provided in Annex: country factsheets.

Table 14: Overview of policies – Brazil

Name	Overview
Government Support Programme for Bioethanol[81]: Proálcool programme	*Objective*: increasing uptake of bioethanol *Instruments*: tax incentives, COFINS credits, R$5B credit line by BNDES *Authority*: Government of Brazil
Programa Nacional de Producao e uso do Biodiesel (PNBP)[82]	*Objective*: examining economic, social, environmental feasibility of biodiesel production and use *Mechanism*: funds mainly from PRONAF and BNDES in biodiesel infrastructure, R$56M from MCT in 2007/2008 From 69M in 2006 litres produced to 2.7B in 2011 *Authority*: Ministry of Mines and Energy and Ministry of Science, Technology and Innovation
Projeto Onibus Brasileiro a Hidrogenio[83]	*Objective*: demonstrating technical and operational feasibility of FCV, production and storage of hydrogen for city buses *Mechanism*: pilot project of 5 buses and a hydrogen station as a result of Matriz Energetica do Brasil Versao Beta *Authority*: Ministry of Mines and Energy
Programa de C,T&I para o Etanol[84]	*Objective*: financing and promoting national programmes for bioethanol *Outcome*: created Centro de Ciência e Tecnologia do Etanol (CTBE) for R&D on biomass and bioethanol *Authority*: Ministry of Science, Technology and Innovation
Plano Decenal de Expansao de Energia (PDE)[85]	*Objective*: defining national energy strategies till 2023 *Mechanism*: R$75B for bioethanol production, R$250M for new biodiesel production units *Authority*: Energy Research Company and Ministry of Mines and Energy
Plano Decenal de Expansao de Malha Transporte Dutovario (PEMAT)[86]	*Objective*: Outlining specifications of natural gas industry, expanding natural gas pipelines *Mechanism:* $250B attributed to the natural gas sector (2013-2017) *Authority*: Ministry of Mines and Energy

Table 15: Overview of policies – China

Name	Overview
Next-Generation Engine (NGE) strategy[87]	*Objective*: saving 9% fuel consumption and replacing 36% vehicle amount by BGE vehicles by 2020 *Instrument*: tax deduction: Vehicles with 1.6 L engine (or smaller): In 2009, 50% purchase tax deduction; in 2010, 25% purchase tax deduction. *Authority*: State Council
Cellulosic Ethanol Strategy87	*Objective*: production ability of 10 million tons of non-grain based fuel ethanol by 2020 *Authority*: State Council
PEV Strategy87	*Objective*: achieving 10% PEV in EV market by 2020 *Mechanism*: government investment of more than RMB 100 billion in: facilitating the development of the entire PEV industrial chain, Technology R&D in EV industry, Commercialization of EV, Commercialization of HEV and PHEV, Key components of EV, utilities construction. *Authority*: State Council
"10 cities, 1000 units" Energy-Saving and Alternative Energy[88]	*Objective*: promote EV and HEV commercialization in 25 cities *Outcome*: by the end of December 2012, the total amount of demonstration vehicles in the 25 cities reached 27,432. *Authority*: Ministry of Science and Technology, National Development Reform Commission, Ministry of Industry and Information Technology and Ministry of Finance
Shanghai EV	*Objective*: exploring sustainable development of urban transportation via an EV

[81] http://www.oecd.org/sti/biotech/Giacomazzi.pdf
[82] http://www.mme.gov.br/programas/biodiesel/menu/programa/objetivos_diretrizes.html
[83] http://www.mme.gov.br/programas/onibus_hidrogenio
[84] http://www.mct.gov.br/upd_blob/0021/21439.pdf
[85] http://www.epe.gov.br/pdee/forms/epeestudo.aspx
[86] http://www.epe.gov.br/PEMAT/Forms/PEMAT.aspx
[87] http://www.accenture.com/SiteCollectionDocuments/PDF/United_States_China_Race_Disruptive_Transport_Technologies.pdf
[88] http://www.iea-amf.org/app/webroot/files/file/Annual%20Reports/Annual%20Report%202013_Final_.pdf

Name	Overview
Demonstration[89]	pilot city (Shanghai) *Instrument*: built demonstration project, set up three international communication platforms. *Authority*: Ministry of Industry and Information Technology (MIIT), Ministry of Finance (MOF)
Direct subsidy for EV and hybrid vehicle buyers[90]	*Objective*: Promote sales of EV and HEV *Mechanism*: For domestic cars: 7200 EUR available to buyers of all-electric cars with a range of over 250 km; 4200 EUR for plug-in hybrid vehicles that go for over 50 km. *Authority*: Ministry of Industry and Information Technology (MIIT), Ministry of Finance (MOF)
Exempted EV from City Car-Purchase Restrictions[91]	*Objective*: promote EV sales *Instrument*: Beijing citizens purchasing pure electric vehicles will no longer be exempt from participation in the city's car license plate lottery *Authority*: Beijing Municipal Commission of Transport
Public-transport LPG conversion programme[92]	*Objective*: introduced LPG to more Chinese cities public transport *Mechanism*: 11 more big cities in 2008. The total number of cities promoting LPG reached 25 by the end of 2009. *Authority*: National and local governments
12th 5-year Development Plan guidelines on alternative fuels[93]	*Objective*: Promote Coal liquefaction and gasification technologies as well as accelerating the introduction of biofuels *Mechanism*: Allocation of 15% of GDP on renewable energy and energy efficiency technology by 2020. Mandatory targets of emissions reduction in road and freight transport as well as natural gas use. *Authority*: State Council
LPG tax deduction90	*Objective*: Improve Liquefied petroleum gas (LPG) price competitive *Instrument*: Tax deduction of autogas *Authority*: Ministry of Finance (MOF)

Table 16: Overview of policies – Japan

Name	Overview
National Energy Strategy[94]	*Objective*: Reducing dependence on oil to 80% and improving energy efficiency by 30% by 2030 *Authority*: Ministry of Economy, Trade and Industry (METI)
Next-Generation vehicle fuel Initiative[95]	*Objective*: Introducing four alternative technologies *Authority*: Ministry of Economy, Trade and Industry (METI)
Developing Soft Cellulosic Resources Utilization Technology[96]	*Objective*: Soft Cellulosic Resources Utilization technology innovation *Mechanism*: Developed three Model Demonstration Projects of Local Biofuel Use *Authority*: Ministry of Agriculture, Forestry and Fisheries (MAFF)
Government built bioethanol production facility at Miyako-jima[97]	*Objective*: Promote bioethanol commercialization *Mechanism*: Trial operations in 2011 and later was restarted Japan Alcohol Corporation *Authority*: Ministry of the Environment (MOE)
Bioethanol project Emissions reduction methodology[98]	*Objective*: Develop greenhouse gas emissions reduction from bioethanol project *Outcome*: Enabled application of the Japan Verified Emission Reduction System *Authority*: DCC
New National Energy Strategy for bioethanol vehicles94	*Objective*: Promote bioethanol application *Mechanism*: Goal to re-examine the regulation on the upper blending limit for oxygenated compounds that contain ethanol *Authority*: Ministry of Economy, Trade and Industry (METI)

[89] http://www.evzonechina.com/en/activity/show.aspx?id=11
[90] http://www.mof.gov.cn/index.htm
[91] http://www.cars21.com/news/viewprintable/5828
[92] http://202.116.197.15/cadalcanton/Fulltext/21300_2014319_102457_211.pdf
[93] http://www.amcham-shanghai.org/amchamportal/infovault_library/2011/Chinas_12th_Five-Year_Plan_Implications_for_Greentech.pdf
[94] http://www.iea.org/policiesandmeasures/pams/japan/name-24049-en.php
[95] http://www.cev-pc.or.jp/english/events/okinawa2014/02.pdf
[96] http://www.jsae.or.jp/e07pub/yearbook_e/2014/docu/04_conservation_of_resources.pdf
[97] https://www.env.go.jp/en/focus/070319.html
[98] http://www.asiabiomass.jp/english/topics/1101_02.html

Name	Overview
New National Energy Strategy for Electric and fuel cell vehicles94	*Objective*: Promote the dissemination of electric and fuel cell vehicles *Authority*: Ministry of Economy, Trade and Industry (METI)
EV/PHEV town project[99]	*Objective*: Develop demonstration projects *Mechanism*: Several towns as demonstration sites *Authority*: Ministry of Economy, Trade and Industry (METI)
Hydrogen demo programme[100]	*Objective*: Develop demonstration projects *Mechanism*: Involving 14 energy related companies and 4 auto companies are pursuing a number of demonstration projects *Authority*: RAHS
Public financial incentive for Battery Electric Vehicle infrastructure94	*Objective*: applicable nationally to land transport infrastructure *Instrument*: Public sector financial support 50% of cost of charging (DC fast or AC normal) *Authority*: Ministry of Economy, Trade and Industry (METI)
Public financial incentive for Fuel Cell Vehicle infrastructure94	*Objective*: Promoting the development of infrastructure of BEV and FCV *Mechanism*: USD 65M for H_2 infrastructure and production *Authority*: Ministry of Economy, Trade and Industry (METI)
Kanagawa city development[101]	*Objective*: Increasing the use of EVs to 3,000 in the prefecture by FY2014, and to present programmes to be undertaken by the national government, K.P.G., and various businesses *Outcome*: Kanagawa has more than 2,100 EVs. As of January 31, 2012, the prefecture has 109 DC quick chargers and 341 100/200V outlets *Authority*: City Council

Table 17: Overview of policies – Russia

Name	Overview
Bio2020[102]	*Objective*: Creating the basis for biofuel industry and achieving 10% biofuel share in transport *Mechanism*: 367B RUB (4.9 billion euro) by 2020 for Bioenergetics *Authority*: Russian Federal Government
Federal Program for Energy Savings and Energy Efficiency[103]	*Objective*: Reducing energy intensity of Russia's GDP by 13.5% by 2020 *Mechanism*: Providing financial incentive of 9.5T RUB for regional energy savings programmes (695B RUB (9 billion euro) from federal and regional funding, rest by private investments) *Authority*: Russian Federal Government
Energy Strategy of Russia[104]	*Objective*: Setting targets for energy intensity reduction and share of renewable energy by 2030 *Authority*: Russian Ministry of Energy
Gazprom Gazomotornoye Toplivo Investment Program[105]	*Objective*: Providing incentives for CNG and LNG vehicles *Mechanism*: 13.8B RUB (180 Million EUR) for construction of CNG/LNG filling stations, 10 pilot projects to convert public and municipal freight transport to natural gas Vehicles. Constructing 48 CNG stations, upgrading 7 and working on 145 other. Running LNG projects Vladivostok LNG Baltic LNG, LNG regasification terminal in the Kaliningrad *Authority*: Gazprom

[99] http://www.meti.go.jp/english/press/2012/0119_02.html
[100] http://www.theicct.org/sites/default/files/HySUT_Report_June5_2012_Rev1.pdf
[101] https://www.iea.org/publications/freepublications/publication/EVCityCasebook.pdf
[102] http://www.fp7-bio.ru/Booklets/BIO2020%20(eng)%20-%20short.pdf
[103] http://www.iea.org/policiesandmeasures/pams/russia/name-30184-en.php
[104] http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_Moscow_Russian%20Federation_6-30-2014.pdf
[105] http://www.gazprom.com/about/subsidiaries/list-items/gazprom-gazomotornoye-toplivo/

Table 18: Overview of policies – South Korea

Name	Overview
Biodiesel fuel mandate[106]	*Objective*: Obligations to blend transportation fuel with a specific % of an alternative fuel *Authority*: Ministry of Trade, Industry and Energy (MTIE)
Natural gas vehicle support measures[107]	*Objective*: Promote natural gas usage in public transport sector *Instrument*: Offering subsidies and low-priced natural gas to city buses *Authority*: Ministry of Commerce, Industry and Energy (MOCIE)
Korean Renewable Fuel Standard[108]	*Objective*: Promote Biodiesel and Bioethanol *Mechanism*: Penalty in case of violation of blend, long term blend plan from 2015 to 2023 *Authority*: Ministry of Trade, Industry and Energy (MTIE)
Development Plan for an Energy-Saving and Alternative Energy Automotive Industry[109]	*Objective*: Making electric drive a major technology *Authority*: State Council

Table 19: Overview of policies – USA

Name	Overview
Clean Cities[110]	*Objective*: Reducing petrol use in transport by 2.5 billion gallons per year by alternative fuels by 2020 *Mechanism*: 500 Transportation projects, USD 377M in grants, saved 4.6 billion gallons of petroleum, placed 400,000 AFV on road, saved 6.6M tons of greenhouse gas emissions Petroleum savings: 13.8% EV, 8.7% E85, 11.1% biodiesel 45.8% natural gas and 5.5% LPG *Authority*: US Department of Energy
Renewable Fuel Standard[111]	*Objective*: Increasing the volume of renewable fuel to 36 billion gallons by 2022 *Outcome*: 19 billion gallons so far *Authority*: Environmental Protection Agency
American Recovery and Reinvestment Act[112]	*Objective*: Promoting investments in energy independence and renewable energy technologies *Mechanism*: USD 17 billion dollars of grants to NREL for renewable energy technologies, USD 387M electrical efforts, USD 2B battery manufacturing, USD 590M advanced bio refinery projects, USD 107M advanced biofuels research and fuelling infrastructure *Authority*: US Department of Energy
Energy Policy Act[113]	*Objective*: Reducing dependence on oil imports and improving air quality *Mechanism*: USD 200 million for advanced vehicle demonstration and pilot programmes, USD 40M for HEV, Fuel cell and hydrogen systems USD 15M to USD 65M per year *Authority*: US Department of Energy
CO_2 and Corporate Average Fuel Economy (CAFE) standards[114]	*Objective*: Reducing energy consumption by increasing fuel economy of cars and light trucks for model years 2017 through 2025 *Outcome*: Between 2008 and 2013, a 16.9% improvement in CAFE performance *Authority*: National Fire Protection Association and Environmental Protection Agency
Biomass Crops Assistance Program[115]	*Objective*: Providing incentives in the agricultural sector for production of biofuels *Mechanism*: USD 25 million of mandatory funding for 2014-2018

[106] http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Bio-Fuels%20Production_Seoul_Korea%20-%20Republic%20of_2-10-2010.pdf
[107] http://www.google.nl/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=2&ved=0CCkQFjAB&url=http%3A%2F%2Feng.me.go.kr%2Feng%2Ffile%2FreadDownloadFile.do%3Bjsessionid%3D70IZu7addnZLoclc6UFNaM1tkpmT8AaQeGORyN2R1I1yzHl32G9bFcmRMUBdmUEq.meweb1vhost_servlet_engine3%3FfileId%3D92446%26fileSeq%3D1&ei=vB5LVf3QJ4uwUcTagIgI&usg=AFQjCNG_YJPhJb0kfvjd0WDKI-Dxzkpu5g&sig2=c8UX6ETtPmla5NPVpbsMig&bvm=bv.92765956,d.d24
[108] http://www.kemco.or.kr/renew_eng/new/rfs.aspx
[109] http://www.iea.org/Textbase/npsum/Korea2012SUM.pdf
[110] http://www1.eere.energy.gov/cleancities/
[111] http://www.epa.gov/oms/fuels/renewablefuels/
[112] http://www.accenture.com/SiteCollectionDocuments/PDF/United_States_China_Race_Disruptive_Transport_Technologies.pdf
[113] http://www.iea-amf.org/app/webroot/files/file/Annual%20Reports/Annual%20Report%202013_Final_.pdf
[114] http://www.nhtsa.gov/fuel-economy/
[115] http://www.fsa.usda.gov/programs-and-services/energy-programs/index

Name	Overview
	Authority: US Department of Agriculture
H_2USA[116]	*Objective*: Coordinating research and identifying cost-effective solutions to advance hydrogen infrastructure *Outcome*: Automotive fuel cell costs reduced by more than 35% since 2008 and by more than 80% since 2002 *Authority*: US Department of Energy
Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP)[117]	*Objective*: Develop and deploy alternative and renewable fuels and advanced transportation technologies *Impact*: Has invested more than USD 531 million to date, funded more than 462 clean transportation projects, provided USD 100 million annually *Authority*: California Energy Commission

Table 20 specifies which technologies each country-specific policy, mentioned above, applies to. Additionally these policies have been categorised according to their type (law/regulation, guideline, binding target, indicative target, R&D, demonstration and financial incentive) and mechanism (innovation support, incentive to supply, market uptake and demand management). Key policies and measures are mostly focused on road transportation.

Table 20: **Summary of national policies and measures: type, mechanism and target technology**

Country	Policy	Type	EV	H_2	Biofuels	NG	LPG
Brazil	Government Support Programme for Bioethanol				Yes		
	Programa Nacional de producao e uso do Biodiesel				Yes		
	Projeto Onibus Brasileiro a Hidrogenio			Yes			
	Programa de C,T&I para o etanol				Yes		
	Plano Decenal de Expansao de Energia				Yes	Yes	
	Plano Decenal de Expansao de Malha Transporte Dutovario					Yes	
China	Next-Generation Engine Strategy		Yes				
	Cellulosic Ethanol Strategy				Yes		
	PEV Strategy		Yes				
	"10 Cities, 1000 Units" Energy Saving and Alternative Energy		Yes				
	Shanghai Demonstration Project		Yes				
	Direct subsidy for EV and hybrid vehicle buyers		Yes				
	Exempted EV from City Car-Purchase Restrictions		Yes				
	Public-transport LPG conversion programmes						Yes
	LPG tax deduction						Yes
	12th 5-year Development Plan guidelines on alternative fuels				Yes	Yes	
Japan	National energy strategy overall target		Yes				
	Next-generation vehicle fuel initiative		Yes	Yes	Yes	Yes	
	Developing Soft Cellulosic Resources Utilization Technology				Yes		
	Government built bioethanol production facility at Miyako-jima				Yes		
	Bioethanol project Emissions reduction methodology				Yes		
	New National Energy Strategy for				Yes		

116 http://h2usa.org/
117 http://www.nrel.gov/tech_deployment/arfvtp.html

Country	Policy	Type	EV	H_2	Biofuels	NG	LPG
	bioethanol vehicles						
	New National Energy Strategy for Electric and fuel cell vehicles	R&D; demonstration	Yes	Yes			
	EV/PHEV town project	demonstration	Yes				
	Hydrogen demo programme	demonstration		Yes			
	Public financial incentive for Battery Electric Vehicle infrastructure	$	Yes				
	Public financial incentive for Fuel Cell Vehicle infrastructure	$		Yes			
	Kanagawa city development	indicative target	Yes				
Russia	Bio2020	indicative target; R&D			Yes		
	Federal Program for Energy Savings and Energy Efficiency	indicative target; R&D	Yes	Yes	Yes	Yes	Yes
	Energy Strategy of Russia	indicative target; guideline; R&D	Yes	Yes	Yes	Yes	Yes
	Gazprom Gazomotornoye Toplivo Investment Program	R&D; demonstration				Yes	
South Korea	Biodiesel fuel mandate	Law/regulation			Yes		
	Natural gas vehicle support measures	$				Yes	
	Korean Renewable Fuel Standard	Law/regulation			Yes		
	Development Plan for an Energy-Saving and Alternative-Energy Automotive Industry	R&D; demonstration; binding target			Yes		
USA	Clean Cities	R&D; indicative target	Yes		Yes	Yes	Yes
	Renewable Fuel Standard	Law/regulation; binding target			Yes		
	American Recovery and Reinvestment Act	R&D	Yes	Yes	Yes	Yes	Yes
	Energy Policy Act	Law/regulation; R&D	Yes	Yes	Yes	Yes	Yes
	CO_2 and CAFE standards	binding target	Yes	Yes		Yes	
	Biomass Crop Assistance Program	$			Yes		
	H_2USA	R&D		Yes			
	Alternative and Renewable Fuel and Vehicle Technology Program	R&D	Yes	Yes	Yes	Yes	Yes

LEGEND:
Innovation support; Incentive to supply; Market uptake; Demand management
Law/regulation; guideline; binding target; indicative target; R&D; demonstration; **$** financial incentive

The USA and has policies in place aimed at all the fuels under study. Besides incentives market uptake policies are important. Brazil focusses on biofuels and natural gas, mainly via incentives and demand management. China has targeted electric driving via their policies as the dominant "fuel", whereas South Korea choose biofuels, both via innovation support, incentives, market uptake and demand management. In Russia all fuels are in the development state and at the moment the policies are aimed at innovation support.

Standards

For each of the fuels under study the standards for important parts of the vehicle and refuelling infrastructure are considered. Main goal here is to identify barriers for European car manufacturers to sell their products rather than learning from these standards. This section is mostly focused on road transport.

Electricity

Table 21 provides an overview of existing electricity standards and examples of vehicle models in the six countries. These standards refer to either the electric charging system, general vehicle equipment or the battery pack. For every standard, four classifications apply, as indicated with the colour and shape coding below: international or domestic, conductive or inductive, slow or fast charging, AC or DC.

Table 21: Overview of standards applicable to electric vehicles in the countries of study

Country	Charging System	Equipment	Battery	Example vehicle models
Brazil	**ANBT NBR IEC 61851**[118]: EV conductive charging system	**ABNT NBR IEC 62196**[119]: Plugs, socket-outlets, vehicle connectors and vehicle inlets-Conductive charging		
China	**GB/T 18487**[120]: EV conductive charging system	**GB/T 20234**[121]:Connection set of conductive charging for EV **QC/T 841**[122]: EV conductive charge coupler		BYD E6, BYD Ebus, DANZA
Japan	**JISD 61851**[123]: EV conductive charging system	**JISD 62196**[124]: Plugs, socket-outlets, vehicle connectors and vehicle inlets-Conductive charging **SAE J1772**[125]: EV conductive charge coupler **JEVS G105 CHAdeMo**[126]: Quick charger **JEVS G107**[126]: EV inductive charging system **JEVS C601**[126]: EV charging plug and socket	**JEVS Z807**[126]: Terms of the EV battery	Nissan Leaf
South Korea	**KSR IEC 61851**[127]: EV conductive charging system	**KSC IEC 62196**[128]: Plugs, socket-outlets, vehicle connectors and vehicle inlets-Conductive charging	**KSR 1200**[129]: General requirements of exchangeable battery for EV **KSR 1201**[129]: General requirements for battery monitoring system of EV	Kia Soul EV
USA	**SAE J2293**[130]: Energy transfer system for EV	**UL 2251**[132]: Plugs, receptacle and couplers for electric vehicles **SAE J1772**[125]: EV conductive	**UL 2580**[134]: Batteries for uses in EV	Tesla Model S

[118] http://www.abntcatalogo.com.br/norma.aspx?ID=255680
[119] http://www.abntcatalogo.com.br/norma.aspx?ID=258770
[120] http://www.spc.org.cn/gb168/online/GB%252FT%252018487.1-2001/
[121] http://www.spc.org.cn/gb168/online/GB%252FT%252020234.1-2011/
[122] http://www.chinesestandard.net/PDF-English-Translation/QCT841-2010.html
[123] http://www.webstore.jsa.or.jp/webstore/Com/FlowControl.jsp?lang=en&bunsyoId=IEC+61851-1+Ed.+2.0%3A2010&dantaiCd=IEC&status=1&pageNo=0
[124] http://www.webstore.jsa.or.jp/webstore/Com/FlowControl.jsp?lang=en&bunsyoId=IEC+62196-1+Ed.+3.0%3A2014&dantaiCd=IEC&status=1&pageNo=0
[125] http://standards.sae.org/j1772_201210/
[126] http://www.evaap.org/pdf/jevs.pdf
[127] https://webstore.iec.ch/publication/6029
[128] https://webstore.iec.ch/publication/6582
[129] http://www.cpinc.com/Kobold/Flow/LowVolume_FlowmeterAndSwitches/KSR-SVN_LowVolumeFlowSwitch_LiquidsORGases_datasheet_0.pdf
[130] http://standards.sae.org/j2293/1_200807/

Country	Charging System	Equipment	Battery	Example vehicle models
	SAE J2954[131]: Wireless charger	charge coupler **SAE J1772**[125]: EV conductive charge coupler – Combo connector **SAE J1773**[133]: EV inductively Coupled Charging		

: Conductive : Inductive	: Levels 1 & 2 : Level 3 (fast)	AC DC	: Domestic : International

The for EU car manufacturers important markets Japan, China and USA have produced domestic standards, making it difficult to produce vehicles which fulfil all the requirements of these standards, especially regarding charging standards and equipment. Japan and USA use for instance the same standard for conductive charging, while in the EU international IEC standards apply.

Hydrogen

In the following table, we put forward the existing standards of hydrogen technology, fuels and vehicles in every country as well as examples of vehicle models on the road. The most important aspects of hydrogen-fuel technology to consider are fuel system, fuel tank, fuel specifications, refuelling/dispensing and safety. Standards are classified according to these aspects and their geographical scope.

132 http://ulstandards.ul.com/standard/?id=2251
134 http://ulstandards.ul.com/wp-content/uploads/2015/01/s2580_2.pdf
131 http://standards.sae.org/wip/j2954/
133 http://standards.sae.org/j1773_201406/

Table 22: Overview of standards applicable to hydrogen vehicles in the countries of study

Standard	Brazil	China	Japan	Russia	Korea	USA
Fuel system						
SAE J2579[135]: Standard for Fuel Systems in Fuel Cell and Other Hydrogen Vehicles						(2008)
Fuel tank						
CSA America HGV2[136]: Standard Hydrogen Vehicle Fuel Containers						(2014)
ISO 13985/2006[137]: Liquid hydrogen – Land vehicle fuel tanks			(2006)	(2013)	(2009)	
ISO 15869/2009[138]: Gaseous hydrogen and hydrogen blends - Land vehicle fuel tanks			(2009)			
Fuel specifications						
SAE J2719[139]: Hydrogen Fuel Quality for Fuel Cell Vehicles						(2005)
ISO 14687/1992[140]: Hydrogen fuel-Product specification	(2010)		(1999)	(2013)	(2009)	
ISO 12619/2014[141]: Road vehicles - Compressed gaseous hydrogen and hydrogen/natural gas blend fuel system components			(2014)			
Refuelling/dispensing						
SAE J2600[142]: Compressed Hydrogen Vehicle Fuelling						(2002)
SAE J2601[143]: Fuelling Protocols for Gaseous Hydrogen Surface Vehicle						(2014)
SAE J2799[144]: Hydrogen Surface Vehicle to Station Communications Hardware and Software						(2014)
ISO 17268/2012[145]: Compressed hydrogen surface vehicle refuelling connection devices	(2014)	(2014)	(2012)	(2012)	(2012)	
ISO 13984/1999[146]: Liquid hydrogen – Land vehicle fuelling system interface		(2014)	(1999)		(2009)	
Safety						
SAE J2578[147]: Recommended Practice for General Fuel Cell Vehicle Safety						(2002)
ISO 23273/2013[148]: Fuel cell road vehicle – Safety Specifications			(2013)	(2013)	(2013)	
Example vehicle models						
Example vehicle models			Toyota FCV-R		Hyundai - Kia ix35 FCEV	GM HydroGen4

LEGEND: *Domestic; : International; : Applicable (year)*

135 http://standards.sae.org/j2579_201303/
136 http://www.fuelcellstandards.com/2.1.3.7.htm
137 http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=39892
138 http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=52871
139 http://standards.sae.org/j2719_201109/
140 http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=24769
141 http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=51569
142 http://standards.sae.org/j2600_201211/
143 http://standards.sae.org/j2601_201407/
144 http://standards.sae.org/j2799_201404/
145 http://www.iso.org/iso/catalogue_detail.htm?csnumber=51194
146 http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=23570
147 http://standards.sae.org/j2578_201408/
148 http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=64047

The for EU car manufacturers important market USA has produced domestic standards, while all other countries (including EU) follow international standards. This introduces difficulties for all vehicle manufacturers outside the USA to sell their vehicles there. The safety standards in Japan for refuelling stations might be too strict, requiring additional costs which might not be necessary.

Biofuels

Biofuels can be blended and used in many different concentrations. Regulations and specifications of both bioethanol and biodiesel composition vary widely between countries. Requirements refer to blending volumes for biofuels with gasoline or diesel whereas specifications refer to the quality of the biofuel that is to be blended. These standards are either mandatory on a national scale, optional if they have already been introduced but used on a voluntary basis, and demonstrative if these standards are only used in pilot projects. Table 23 depicts the bioethanol blends currently in place in the countries of study and indicates if they are mandatory, applicable to all vehicles and valid in every region. Table 24 summarises the same for the biodiesel blends.

Table 23: Overview of fuel blends for bioethanol in the countries of study

Country	E3	E5	E10	E15	E18-25	E75-85	E100
Brazil					Req. ANP36[156]		Spec. ANP36[150]
China			Req. 6 provinces and 30 cities				
Japan	Req. JASOM361[149]		Standard JASOM361[149]				
Russia							
Korea	Req.	Req.					
USA			Req.	Req.		Req. ASTMD5798[150]	Spec. ASTMD4806[163]

LEGEND: Mandatory; Optional; Demonstrative;
Requirement (Req.): *standard for blending volumes;* **Specification (Spec.)**: *standard for biofuel quality*

Table 24: Overview of fuel blends for biodiesel in the countries of study

Country	B2-4	B5-7	B6-20	B20	B100
Brazil		Requirement ANP42[159]			
China	Requirement Hainan only				Specification GBT20828[151]
Japan		Requirement JIS K 2390[152]		Specification Municipal buses in Kyoto	Specification Garbage trucks in Kyoto
Russia					
South Korea	Requirement KSM2619[153]			Requirement	Specification
USA			Requirement ASTMD7467[154]		Specification ASTMD6751[155]

LEGEND: Mandatory; Optional; Demonstrative;
Requirement: *standard for blending volumes;* **Specification**: *standard for biofuel quality*

149 https://global.ihs.com/doc_detail.cfm?document_name=JASO%20M361&item_s_key=00517609
150 http://www.astm.org/Standards/D5798.htm
151 http://www.spc.org.cn/gb168/online/ISO%252020828%253A2006%2520EN/
152 http://kikakurui.com/k2/K2390-2008-01.html
153 http://www.freestd.us/soft4/4397710.htm
154 http://www.astm.org/Standards/D7467.htm
155 http://www.astm.org/Standards/D6751.htm

Following our focus on biofuel blends, Table 25 provides a brief description of other existing standards related to biofuel composition, quality, test method and sustainability.

Table 25: Overview of standards applicable to biofuels in the countries of study

Country	Ethanol	(Bio)diesel	ISCC	ISO/PC 248	RSB
Brazil	**ANP 36**[156]: Specifications for hydrous and anhydrous ethanol blends **Bonsucro Standard**[157]: Production and chain of custody of sugar cane	**ABNT NBR 15512**[158]: Storage, transport, supply and quality control of biodiesel and diesel **ANP 42**[159]**:** Specifications for Biodiesel B100	○	○	○
China			○	○	○
Japan			○	●	○
Russia	**GOST R 54200**[160] Biofuel specifications and classes	**GOST R 53605**[161] Automotive fuels - Fatty acid methyl esters (FAME) for diesel engines **GOST R 54200**[162]: Biofuel specifications and classes	○	○	
South Korea			○	○	○
USA	**ASTM D4806**[163]: Standard Specification for Denatured Fuel Ethanol for Blending with Petrol for Use as Automotive Spark Ignition Engine Fuel	**ASTM D7806**[164]: Standard Test Method for Determination of the Fatty Acid Methyl Ester (FAME) Content of a Blend of Biodiesel and Petroleum-Based Diesel Fuel Oil **ASTM D6751**[165]: Standard Specification for Biodiesel Fuel (B100) Blend Stock for Distillate Fuels **MDA Social Fuel Stamp**[166]	○	○	○

LEGEND:
For international standards:

- ***ISCC**: International Sustainability and Carbon Certification*
- ***ISO/PC 248**: Sustainability Criteria for Bioenergy*
- ***RSB**: Roundtable on Sustainable Biomaterials*

○ *Applicable;* ● *Observing country*

The different standards in the different countries does not help to produce a 'global vehicle' which can cope with all the different fuels. In Europe typically EN standards are used. EN 14214 is a European Standard that describes the requirements and test methods for FAME - the most common type of biodiesel.

Natural gas

We divided Natural Gas standards into Compressed Natural Gas (CNG) and Liquefied Natural Gas (LNG). First, Table 26 lists the existing standards, domestic and international, under five technology-related categories in regard to vehicle fuel system, on-board cylinders, fuelling station, safety or quality.

[156] http://www.anp.gov.br/brasil-rounds/round9/round9/Diario_oficial/Resolucao36.pdf
[157] http://bonsucro.com/site/production-standard/
[158] http://www.abntcatalogo.com.br/norma.aspx?ID=322742
[159] http://nxt.anp.gov.br/NXT/gateway.dll/leg/resolucoes_anp/2011/agosto/ranp%2042%20-%202011.xml
[160] http://runorm.com/product/view/2/40750
[161] http://www.runorm.com/product/view/2/37972
[162] http://www.runorm.com/product/view/2/40750
[163] http://www.astm.org/Standards/D4806.htm
[164] http://www.astm.org/Standards/D7806.htm
[165] http://www.astm.org/Standards/D6751.htm
[166] http://www.cifor.org/publications/pdf_files/WPapers/WP71CIFOR.pdf

Table 26: Overview of standards applicable to CNG vehicles in the countries of study

Country	Vehicle fuel system	On-board cylinder	Fuelling station	Safety	Quality
Brazil	● **INMETRO / MDIC 417 ISO 15500**[167]: Road vehicles - CNG fuel system components ● **INMETRO / MDIC 257**[168]: Conformity assessment system components for CNG	● **INMETRO / MDIC 298**[169]: Cylinders for storage of CNG Fuel on Motor Vehicles. ● **NM ISO 11439**[170]: High pressure cylinders for the on-board storage of natural gas as a fuel for automotive vehicles ● **INMETRO / MDIC 328**[171]: Valve Cylinder Storage CNG vehicles	● **ABNT NBR 15600**[172]: CNG storage and decompressing station ● **ABNT NBR 12236**[173]: Criteria of project, building and operation of CNG filling station	● **INMETRO / MDIC 122**[174]: Seal for CNG vehicle after safety inspection	● **ISO 15403**[175]: Natural gas for use as a compressed fuel for vehicles – Designation of the quality
China	● **GB/T 20735**[176]: Pressure regulator of CNG vehicles ● **GB/T 18363**[177]: Filling receptacle of CNG vehicle	● **GB/T 17926**[178]: CNG cylinder valve for vehicle ● **GB 19158**[179]: Steel cylinders for the storage of CNG ● **GB 24160**[180]: Composite cylinders with steel liner for the on-board storage of CNG as a fuel for automotive vehicles	● **GB/T 19237**[181]: CNG dispenser for vehicle ● **GB/T 19236**[182]: Fuelling nozzle for CNG dispenser		
Japan	● **ISO 15500**[183]: Road vehicles - CNG fuel system	● **JGA NGV02**[184]: CNG vehicle fuel containers	● **ISO 14469**[185]: Road vehicles - CNG refuelling connector ● **ISO 15501**[186]:		● **ISO 15403**[175]: Natural gas for use as a compressed

[167] http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=29020
[168] http://www.inmetro.gov.br/LEGISLACAO/detalhe.asp?seq_classe=1&seq_ato=805
[169] http://www.mme.gov.br/documents/10584/1139097/Portaria_Interministerial_nx_298_2008.pdf/b6160a46-f246-4319-bbbb-25d3e0606d7e
[170] http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=44755
[171] http://ftp.inmetro.gov.br/legislacao/detalhe.asp?seq_classe=1&seq_ato=1592
[172] http://www.abntcatalogo.com.br/norma.aspx?ID=57582
[173] http://www.abntcatalogo.com.br/norma.aspx?ID=2920
[174] http://www.inmetro.gov.br/LEGISLACAO/detalhe.asp?seq_classe=1&seq_ato=778
[175] http://www.iso.org/iso/catalogue_detail.htm?csnumber=44211
[176] http://www.spc.org.cn/gb168/online/GB%252FT%252020735-2006/
[177] http://www.spc.org.cn/gb168/online/GB%252FT%252018363-2001/
[178] http://www.spc.org.cn/gb168/online/GB%252017926-2009/
[179] http://www.spc.org.cn/gb168/online/GB%252019158-2003/
[180] http://www.spc.org.cn/gb168/online/GB%252024160-2009/
[181] http://www.spc.org.cn/gb168/online/GB%252FT%252019237-2003/
[182] http://www.spc.org.cn/gb168/online/GB%252FT%252019236-2003/
[183] http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=29020

Country	Vehicle fuel system	On-board cylinder	Fuelling station	Safety	Quality
	components ● **JGA NGV03**[184]: Fuel system components for CNG powered vehicles		Road vehicles - CNG fuel systems ● **JGA NGV04**[184]: Natural Gas dispensing system		fuel for vehicles – Designation of the quality
Russia	● **ISO 15500**[183]: Road vehicles - CNG fuel system components ● **ECE R110**[187]: Specific components of motor vehicles using CNG in their propulsion system	● **ECE R110**[187]: Specific components of motor vehicles using CNG in their propulsion system ● **GOST R 51753**[188]: High pressure cylinders for CNG as a fuel for automotive vehicles			
Korea	● **KS ISO 15500**[183]: Road vehicles - CNG fuel system components	● **KSB ISO 11439**[170]: High pressure cylinders for the on-board storage of natural gas as a fuel for automotive vehicles	● **KS R ISO14469**[185]: Road vehicles - CNG refuelling connector		● **KS I ISO 15403**[175]: Natural gas for use as a compressed fuel for vehicles – Designation of the quality
USA	● **ANSI/IAS PRD 1**[189]: Pressure Relief Devices for NGV Fuel Containers ● **ANSI NGV3/ CSA 12.3**[184]: Fuel system components for CNG powered vehicles	● **ANSI NGV2**[184]: CNG vehicle fuel containers	● **ANSI NGV1**[184]: CNG vehicle fuelling connection devices ● **NFPA30**[190]: Safeguards for dispensing liquid/gaseous motor fuels in fuel tanks of automotive vehicles and marine craft ● **NGV 4/CSA 12**[184]: Natural Gas dispensing system	● **SAE J1616**[191]: Recommended Practice for Compressed Natural Gas Vehicle Fuel	● **NFPA52**[192]: Vehicular gaseous fuel systems code

In the same way, Table 27 summarises the standards applied to LNG vehicles in terms of vehicle component, fuelling station component or fuel quality.

[185] http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=24421
[186] http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=51555
[184] http://www1.eere.energy.gov/cleancities/pdfs/ngv_codes_regulations_seiff.pdf
[187] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:120:0001:0108:EN:PDF
[188] http://www.runorm.com/product/view/2/20812
[189] http://www.scc.ca/en/standardsdb/standards/17767
[190] http://www.nfpa.org/codes-and-standards/document-information-pages?mode=code&code=30
[191] http://standards.sae.org/j1616_199402/
[192] http://www.nfpa.org/codes-and-standards/document-information-pages?mode=code&code=52

Table 27: Overview of standards applicable to LNG vehicles in the countries of study

Country	Vehicle	Fuelling station	Quality
Brazil		**ABNT NBR 15244**[193]: Criteria of project, building and operation of vehicular natural gas filling system from LNG	
China	**GB/T 24963**[194]: Installation and equipment for LNG - Ship to shore interface **GB/T 20368**[195]: Production, storage and handling of LNG	**GB/T 26980**[196]: LNG vehicular fuelling systems code	
Japan		**ISO 12614**[197]: Road vehicles - Liquefied natural gas (LNG) fuel system components	
Russia	**ECE R110**[187]: Specific components of motor vehicles using LNG in their propulsion system		
Korea	**KS V 7474**[198]: Safety valve for cargo tank of LNG carriers **KS B 6941**[199]: General Standard for LNG Storage Tank		
USA	**BSR/CSA LNG -201x**[200]: Standard for LNG Fuel Connection Devices **SAE J2343**[201]: Recommended Practice for LNG Medium and Heavy-Duty Powered Vehicles	**SAE J2645**[202]: LNG Vehicle Metering and Dispensing Systems - Truck and Bus	**SAE J2699**[203]: LNG Vehicle Fuel

Only Korea (CNG) and Japan (LNG) have used international standards, and not introduce barriers to foreign car manufacturers. European Countries support the development of international standards within ISO for refuelling stations and LNG equipment. Some countries however require additional

There are few standards for bio-methane use in vehicles in the countries under study (only in Sweden) even though multiple bio-methane feasibility and potential studies are underway. Most bio-methane standards are gas grid injection specifications, predominantly in European countries[204]. When bio-methane from the grid is used as a vehicle fuel (can be a mixture from natural gas and bio-methane) the same quality criteria as above apply. Nonetheless:

- In January 2015, the ANP205 published its Resolution N.8 setting specifications of bio-methane produced from organic waste and its application for natural gas vehicles, residences and businesses. The first bio-methane powered bus in Brazil was used in Rio Grande do Sul in January 2015[206].
- In the USA there are 8 ongoing state projects for bio-methane from landfills, fuelling around 600 trucks[207].

193 http://www.abntcatalogo.com.br/norma.aspx?ID=69
194 http://www.spc.org.cn/gb168/online/GB%252FT%252024963-2010/
195 http://www.spc.org.cn/gb168/online/GB%252FT%252020368-2012/
196 http://www.spc.org.cn/gb168/online/GB%252FT%252026980-2011/
197 http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=57661
198 http://www.kssn.net/StdKS/ks_detail.asp?k1=V&k2=7474&k3=1
199 http://www.kssn.net/StdKS/ks_detail.asp?k1=B&k2=6941&k3=1
200 http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rrd_25.pdf
201 http://standards.sae.org/j2343_200807/
202 http://standards.sae.org/j2645_200904/
203 http://standards.sae.org/j2699_201107/
204 http://european-biogas.eu/wp-content/uploads/2014/03/8_Mattias-Svensson_standards.pdf
205 http://nxt.anp.gov.br/NXT/gateway.dll/leg/resolucoes_anp/2015/janeiro/ranp%208%20-%202015.xml?f=templates$fn=document-frame.htm$3.0$q=$x=$nc=1926
206 http://www.ngvjournal.com/new-milestone-for-natural-gas-in-brazil-biomethane-is-now-regulated/
207 http://energy-vision.org/wordpress/wp-content/uploads/2012/05/EV-RNG-Facts-and-Case-Studies.pdf

- China[208] has four biogas plants for commercial supply of bio-methane as a vehicle fuel, mostly for taxis and buses.
- The first bio-methane filling station was opened in Seoul in South Korea in 2009[209]. The second biogas upgrading installation was installed in Daegu in 2013 for city buses and other public vehicles.

Obviously international standards provide a level playing field for the introduction of new technology. When industry in some counties develop new technologies faster than others they introduce local standards to speed up the introduction of the technology, because it helps to get new technology accepted by markets. This can hamper the introduction of other technology to that market.

Waterborne & Airborne transport
Many standards are in place for waterborne and airborne transport, mainly because of safety reasons. Only a few standards specifically aim biofuels, these are listed below.

Table 28: Overview of standards applicable to biofuels in waterborne transport

Name	Description
ISO 8217[210]	Marine fuel standards, include 10 grades of residual fuel. FAME is in process of being adapted as a blending component for heavy marine fuel (expected up to 7% concentration).
Energy Efficiency Design Index (EEDI)[211]	Introduced in the IMO's MARPOL Annex VI, imposes mandatory measures to reduce greenhouse gas emissions in international shipping and creates a common metric to improve ship efficiency. Phased in from 2013 to 2025.

Table 29: Standards in use or applicable to biofuels in aviation

Name	Description
Sustainability standards	▪ **Roundtable on Sustainable Biomaterials** (RSB)[212] ▪ **International Sustainability and Carbon Certification** (ISCC)[213]: the most widely used voluntary certification scheme recognised under the European Renewable Energy Directive ▪ **US Renewable Fuel Standard** (RFS)[214]
ASTM standards (technical standards)	▪ **ASTM D4054[215]** – "Standard Practice for Qualification and Approval of New Aviation Turbine Fuels and Fuel Additives" provides guidance on the evaluation of alternative jet fuel. It outlines an iterative process for testing of properties, composition and performance. ▪ **ASTM D7566[216]** – "Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons", issued Sep. 2009. Relevant to 'drop in' fuels with identical composition and properties to petroleum-derived jet A/A1 fuel. Includes two annexes for Fischer Tropsch (FT) and Hydroprocess Esters and Fatty Acids (HEFA), and stipulates a limit of 50% blend volume. Fuels meetings these criteria can be re-identified as conventional fuels in the distribution infrastructure.

Especially for waterborne shipping changes still needs to be made before alternative fuels are accepted as a safe alternative to conventional fuels on which the current rules and regulations are based.

For aviation many initiatives are working on standards for drop-in-fuels, making the uptake of biofuels in aviation as easy as possible.

208 https://www.dbfz.de/fileadmin/user_upload/Vortraege/BiogasWorld2014/16_Bischoff_End.pdf
209 http://www.keei.re.kr/keei/download/seminar/101217/DI101217_a09.pdf
210 http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=59479
211 http://www.theicct.org/sites/default/files/publications/ICCTpolicyupdate15_EEDI_final.pdf
212 http://rsb.org/
213 http://www.isealalliance.org/online-community/organisations/iscc-international-sustainability-and-carbon-certification
214 http://www.afdc.energy.gov/laws/RFS.html
215 http://www.astm.org/Standards/D4054.htm
216 http://www.astm.org/Standards/D7566.htm

Technological developments

With alternative fuels and technologies seen as promising complements to petroleum in the near future and possible substitutes in the long run, continuous technological developments are needed to encourage market take-up of such technologies. R&D programmes have already led to successful demonstration of alternative fuel solutions in transport but further technological improvements coupled with policy action are key to promoting the use of alternative fuels on a wider scale. Below, Table 30 summarises the main research areas of each technology including the most important country-specific developments to date.

Table 30: **Main technological developments so far**[217]

Technology	Current status	Main Focus	Examples of current developments
Electricity	Mature technology in USA, Japan and China with commercialisation of mass produced vehicles At R&D stage in Brazil, South Korea and Russia	Electric battery performance and efficiency	The US Department of Energy implemented the EV Everywhere Grand Challenge in 2012, still in place today, for R&D, Testing, Modelling of EVs across the country to improve performance of vehicle components Chinese electric car manufacturers SAIC and BYD have invested in R&D programmes for continuous improvements in EV technology in China The first Russian EVs have been tested in regional pilot programmes Examples of available EV models worldwide: Tesla S, Chevy Volt, Nissan Leaf, BYD e6, BMW i3
Hydrogen	At demonstration stage in most countries	Fuel cell technology	Ministry of Mines and Energy is working in partnership with other national institutions in Brazil to provide substantial technological and financial support to R&D projects for production, transportation, storage and distribution of hydrogen Toyota has been approved by METI in Japan for self-inspection of hydrogen tanks of their vehicles
Biofuels	Mature and widespread in Brazil Scaling-up in USA At R&D stage in other countries	Biofuel blends and Alternative biofuels	In the USA, Commercial Aviation Alternative Fuels Initiative (CAAFI) is actively studying the deployment of alternative jet-fuels for commercial flights Petrobras in Brazil is currently carrying out and financing technical and commercial feasibility studies for second generation biofuels
Natural gas	Mature technology in Brazil and China Scaling-up in USA, China and Russia At R&D stage in other countries	Im-provements in cylinders and connection with filling stations	Local CNG programmes have been tested and analysed in Brazil to further investigate national vehicle deployment Gazprom is currently investing in R&D on improvements in refuelling and storage infrastructure, constructing filling stations and financing demonstration projects of vehicle deployment in Russia

[217] For this table information has been drawn from websites and reports of governments, car manufacturers, gas suppliers, technology and R&D associations related to hydrogen, electric and biofuel and energy agencies.

Table 31: Overview of bio jet fuel production routes (source: adapted after (Ecofys, 2013))

Production route	Certified for aviation	Type of feedstock	Current technology status	Remarks
Hydrogenated Vegetable Oil (HVO) or Hydroprocessed Esters and Fatty Acids (HEFA)	Yes (2011)	Vegetable oils, waste streams from food industry, by-products of vegetable oil refining, algal oil	Proven and applied commercially (except for algal oil)	Currently the most popular route to produce bio jet fuel. The blending limit is 50%.
Fischer-Tropsch (FT)	Yes (2009)	Woody (lignocellulosic) biomass	Proven but not applied commercially	BA and Solena are cooperating to open a FT bio jet plant in 2015. The blending limit is 50%.
Farnesane (Kotrba, 2014)	Yes (2014)	Iso-Paraffin from sugarcane	Pilot phase	Used in Brazil since July 2014. Produced according to ASTM D7566 standard. The blending limit is 10%.
Hydrogenated Pyrolysis Oil (HPO)	No	Woody (lignocellulosic) biomass	Pilot phase	
Other biomass-/sugar-based biofuels	No	Sugars, Starches		Alcohol-to-Jet route under consideration for ASTM certification

Public acceptance

When a new type of technology is available to the market, still the public acceptance needs to be in favour of these technologies before they get accepted into the market. For example the introduction of E10 (10% ethanol in gasoline) in Germany in 2011 had a poor start because consumers had concerns about damage to their vehicles, whereas the introduction of the same fuel blend in France has been smoother. In 2014 the share of E10 now stands at 17% of gasoline sales in Germany, still less than in France[218].

(KPMG, 2014) studied the public acceptance towards new vehicle technologies in BRIC countries (Brazil, Russia, China and India) versus TRIAD (Japan, Western Europe and North America). From this analysis a growing proportion of customers in the BRIC auto markets are expected to demand greener vehicles, which may be a response to the level of pollution in some of the teeming megacities in China, Brazil, India and Russia. Over the next 5 years, plug-in hybrids are forecast to attract the greatest demand of any electric vehicle, for both TRIAD and BRIC markets. Overall the top priority for buyers remains fuel efficiency.

For the dominant alternative fuel vehicles per country the public perception is described in more detail below.

[218] http://www.ethanolproducer.com/articles/10797/euundefineds-struggle-for-e10

Electricity (China, Japan and USA)
In China public acceptance of electric bicycles is very high, since they make fast and cheap commuting possible. The batteries are cheap lead acid and the maximum allowed speed is often altered (Garth, 2009). The infrastructure cannot follow the uptake and might lower the consumer acceptance.

In the USA, from a 2013 study, only 36% of consumers have a favourable opinion of the electric car[219]. A 2015 study shows this raised to 54%, while almost one-third say they will consider buying an EV in their next car purchase[220]. The limited choice of existing models also constrains consumers just like the widespread perception of a lack of infrastructure (charging points, specialised car workshop, etc…) that are able to welcome them as well as the limited autonomy. Reliability and safety of the car, the fuel economy achieved and ease of use are not associated to electric vehicles (EV) in the minds of consumers. The cost of purchasing and maintaining an electric car is the main barrier to its acquisition. Although many people think that because of the design the maintenance cost go down compare to conventional vehicles. This is not the case, like for instance with Tesla[221].

In Japan 82% of consumers surveyed are in favour of EVs. The Japanese see direct benefits (ease of use, security, reliability, etc.) that are primarily associated with electric vehicles. 61% say they have a good knowledge of the subject and 63% are open to the idea of buying one.

Hydrogen (small market)
The main concern with hydrogen vehicles is safety. Safety concerns include the pressurised storage of hydrogen on-board vehicles. Hydrogen gas is odourless, colourless, and tasteless, and thus unable to be detected by human senses. Unlike natural gas or LPG, hydrogen cannot be odorised to aid human detection; furthermore, current odorants contaminate fuel cells and impair cell functioning. It is also more combustible than gasoline, although flames produce lower radiant heat which limits the chance of secondary fires. Improved on-board storage will reduce safety concerns. Consumers will have to become familiar with and embrace fuel cell technology before FCVs can become widespread. In addition, the durability and reliability of fuel cells will need to be comparable to the lifetime of a conventional passenger vehicle, approximately 14 years[222].

Biofuels (Brazil and USA)
In Brazil the public perception was assessed on biofuels (Unicamp Global-Bio-Pact, 2011). The people are negative to the production of ethanol since production used to be based on slavery. Also food versus fuel discussion influenced a people against biofuels. Positive aspects were: good for the environment and good for the economy.

In the USA the people are negative about corn-based ethanol (Delshad, 2013). In 2013 37 percent of respondents who agreed with the statement “using biofuels, such as ethanol, is a good idea”, compared with 79 percent of respondents who agreed with the same statement in a national phone survey from 2008. The public is willing to pay only slightly more per gallon of fuel to use biofuels instead of gasoline. Support for advanced “cellulosic” biofuels, however, has remained relatively high.

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[219] http://theconsumerfactor.com/en/reasons-why-consumers-do-not-purchase-electric-vehicles/
[220] http://www.consumeraffairs.com/news/consumers-dont-know-much-about-electric-vehicles-but-view-them-positively-102915.html
[221] http://www.torquenews.com/1083/myth-busted-electric-vehicles-cost-more-maintain-gas-cars-do
[222] http://www.c2es.org/technology/factsheet/HydrogenFuelCellVehicles#_edn39

Natural Gas (Brazil, China and India)

Natural gas is cheaper than any oil based fuel in Brazil. The driver for the public is economics. In Brazil sometimes natural gas is cheaper than ethanol and vice versa.

In China the public perception towards natural gas is good, since it is both perceived as clean and cheap. In India the people were not so enthusiastic about the development of the new gas pipeline infrastructure. Also the limited range was seen as an issue. The development of the NGV industry in India has largely been driven by mandates issued by the Supreme Court of India (APEC, 2009).

LPG (Russia and South Korea)

The main government incentive for autogas in Russia is the exemption from excise duty. This, in conjunction with a relatively low pre-tax LPG price, provides a large price differential against gasoline and, to a lesser extent, diesel at the pump.

Environmental restrictions on the use of diesel vehicles have been an important factor behind the success of autogas in Korea (WLPGA, 2012). Also incentives offered to autogas consumers have been very successful (APEC, 2009). General worries are related to the safety and reliability of autogas.

Costs

According to BCG[223] automotive suppliers already searched for production locations where labour cost was cheap, e.g. China, Mexico and Poland. What is new is that because of the shift in global demand of cars to China and India also the wish to have the suppliers close to the car factories is a driver. The most important cost drivers for vehicle production are not the local labour, but material (50%), main machine costs (12%) and overhead labour cost (10%)[224]. Toyota for example (interview: Bart Eelen, 2015) explained that while the production of the Mirai will initially be based in Japan, once the European market increases enough, investments in factories will necessarily be localised where the demand is located.

Overall Costs of alternative fuel technology

Every alternative fuel technology differs in feedstock, production (both for the fuel and the vehicle), transmission as well as distribution costs and in some cases costs vary widely between countries.

Table 32 analyses the cost breakdown of every technology, highlighting the most paramount cost component, and compares their competitiveness and potential, taking into consideration sensitivity to change and future trends.

[223] https://www.bcgperspectives.com/content/articles/automotive_proximity_paradox_balancing_auto_supplier_manufacturing_networks/?chapter=3#chapter3
[224] http://in3.dem.ist.utl.pt/master/thesis/98files/6thesis.pdf

Table 32: Comparison of current costs per technology and future trends[225]

Technology	Current status	Trends
Electricity	▪ Major cost component is battery pack production and development ▪ Transmission costs via electricity grid are rather low, in comparison to other more complex technologies ▪ Operational costs vary with vehicle performance and country but contribute little to the total costs of ownership of EVs	▪ Cost reduction trends of EVs depend on the rate of deployment. The commercialization of mass production EVs is starting in the USA, Japan and China. As a result, cost-competitiveness is expected to increase rapidly ▪ Brazil focuses mostly on biofuels, making it difficult to also get EV deployment under the attention of vehicle buyers ▪ OEMs in Korea do not cope with big competition in South Korea due to early stage of development of EV technology: Koreans buy Korean cars (only <1% are imports) ▪ EV technology is almost non-existent in Russia
Hydrogen	▪ Major cost component is transportation of hydrogen (under high pressure or very low temperatures) and platinum in fuel cells and water splitting cathodes ▪ Costs in storage and refuelling infrastructure are high	▪ Hydrogen technology is still at an R&D stage in most countries of study ▪ Should small demonstration projects be implemented on a wider scale, competitiveness of hydrogen-fuelled vehicles is expected to increase slowly, especially in China, Japan and USA which have started implementing this alternative fuel
Biofuels	▪ Major cost component is feedstock: 90% for biodiesel, 60-80% for ethanol and 30-45% for advanced biofuels. Seasonal fluctuations in cost are also important and impact the stability of supply chains. ▪ Infrastructure costs are low as biofuels are primarily blended into other existing fuels ▪ Transportation costs remain high as the majority of bio refineries are located far from dispensing stations ▪ Capital costs for advanced biofuels are higher than for first-generation biofuels	▪ Ethanol is already a mature and competitive market in Brazil and the USA ▪ However, there is still little emphasis on biofuels in South Korea, Japan, Russia and China ▪ Production costs are sensitive to food-based feedstock market: food prices are high and are expected to increase by 2020, impacting viability of biofuels ▪ Advanced biofuels are just scaling up and are less dependent on feedstock prices. Production costs could fall to competitive levels ▪ Bio-jetfuels are currently produced in small quantities. If conventional jet fuel prices would increase (end of 2014 they are decreasing) and with further technological developments in alternative fuel pathways, there is significant potential for biojet fuel
Natural gas	▪ Evenly distributed between feedstock, fuel transport, storage and refuelling ▪ Infrastructure costs are low for CNG as the technology is already widespread in most countries and pipeline networks are in place ▪ The CNG refuelling stations are expensive, since they require both compressors and buffers ▪ The LNG refuelling stations are expensive, since they require cryogenic storage and pumps ▪ The costs for producing natural gas are so low that still the fuel can be offered at competitive process at the pump	▪ Total costs of ownership for natural gas vehicles are often lower than for other advanced technologies (e.g. electric vehicles and biofuels) ▪ With the existing infrastructure and with more funding for improvements in pipeline network and refuelling stations (e.g. in Russia), the availability of natural gas for transport is bound to increase and the technology can be expected to take off rapidly

[225] For this table information has been drawn from websites and reports of governments, car manufacturers, gas suppliers, technology and R&D associations related to hydrogen, electric and biofuel and energy agencies.

Technology	Current status	Trends
LPG	▪ Evenly distributed between feedstock, fuel transport, storage and refuelling	▪ LPG technology is already mature in Russia and Korea due to availability of feedstock and existing infrastructure ▪ LPG deployment is low on the agenda of other countries and not financially stimulated. Therefore an uptake is not expected in these countries in the near future

Costs (projections) of refuelling stations

According to Toyota, hydrogen refuelling stations could cost up to 600 million yen – 700 million yen (approximately €5 million), which is however half the price of the prototype H_2 station in Bolzano, Italy (€9.5 million). Most costs are related to security requirements set by law, which could potentially be saved through a set of regulatory simplifications and by lowering of standards, which the Japanese government seems to be considering[226]. While the cost of the infrastructure is expected to lower as economies of scale and technology develop, estimates can hardly be made at this early stage. (Interview: Bart Eelen, 2015) claims that decreasing costs have already been reported by manufacturers, as the technology develops. Every station is currently developed as a prototype project, which entails higher costs compared to an established process.

According to the Energy Information Administration, in the USA a LNG fuelling site can range from USD 1 to USD 4 million[227] (1.8 for a CNG station). This construction cost is expected to lower in the near future because of economy of scale, even if it is hard to assess the percentage of cost reduction toward the upcoming decades.

The cost of a single electric slow charging at home vary from several hundreds of euro's to USD 60,000 euro per curb side charger[228]. The standardised fast charger stations currently installed by Fastned (with at least two fast chargers) in the Netherlands cost around €200,000[229]. Others report cost varying from €400 for a slow home charger to €30,000/plug for public fast chargers (IEA, 2013).

Costs of alternative fuel and energy

The following figures provide an overview of fuels production and driving costs for selected technologies and energy sources. These figures, derived from data presented in the International Energy Agency's report on alternative transportation fuels (IEA, 2013), also present data for different crude oil prices and technology maturity scenarios. In the current tech scenario emerging technologies have not fully benefited from economies of scale or know-how.

The data on fuel production costs shows that crude oil prices are an important factor affecting the competitiveness of alternative transport fuels. It also shows that further cost decline is expected for most alternative fuels. Hydrogen fuel, in particular, is expected to witness significant cost declines as technology maturity progresses. In the current technology scenario, fossil-based natural gas and coal- and natural gas-derived synthetic fuels are most cost-competitive with gasoline.

[226] Gordon-Bloomfield N. 2014 Japanese Government Revises Rules on Hydrogen Refuelling Stations to Make Them Easier to Install *Transport Evolved* [available at: https://transportevolved.com/2014/12/03/japanese-government-revises-rules-hydrogen-refuelling-stations-make-easier-install/] (Accessed 05/06/2015)
[227] From the Alternative Fuels Data Centre, accessed on 05/06/2015, available at: http://www.afdc.energy.gov/fuels/natural_gas_infrastructure.html
[228] http://cleantechnica.com/2014/05/03/ev-charging-station-infrastructure-costs/
[229] http://www.npex.nl/de-beurs/fastned/fastned-bv

Sugarcane ethanol, a relatively mature technology, is also cost-competitive, even with relatively low crude oil prices. Other biofuels and electricity have the potential to be cost-competitive with gasoline, depending on crude oil prices.

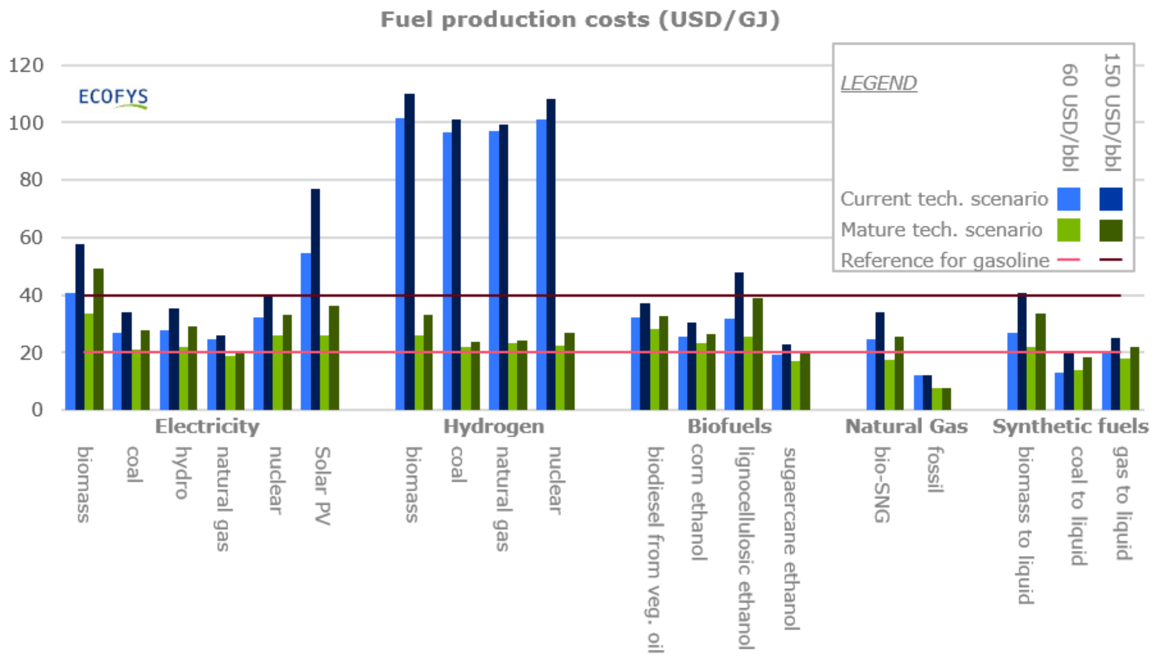

Figure 25: Fuel production costs for a selection of alternative fuels and energy sources (source: adapted from IEA, 2013)

Driving costs provide additional insights into the cost-competitiveness of alternative transport technologies. Figure 26 shows that the cost-competitiveness of alternative transport technologies is also sensitive to crude oil prices and varies significantly depending on technology maturity. A number of alternative fuels are however already cost-competitive. Electricity, in particular has significantly lower driving costs than gasoline in all scenarios and for all energy sources. Biofuels, natural gas and synthetic fuels are also cost-competitive in a number of scenarios. Hydrogen, however, is only expected to become competitive in a mature technology scenario in light of high fuel prices.

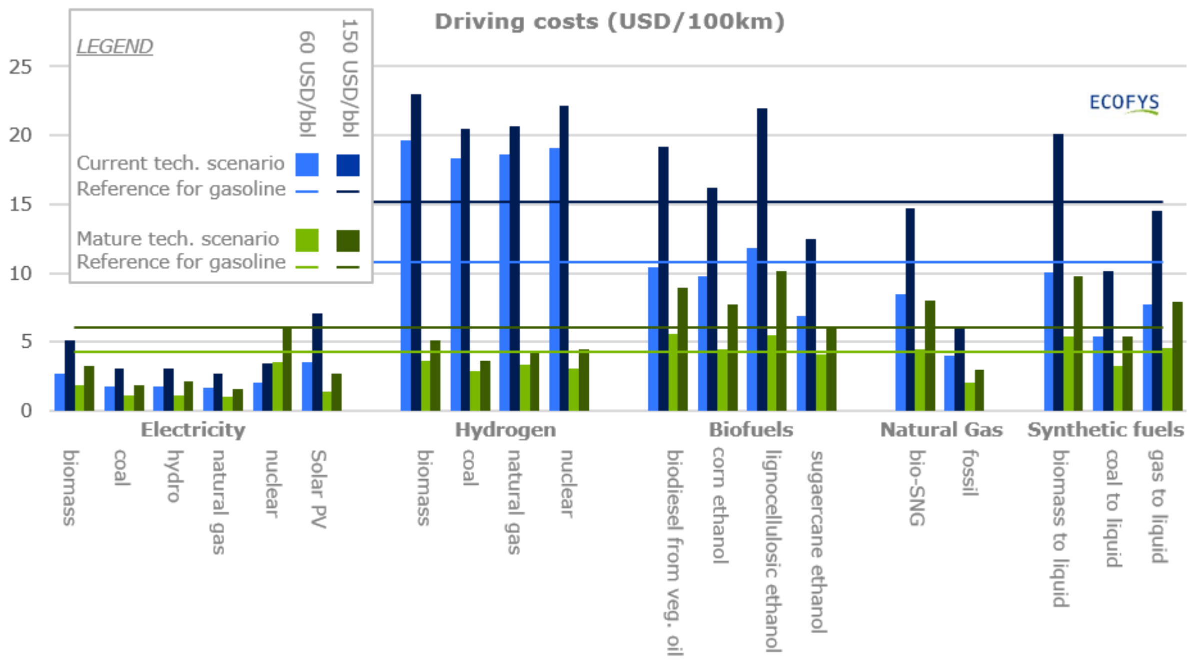

Figure 26: Driving costs for a selection of alternative transportation fuels and energy sources (source: adapted from IEA, 2013)

Costs of alternative fuel vehicles: fuel system components

A conventional fuel system (steel or plastic tank, hoses, pump and injectors) is responsible for a fraction of the vehicle costs, less than 1% of the manufacturing costs. Volvo group explained (interview: Klintbom) that fuel systems for liquid fuels the cost will be minor. The costs for the use of HVO will therefore be also minor. Even the use of DME can be done cost neutral from the vehicle side, when the systems are produced at a larger scale.

The average price of a new car in the USA is just over USD 25,000 (not including light trucks)[230]. The use of alternative fuels and or electricity increase the fuel system costs (and sometimes requires another drivetrain), sometimes to a significant amount of the vehicle costs. (ECF 2014) estimates that fuel cell vehicles production costs in 2020 might be €9,300 more expensive than the average conventional vehicle, pure electric €6,400 more and a plug-in passenger car €4,300 more. A CNG or LPG vehicle is €1,000 more expensive than a gasoline car on which it is based.

The cost of hydrogen vehicles met a steep reduction due to technological development, from the over €94,000[231] Hyundai ix35 FCEV to approximately €78,500 of the Toyota Mirai[232]. This is overall higher than an average same-class conventional fuel vehicle, however, subsidies make the cost to be affordable and more attractive to consumers. As reported by stakeholders (interview: Bart Eelen, 2015) the aim is to reduce costs over time and, accordingly, prices are expected to decrease as the technology further develops. Indeed, the cost of the technology strongly impacts on the consumer price of the final product.

230 http://cta.ornl.gov/vtmarketreport/pdf/2014_vtmarketreport_full_doc.pdf
231 The Hyundai ix35 FCEV in the UK is retailed at £53,105 for private buyers, with that headline price inclusive of a substantial £15,000 government incentive. See http://www.autoexpress.co.uk/hyundai/89099/hyundai-ix35-fuel-cell-car-to-cost-53k-in-the-uk
232 Retail price inclusive of VAT in Germany. See http://insideevs.com/european-sales-toyota-mirai-begin-september/

In particular:

- The number of units that are produced is still low and, therefore, no economies of scale are achieved;
- The production line is still in part non-standardised and requires substantial human labour, which cost necessarily impact the vehicle consumer price;
- Although the technology has been researched since the 90s, the vehicle represents a first generation product: in order to guarantee reliability standards, higher expenses on components and engineering are necessary. Next generation products will build on current experience to optimise cost of components and engineering processes.

All the mentioned elements contribute to raise the price of the Mirai. However, in the next 10 to 15 years (interview: Bart Eelen, 2015) reports that Toyota expects costs to be in line with those of conventional fuelled vehicles.

The performance of the Mirai (as well as that reported for the Honda FCV) is comparable to that of conventional fuel cars, with a cruising range of about 500km - 650 km, and refuelling time requiring only three minutes.

For fuel cell systems the major cost component is platinum in the fuel cell and the water splitting cathode. Hyundai's Tucson Fuel cell vehicle is priced in 2015 at the equivalent of USD 139,000 (excluding subsidies) in Korea; Toyota's Mirai Fuel Cell vehicle (100kW) is priced at the equivalent of USD 62,000 (excluding subsidies) in Japan.

Fuel Cells need to cost USD 30/kW in order to be cost competitive with internal combustion engines[233]. The cost of an 80kW net automotive polymer electrolyte membrane (PEM) fuel cell system based on 2012 technology and operating on direct hydrogen is projected to be USD 47/kW when manufactured at a volume of 500,000 units/year[234]. Both the production volumes need to go up and the amount of platinum per kW need to go down before Fuel Cell vehicles are cost competitive. Most studies do not expect this to happen before 2030-2040.

The major cost component for electrical propulsion is the energy storage: battery pack production and development. Cost reduction trends of EVs depend on the rate of deployment. The commercialization of mass production EVs is starting in the USA, Japan and China. As a result, cost-competitiveness is expected to increase rapidly. A replacement battery for the Tesla Roadster in 2009 was available for USD 36,000, or USD 680/kWh. The price dropped to about USD 400/kWh for the Tesla S in 2014 (and is expected to go down another 30% to a value that Tesla can sell its Tesla 3 for USD 35,000 when Tesla's Gigafactory is ready in 2017. Tesla and its partners will invest ≈USD 4-5 billion in the Gigafactory through 2020. It should be able to build batteries for 500,000 vehicles annually in 2020[235]. People associated with Tesla have said Tesla S battery packs would cost under USD 200/kWh[236].

[233] http://www.iphe.net/docs/Fact_Sheets/Fuel_Cells.pdf
[234] http://www.hydrogen.energy.gov/pdfs/12020_fuel_cell_system_cost_2012.pdf
[235] http://www.teslamotors.com/sites/default/files/blog_attachments/gigafactory.pdf
[236] http://www.greencarreports.com/news/1084682_what-goes-into-a-tesla-model-s-battery--and-what-it-may-cost

Figure 27: Tesla Motors Model S lithium ion battery pack

The most important additional cost for the use of natural gas or bio-methane on board is from the storage containers. In the case of CNG these are pressurised at typically 200-250 bars. LNG double-walled vacuum-insulated pressure vessels store the LNG at cryogenic temperature (-162 degrees), and pressurised at maximum 15 bars. LPG storage on board requires a pressurised storage container, operated typically at 8 bar and tested for safety at maximum 27 bars. Furthermore injectors need to be added that inject the fuel into the inlet or directly into the combustion chamber.

For CNG and LPG the manufacturing costs for the passenger car fuel system are in the same order, around €1,000. The CNG storage cylinders are produces all around the world, with large production facilities in China, India and the USA. LNG storage is more expensive and typically used for larger vehicles (trucks and ships). LNG storage requires heavily insulated pressurises cylinders, that still start to evaporate methane after 7-10 days of stand-still[237]. The largest producers of LNG tanks for trucks are Chart[238] (originally from England) and Cryostar[239] (originally from Switzerland). A double tank system that provides enough fuel for 1,000 km cost around €25,000 and a large single tank around €22,000.

As reported by the Caixin Media Group[240], in 2014 the acquisition cost of LNG vehicles was still higher than for equivalent diesel vehicles: the incremental cost of buses and coaches was about 50,000 yuan (€7,200), whereas for trucks this was in the region of 80,000 yuan (€11,500).

[237] http://www.truckinginfo.com/channel/fuel-smarts/product/detail/2013/04/chart-improves-lng-truck-fuel-system.aspx
[238] http://www.chartindustries.com/
[239] http://www.cryostar.com
[240] From Omnipotent website, Caixin Media Group, accessed on 24/06/2015, available at: http://www.wusuobuneng.com/archives/4960&prev=search

According to Zhangjiagang Rich Reiter species Equipment Co.[241] the difference in cost between diesel and LNG heavy-duty trucks can be as little as 70,000 yuan (€10,000). Volvo Group explained (interview: Klintbom, 2015) that the LNG trucks in China are less efficient than conventional diesel, since they use Otto engines. These engines are 20% cheaper than diesel engines, which helps to bring the initial cost of the vehicle down. The LNG storage tank is bought on the international market and the price for that is similar around the globe.

There are no big (expensive) changes needed at the vehicle level for biofuels, and none with drop-in fuels. Dedicated vehicles which can run high blends of biodiesel and ethanol often require some adjustments (fuel and engine parts seals and elastomers, engine management) to be able to deal with the different fuel specifications.

The cost related to the E10 flexi fuel system are in the order of USD 100 per vehicle compared to 100% gasoline, and USD 25 more for a E85 flexi fuel compared to a E10 according to (TNO, 2011). Conversion kits for conversion from gasoline to E85 are available from a few hundred euros.

Costs of alternative fuel vehicles: powertrain components

Most alternative fuels do not require an alternative powertrain. Four of the fuels studied in this report can be used on conventional powertrains: Biofuels, natural gas, LPG and synthetic fuels. For electric and fuel cell vehicles electric powertrains (and electric motor) is required. Furthermore a fuel cell vehicle is nowadays always a hybrid vehicle, with a battery for energy recovery and way to introduce a smaller fuel cell, the most expensive part.

In electric vehicles a multispeed transmission is not needed and even a reverse is not needed since the electric motor can also be operated in reverse, unlike a conventional internal combustion engine in a car (Argonne, 1999). However, because at vehicle stop there is no engine running all auxiliaries need to be powered from something else than the ICE, and that is typically more expensive. The electric motor and controller costs are in the order of USD 20 per kW. About the same as for the conventional internal combustion engine (Offer, 2009). The additional costs for electric and fuel cell passenger cars are therefore dominated by their batteries or fuel cell & battery parts. In an optimistic scenario for 2030 the fuel cell vehicles will probably be more expensive than a 25kWh EV.

The EV powertrain is expected to be around three times more expensive than the conventional powertrain in 2030 (Offer, 2009). Potentially less costly hydraulic hybrids have been developed by Peugeot and US EPA. In the USA the system has developed in a Parker Hannifin Runwise system for refuse trucks[242]. Interestingly the system is now used in combination of a CNG system in a demonstration project where Parker Hannifin partnered with Autocar LLC., Heil and Republic Services Inc. in Chula Vista, California[243].

[241] From Zhangjiagang Rich Reiter species Equipment Co., accessed on 24/06/2015, available at: http://www.furuise.com/content/509/&prev=search
[242] http://www.greencarcongress.com/2014/10/20141009-runwise.html
[243] http://www.parker.com/portal/site/PARKER/menuitem.31c35c58f54e63cb97b11b10237ad1ca/?vgnextoid=15d48959af246410VgnVCM100000200c1dacRCRD&vgnextchannel=9104fbdc71fd7310VgnVCM100000200c1dacRCRD&vgnextfmt=default

A similar system for passenger cars was under investigation by many OEMs, among which Peugeot. Peugeot even announced vehicles using the system. However, Peugeot shelved the project early 2015, the maker is unable to provide the €500,000,000 required for developing the technology. It was not possible for the company to go at it alone, and the system would have required about 500,000 units to make the project sensible[244]. Hydraulic hybrids (like the one Peugeot has been working on) have the potential to be produced at low cost compared to electric hybrids, as the material costs (oil and steel) are lower than for batteries electric hybrids (batteries and electric controllers).

[244] http://www.motorstown.com/news/4631-innovative-hybrid-air-technology-shelved-by-peugeot-citroen-.html

Annex B: Data tables

Country profiles

Table 33: Selection of demographic, economic and energy indicators for the countries of study (source: public domain, US EIA)

Country	Brazil	China	India	Japan	Russia	S. Korea	USA
Total population (millions)	202.7	1,355.7	1,236.3	127.1	142.4	49.0	318.9
Urban share (%)	84.60%	50.6%	31.3%	91.3%	73.8%	83.2%	82.4%
Land area (thousand km2)	8,515	9,597	3,287	378	17,098	100	9,827
GDP ppp (billion $)	2,416	13,390	4,990	4,729	2,553	1,666	16,720
GDP per capita ($/year)	12,100	9,800	4,000	37,100	18,100	33,200	52,800
Electricity (Net generation, TWh)	530.39	4,490.54	974.88	963.03	996.82	494.7	4,047.77
Electricity (Net consumption, TWh)	478.75	4,207.71	757.95	983.06	869.27	472.19	3,882.60
Oil, production (million bbl/day)	2.69	4.46	0.98	0.14	10.53	0.06	12.35
Oil, consumption (million bbl/day)	3.10	10.12	3.51	4.53	3.32	2.32	18.89
Natural gas (Production, billion m3)	21.30	117.10	33.70	4.57	604.81	0.52	687.59
Natural gas (Consumption, billion m3)	37.60	161.60	51.40	127.21	413.50	53.16	737.2

Electric vehicles

Table 34: Battery Electric Vehicles (BEV) and Plug-in Hybrid Vehicles (PHEV) sales and market shares for leading markets in 2014 (source: IEA, 2015)

Country	BEV sales	% global BEV market	PHEVs sales	% global PHEV market	Total EV sales	Total market share
China	37800	22.2%	16200	12.8%	54000	18.2%
Japan	20000	11.7%	20000	15.8%	40000	13.5%
USA	58500	34.3%	58500	46.4%	117000	39.4%
Rest of the World	54221	31.8%	31508	25.0%	85730	28.9%

Table 35: Market share of electric passenger cars in leading electric vehicle markets, % of total passenger vehicle sales in 2012 & 2013 (source: ICCT, 2014), and 2014 (source ZSW, 2015)

Country	2012	2013	2014*
Norway	3.3%	6.1%	14.0%
Netherlands	1%	5.6%	3.9%
USA	0.8%	1.3%	1.5%
France	0.5%	0.8%	0.8%
Japan	0.5%	0.6%	0.7%
Sweden	0.3%	0.5%	1.0%
Denmark	0.3%	0.3%	0.6%
Austria	0.1%	0.2%	0.4%
Germany	0.1%	0.2%	0.2%
UK	0.1%	0.2%	3.0%
China	0.1%	0.1%	1.1%

*Note: data for 2014 is extrapolation of 2013 data based on vehicle sales ratio

Hydrogen

Table 36: Distribution of hydrogen fuelling stations worldwide (source: www.h2stations.org)

Country	Stations in service	Planned stations	Stations out of service
Europe	72	na	na
Brazil	1	0	1
China	2	1	1
India	3	1	1
Japan	22	17	12
Russia	0	0	0
S. Korea	12	0	0
USA	58	26	44
RoW	16	na	na
TOTAL	186	na	na

Biofuels

Table 37: Biodiesel consumption, million tonnes (source: US EIA, Eurostat)

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
EU	0.75	0.86	1.08	1.37	1.96	2.76	4.80	6.97	9.23	11.22	12.17	12.52	11.41
Brazil	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.33	1.00	1.41	2.22	2.35	2.51
China	0.00	0.01	0.01	0.01	0.01	0.04	0.21	0.10	0.26	0.53	0.51	0.77	0.82
India	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.01	0.05	0.05	0.05	0.06
Japan	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Russia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
South Korea	0.00	0.00	0.00	0.00	0.01	0.01	0.05	0.09	0.17	0.26	0.34	0.33	0.33
USA	0.00	0.03	0.06	0.05	0.09	0.31	0.89	1.22	1.07	1.11	0.94	2.98	3.13
RoW	0.01	0.01	0.01	0.01	0.02	0.06	0.13	0.39	0.91	1.47	2.35	3.04	3.62
WORLD	0.75	0.91	1.16	1.44	2.09	3.21	6.16	9.13	12.65	16.07	18.57	22.04	21.90

Table 38: Ethanol consumption, million tonnes (source: US EIA, Eurostat)

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
EU	0.09	0.10	0.23	0.36	0.49	0.90	1.43	1.84	2.82	3.56	4.51	4.78	5.23
Brazil	7.65	6.49	7.35	6.61	8.12	8.34	8.91	12.02	15.44	18.04	17.52	15.25	16.45
China	0.00	0.00	0.23	0.63	0.79	0.95	1.28	1.32	1.58	1.72	1.68	1.78	1.98
India	0.13	0.14	0.15	0.15	0.16	0.17	0.19	0.21	0.23	0.08	0.04	0.29	0.24
Japan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.04	0.04
Russia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
South Korea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
USA	4.93	5.21	6.20	8.46	10.60	12.14	16.40	20.60	28.90	33.03	38.48	38.58	38.44
RoW	0.27	0.26	0.26	0.29	0.28	0.45	0.67	1.46	1.84	2.31	2.84	3.81	3.98
WORLD	13.08	12.20	14.42	16.49	20.45	22.96	28.88	37.45	50.81	58.75	65.10	64.55	66.38

Natural Gas

Table 39: Number of natural gas vehicles on the road by type, thousands (source: NGVA Europe)

Country	LD vehicles	MD+HD buses	MD+HD trucks	Other	Date
EU	1,079.7	13.2	5.5	0.5	2013*
Brazil	1,744.0	0.0	0.0	0.0	Feb-13
China	1,089.1	376.0	61.9	50.0	May-13
India	1,469.0	23.4	0.7	6.9	Feb-12
Japan	16.6	1.6	22.5	2.0	Mar-13
Russia	65.0	10.0	15.0	0.1	Jun-13
South Korea	3.0	31.8	1.0	0.0	Jan-13
USA	231.4	14.6	4.0	0.0	Feb-13
RoW	10,612.3	310.8	257.4	211.4	
WORLD	16,310.1	781.4	368	270.9	

*Note: 2013 for all EU countries except Lithuania (2012), Latvia, Portugal and UK (2011)

Table 40: Number of natural gas refuelling stations by type (source: NGVA Europe)

Country	CNG	C-LNG	LNG	Date
EU	3,280	36	29	2013*
Brazil	1,793	0	0	Feb-13
China	3,350	400	1,330	May-13
India	724	0	0	Feb-12
Japan	314	0	0	Mar-13
Russia	252	1	1	Jun-13
South Korea	190	0	0	Jan-13
USA	1,438	0	46	Mar-13

*Note: 2013 for all EU countries except Lithuania (2012), Latvia, Portugal and UK (2011)

LPG

Table 41: LPG consumption in the countries of study, million tonnes (source: WLPGA, 2005, 2012, 2014)

Country	2000	-01	-02	-03	-04	-05	-06	-07	-08	-09	-10	-11	-12	2013
EU	3.02	3.58	3.69	3.60	3.93	4.26	4.39	4.48	4.58	4.67	4.78	5.03	5.27	5.42
Brazil	0	0	0	0	0	0	0	0	0	0	0	0	0	0
China	0.34	0.50	0.64	0.69	0.66	0.63	0.85	0.91	0.85	0.88	0.91	0.77	0.63	0.73
India	0	0	0	0	0.04	0.08	0.14	0.28	0.25	0.32	0.32	0.33	0.34	0.32
Japan	1.60	1.54	1.54	1.53	1.58	1.62	1.56	1.58	1.49	1.40	1.20	1.13	1.05	0.98
Russia	0.60	0.70	0.75	0.78	0.69	0.60	0.81	1.00	1.00	1.04	2.30	2.48	2.65	2.85
South Korea	1.03	1.33	1.36	1.74	2.86	3.99	4.02	4.36	4.38	4.46	4.45	4.28	4.10	3.99
USA	0.72	0.75	0.74	0.73	0.74	0.76	0.77	0.68	0.60	0.59	0.58	0.50	0.41	0.41
RoW	7.06	7.03	7.26	7.37	6.68	5.98	6.85	7.06	7.60	7.97	8.32	9.18	10.0	10.1

Note: data for 2004 and 2011 is interpolated

Table 42: LPG vehicles in use, millions (source: WLPGA, 2005, 2012, 2014)

Country	2000	-01	-02	-03	-04	-05	-06	-07	-08	-09	-10	-11	-12	2013
EU	2.73	3.13	3.44	3.47	3.91	4.34	4.50	4.63	4.78	5.52	5.97	6.52	7.07	7.41
Brazil	0	0	0	0	0	0	0	0	0	0	0	0	0	0
China	0.07	0.10	0.13	0.13	0.13	0.13	0.17	0.12	0.10	0.12	0.14	0.14	0.14	0.14
India	0	0	0	0	0	0	0.25	0.50	0.55	1.52	1.32	1.64	1.95	2.10
Japan	0.29	0.29	0.29	0.29	0.29	0.30	0.30	0.29	0.29	0.28	0.29	0.27	0.24	0.23
Russia	0.40	0.50	0.53	0.55	0.53	0.50	0.50	0.60	0.60	0.58	1.28	1.89	2.50	3.00
South Korea	1.21	1.43	1.63	1.72	1.81	1.89	2.05	2.19	2.32	2.30	2.30	2.37	2.43	2.41
USA	0.18	0.19	0.19	0.19	0.19	0.20	0.21	0.20	0.19	0.20	0.20	0.37	0.54	0.54
RoW	2.62	2.80	2.81	3.06	3.58	4.10	4.39	4.77	5.81	5.92	5.97	7.30	8.63	9.06
WORLD	7.5	8.44	9.02	9.41	10.4	11.5	12.4	13.3	14.6	16.4	17.5	20.5	23.5	24.9

Note: data for 2004 and 2011 is interpolated

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- Electric Vehicle Association of Asia Pacific, www.evaap.org
- European Electro-Mobility Observatory: www.ev-observatory.eu
- EVsRoll, www.evsroll.com
- Fuel Cell & Hydrogen Energy Association, www.fchea.org
- Fuel Cell Today, www.fuelcelltoday.com
- Fuel Switch, www.fuelswitch.nl
- Green Car Congress, www.greencarcongress.com
- H2Mobility, www.H2mobility.org
- H2Stations, www.h2stations.org
- International Council for Clean Transportation, www.theicct.org
- International Energy Agency, Hybrid & Electric Vehicle Implementing Agreement, www.ieahev.org
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List of Interviewees (2015)

- Lloyds Register: Kim Tanneberger (lead specialist) & Timothy Wilson (principal specialist)
- Fastned: Niels Korthals Altes (Chief Commercial Officer) & Michiel Langezaal (Co-founder and CEO)
- NGVA Europe: Lennart Pilskog (General Manager)
- Airbus: Frederic Eychenne (Environmental Manager)
- International Association for Natural Gas Vehicles: Diego Goldin (Executive Director NGV Global)
- Federal University of Rio de Janeiro: Prof. Roberto Schaeffer (Environmental Engineering)
- KVNR: Nick Lurkin (Staff Member Environmental Affairs)
- Royal Belgian Shipowners Association: Ludovic Laffineur (Head of Marine policy and Innovation)
- UPS: Peter Harris (Director of Sustainability for Europe, the Middle East and Africa)
- Toyota: Bart Eelen (Senior Manager Public Relations)
- Volvo Group: Patrik Klintbom (Director Environment and Energy)

Annex D: Country factsheets

ECOFYS
sustainable energy for everyone

COUNTRY FACTSHEET
Brazil

Country profile	
Demography	**Energy**
Population: 202,656,788 (2014)	Electricity production: 530.4 GkWh (2013)
Urban share: 84.6 % (2014)	Electricity consumption: 478.8 GkWh (2013)
Rural share: 15.4 % (2014)	Oil production: 2,693.9 kbbl/day (2013)
Geography	Oil consumption: 3097.0 kbbl/day (2013)
Land area: 8,514,877 km^2	Oil, proved reserves: 13.2 Gbbl (2013)
Economics:	Natural gas production: 21.3 Gm^3 (2013)
GDP: 2,416 G$ (2013)	Natural gas consumption: 37.6 Gm^3 (2013)
GDP per capita: 12,100 $/year (2013)	Natural gas, proved reserves: 388.8 Gm^3 (2013)

Alternative transportation market overview

Electricity	Hydrogen	Biodiesel	Ethanol	Natural gas	Bio-methane	LPG
◆ (orange, small)	◆ (orange, small)	◆ (orange, small)	⬆ (green, medium)	▲ (green, medium)	◆ (red, small)	◆ (red, small)

National status (colour)	***International status (size)***	***Trend (shape)***
●*: high attention*	●*: leading market*	⬆*: strong/consistent growth*
●*: on the agenda*	●*: medium market*	▲*: growth trend*
●*: minimal consideration*	●*: small market*	◆*: stable market or inconsistent trend*
		⬇*: decreasing market*

Policies & measures

Name	**Target**	**Timeline**	**Description**
Government Support Programme for Bioethanol	**Competent authority:** Government of Brazil (GOB) **Timeline:** Initially known as Pro-Alcool Program in 1975 by the Brazilian Government. **Target technology:** Biofuels **Geography:** National **Mechanism:** Demand Management **Type:** Law/regulation, Financial incentive **Aim:** Increasing the uptake of bioethanol **Practice:** Setting bioethanol blending mandate in gasoline according to regulations from Sugar and Ethanol Interministerial Council (CIMA). Law 8723 sets mandatory blending levels of 18 to 25%. In 2011, due to high international sugar prices and poor harvest, blend rate dropped to E20. E25 reinstated in 2012. Tax incentives, COFINS credits, R$5 billion credit line by BNDES.		
Programa Nacional de Produção e uso do Biodiesel (PNPB)	**Competent authority:** Ministry of Mines and Energy (MME) and Ministry of Science, Technology and Innovation (MCTI) **Timeline:** Created in 2004. **Target technology:** Biofuels **Geography:** National **Mechanism:** Market uptake, Demand management **Type:** R&D, Law/regulation		

Policies & measures	
	Aim: Examining economic, social, environmental feasibility of biodiesel production and use. **Practice:** Introducing mandates, defining federal tax model for biodiesel, establishing conditions for producer and importer registration. Law 11097 passed in 2005 mandated a minimum 2% biodiesel by 2008 and 5% by 2013. Law 13.033 for new blends at 7% from November 2014. Funds mainly from PRONAF and BNDES in biodiesel infrastructure, R$56 million from MCT in 2007/2008. **Impact:** 69 million litres produced in 2006 to 2.7 billion litres in 2011.
Projeto Onibus Brasileiro a Hidrogenio	**Competent authority:** Ministry of Mines and Energy (MME) **Timeline:** Started in 2002 up to 2011. **Target technology:** Hydrogen **Geography:** Sao Paulo **Mechanism:** Innovation support **Type:** Demonstration **Aim:** Demonstrating technical and operational feasibility of FCV, production and storage of hydrogen. **Practice:** Pilot project of 5 buses and a hydrogen station as a result of Matriz Energetica do Brasil Versao Beta. **Impact:** Pilot project with national impact.
Programa de C,T&I para o etanol	**Competent authority:** Ministry of Science, Technology and Innovation (MCTI) **Timeline:** Implemented in 2007 with a 3-year scope. **Target technology:** Biofuels **Geography:** National **Mechanism:** Incentive to supply **Type:** R&D **Aim:** Financing and promoting national programmes for bioethanol. **Practice:** R$16 million in 2007 for biodiesel. First investments R$5 million for Training of HR for the biofuel sector, R$17 million for support of R&D projects on liquid biofuels (2007), R$26 million funded by the FNDCT for R&D in biodiesel production (2008). **Impact:** Created Centro de Ciência e Tecnologia do Etanol (CTBE) for R&D on biomass and bioethanol.
Plano Decenal de Expansão de Energia (PDE)	**Competent authority:** Energy Research Company (EPE) and Ministry of Mines and Energy (MME) **Timeline:** Created in 2006, updated annually. **Target technology:** Biofuels, Natural Gas **Geography:** National **Mechanism:** Incentive to supply **Type:** R&D, Indicative target **Aim:** Defining national energy strategies till 2023. **Practice:** Analysing supply and demand in energy sector till 2022, including NG and biofuels in transport. R$75 billion for bioethanol production, R$250 million for new biodiesel production units.
Plano Decenal de Expansao de Malha Transporte Dutoviario	**Competent authority:** Ministry of Mines and Energy (MME) **Timeline:** Ten-year plan created in 2013. **Target technology**: Natural Gas **Geography:** National **Mechanism:** Incentive to supply

Policies & measures	
(PEMAT)	**Type:** R&D **Aim**: Outlining specifications of NG industry, expanding NG pipelines. **Mechanism**: Planning expansion and construction of pipelines to transport natural gas considering technical, economic and environmental aspects till 2022. $250 billion attributed to the NG sector (2013-2017). **Impact:** First pipeline approved between the cities of Itaboraí and Guapimirim, linking Petrobras' COMPERJ petrochemical complex to pipeline network in Rio de Janeiro. Provisions regarding other potential pipelines.

Markets & infrastructure	
Electricity BEV vehicles sold per year: na Share of global BEV market: na PHEV vehicles sold per year: na Share of global PHEV market: na EV in circulation: na Charging stations: na	**Hydrogen** Fuelling stations, in operation: 1 (2014) Fuelling stations, planned: 0 (2014) Fuelling stations, out of operation: 1 (2014)
Biofuels Biodiesel production: 2590.7 kt (2012) Biodiesel consumption: 2335.6 kt (2011) Global share of biodiesel consumption: 11 % (2011) Ethanol production: 18572.1 kt (2012) Ethanol consumption: 17881.9 kt (2011) Global share of ethanol consumption: 25.8 % (2011)	**Natural gas** Consumption, reported: 141.6 MNm3 (2012) Consumption, theoretical: 313.9 MNm3 (2012) Light duty NGVs: 1,743,992 (2013) Medium & heavy duty NG Buses: 0 (2013) Medium & heavy duty NG Trucks: 0 (2013) Other NGVs: 0 (2013) Share of NGVs worldwide: 9.8 % (2013) Share of L-M-HD vehicles in country: 5.0 % (2013) CNG stations: 1793 (2013) Share of CNG stations worldwide: 8.1 % (2013)
LPG Consumption: na Share of global LPG consumption: na Vehicles in circulation: na Share of LPG vehicles worldwide: na	

Technological developments	
Technology	**Description**
Electricity and Hydrogen	• **MME and UNICAMP**: Projeto Vega (2005) establishing a testing platform for electric vehicles using fuel cells, providing technical knowledge and support, dimensioning and operating propulsion systems of fuel cell vehicles • **MME and UNDP:** Projeto Onibus a Hidrogeno (2006) studying operational viability of hydrogen production and storage infrastructure for bus fleet in Sao Paulo and Rio de Janeiro, developing Brazilian leadership in fuel cell buses • **Deere&Co, Hydrogenics and Dynetek81:** Fuel cell development for vehicles and machines used for agricultural purposes • **MME:** In partnership with universities, research institutions, companies and government agencies for projects related to hydrogen and electricity production

Technological developments	
	between (2007-2020). Developing Brazilian leadership in hydrogen sector, providing technological support, encourage R&D projects for production, transport, storage, conversion and distribution of hydrogen, studying logistics of hydrogen production, focusing on fuel cell development, establishing norms and regulations • **Various intraministerial institutions:** Produção e Uso do Hidrogênio no Brasil programme (2007) for developing hydrogen use in different sectors, including transport.
Biofuels	• **Sustainable Aviation Biofuels for Brazil (SABB):** Flightpath to Aviation Biofuels in Brazil (Action Plan, initiated by ICAO). Collaborative effort of FAPESP, Boeing and Embraer. Identifying gaps and barriers related to the production, transportation and use of biofuels for aviation, promoting research and commercialization of a sustainable aviation biofuels supply chain with GHG mitigation • **National Bank for Social and Economic Development (BNDES):** "Paiss Agricola" program for agricultural R&D for sugar-ethanol sector (R$1.9 billion, including investments in advanced biofuels in July 2014) • **SG Biofuels SGB**: With agricultural research institution Embrapa and biodiesel refiner Fiagril (2013) for developments of jatropha as next generation crop for biodiesel and biojetfuel • **Petrobras:** Through the Petrobras Research and Development Center (Cenpes), investments of $0.7 billion so far in renewable sources and biofuels (3 biofuel plants with capacity of 326,000 m3/year, 2 in partnership, 10 ethanol plants). Developing fuels derived from plants and animal fats for biodiesel, studying technical and commercial feasibility for several types of biofuels, introducing the HBio technology (vegetable oil as feedstock for bioethanol, hydrogenation of the mixture diesel and vegetable oil, present in 5 refineries in 2007)
Natural Gas	• **LNG**: Two LNG import facilities (Pecem and Rio de Janeiro), ongoing expansion projects. Third plant being built at Todos Os Santos Bay bringing overall LNG import capacity to 15 billion m3 per year • **CNG**: Taxi fleets in Rio de Janeiro and Sao Paulo adapted to run on CNG with financial incentive given by Government to drivers, set up for World Cup and Olympic Games • **Bio-methane**: first bio-methane powered bus in Brazil was used in Rio Grande do Sul in January 2015

Market players		
Name	**Involvement**	**Notes**
Ministerio de Minas e Energía (MME)	Implementation of R&D programmes, regulations, laws, national initiatives financial incentives in the energy sector, including alternative fuels.	**Type:** Government authority **Technology:** All **Sector:** All
Agência Nacional do Petróleo, Gás Natural e Biocombustíveis (ANP)	Implementation of national policies, establishment of rules, norms and resolutions, regulation of activities, promotion of bids, contracts and agreements with other public agencies and industries in the field of natural gas and biofuels.	**Type:** Government agency **Technology:** NG and biofuel **Sector:** All

Market players		
Comissao Executiva Interministerial do Biodiesel (CEIB)	Subordinate of Casa Civil da Presidência da República, in cooperation with President Committee and 12 Ministries. Viability of production and use of vegetable oil-based biodiesel as alternative energy source, implementation of national laws and rules and main responsible for PNPB.	**Type:** Government coalition **Technology:** Biofuel
Ministerio de Cienca, Tecnologia e Inovacao (MCTI)	Implementation of national policy of technological scientific research and innovation, coordination of activities, promotion of R&D in renewable energies and clean energy technologies, with emphasis on biodiesel and ethanol, through Rede Brasileira de Tecnologia de Biodiesel (RBTB) and Centro de Ciência e Tecnologia do Etanol (CTBE).	**Type:** Government authority **Technology:** Biofuel
International Civil Aviation organization (ICAO)	Dissemination of information, database of activities, development of national standards, support of fuel producers cooperation and fuel supply agreements, initiatives and projects on alternative fuels for aviation, for example Sustainable Aviation Biofuels for Brazil (SABB).	**Type:** UN specialized agency **Technology:** Biofuel **Sector:** Air
Fundo Nacional de Desenvolvimento Científico e Tecnológico (FNDCT)	Financing of R&D activities, company incubator, support of private/public agreements, education in science, including the biofuel sector.	**Type:** National Fund **Technology:** All
National Bank for Social and Economic Development (BNDES)	Financial support mechanisms to Brazilian companies of all sizes as well as public administration entities, enabling investments in all economic sectors. innovation, local development and socio-environmental development, including efficient means of transport, part of the Climate Fund Program and guidelines and environmental criteria for the sugar and ethanol sector.	**Type:** National bank **Technology:** All
Aliança Brasileira para Biocombustíveis de Aviação (ABRABA)	Promotion of public and private initiatives for the development, certification, and commercial production of sustainable biofuels for aviation.	**Type:** Partnerships with public policy makers, airlines, aircraft manufacturers, airport systems and air traffic control **Technology:** Biofuel **Sector:** Air
Petrobras	Production of biodiesel and bioethanol, research initiatives in biofuel technology through Petrobras Research and Development Center (Cenpes).	**Type:** Energy company **Technology:** NG and Biofuel **Sector:** All

Market players		
Empresa de Pesquisa Energética (EPE)	Support of long-term federal energy plans with MME, investments in R&D, promotion of activities and agreements, including Natural Gas and Biofuels for the transport sector.	**Type:** Public research company **Technology:** All
GOL Airlines	Various partnerships to bring biojet fuel to their flights.	**Type:** Airline company **Technology:** Biofuel **Sector:** Air
União da Indústria de Cana-de-Açúcar (UNICA)	Implementation of rules and standards, promotion of agreements/partnerships, communication and education in ethanol production and use.	**Type:** Coalition of public/private companies **Technology:** Biofuel **Sector:** Air

Standards	
Type	**Description**
Electricity	**Name:** ANBT NBR IEC 61851 EV conductive charging system **Competent authority:** Associação Brasileira de Normas Técnicas **Specific target:** Charging system **Description:** International. Conductive AC and DC fast charging. Established in 2013. Specifies general requirements, AC electric vehicle charging station, EV requirements for conductive connection to AC/DC supply.
	Name: ANBT NBR IEC 62196 Plugs, socket-outlets, vehicle connectors and vehicle inlets — Conductive charging **Competent authority:** Associação Brasileira de Normas Técnicas **Specific target:** Equipment **Description:** International. Conductive AC and DC fast charging. Established in 2013. Covers basic interface accessories for vehicle, for use in conductive charging systems.
Hydrogen	**Name:** ISO 14867/1992 Hydrogen fuel – Product specification **Competent authority:** Associação Brasileira de Normas Técnicas **Specific target:** Fuel specifications **Description:** International. Confirmed in 2010. Specifies quality characteristics of hydrogen fuel to ensure uniformity of the hydrogen product for utilization in fuel cell power systems.
	Name: ISO 17268/2012 Compressed hydrogen surface vehicle refuelling connection devices **Competent authority:** Associação Brasileira de Normas Técnicas **Specific target:** Refuelling/dispensing **Description:** International. Confirmed in 2014. Specifies design, safety and operation characteristics of gaseous hydrogen land vehicle refueling connectors.
CNG	**Name:** INMETRO/MDIC 417 ISO 15500 Road vehicles – CNG fuel system components **Competent authority:** Associação Brasileira de Normas Técnicas **Specific target:** Vehicle fuel system **Description:** International. Established in 2007. Approves Technical Regulations of Quality Components for Installation System for Natural Gas Vehicles.

Standards	
	Name: INMETRO/MDIC 257 Conformity assessment system components for CNG **Competent authority:** Associação Brasileira de Normas Técnicas **Specific target:** Vehicle fuel system **Description:** Domestic. Implemented in 2002. Establishes a mechanism for conformity assessment system components for CNG.
	Name: INMETRO/MDIC 298 Cylinders for storage of CNG fuel on motor vehicles **Competent authority:** Associação Brasileira de Normas Técnicas **Specific target:** On-board cylinders **Description:** Domestic. Established in 2008. Approves the Mercosur Technical Regulation of cylinders for storage of Natural Gas - CNG Fuel Used as the Board of Motor Vehicles.
	Name: NM ISO 11439 Gas cylinders - High pressure cylinders for the on-board storage of NG as a fuel for automotive vehicles **Competent authority:** Associação Brasileira de Normas Técnicas **Specific target:** On-board cylinders **Description:** International. Established in 2013. Specifies rrequirements for light-weight refillable gas cylinders intended only for on-board storage of high pressure CNG as a fuel for automotive vehicles.
	Name: INMETRO/MDIC 328 Valve cylinder storage CNG vehicles **Competent authority:** Associação Brasileira de Normas Técnicas **Specific target:** On-board cylinders **Description:** Domestic. Established in 2010. Approval of Resolution No. 33/10 Mercosur - Mercosur Technical Regulation.
	Name: ANBT NBR 15600 CNG storage and decompressing station **Competent authority:** Associação Brasileira de Normas Técnicas **Specific target:** Fuelling station **Description:** Domestic. Established in 2010. Specifies design, construction and operation of fuelling stations.
	Name: ANBT NBR 12236 Criteria of project, building and operation of CNG filling station. **Competent authority:** Associação Brasileira de Normas Técnicas **Specific target:** Fuelling station **Description:** Domestic. Established in 2013. Specifies design, construction and operation of fuelling stations.
	Name: INMETRO/MDIC 122 Seal for CNG vehicle after safety inspection **Competent authority:** Associação Brasileira de Normas Técnicas **Specific target:** Safety **Description:** Domestic. Established in 2002. All motor road vehicles, with a system of CNG, to be identified with the seal NG vehicle after vehicle safety inspection performed.
	Name: ISO 15403 NG for use as a compressed fuel for vehicles – Designation of quality **Competent authority:** Associação Brasileira de Normas Técnicas **Specific target:** Quality **Description:** International. Established in 2006. Designates quality, specification of the quality of CNG fuel. Provide manufacturers, vehicle operators, fuelling station operators and others involved in the compressed-natural-gas vehicle industry with information on the fuel quality for natural gas vehicles (NGVs) required to develop and operate compressed-natural-gas vehicle equipment.

Standards	
LNG	**Name:** ABNT NBR 15244 Criteria of project, building and operation of vehicular natural gas filling system from LNG **Competent authority:** Associação Brasileira de Normas Técnicas **Specific target:** Fuelling station **Description:** Domestic. Confirmed in 2005. Establishes requirements for design, construction and operation of fuelling stations.
Bio-methane	**Name:** Resolução 8 **Competent authority:** Agência Nacional do Petróleo, Gás Natural e Biocombustíveis **Specific target:** Fuel quality **Description:** Setting specifications of bio-methane produced from organic waste and application for natural gas vehicles, residences and businesses. First bio-methane powered bus in Brazil rolled out in Rio Grande do Sul in January 2015.
Biofuel blends	**Name:** Resolução ANP no. 42 **Competent authority:** Agência Nacional do Petróleo, Gás Natural e Biocombustíveis (ANP) **Specific target:** B5-7 **Description:** Established in 2005. For commercial specification of biodiesel only. Mandate was set at 5% (B5) till July 2014, from July to November 2014, blend of B6 introduced. As of November 2014, B7.
	Name: Resolução ANP no. 36 **Competent authority:** Agência Nacional do Petróleo, Gás Natural e Biocombustíveis (ANP) **Specific target:** E18-25, E100 **Description:** Established in 2005. For hydrous and anhydrous ethanol. Blends are constantly revised and adjusted but very between 18 and 25%. Brazilian Sugarcane Industry Association (UNICA) currently pushing for 27.5% blend, under discussion with government. Anhydrous ethanol mixed with gasoline, 20–25% in volume (compulsory). Hydrous ethanol used in ethanol cars E100 and Flexible Fuel Vehicles (voluntary). As of May 2013, ethanol blend of 25%.
Biofuels	**Name:** Resolução ANP no. 36 Specifications for hydrous and anhydrous ethanol blends **Competent authority:** Agência Nacional do Petróleo, Gás Natural e Biocombustíveis (ANP) **Specific target:** Ethanol **Description:** Established in 2005. Chemical specifications of fuel.
	Name: Bonsucro standard - Production and chain of custody of sugar cane **Competent authority:** Better Sugar Cane Initiative **Specific target:** Ethanol **Description:** Qualifies sugarcane biofuel producers, mills and processors. Both sugar and biofuel markets.
	Name: ABNT NBR 15512 Biodiesel — Storage, transport, supply and quality control of biodiesel and diesel BX **Competent authority:** Associação Brasileira de Normas Técnicas (ABNT) **Specific target:** Biodiesel **Description:** Established in 2014. Provides general requirements and processes of storage, transport and supply of biofuel.

Standards	
	Name: Resolução ANP no. 46 Specifications for Biodiesel B100 **Competent authority:** Agência Nacional do Petróleo, Gás Natural e Biocombustíveis (ANP) **Specific target:** Biodiesel **Description:** Established in 2005. Chemical specifications of fuel.
	Name: ISCC Standard **Competent authority:** International Sustainability and Carbon Certification (ISCC) **Description:** Created in 2010 and open for stakeholder contribution (around 250 international associations, corporations, research institutions and NGOs). Examines operational sustainability based on ISCC system by members. Developed the first internationally recognised certification system for biomass. Provides proof of compliance with environmental, social and traceability criteria, and qualifies biomass or biofuel companies for legal recognition. Covers entire supply chains, all kinds of biomass, provides audits on ISCC system documents, offers unique tool of GHG calculation. More than 4800 certificates issued worldwide.
	Name: ISO/PC 248, Sustainability Criteria for Bioenergy **Competent authority:** ISO Technical Management Board (TMB) under initiative led by Associação Brasileira de Normas Técnicas (ANTP) **Description:** First published in 2009. Revision under way for April 2015. Providing international expertise and best practice, identifying criteria that could prevent bioenergy from being harmful to the environment or leading to negative social impacts. Based on consensus of countries. ISO 13065: Standard as a result of ISO/PC 248 meeting in 2010 to meet alternative fuel targets providing transparent basis for all market actors to comply with legal requirements. Regarding production and use of bioenergy in relation to biodiversity, reduction of GHG emissions and promotion of economic and social development in areas where bioenergy is produced.
	Name: RSB standard – Biofuel certification **Competent authority:** Roundtable on Sustainable Biomaterial (RSB) **Description:** Refers to social and environmental assurance through certification to the Roundtable for Sustainable Biomaterials (RSB) standard. Applies to the production, processing, conversion, trade and use of biomass and biofuels, and can be sought by feedstock and biofuel producers and processors, as well as biofuel blenders.

COUNTRY FACTSHEET

China

Country profile	
Demography Population: 1,355,692,576 (2014) Urban share: 50.6% (2014) Rural share: 49.4% (2014) **Geography** Land area: 9,596,960 km² **Economics**: GDP: 13,390 G$ (2013) GDP per capita: 9,800 $/year (2014)	**Energy** Electricity production: 4,490.5 GkWh (2013) Electricity consumption: 4,207.7 GkWh (2013) Oil production: 4,459.4 kbbl/day (2013) Oil consumption: 10,116.6 kbbl/day (2013) Oil, proved reserves: 24.4 Gbbl (2013) Natural gas production: 117.1 Gm³ (2013) Natural gas consumption: 161.6 Gm³ (2013) Natural gas, proved reserves: 4,399.9 Gm³ (2013)

Alternative transportation market overview

Electricity	Hydrogen	Biodiesel	Ethanol	Natural gas	Bio-methane	LPG
⬆	▲	▲	▲	⬆	◆	▲

National status (colour)	International status (size)	Trend (shape)
●: high attention *●: on the agenda* *●: minimal consideration*	*●: leading market* *●: medium market* *●: small market*	*⬆: strong/consistent growth* *▲: growth trend* *◆: stable market or inconsistent trend* *⬇: decreasing market*

Policies & measures

Name	Target	Timeline	Description
Next-generation engine (NGE) strategy	**Competent authority:** State Council **Timeline:** present towards 2020 **Target technology:** Next-generation engine (NGE) **Geography:** National **Mechanism:** Market uptake **Type:** Indicative target, Financial incentive, Guideline **Aim:** By 2020, NGE vehicles will account for 36 percent of total vehicle amount, and save 8.9 percent fuel consumption. (Does not include HEV) **Practice:** Tax deduction: Vehicles with 1.6 L engine (or smaller): In 2009, 50-percent purchase tax deduction; in 2010, 25-percent purchase tax deduction. Guideline: Encourage engine technology development; encourage low emission vehicles with high energy efficiency.		
Cellulosic ethanol strategy	**Competent authority:** State Council **Timeline:** present towards 2020 **Target technology:** Cellulosic ethanol **Geography:** National **Mechanism:** Market uptake **Type:** Indicative target, Guideline, **Aim:** By 2020, non-grain-based fuel ethanol annual production ability will reach 10		

Policies & measures	
	million tons. (3.6 billion gallons) **Practice:** Guideline: Biofuel development should not compete with crops intended for human consumption. Policy inclines to cellulosic ethanol.
Plug-in electric vehicle(PHEV) strategy	**Competent authority:** State Council **Timeline:** present towards 2020 **Target technology:** PHEV **Geography:** National **Mechanism:** Innovation support, Incentive to supply **Type:** Indicative target, R&D **Aim:** By 2020, PEV account for 10 percent of China's total vehicle population. **Practice:** Investment: Government will invest more than RMB 100 billion (US$15 billion) in the next 10 years, to facilitate the development of the entire PEV industrial chain, Technology R&D in EV industry, RMB 50 billion (US$7.4 billion) Commercialization of EV, RMB 30 billion (US$4.4 billion) Commercialization of HEV and PHEV, RMB 20 billion (US$3 billion) Key components of EV, RMB 10 billion (US$1.5 billion) Utilities construction, RMB 5 billion (US$800 million)**.**
"10 cities, 1000 units" Energy-Saving and Alternative-Energy Vehicle Demonstration	**Competent authority:** Ministry of Science and Technology**,** National Development Reform Commission, Ministry of Industry and Information Technology and Ministry of Finance **Timeline:** 2009-2012 **Target technology:** EV and HEV **Geography:** selection of 10 cities **Mechanism:** Innovation support, Incentive to supply, Demand management **Type:** Financial incentive, Demonstration **Aim:** Promote EV and HEV commercialization **Practice:** Battery electric vehicles (BEVs) and hybrid electric vehicles (HEVs) were placed in the field as public buses, Taxis, postal cars, and service cars through government financial subsidies. By the end of 2010, this program had expanded from ten to 25 cities. **Impact:** By the end of December 2012, the total amount of demonstration vehicles in the 25 cities reached 27,432, including 23,032 various vehicles in public service areas and 4,400 privately owned vehicles. There were 12,156 hybrid buses, 3,703 hybrid passenger cars, 2,526 pure electric buses (including plug-in electric buses), 6,853 pure electric passenger cars (including plug-ins), and 2,194 other types.
Shanghai EV Demonstration	**Competent authority:** Ministry of Industry and Information Technology and Ministry of Finance **Timeline:** In January 2011 **Target technology:** EV **Geography:** Regional **Mechanism:** Innovation support **Type:** Demonstration **Practice:** China appointed Shanghai as the EV pilot city in China and the Jiading district of Shanghai as the EV international demonstration zone. The implementation plan of the Shanghai EV international pilot city is to: 1) spend three years building a demonstration base for exploring sustainable development of urban transportation; 2)

Policies & measures	
	organize automotive enterprise clubs and customer clubs; 3) set up three international communication platforms (EV pilot city forum, EV exhibition and EV Championship); and 4) construct four function centers (Commercial Mode Innovation Center, Demonstration Evaluation Center, Operation Service Center and Test Drive/Ride Center).
Direct subsidy for EV and hybrid vehicle buyers	**Competent authority:** Ministry of Industry and Information Technology and Ministry of Finance **Timeline:** 2010-2015 **Target technology:** EV and hybrid **Geography:** **Mechanism:** Market uptake **Type:** Financial incentive **Aim:** Promote sales of EV and HEV **Practice:** The largest subsidy option, of RMB 60,000 (about 7200 EUR), is available to buyers of all-electric cars with a range of over 250 kilometers; the smallest is RMB 35,000 (about 4200 EUR) for plug-in hybrid vehicles that go for over 50 kilometers. Those are available only to buyers of domestic-brand cars. **Impact:** Some provinces or cities (e.g., Beijing, Shanghai, and Guangdong) provide additional bonuses that may double the amount provided at the national level.
Exempted EV from City Car-Purchase Restrictions	**Competent authority:** Beijing Municipal Commission of Transport **Timeline:** Since 2013 **Target technology:** EV **Geography:** Regional **Mechanism:** Demand management **Type:** Law/regulation **Aim:** Promote EV sales **Practice:** Beijing citizens purchasing pure electric vehicles will no longer be exempt from participation in the city's car license plate lottery which is a mainly mechanism of car purchase restriction in order to cut traffic congestion.
Public-transport Liquefied petroleum gas (LPG) conversion programmes	**Competent authority:** **Timeline:** Since 2001 **Target technology:** LPG **Geography:** National **Mechanism:** Market uptake **Type:** Demonstration **Practice:** Introduced Autogas to more Chinese cities and nine were selected to carry out field trials for Autogas use in cars (Beijing, Shanghai, Chongqing, Haikou, Xi'an, Harbin, Urumqi, Shenzhen and Mianyang). **Impact:** Introduced in 11 more big cities in 2008. The total number of cities promoting Autogas reached 25 by the end of 2009. Guangzhou, all of the city's 18 000 taxis and 90% of its 8 000 buses run on the fuel.1 In Hong Kong, all the city's 20 000 taxis now run on Autogas.
Liquefied petroleum gas (LPG) tax deduction	**Competent authority:** Ministry of Finance **Timeline:** Since 2010 **Target technology:** LPG

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Policies & measures	
	Geography: national **Mechanism:** Market uptake **Type:** Financial incentive **Aim:** Improve Liquefied petroleum gas (LPG) price competitive **Practice:** The central government levies no consumption tax on Autogas; the tax is levied on gasoline and diesel (the rates were increased sharply in 2009). In addition, VAT is levied at a rate of 17% on gasoline and diesel, but only 13% on Autogas. Wholesale and retail prices are controlled by the authorities, though there is some flexibility for retailers to adjust prices. **Impact:** Pump price of Autogas was only 60% of that of gasoline and 61% of that of diesel in 2010
12th 5-year Development Plan guidelines on alternative fuels	**Competent authority:** State Council **Timeline:** 2011-2015 **Target technology:** Coal liquefaction and gasification technologies as well as accelerating the introduction of biofuels **Geography:** national **Mechanism:** Innovation support, Incentive to supply, Market uptake **Type:** Indicative target, Guideline, Financial incentive **Aim:** Develop alternative fuels for replacing oil (hereinafter, petroleum alternative fuels). **Practice:** Energy and Environment is one of the three main pillars of the programme with the aim to set more mandatory green targets, promote energy savings and deploy renewable energy technology. Objectives include increasing the portion of non-fossil fuels in the energy mix from 8.3% to 11.4% in five years, setting a carbon intensity reduction target of 17% based on 2010 levels, and investing approximately 15% of GDP in technology around energy efficiency, clean vehicles and renewable energy. The 2015 targets for natural gas are increasing the portion of the energy mix from 4% to 8% and producing 170 billion m3. Other targets are set to a 30% reduction in total oil consumption and carbon intensity from new vehicles, a 15% emissions reduction for passenger operators and a 20% emissions reduction for freight operators.

Markets & infrastructure	
Electricity BEV vehicles sold per year: 8,733 (2012) Share of global BEV market: 16 % (2012) PHEV vehicles sold per year: 1201 (2012) Share of global PHV market: 2 % (2012) EV in circulation: 11,573 (2012) Charging stations: 8,107 (2012)	**Hydrogen** Fuelling stations, in operation: 2 (2014) Fuelling stations, planned: 1 (2014) Fuelling stations, out of operation: 1 (2014)
Biofuels Biodiesel production: 818.0 kt (2012) Biodiesel consumption: 363.3 kt (2011) Global share of biodiesel consumption: 1.7 % (2011) Ethanol production: 1,982.1 kt (2012)	**Natural gas** Consumption, reported: na Consumption, theoretical: 1,514.3 MNm3 (2012) Light duty NGVs: 1,089,070 (2012) Medium & heavy duty NG Buses: 376,025 (2012)

Markets & infrastructure	
Ethanol consumption: 1,779.1 kt (2011) Global share of ethanol consumption: 2.6 % (2011)	Medium & heavy duty NG Trucks: 61,905 (2012) Other NGVs: 50,000 (2012) Share of NGVs worldwide: 8.9 % (2012) Share of L-M-HD vehicles in country: 1.5 % (2012) CNG stations: 3,350 (2012) Share of CNG stations worldwide: 15.1 % (2012)
LPG Consumption: 909 kt (2010) Share of global LPG consumption: 4.0 % (2010) Vehicles in circulation: 143,000 (2010) Share of LPG vehicles worldwide: 0.8 % (2010)	

Technological developments	
Technology	**Description**
Next-generation engine	• Next-generation engine (**NGE**) Downsized gasoline direct injection, Energy-efficiency saving approximately 5 percent • Next-generation engine (**NGE**) Turbocharger, Energy-efficiency saving 3 to 5 percent(dynamic strength improvement) • Next-generation engine (**NGE**) Entire aluminum engine, Energy-efficiency saving 2 to 3 percent (weight reduction) • Next-generation engine (**NGE**) Variable valve timing, Energy-efficiency saving 1 to 3 percent
Ethanol	• Chinese companies are seeking international cooperation within technology R&D. • **COFCO** and **Sinopec** are collaborating with Novozymes on R&D for cellulosic ethanol production. With expected technological breakthroughs in the next three to five years—including better enzymes, efficient yeast strains to convert both C5 and C6 sugars, integrated and optimized engineering processes, and comprehensive utilization of side products like lignin—the unit cost of ethanol production will be reduced dramatically and may be competitive against corn-based ethanol.
EV	• China **BYD** investment on R&D: RMB 2 billion (US$300 million) on the R&D of PEV • **SAIC** investment on R&D: RMB 6 billion (US$900 million) on R&D of EV (RMB 2 billion on new power system; RMB 2 billion on vehicle design; RMB 2 billion on key component) • **DFAC** investment on R&D: RMB 33 billion (US$4.9 billion) on R&D of EV in the next 10 years.
DME for vehicles	• Currently in China, a **market for DME** for vehicles has developed, and production capacity has reached 13 million tons. In Shanghai, a field test of 10 city buses in a commercial bus line that are running on DME is being conducted now.
Fuel cells	• Use of six **fuel cell buses** in China for the 2008 Olympic games and 2010 World Expo.
Bio-methane	• China has four **biogas plants** for commercial supply of bio-methane as a vehicle fuel, mostly for taxis and buses.

Market players	
Name	**Notes**
FOTON	state-owned
BYD Auto	private
FAW	state-owned
BAIC Group	state-owned
CHANAN	state-owned
DONG FENG	
CHANGCHENG Auto	private
GEELY Auto	private
CHERY Auto	
BYD	private
SAIC Motor	
FAW-VW	Joint venture
Dongfeng Nissan	Joint venture

Standards	
Type	**Description**
Electricity	**Name:** GB/T 18487 EV conductive charging system **Competent authority:** Standardization Administration of China (SAC) **Specific target:** Charging system **Description:** International. Conductive AC and DC fast charging. Implemented in 2001. Provides general requirements, AC/DC charging station information, EV conductive connection requirements.
	Name: GB/T 20234 Connection set of conductive charging for EV **Competent authority:** Standardization Administration of China (SAC) **Specific target:** Equipment **Description:** Domestic. Conductive AC and DC fast charging. Implemented in March 2012. Specifies general requirements of connection set, AC charge coupler, DC charge coupler. Corresponds to IEC 62196.
	Name: QC/T 841 EV conductive charge coupler **Competent authority:** National Automotive Standardization Technical Committee **Specific target:** Equipment **Description:** Domestic. Conductive AC charging. Implemented in 2011. Industrial standard with gefinitions, technical parameters, charging mode, classification, performance requirements, test methods and inspection rules. Specifies 2 charging interfaces (in-car charger AC power, DC power for the electric vehicle).
	Name: BYD E6, BYD Ebus, DANZA **Competent authority:** BYD Build Your Dreams **Specific target:** Example vehicle models **Description:** Limited release in 2010, 2014 for buses. Chinese made electric car and electric ebus. Preparing launch of DENZA EV in a joint venture with Daimler in 2014. Equipped with standard AC charging box.

Standards	
Hydrogen	**Name:** GB/T 30719 Liquid hydrogen land vehicle fueling system interface **Competent authority:** Standardization Administration of China (SAC) **Specific target:** Refuelling/dispensing **Description:** International. Implemented in 2014. Equivalent to ISO 13984.
	Name: GB/T 30718 – Compressed hydrogen surface vehicle refuelling connection devices **Competent authority:** Standardization Administration of China (SAC) **Specific target:** Refuelling/dispensing **Description:** International. Confirmed in 2014. Specifies design, safety and operation characteristics of gaseous hydrogen land vehicle refuelling connectors. Equivalent to ISO 17268.
CNG	**Name:** GB/T 20735 Pressure regulator of CNG vehicles **Competent authority:** Standardization Administration of China (SAC) **Specific target:** Vehicle fuel system **Description:** Domestic. Established in 2006.
	Name: GB/T 18363 Filling receptacle of CNG vehicle **Competent authority:** Standardization Administration of China (SAC) **Specific target:** Vehicle fuel system **Description:** Domestic. Established in 2001.
	Name: GB/T 17926 CNG cylinder valve for vehicle **Competent authority:** Standardization Administration of China (SAC) **Specific target:** On-board cylinder **Description:** Domestic. Established in 2009.
	Name: GB19158 Steel cylinders for the storage of CNG **Competent authority:** Standardization Administration of China (SAC) **Specific target:** On-board cylinder **Description:** Domestic. Established in 2003.
	Name: GB 24160 Composite cylinders with steel liner for the on-board storage of CNG as a fuel for automotive vehicles **Competent authority:** Standardization Administration of China (SAC) **Specific target:** Vehicle fuel system **Description:** Domestic. Established in 2009.
	Name: GB/T 19237 CNG dispenser for vehicle **Competent authority:** Standardization Administration of China (SAC) **Specific target:** Fuelling station **Description:** Domestic. Established in 2003.
	Name: GB/T 19236 Fuelling nozzle for CNG dispenser **Competent authority:** Standardization Administration of China (SAC) **Specific target:** On-board cylinder **Description:** Domestic. Established in 2003.
LNG	**Name:** GB/T 24963 Installation and equipment for LNG – Ship to shore interface **Competent authority:** Standardization Administration of China (SAC) **Specific target:** Vehicle **Description:** Domestic. Established in 2010.

Standards	
	Name: GB/T 20368 Production, storage and handling of LNG **Competent authority:** Standardization Administration of China (SAC) **Specific target:** Vehicle **Description:** Domestic. Established in 2012.
	Name: GB/T 26980 LNG vehicular fuelling systems code **Competent authority:** Standardization Administration of China (SAC) **Specific target:** Fuelling station **Description:** Domestic. Established in 2011.
Biofuel blend	**Name:** GB/T20828 Standard for quality control of Diesel fuel BD100 **Competent authority:** National Energy Administration of China **Specific target:** B2-4, B100 **Description:** For blending purposes only. As of 2011, two places in Hainan province implemented biodiesel pilot programs with a blend rate of 2-4%. No official national specification for biodiesel and biodiesel cannot be sold to state owned gas stations, most of it being sold in small private gas stations in the countryside. Specifies 17 items on biodiesel fuel blend stock for distillate fuels.
	Name: Act for Testing Expansion of Ethanol-Blended Gasoline for Cars **Competent authority:** National Energy Administration of China **Specific target:** E10 **Description:** First launched in 2002, mandates introduced in some part of China since 2008. Production premised on use based mandatory blend or consumption planning by the government. No official national specification for ethanol. As of 2014 mandatory blend of ethanol E10 in 6 provinces (Heilongjiang, Jilin, Liaoning, Henan, Anhui, and Guangxi) and another 30 cities in 5 other provinces, accounting for almost 25% of China's total gasoline consumption. In practice the blend rate ranges from 8 to 12%. Ethanol is not allowed to be blended outside of these designated markets. Features Administrative Instructions for Testing Expansion of Ethanol-Blended Gasoline for Cars launched via demonstration projects in 2004.
Biofuels	**Name:** ISCC Standard **Competent authority:** International Sustainability and Carbon Certification (ISCC) **Description:** Created in 2010 and open for stakeholder contribution (around 250 international associations, corporations, research institutions and NGOs). Examines operational sustainability based on ISCC system by members. Developed the first internationally recognised certification system for biomass. Provides proof of compliance with environmental, social and traceability criteria, and qualifies biomass or biofuel companies for legal recognition. Covers entire supply chains, all kinds of biomass, provides audits on ISCC system documents, offers unique tool of GHG calculation. More than 4800 certificates issued worldwide.

Standards	
	Name: ISO/PC 248, Sustainability Criteria for Bioenergy **Competent authority:** ISO Technical Management Board (TMB) under initiative led by Associação Brasileira de Normas Técnicas (ANTP) **Description:** First published in 2009. Revision under way for April 2015. Providing international expertise and best practice, identifying criteria that could prevent bioenergy from being harmful to the environment or leading to negative social impacts. Based on consensus of countries. ISO 13065: Standard as a result of ISO/PC 248 meeting in 2010 to meet alternative fuel targets providing transparent basis for all market actors to comply with legal requirements. Regarding production and use of bioenergy in relation to biodiversity, reduction of GHG emissions and promotion of economic and social development in areas where bioenergy is produced.
	Name: RSB standard – Biofuel certification **Competent authority:** Roundtable on Sustainable Biomaterial (RSB) **Description:** Refers to social and environmental assurance through certification to the Roundtable for Sustainable Biomaterials (RSB) standard. Applies to the production, processing, conversion, trade and use of biomass and biofuels, and can be sought by feedstock and biofuel producers and processors, as well as biofuel blenders.

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COUNTRY FACTSHEET
India

Country profile

Demography	Energy
Population: 1,236,344,631 (2014)	Electricity production: 974.9 GkWh (2013)
Urban share: 31.3 % (2014)	Electricity consumption: 758.0 GkWh (2013)
Rural share: 68.7 % (2014)	Oil production: 982.2 kbbl/day (2013)
Geography	Oil consumption: 3,509.0 kbbl/day (2013)
Land area: 3,287,263 km^2	Oil, proved reserves: 5.7 Gbbl (2013)
Economics:	Natural gas production: 33.7 Gm^3 (2013)
GDP: 4,990 G$ (2013)	Natural gas consumption: 51.4 Gm^3 (2013)
GDP per capita: 4,000 $/year (2013)	Natural gas, proved reserves: 1,330.0 Gm^3 (2013)

Alternative transportation market overview

Electricity	Hydrogen	Biodiesel	Ethanol	Natural gas	Bio-methane	LPG
◆ (orange, small)	▲ (orange, small)	◆ (red, small)	▲ (red, small)	⬆ (green, medium)	◆ (red, small)	▲ (red, medium)

National status (colour)	*International status (size)*	*Trend (shape)*
● *: high attention* (green)	● *: leading market* (large)	⬆ *: strong/consistent growth*
● *: on the agenda* (orange)	● *: medium market* (medium)	▲ *: growth trend*
● *: minimal consideration* (red)	● *: small market* (small)	◆ *: stable market or inconsistent trend*
		⬇ *: decreasing market*

Markets & infrastructure

Electricity	Hydrogen
BEV vehicles sold per year: na	Fuelling stations, in operation: 3 (2014)
Share of global BEV market: 0.8% (2012)	Fuelling stations, planned: 1 (2014)
PHEV vehicles sold per year: na	Fuelling stations, out of operation: 1 (2014)
Share of global PHV market: na	
EV in circulation: 1,428 (2012)	
Charging stations: 999 (2012)	
Biofuels	**Natural gas**
Biodiesel production: 103.5 kt (2012)	Consumption, reported: 163.2 MNm3 (2012)
Biodiesel consumption: 103.8 kt (2011)	Consumption, theoretical: 337.3 MNm3 (2012)
Global share of biodiesel consumption: 0.5 % (2011)	Light duty NGVs: 1,469,004 (2012)
Ethanol production: 1,701.7 kt (2012)	Medium & heavy duty NG Buses: 23,376 (2012)
Ethanol consumption: 273.7 kt (2011)	Medium & heavy duty NG Trucks: 715 (2012)
Global share of ethanol consumption: 0.4 % (2011)	Other NGVs: 6,905 (2012)
	Share of NGVs worldwide: 8.5 % (2012)
	Share of L-M-HD vehicles in country: 3.5 % (2012)
	CNG stations: 724 (2012)
	Share of CNG stations worldwide: 3.3 % (2012)

LPG
Consumption: 321 kt (2010)
Share of global LPG consumption: 1.4 % (2010)
Vehicles in circulation: 1,321,000 (2010)
Share of LPG vehicles worldwide: 7.6 % (2010)

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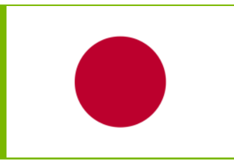
COUNTRY FACTSHEET
Japan



Country profile	
Demography Population: 127,103,388 (2014) Urban share: 91.3 % (2014) Rural share: 8.7 % (2014) **Geography** Land area: 377,915 km^2 **Economics**: GDP: 4,729 G$ (2014) GDP per capita: 37,100 ($/year)	**Energy** Electricity production: 963.0 GkWh (2013) Electricity consumption: 983.1 GkWh (2013) Oil production: 135.4 kbbl/day (2013) Oil consumption: 4,530.8 kbbl/day (2013) Oil, proved reserves: 0.04 Gbbl (2013) Natural gas production: 4.6 Gm^3 (2013) Natural gas consumption: 127.2 Gm^3 (2013) Natural gas, proved reserves: 21.0 Gm^3 (2013)

Alternative transportation market overview

Electricity	Hydrogen	Biodiesel	Ethanol	Natural gas	Bio-methane	LPG
⬆	▲	◆	◆	◆	◆	⬇

National status (colour)	International status (size)	Trend (shape)
●: *high attention* ●: *on the agenda* ●: *minimal consideration*	●: *leading market* ●: *medium market* ●: *small market*	⬆: *strong/consistent growth* ▲: *growth trend* ◆: *stable market or inconsistent trend* ⬇: *decreasing market*

Policies & measures

Name	Target	Timeline	Description
National energy strategy overall target	**Competent authority:** Ministry of Economy, Trade and Industry (METI) **Timeline:** 2006-2030 **Target technology:** all **Geography:** National **Mechanism:** Innovation support **Type:** Indicative target or Binding target **Aim:** Reduce transportation sector dependence on oil to 80% and improve energy efficiency to 30% by 2030		
Next-generation vehicle fuel initiative	**Competent authority:** Japan's Ministry of Economy, Trade and Industry (METI) **Timeline:** Since December 2006 **Target technology:** **Mechanism:** Innovation support **Type:** R&D **Aim:** Focuses on the further development and introduction of four technologies: (1) biofuel, (2) clean diesel fuel, (3) next-generation battery, and (4) fuel cell/hydrogen-based technologies.		

Policies & measures	
Developing Soft Cellulosic Resources Utilization Technology	**Competent authority:** Ministry of Agriculture, Forestry and Fisheries (MAFF) **Timeline:** In 2012 **Target technology:** Bioethanol **Mechanism:** Innovation support **Type:** R&D, Demonstration **Impact:** The project has been succeeded by three Model Demonstration Projects of Local Biofuel Use
Government built bioethanol production facility at Miyako-jima	**Competent authority:** Ministry of the Environment **Timeline:** In 2011 **Target technology:** Bioethanol **Geography:** Regional (Miyako-jima) **Mechanism:** Incentive to supply **Type:** Demonstration **Impact:** It ended trial operations in 2011 and later was restarted Japan Alcohol Corporation is the designated managing entity, with operations carried out by the city government.
Bioethanol project Emissions reduction methodology	**Competent authority:** Domestic Credit Certification Committee **Timeline:** November 30, 2012 **Target technology:** Bioethanol **Geography:** National **Mechanism:** Innovation support **Type:** Guideline **Aim:** Develop greenhouse gas emissions reduction from bioethanol project **Impact:** Enabled application of the Japan Verified Emission Reduction System
New National Energy Strategy for bioethanol vehicles	**Competent authority:** Ministry of Economy, Trade and Industry (METI) **Timeline:** 2006-2020 **Target technology:** Bioethanol **Mechanism:** Demand management, Incentive to supply **Type:** Law/regulation **Practice:** By 2020, re-examine the regulation on the upper blending limit for oxygenated compounds that contain ethanol, with goals of (1) speeding up improvements to the biomass-derived fuel supply infrastructure through the use of environmental and safety countermeasures in gas stations and (2) prompting the automobile industry to accept 10% ethanol mixed gasoline. Moreover, strive to spread the use of diesel cars, the exhaust of which, terms of emissions, is no worse that of gasoline cars. This effort is also important with regard to the use of gasto-liquid (GTL) technologies because a related goal is to promote the use of GTL technologies by the middle of 2010. Examine (1) the existing support for regional efforts designed to expand domestic bioethanol production and (2) the development of support for importing biomass-derived fuels, such as bioethanol. Promote the supply of new fuels, such as biomass-derived fuels. Improve economic efficiency by promoting the development of highly efficient ethanol production and GTL technologies. **Impact:** Since the Great East Japan Earthquake on March 11, 2011, there were major discussions about establishing a new basic energy plan for Japan. The new plan was approved in a Cabinet meeting on April 11, 2014.

Policies & measures	
New National Energy Strategy for Electric and fuel cell vehicles	**Competent authority:** Ministry of Economy, Trade and Industry (METI) **Timeline:** 2006-2014 **Target technology:** Electric and fuel cell vehicles **Geography:** National **Mechanism:** Innovation support **Type:** R&D, Demonstration **Aim:** Promote the dissemination of electric and fuel cell vehicles, which are already about to be put into practical use. **Practice:** Work on the intensive technical development of next-generation batteries and fuel cell vehicles. Establish a safe, simple, efficient, and low-cost hydrogen storage technology. Promote the development and practical application of next-generation vehicles. **Impact:** Since the Great East Japan Earthquake on March 11, 2011, there were major discussions about establishing a new basic energy plan for Japan. The new plan was approved in a Cabinet meeting on April 11, 2014.
EV/PHV town project	**Competent authority:** Ministry of Economy, Trade and Industry (METI) **Timeline:** 2010-2012 **Target technology:** EV/PHV **Mechanism:** Innovation support **Type:** Demonstration **Practice:** Selected several towns as demonstration sites, and bringing together the government actors, municipal governments and local companies to enhance market penetration. (Teratani, 2012)
Hydrogen demo programme	**Competent authority:** The Research Association of Hydrogen Supply/Utilization Technology (HySUT) **Target technology:** Hydrogen **Geography:** Regional **Mechanism:** Innovation support **Type:** Demonstration **Practice:** Involving 14 energy related companies and 4 auto companies are pursuing a number of demonstration projects, including a hydrogen pipeline in Kitakyusyu city built to supply hydrogen to houses, plants, and hydrogen stations
Public financial incentive for Battery Electric Vehicle infrastructure	**Competent authority:** Ministry of Economy, Trade and Industry (METI) **Target technology:** Battery Electric Vehicle **Mechanism:** Market uptake **Type:** Financial incentive **Practice:** Public sector financial support 50% of cost of DC fast charging; 50% of AC normal charging.
Public financial incentive for Fuel Cell Vehicle infrastructure	**Competent authority:** Ministry of Economy, Trade and Industry (METI) **Target technology:** Fuel Cell Vehicle **Mechanism:** Market uptake **Type:** Financial incentive **Practice:** METI - 65 million USD for H2 infrastructure (and vehicle demo), H2 production, transport and storage; budget still to be decided on support for future roll-out of 100 HRS

Policies & measures	
Kanagawa city development	**Competent authority:** City Council **Timeline:** 2008 -2011 **Target technology:** EV **Mechanism:** Market uptake **Type:** Indicative target **Aim:** Kanagawa EV Promotion measures established the goal of increasing the use of EVs to 3,000 in the prefecture by FY2014, and to present programs to be undertaken by the national government, K.P.G., and various businesses. **Practice:** Based on sales of previous hybrid vehicles, which reached 3,000 within five years of their introduction to the market, Kanagawa set a target of 3,000 EVs by 2013. The objective is to create an environment where the rate of electric vehicle sales will equal or surpass hybrid adoption. **Impact:** Kanagawa has more than 2,100 EVs. As of January 31, 2012, the prefecture has 109 DC quick chargers and 341 100/200V outlets

Markets & infrastructure	
Electricity BEV vehicles sold per year: 15,937 (2012) Share of global BEV market: 28% (2012) PHEV vehicles sold per year: 6,528 (2012) Share of global PHV market: 12% (2012) EV in circulation: 44,727 (2012) Charging stations: 5,009 (2012)	**Hydrogen** Fuelling stations, in operation: 22 (2014) Fuelling stations, planned: 17 (2014) Fuelling stations, out of operation: 12 (2014)
Biofuels Biodiesel production: 12.6 kt (2012) Biodiesel consumption: 15.6 kt (2011) Global share of biodiesel consumption: 0.1 % (2011) Ethanol production: 25.0 kt (2012) Ethanol consumption: 45.6 kt (2011) Global share of ethanol consumption: 0.1 % (2011)	**Natural gas** Consumption, reported: na Consumption, theoretical: 75.4 MNm3 (2012) Light duty NGVs: 16,564 (2013) Medium & heavy duty NG Buses: 1,560 (2013) Medium & heavy duty NG Trucks: 22,516 (2013) Other NGVs: 1,950 (2013) Share of NGVs worldwide: 0.2 % (2013) Share of L-M-HD vehicles in country: 0.1 % (2013) CNG stations: 314 (2013) Share of CNG stations worldwide: 1.4 % (2013)
LPG Consumption: 1,202 kt (2010) Share of global LPG consumption: 5.3 % (2010) Vehicles in circulation: 288,000 (2010) Share of LPG vehicles worldwide: 1.6 % (2010)	

Technological developments	
Technology	**Description**
Hydrogen research focus	• In Japan, reports on hydrogen engines were published by the group of Tokyo City University and the National Traffic Safety and Environment Laboratory (NTSEL), Mazda, and Kinki University. Mazda announced a method of improving thermal efficiency in homogeneous-charge, premixed combustion; it focuses on the practicality of a rotary

Technological developments	
	engine using hydrogen as the fuel. • Toyota was approved in 2014 by METI to self-inspect and manufacture hydrogen tanks for fuel cell vehicles. Japanese law requires all pressurized gas containers and accessories to be certified (must meet 194 different requirements and demonstrate a high-level manufacturing quality management system) and undergo extensive safety inspections during the manufacturing process. Toyota can now conduct its own inspections.
Dimethyl Ether (DME) Field tests	• Field tests on two 3.5-ton, DME, gull-wing trucks built by the Isuzu Advanced Engineering Center and registered for commercial use (green license plates) are continuing. The test vehicle in the Kanto region completed the field test at the end of July 2011 after driving a total of 100,000 km. As of the end of February 2012, the test vehicle in the Niigata region had been driven a total of 95,000 km, and the project was finished in 2013.
DME Fuel	• In Japan, two DME trucks are running (with business license plates), with the goal being to develop technical regulations for DME vehicles. The situation in Japan has changed, and commercialization of DME fuel is being accelerated.

Standards	
Type	**Description**
Electricity	**Name:** JISD 61851 EV conductive charging system **Competent authority:** Japan Automobile Research Institute **Specific target:** Charging system **Description:** International. Conductive AC and DC fast charging. Established in 2014. Specifies general requirements, AC electric vehicle charging station, EV requirements for conductive connection to AC/DC supply.
	Name: JISD 62196 Plugs, socket-outlets, vehicle connectors and vehicle inlets — Conductive charging **Competent authority:** Japan Automobile Research Institute **Specific target:** Equipment **Description:** International. Conductive AC and DC fast charging. Established in 2014. Covers basic interface accessories for vehicle, for use in conductive charging systems.
	Name: SAE J1772 EV conductive charge coupler **Competent authority:** SAE International **Specific target:** Equipment **Description:** Domestic. Conductive Level 1 and 2 AC charging.
	Name: JEVS G105 CHAdeMO Quick charger **Competent authority:** CHAdeMO Association **Specific target:** Equipment **Description:** Domestic. Conductive AC and DC fast charging. Established in 2012.
	Name: JEVS G107 EV inductive charging system **Competent authority:** CHAdeMO Association **Specific target:** Equipment **Description:** Domestic. Inductive AC charging.

Standards	
	Name: JEVS C601 EV charging plug and socket **Competent authority:** CHAdeMO Association **Specific target:** Equipment **Description:** Domestic. Conductive AC charging.
	Name: JEVS Z807 Terms of the EV battery **Competent authority:** CHAdeMO Association **Specific target:** Battery
	Name: Nissan Leaf **Competent authority:** Nissan **Specific target:** Example vehicle models **Description:** Introduced in the market in December 2010. Number 1 selling EV car in the world. Available in 3 grades (G, X, S). Equipped with quick chargers. Battery swap option for Model S.
Hydrogen	**Name:** ISO 13985/2006 Liquid hydrogen – Land vehicle fuel tanks **Competent authority:** Japanese Standard Association (JSA) **Specific target:** Fuel tank **Description:** International. Established in 2006. Specifies construction requirements for refillable fuel tanks for liquid hydrogen used in land vehicles.
	Name: ISO TS 15869/2009 Gaseous hydrogen and hydrogen blends - Land vehicle fuel tanks **Competent authority:** Japanese Standard Association (JSA) **Specific target:** Fuel tank **Description:** International. Established in 2009. Specifies rrequirements for lightweight refillable fuel for on-board storage of high-pressure compressed gaseous hydrogen or hydrogen blends on land vehicles.
	Name: ISO 14867/1992 Hydrogen fuel – Product specification **Competent authority:** Japanese Standard Association (JSA) **Specific target:** Fuel specifications **Description:** International. Confirmed in 1999, revised in 2012. Specifies quality characteristics of hydrogen fuel to ensure uniformity of the hydrogen product for utilization in fuel cell power systems.
	Name: ISO 12619/2014 Road vehicles -- Compressed gaseous hydrogen (CGH2) and hydrogen/natural gas blend fuel system components **Competent authority:** Japanese Standard Association (JSA) **Specific target:** Fuel specifications **Description:** International. Established in 2014. Specifies general requirements, performance and safety, pressure regulator.
	Name: ISO 17268/2012 Compressed hydrogen surface vehicle refuelling connection devices **Competent authority:** Japanese Standard Association (JSA) **Specific target:** Refuelling/dispensing **Description:** International. Adopted in 2012. Specifies design, safety and operation characteristics of gaseous hydrogen land vehicle refuelling connectors.
	Name: ISO 13984/1999 – Liquid hydrogen land vehicle fueling system interface **Competent authority:** Japanese Standard Association (JSA) **Specific target:** Refuelling/dispensing **Description:** International. Established in 1999.

Standards	
	Name: ISO 23273/2013 – Fuel cell road vehicle – Safety Specifications **Competent authority:** Japanese Standard Association (JSA) **Specific target:** Safety **Description:** International. Last updated in 2013. Specifies requirements for fuel cell vehicles against hydrogen-related hazards. Only applies to vehicles where compressed hydrogen is used as fuel for the fuel cell system.
	Name: : Toyota FCV-R **Competent authority:** Toyota **Specific target:** Example vehicle models **Description:** First fuel cell prototype demonstrated in 1996. 5 revisions since then. Production of hydrogen Prius began in 2014. Commercialisation plans for 2015. Toyota and BMW jointly developing a fundamental fuel cell vehicle platform by 2020 (fuel cell, hydrogen tank, electric motor, battery system). First prototype hydrogen fuel cell powered RAV4, FCHV-2 (methanol-fuelled), FCHV-3 (metal hydride storage), FCHV-4 (pressurised hydrogen storage), FCHV-5 (hydrogen–gasoline hybrid), and most recently the FCHV-adv.
CNG	**Name: :** ISO 15500 Road vehicles – CNG fuel system components **Competent authority:** International Standard Organization (ISO) **Specific target:** Vehicle fuel system **Description:** International. First version in 2000, revised in 2012. In 20 parts corresponding to each component.
	Name: : JGA NGV03 Fuel system components for CNG powered vehicles **Competent authority:** The Japan Gas Association **Specific target:** Vehicle fuel system **Description:** Domestic. Established in 2012. Establishes requirements for newly produced CNG fuel system components such as valves, gas injector, pressure regulator, filters…
	Name: : JGA NGV02 CNG vehicle fuel containers **Competent authority:** The Japan Gas Association **Specific target:** On-board cylinder **Description:** Domestic. First in 2007, revised in 2012. Establishes requirements that vehicle fuel storage container manufacturers must design, manufacture, test and certify their containers for sale. All vehicle fuel storage containers manufactured to the ANSI NGV2 Standard must have a label indicating among other things the expiration date of the container.
	Name: : ISO 14469 Road vehicles – CNG refuelling connector **Competent authority: :** International Standard Organization (ISO) **Specific target:** Fuelling station **Description:** International. First edition in 2004, 2006, 2007. Specifies CNG refuelling nozzles and receptacles constructed entirely of new and unused parts and materials, for road vehicles powered by CNG. Applicable to CNG in accordance with ISO 15403.
	Name: : ISO 15501 Road vehicles – CNG fuel systems **Competent authority:** International Standard Organization (ISO) **Specific target:** Fuelling station **Description:** International. First version in 2001, revised in 2012.

Standards	
	Name: : JGA NGV04 NG dispensing systems **Competent authority:** The Japan Gas Association **Specific target:** Fuelling station **Description:** Domestic. Established in 2014. Establishes requirements for newly manufactured CNG hose assemblies, intended for use in natural gas dispensing stations. Categorized by hose assembly connecting the dispenser to the fueling nozzle and hose assemblies used on other station equipment.
	Name: : ISO 15403 NG for use as a compressed fuel for vehicles – Designation of the quality **Competent authority:** International Standard Organization (ISO) **Specific target:** Quality **Description:** International. Established in 2006. Designates quality, specification of the quality of CNG fuel. Provide manufacturers, vehicle operators, fuelling station operators and others involved in the compressed-natural-gas vehicle industry with information on the fuel quality for natural gas vehicles (NGVs) required to develop and operate compressed-natural-gas vehicle equipment.
LNG	**Name: :** ISO 12614 Road vehicles – Liquefied natural gas fuel system components **Competent authority:** International Standard Organization (ISO) **Specific target:** Fuelling station **Description:** International. Established in 2014. Has 18 different parts corresponding to LNG components.
Biofuel blends	**Name:** JIS K 2390 Fatty Acid methyl ester (FAME) as blend stock **Competent authority:** Japanese Automotive Standards Organization (JASO) **Specific target:** B5, B20, B100 **Description:** Introduced in 2008, reaffirmed in 2012. Blend rate is 5%. With a special approval from METI, operators are able to use biodiesel with a higher blend rate for trucks and buses (blends of B20 introduced for municipal buses, B100 for city garbage trucks in the City of Kyoto). No national mandate, optional blend. Only for blending purposes. Non mandatory specification standard (JASO/JIS) for FAME as a blending component in diesel oil, up to 5% in mass. JAMA (Japan Automobile Manufacturers Association) drafted the 'JAMA Recommendation on FAME (B100) Specification for up to B5 Blends' specifically suited for the climate in ASEAN region.
	Name: JASOM361 Automotive fuels-Ethanol as blend stock **Competent authority:** Japanese Automotive Standards Organization (JASO) **Specific target:** E3, E10 **Description:** Introduced in 2006. E3 available in some stations. Government permitted sales of E10 gasoline in 2012. No nationalized standard yet. Up to 3% in volume ethanol can be blended into gasoline. JAMA (Japan Automobile Manufacturers Association) drafted the 'JAMA Recommendation on bio-ethanol (E100) Specification for up to E10 Blends' specifically suited for the climate in ASEAN region.
Biofuels	**Name:** ISCC Standard **Competent authority:** International Sustainability and Carbon Certification (ISCC) **Description:** Created in 2010 and open for stakeholder contribution (around 250 international associations, corporations, research institutions and NGOs). Examines operational sustainability based on ISCC system by members. Developed the first internationally recognised certification system for biomass. Provides proof of compliance with environmental, social and traceability criteria, and qualifies biomass or biofuel companies for

Standards	
	legal recognition. Covers entire supply chains, all kinds of biomass, provides audits on ISCC system documents, offers unique tool of GHG calculation. More than 4800 certificates issued worldwide.
	Name: ISO/PC 248, Sustainability Criteria for Bioenergy **Competent authority:** ISO Technical Management Board (TMB) under initiative led by Associação Brasileira de Normas Técnicas (ANTP) **Description:** First published in 2009. Japan as observing country. Not applied yet. **Name:** RSB standard – Biofuel certification **Competent authority:** Roundtable on Sustainable Biomaterial (RSB) **Description:** Refers to social and environmental assurance through certification to the Roundtable for Sustainable Biomaterials (RSB) standard. Applies to the production, processing, conversion, trade and use of biomass and biofuels, and can be sought by feedstock and biofuel producers and processors, as well as biofuel blenders.

COUNTRY FACTSHEET

Russia

Country profile	
Demography Population: 142,470,272(2014) Urban share: 73.8 % (2014) Rural share: 26.2 % (2014) **Geography** Land area: 17,098,242 km^2 **Economics**: GDP: 2,553 G$ (2013) GDP per capita: 18,100 $/year (2013)	**Energy** Electricity production: 996.8 GkWh (2013) Electricity consumption: 869.3 GkWh (2013) Oil production: 10,553.7 kbbl/day (2013) Oil consumption: 3,320.0 kbbl/day (2013) Oil, proved reserves: 80.0 Gbbl (2013) Natural gas production: 604.8 Gm^3 (2013) Natural gas consumption: 413.5 Gm^3 (2013) Natural gas, proved reserves: 47,798.8 Gm^3 (2013)

Alternative transportation market overview

Electricity	Hydrogen	Biodiesel	Ethanol	Natural gas	Bio-methane	LPG
◆ (red, small)	◆ (red, small)	◆ (red, small)	◆ (red, small)	◆ (orange, medium)	◆ (red, small)	⬆ (green)

National status (colour)	*International status (size)*	*Trend (shape)*
● (green): *high attention* ● (orange): *on the agenda* ● (red): *minimal consideration*	⬤: *leading market* ●: *medium market* •: *small market*	⬆: *strong/consistent growth* ▲: *growth trend* ◆: *stable market or inconsistent trend* ⬇: *decreasing market*

Policies & measures

Name	Target	Timeline	Description
Bio2020	**Competent authority:** Russian Federal Government (RFG) **Timeline:** Created in 2012. **Target technology:** Biofuels **Geography:** National **Mechanism:** Innovation support **Type:** Indicative target, R&D **Aim:** Creating the basis for biofuel industry and achieving 10% biofuel share in transport. **Practice:** Investing in development of different branches of biotechnology sector. 367 billion RUB by 2020 for Bioenergetics. Target of 5% share of the world market of motor biofuels by 2020. Funded by federal budget, budgets of constituent territories of the Russian Federation, local budgets and off-budget financing. **Impact:** Transport sector not a priority due to pressure from oil industry.		
Federal Program For Energy Savings and Energy Efficiency	**Competent authority:** Russian Federal Government (RFG) **Timeline:** 2010-2020. **Target technology:** All **Geography:** National **Mechanism:** Innovation support **Type:** Indicative target, R&D		

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Policies & measures	
	Aim: Reducing energy intensity of Russia's GDP by 13.5% by 2020. **Practice:** Based on Decree N. 2446-R. Providing financial incentives of 9.5 trillion RUB for regional energy savings programs (695 billion RUB from federal and regional funding, rest by private investments). Establishing government guarantees for certain projects in transport sector. **Impact:** Total incentives of 22% for the oil and gas sector, including transport.
Energy Strategy of Russia	**Competent authority:** Russian Ministry of Energy (MOE) **Timeline:** Created in 2010 till 2030. Extended in 2009 as was originally for 2020. **Target technology:** All **Geography:** National **Mechanism:** Innovation support **Type:** Indicative target, guideline, R&D **Aim:** Setting targets for energy intensity reduction and share of renewable energy by 2030. **Practice:** Based on Decrees N. 1234-r, N. 1662-r and N.1715-p. Maximizing effective use of renewable energy sources and potential of the energy sector, setting long-term objectives of development, providing guidelines and mechanisms of state energy policy, supporting R&D measures and providing technical assistance. Implemented in three stages: overhaul of the energy sector, technology developments within fuel sector, energy efficiency measures. **Impact:** 56% energy intensity reduction target by 2030 in comparison to 2005.
Gazprom Gazomotornoye Toplivo Investment Program	**Competent authority:** Gazprom **Timeline:** Implemented in 2013. **Target technology:** Natural gas **Geography:** Regional **Mechanism:** Innovation support, Incentive to supply **Type:** R&D, Demonstration **Aim:** Providing incentives for CNG and LNG vehicles. **Practice:** 13.8 billion RUB for construction of CNG/LNG filling stations, 10 pilot projects to convert public and municipal freight transport to NG Vehicles. Constructing 48 CNG stations, upgrading 7 and working on 145 other. Running LNG projects Vladivostok LNG Baltic LNG, LNG regasification terminal in the Kaliningrad.

Markets & infrastructure	
Electricity BEV vehicles sold per year: na Share of global BEV market: na PHEV vehicles sold per year: na Share of global PHV market: na EV in circulation: na Charging stations: na	**Hydrogen** Fuelling stations, in operation: 0 (2014) Fuelling stations, planned: 0 (2014) Fuelling stations, out of operation: 0 (2014)
Biofuels Biodiesel production: na Biodiesel consumption: na Global share of biodiesel consumption: na	**Natural gas** Consumption, reported: 93.0 MNm3 (2012) Consumption, theoretical: 99.0 MNm3 (2012) Light duty NGVs: 65,000 (2013)

Markets & infrastructure	
Ethanol production: 543.0 kt (2012) Ethanol consumption: na Global share of ethanol consumption: na	Medium & heavy duty NG Buses: 10,000 (2013) Medium & heavy duty NG Trucks: 15,000 (2013) Other NGVs: 50 (2013) Share of NGVs worldwide: 0.5 % (2013) Share of L-M-HD vehicles in country: 0.3 % (2013) CNG stations: 252 (2013) Share of CNG stations worldwide: 1.1 % (2013)
LPG Consumption: 2300 kt (2010) Share of global LPG consumption: 10.1 % (2010) Vehicles in circulation: 1,282,000 (2010) Share of LPG vehicles worldwide: 7.3 % (2010)	

Technological developments	
Technology	**Description**
Electricity and Hydrogen	• **Moscow United Electric Grid Company**: First EV charging station in Russia, built in Moscow in 2012 • **AvtoVAZ**: First Russian-made electric car El Lada in 2011, originally used as taxis. Low-volume pilot production program of 1.2 million RUB for the electric El Lada in 2012 • **Federal Organisation for Science and Innovation (FASI):** Russian fuel cell and hydrogen R&D program (Research in hydrogen production, storage, purification and fuel cells), major development include LADA Antel-2 Hydrogen-Air motor and ZIL-5301-HYBRID Combined hydrogen power drive. 200 million RUB spent on 10 projects (2005), 450 million RUB on 48 projects (2007) • **Yo-Auto**: First hybrid electric car Yo-Mobile, in joint venture Yarovit/ONEXIM Group announced in 2010 with an aim of 20,000 cars a year. The Russian entrepreneur Mikhail Prokhorov sold the project, in 2014, to FGUP NAMI (federal state unitary enterprise) for 1€ (Plant already available near St. Petersburg but real production pushed back to 2015)
Natural Gas	• **Kamaz**: Launched the CNG Bravis (2013, CNG city bus in Chelyabinsk, in joint-venture with MARCOPOLO). Completed the 2,700km test race in the Silk Way Rally Raid (2013) • **2013-2014 Gazprom Gazomotornoye Toplivo Investment Program:** Provided 13.8 billion RUB for construction of CNG filling stations, cryogenic filling stations and LNG facilities in more than 30 Russian cities. Collaboration with regional authorities on 10 pilot projects to convert public and municipal freight transport to NG Vehicles. Agreements on of methane as a vehicle fuel already signed with 7 regions. Agreements signed with major motor vehicle manufacturers for developments in NG machinery and equipment, with mining clients and mining equipment manufacturers, Memorandum of Cooperation in the NGV sector with Russian Railways. CNG fuel station works by Gazprom (currently constructing 48, upgrading 7 and working on design of 145 other). Running LNG projects Vladivostok LNG (LNG plant of 10 million tons for 2018), Baltic LNG (10 million tons, for 2018), LNG regasification terminal in the Kaliningrad Region (daily capacity of 9 million m3 of gas). • **Chart (gas processing company)**: Development of storage options, filling stations and fuelling systems for marine industry, LNG for trucks and buses, and its own liquefaction technology (obtained GOST-R certification in 2014 for their LNG to be used

Technological developments	
	in the Russian market, European ECE R110 certification) • **Saint Petersburg Initiative SPbI**: Cooperation with TRAFI (Finnish Transport Safety Agency) amongst others (HELCOM, ESSF, IMO), deployment of infrastructure, compliance of norms, investments in green shipping. Launched platform for Green Technology and Alternative Fuels, including LNG and biofuels, organised Conference on "Sustainable Baltic Sea Shipping" on board of LNG fuelled passenger ship Viking Grace in January 2014
Biofuels	• **Russian Railways**: Testing of rapeseed biodiesel on the locomotives in the Voronezh-Kursk depot (2006) • **Institute for Electrification of Agriculture**: Construction of small biogas plants (for individual farms, pyrolysis of biomass, conversion of 70% of dry matter into liquid and gaseous fuel) • **Concept of Development of Bioenergetics and Biotechnologies:** First pilot projects of construction of biogas stations in Belgorod Region and on Strigunov pig complex (2009-2012) • **Russia Industry and Trade Ministry**: Development of alternative fuels for civil aviation 2013 (628 million RUB, developing cryogenic fuels and biofuels for use in aircraft and studying use of NG in aviation) • **Agrodiesel**: In Kostroma Region, pilot project of production of fuel ethanol from non-food vegetables (girasol) with a target of 50,000 tons of bioethanol • **Russian Technologies State Corporation "Rosteknologii":** New plans for construction of biofuel plant in the Irkutsk Region for production of bioethanol from forestry processing wastes (estimated investments of $20 million) • **Airbus and RT-Biotechprom**: Renewable Biojet Fuel Partnership signed in 2013 to make aircraft biofuel from renewable sources in Russia

Market players		
Name	**Involvement**	**Notes**
Federal Government	Decision on policies, measures and targets of the energy sector, including for alternative fuels in Russia.	**Type:** Government Authority **Technology**: All
Russian Energy Agency (REA)	Implementation of federal policy on energy savings and energy efficiency.	**Type:** State institution **Technology**: All
Ministry of Education and Science	Former Federal Organisation for Science and Innovation (FASI), R&D investments for fuel cell and hydrogen technology.	**Type:** Government Authority **Technology**: Electricity and hydrogen
Russian Biofuels Association	Promotes use of biodiesel and bioethanol in Russia and neighbouring countries.	**Type:** Private-public Association **Technology**: Biofuel
AvtoVaz	First Russian made electric car.	**Type:** Car manufacturer **Technology**: Electricity
Gazprom	The only producer and exporter of LNG, controls 16% of world's NG	**Type:** Oil producer and Natural Gas supplier

Market players		
	reserves. Major investments and pilot projects on Russian CNG and LPG market.	**Technology**: LNG and CNG
Kirov BioChemical Plant Ltd	Only producers in Russia of bioethanol from wood waste on industrial scale further used as motor fuel. Projects on hydrogen production.	**Type:** Macrobiological company **Technology**: Biofuel and hydrogen
Yo-engineering	Developed motor and electronics of the Hybrid Transmission for Yo-Auto.	**Type:** Engineering and consulting services for automotive industry **Technology**: Electricity
Caucasus Environmental NGO Network (CENN)	In cooperation with the Global Fuel Economy Initiative (GDEI), developing "Initiation of an Auto Fuel Efficiency Programme in Georgia" for national fuel economy plans, targets and policies.	**Type:** NGO **Technology**: All
Chart	Obtained GOST R certification for LNG vehicle fuel systems.	**Type:** LPG equipment manufacturer **Technology**: LPG
Saint Petersburg Initiative (SPbI)	Investments in "Green Shipping" for preservation of Baltic Sea Environment, especially LPG shipping.	**Type:** Public-private partnership **Sector**: Water

Standards	
Type	**Description**
Hydrogen	**Name:** GOST ISO 13985/2006 Liquid hydrogen – Land vehicle fuel tanks **Competent authority:** Gosudarstvennyy Standart (GOST) **Specific target:** Fuel tank **Description:** International. Established in 2013. Specifies construction requirements for refillable fuel tanks for liquid hydrogen used in land vehicles.
	Name: GOST R 55466 Hydrogen fuel – Product specification **Competent authority:** Gosudarstvennyy Standart (GOST) **Specific target:** Fuel specifications **Description:** International. Established in 2013. Specifies quality characteristics of hydrogen fuel to ensure uniformity of the hydrogen product for utilization in fuel cell power systems. Equivalent to ISO 14867/1992.
	Name: GOST R 54113 Compressed hydrogen surface vehicle refuelling connection devices **Competent authority:** Gosudarstvennyy Standart (GOST) **Specific target:** Refuelling/dispensing **Description:** International. Adopted in 2012. Specifies design, safety and operation characteristics of gaseous hydrogen land vehicle refueling connectors. Equivalent to ISO 17268/2012.

Standards	
	Name: ISO 23273/2013 – Fuel cell road vehicle – Safety Specifications **Competent authority:** Gosudarstvennyy Standart (GOST) **Specific target:** Safety **Description:** International. Last updated in 2013. Specifies requirements for fuel cell vehicles against hydrogen-related hazards. Only applies to vehicles where compressed hydrogen is used as fuel for the fuel cell system.
CNG	**Name: :** ISO 15500 Road vehicles – CNG fuel system components **Competent authority:** International Standard Organization (ISO) **Specific target:** Vehicle fuel system **Description:** International. First version in 2000, revised in 2012. In 20 parts corresponding to each component.
	Name: ECE R110 Specific components of motor vehicles using CNG in their propulsion system **Competent authority:** United Nations Economic Commission for Europe (UNECE) **Specific target:** Vehicle fuel system **Description:** Domestic. First drafted in 1995. Part of the standard on requirements an test methods for CNG vehicle components.
	Name: ECE R110 Specific components of motor vehicles using CNG in their propulsion system **Competent authority:** United Nations Economic Commission for Europe (UNECE) **Specific target:** On-board cylinder **Description:** Domestic. First drafted in 1995. Part of the standard on CNG cylinder requirements. Provides test methods of cylinder design for CNG services.
	Name: GOST R 51753 High pressure cylinders for the on-board storage of NG as a fuel for automotive vehicles **Competent authority:** GOSSTANDARD (Russian Governmental Standards Organization) **Specific target:** On-board cylinder **Description:** Domestic. Implemented in 2002.
LNG	**Name:** ECE R110 Specific components of motor vehicles using LNG in their propulsion system **Competent authority:** United Nations Economic Commission for Europe (UNECE) **Specific target:** Vehicle **Description:** Domestic. First drafted in 1995. Provides test methods of cylinder design for LNG services.
Biofuels	**Name:** GOST R 54200 Biofuel specifications and classes **Competent authority:** Gosudarstvennyy Standart (GOST) **Specific target:** Ethanol, diesel **Description:** Established in 2010. Resources saving. Energy production. Guidance on implementing the best available techniques for improving energy efficiency in fuel combustion
	Name: GOST R 53605 Automotive fuels. Fatty acid methyl esters (FAME) for diesel engines **Competent authority:** Gosudarstvennyy Standart (GOST) **Specific target:** Ethanol **Description:** Established in 2009. Provides general technical requirements.

Standards	
	Name: ISCC Standard **Competent authority:** International Sustainability and Carbon Certification (ISCC) **Description:** Created in 2010 and open for stakeholder contribution (around 250 international associations, corporations, research institutions and NGOs). Examines operational sustainability based on ISCC system by members. Developed the first internationally recognised certification system for biomass. Provides proof of compliance with environmental, social and traceability criteria, and qualifies biomass or biofuel companies for legal recognition. Covers entire supply chains, all kinds of biomass, provides audits on ISCC system documents, offers unique tool of GHG calculation. More than 4800 certificates issued worldwide.
	Name: ISO/PC 248, Sustainability Criteria for Bioenergy **Competent authority:** ISO Technical Management Board (TMB) under initiative led by Associação Brasileira de Normas Técnicas (ANTP) **Description:** First published in 2009. Revision under way for April 2015. Providing international expertise and best practice, identifying criteria that could prevent bioenergy from being harmful to the environment or leading to negative social impacts. Based on consensus of countries. ISO 13065: Standard as a result of ISO/PC 248 meeting in 2010 to meet alternative fuel targets providing transparent basis for all market actors to comply with legal requirements. Regarding production and use of bioenergy in relation to biodiversity, reduction of GHG emissions and promotion of economic and social development in areas where bioenergy is produced.

COUNTRY FACTSHEET

South Korea

Country profile	
Demography	**Energy**
Population: 49,039,986 (2014)	Electricity production: 494.7 GkWh (2013)
Urban share: 83.2 % (2014)	Electricity consumption: 472.2 GkWh (2013)
Rural share: 16.8 % (2014)	Oil production: 59.8 kbbl/day (2013)
Geography	Oil consumption: 2,324.0 kbbl/day (2013)
Land area: 99,720 km^2	Oil, proved reserves: 0 Gbbl (2013)
Economics:	Natural gas production: 0.5 Gm^3 (2013)
GDP: 1,666 G$ (2013)	Natural gas consumption: 53.2 Gm^3 (2013)
GDP per capita: 33,200 $/year (2013)	Natural gas, proved reserves: 5.7 Gm^3 (2013)

Alternative transportation market overview

Electricity	Hydrogen	Biodiesel	Ethanol	Natural gas	Bio-methane	LPG
▲	◆	▲	◆	◆	◆	▲

National status (colour)	*International status (size)*	*Trend (shape)*
●: *high attention*	●: *leading market*	⬆: *strong/consistent growth*
●: *on the agenda*	●: *medium market*	▲: *growth trend*
●: *minimal consideration*	●: *small market*	◆: *stable market or inconsistent trend*
		⬇: *decreasing market*

Policies & measures

Name	Target / Timeline / Description
Biodiesel fuel mandate	**Competent authority:** Ministry of Trade, Industry and Energy **Timeline:** 2002-2013 **Target technology:** Biodiesel **Geography:** National **Mechanism:** Demand management **Type:** Law/regulation **Practice:** Biodiesel has been used as an automotive fuel in Korea since 2002. After a few years of demonstration, the Ministry of Trade, Industry and Energy and Energy decided to introduce BD0.5 nationwide. After that, the blending ratio of BD in diesel oil has been increased gradually, and the blending ratio of BD2 has been fixed since 2010. Major feedstock for BD is waste cooking oil and imported soybean oil and palm oil.
Natural gas vehicle support measures	**Competent authority:** Ministry of Environment **Timeline:** Since 2000 **Target technology:** Natural gas vehicle (NGV) **Mechanism:** Incentive to supply **Type:** Financial incentive **Practice:** Offering subsidies and low-priced natural gas to city buses to reduce air pollution in urban areas and cut greenhouse gas emissions. About 80% of NGVs are original equipment manufacturer (OEM) transit buses, and the rest are OEM trucks and

Policies & measures	
	dual-fuel retrofit passenger cars.
Korean Renewable Fuel Standard	**Competent authority:** Ministry of Trade, Industry and Energy **Timeline:** Released in 2013, long term plan from 2015 to 2023 **Target technology:** Biodiesel and Bioethanol **Geography:** National **Mechanism:** Demand management **Type:** Law/regulation **Aim:** During the first step from 2015 to 2018, the introduction of BE and an increase in the BD percentage up to 2.0–3.0% would be reviewed. In the second step from 2018 to 2020, BE5 and BD5 would be introduced. The final step from 2020 to 2023 would be the BD7 and BE7 era. The introduction of biogas (BG) beginning in 2017is also being considered. **Practice:** Renewable energy fuel must be blended with any transportation fuel; it also indicates that joint indemnity and fraternal insurance should be provided to business operators who work with manufacturers and supply these renewable fuels. According to the revised RFS, oil-refining agents and petroleum import and export agents are obligated to blend transportation fuel with a specified percentage or more of a renewable energy fuel **Impact:** Penalty system for any violator was established. However, the Korean Government, by allowing a two-year grace period to implement the RFS system, enabled oil refinery companies and bioenergy-related enterprises to prepare the fuels. The government felt that the RFS policy would be more acceptable if there was enough time to implement it.
Development Plan for an Energy-Saving and Alternative-Energy Automotive Industry	**Competent authority:** State Council **Timeline:** 2012–2020 **Target technology:** Electric and plug-in hybrid electric vehicle **Mechanism:** Innovation support, Incentive to supply, Market uptake **Type:** R&D, Demonstration, Binding target **Aim:** Make electric as a main technology in the development of alternative vehicles and in the transformation of the automotive industry. Focus on promoting the industrialization of the pure electric and plug-in hybrid electric vehicle. **Projects:** Five tasks, (1)Technical innovation project for energy-saving and alternative-energy vehicles,(2) Scientific plan for industry structure (3) Accelerated promotion of demonstration, (4)Active promotion of charging equipment manufacture, (5) enhancement of step utilization and recycling of power batteries. **Impact**: By 2015, the cumulative production and sales of pure electric vehicle and plug-in hybrid vehicle must be up to 500,000 vehicles. By 2020, the production capacity for pure electric and plug-in hybrid vehicles must up to 2 million, and cumulative production and sales must be more than 5 million cars. By 2015, the average fuel consumption of current passenger vehicles must be reduced to 6.9 L/100 km, and that of energy-saving passenger vehicles must be reduced to 5.9 L/100 km or less. By 2020, the average fuel consumption of current passenger vehicles must be reduced to 5.0 L/100 km, and that of energy-saving passenger vehicles must be reduced to 4.5 L/100 km or less.

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Markets & infrastructure	
Electricity BEV vehicles sold per year: na Share of global BEV market: na PEHV vehicles sold per year: na Share of global PHEV market: na EV in circulation: na Charging stations: na	**Hydrogen** Fuelling stations, in operation: 12 (2014) Fuelling stations, planned: 0 (2014) Fuelling stations, out of operation: 0 (2014)
Biofuels Biodiesel production: 329.0 kt (2012) Biodiesel consumption: 327.0 kt (2012) Global share of biodiesel consumption: 1.5 % (2012) Ethanol production: 145.1 kt (2012) Ethanol consumption: na Global share of ethanol consumption: na	**Natural gas** Consumption, reported: 30.4 MNm3 (2012) Consumption, theoretical: 86.7 MNm3 (2012) Light duty NGVs: 3,049 (2013) Medium & heavy duty NG Buses: 31,833 (2013) Medium & heavy duty NG Trucks: 980 (2013) Other NGVs: 10 (2013) Share of NGVs worldwide: 0.2 % (2013) Share of L-M-HD vehicles in country: 0.2 % (2013) CNG stations: 190 (2013) Share of CNG stations worldwide: 0.9 % (2013)
LPG Consumption: 4,450 kt (2010) Share of global LPG consumption: 19.5 % (2010) Vehicles in circulation: 2,300,000 (2010) Share of LPG vehicles worldwide: 13.2 % (2010)	

Technological developments	
Technology	**Description**
Hydrogen-CNG (HCNG) engine technology development	• Hydrogen-CNG (HCNG) engine technology is currently being developed as part of a government project.
Bio-methane	• The first bio-methane filling station opened in Seoul in 2009. The second biogas upgrading installation was installed in Daegu in 2013 for city buses and other public vehicles.

Market players		
Name	**Involvement**	**Notes**
Daewoo Bus	CNG buses	**Type:** Bus and truck supplier **Technology:** CNG
Hyundai	CNG buses and trucks suppliers, dedicated buses that were recently developed by Hyundai (which also developed a CNG hybrid bus in 2010) and some LNG-diesel dual-fuel trucks with retrofit technology are in use.	**Type:** Car manufacturer **Technology:** CNG
Tata Daewoo	CNG buses and trucks suppliers	**Type:** Commercial vehicle manufacturer **Technology:** CNG

Standards	
Type	**Description**
Electricity	**Name:** KSR IEC 61851 EV conductive charging system **Competent authority:** Korean Agency for Technology and Standards (KATS) **Specific target:** Charging system **Description:** International. Conductive AC and DC fast charging. Established in 2002, revisions of different parts till 2013. Specifies general requirements, AC electric vehicle charging station, EV requirements for conductive connection to AC/DC supply.
	Name: KSR IEC 62196 Plugs, socket-outlets, vehicle connectors and vehicle inlets — Conductive charging **Competent authority:** Korean Agency for Technology and Standards (KATS) **Specific target:** Equipment **Description:** International. Conductive AC and DC fast charging. Established in 2012. Covers basic interface accessories for vehicle, for use in conductive charging systems.
	Name: KSR 1200 General requirements of exchangeable battery for EV **Competent authority:** Korean Agency for Technology and Standards (KATS) **Specific target:** Battery **Description:** Established in May 2014.
	Name: KSR 1201 General requirements for battery monitoring system of EV **Competent authority:** Korean Agency for Technology and Standards (KATS) **Specific target:** Battery **Description:** Established in July 2014.
	Name: Kia Soul EV **Competent authority:** Kia Motors **Specific target:** Example vehicle models **Description:** Launched in May 2014. First Korean electric car. Unveiled and sold in South Korea, will be launched in the US and 14 European countries in 2015. Equipped with lithium-ion polymer battery, electric motor, equipped with both AC charge port (SAE Standard) and fast DC charge port.
Hydrogen	**Name:** KSB ISO 13985/2006 Liquid hydrogen – Land vehicle fuel tanks **Competent authority:** Korean Agency for Technology and Standards (KATS) **Specific target:** Fuel tank **Description:** International. Established in 2009. Specifies construction requirements for refillable fuel tanks for liquid hydrogen used in land vehicles.
	Name: KSB ISO 14867/1992 Hydrogen fuel – Product specification **Competent authority:** Korean Agency for Technology and Standards (KATS) **Specific target:** Fuel specifications **Description:** International. Established in 2009. Specifies quality characteristics of hydrogen fuel to ensure uniformity of the hydrogen product for utilization in fuel cell power systems.

Standards	
	Name: KSB ISO 17268/2012 Compressed hydrogen surface vehicle refuelling connection devices **Competent authority:** Korean Agency for Technology and Standards (KATS) **Specific target:** Refuelling/dispensing **Description:** International. Adopted in 2012. Specifies design, safety and operation characteristics of gaseous hydrogen land vehicle refuelling connectors.
	Name: KSB ISO 13984/1999 – Liquid hydrogen land vehicle fuelling system interface **Competent authority:** Korean Agency for Technology and Standards (KATS) **Specific target:** Refuelling/dispensing **Description:** International. Confirmed in 2009.
	Name: ISO 23273/2013 – Fuel cell road vehicle – Safety Specifications **Competent authority:** Korean Agency for Technology and Standards (KATS) **Specific target:** Safety **Description:** International. Last updated in 2011, two parts withdrawn in 2013. Specifies requirements for fuel cell vehicles against hydrogen-related hazards. Only applies to vehicles where compressed hydrogen is used as fuel for the fuel cell system.
	Name: : ix35 FCEV **Competent authority:** Hyundai-Kia **Specific target:** Example vehicle models **Description:** First revealed in 2010. Production began in 2013. Commercialisation plans for 2015. 1,000 of the vehicles will be built up until 2015 for lease to public and private fleets. First automaker to put hydrogen-powered ix35 Fuel Cell vehicle into mass production. In the long term Hyundai-Kia plans to use Kia brand to sell smaller battery electric vehicles and Hyundai brand to sell larger fuel cell electric vehicles. Equipped with third-generation fuel cell-powered electric vehicle FCEV of Hyundai.
CNG	**Name: :** ISO 15500 Road vehicles – CNG fuel system components **Competent authority:** International Standard Organization (ISO) **Specific target:** Vehicle fuel system **Description:** International. Applied in 2007. In 20 parts corresponding to each component.
	Name: : KSB ISO 11439 High pressure cylinders for the on-board storage of NG as a fuel for automotive vehicles **Competent authority:** Korean Agency for Technology and Standards (KATS) **Specific target:** Vehicle fuel system **Description:** International. Established in 2012. Specifies rrequirements for light-weight refillable gas cylinders intended only for on-board storage of high pressure CNG as a fuel for automotive vehicles.
	Name: : KS R ISO 14469 Road vehicles – CNG refuelling connector **Competent authority:** Korean Agency for Technology and Standards (KATS) **Specific target:** Fuelling station **Description:** International. Confirmed in 2011. Specifies CNG refuelling nozzles and receptacles constructed entirely of new and unused parts and materials, for road vehicles powered by CNG. Applicable to CNG in accordance with ISO 15403.

Standards	
	Name: : KS I ISO 15403 NG for uses as a compressed fuel for vehicles – Designation of quality **Competent authority:** Korean Agency for Technology and Standards (KATS) **Specific target:** Quality **Description:** International. Established in 2010. Designates quality, specification of the quality of CNG fuel. Provide manufacturers, vehicle operators, fuelling station operators and others involved in the compressed-natural-gas vehicle industry with information on the fuel quality for natural gas vehicles (NGVs) required to develop and operate compressed-natural-gas vehicle equipment.
LNG	**Name: :** KS V 7474 Safety valve for cargo tank of LNG carriers **Competent authority:** Korean Agency for Technology and Standards (KATS) **Specific target:** Vehicle **Description:** Domestic. Established in 2007, confirmed in 2012.
	Name: : KS B 6941 General standard for LNG storage tank **Competent authority:** Korean Agency for Technology and Standards (KATS) **Specific target:** Vehicle **Description:** Domestic. Established in 2012.
	Name: : KS B 6941 General standard for LNG storage tank **Competent authority:** Korean Agency for Technology and Standards (KATS) **Specific target:** Vehicle **Description:** Domestic. Established in 2012.
Biofuel blends	**Name: :** KSM2619 **Competent authority:** Korean Agency for Technology and Standards (KATS) **Specific target:** B2-4, B20, B100 **Description:** Blend fixed in 2012, B20 idea first introduced in 2002, tested in 2006-2008. Demonstration program in 130 licensed gas stations in 2006. Government considering making B20 blends mandatory. BD20 Potential viability of a 20% biodiesel blended oil. Refineries responsible for biodiesel blending and distribution. Lowered to 10% in for winter season in 2012. Voluntary agreement between government and petroleum companies. BD100 Specifications for blending use of 2% by the Petroleum and Petroleum Alternative Fuel Business Act. Considering increasing blend to 5%.
	Name: : Ethanol demonstration project **Competent authority:** Korean government MOCIE (Ministry of Commerce, Industry and Energy) **Specific target:** E3, E5 **Description:** Carried out in 2007. Demonstration study of supply of E3 and E5 gasoline, concluding that Korean infrastructure fully compatible. Government currently considering supporting development.

Standards	
Biofuels	**Name:** ISCC Standard **Competent authority:** International Sustainability and Carbon Certification (ISCC) **Description:** Created in 2010 and open for stakeholder contribution (around 250 international associations, corporations, research institutions and NGOs). Examines operational sustainability based on ISCC system by members. Developed the first internationally recognised certification system for biomass. Provides proof of compliance with environmental, social and traceability criteria, and qualifies biomass or biofuel companies for legal recognition. Covers entire supply chains, all kinds of biomass, provides audits on ISCC system documents, offers unique tool of GHG calculation. More than 4800 certificates issued worldwide.
	Name: ISO/PC 248, Sustainability Criteria for Bioenergy **Competent authority:** ISO Technical Management Board (TMB) under initiative led by Associação Brasileira de Normas Técnicas (ANTP) **Description:** First published in 2009. Revision under way for April 2015. Providing international expertise and best practice, identifying criteria that could prevent bioenergy from being harmful to the environment or leading to negative social impacts. Based on consensus of countries. ISO 13065: Standard as a result of ISO/PC 248 meeting in 2010 to meet alternative fuel targets providing transparent basis for all market actors to comply with legal requirements. Regarding production and use of bioenergy in relation to biodiversity, reduction of GHG emissions and promotion of economic and social development in areas where bioenergy is produced.
	Name: RSB standard – Biofuel certification **Competent authority:** Roundtable on Sustainable Biomaterial (RSB) **Description:** Refers to social and environmental assurance through certification to the Roundtable for Sustainable Biomaterials (RSB) standard. Applies to the production, processing, conversion, trade and use of biomass and biofuels, and can be sought by feedstock and biofuel producers and processors, as well as biofuel blenders.

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COUNTRY FACTSHEET

USA

Country profile	
Demography	**Energy**
Population: 318,892,103 (2014)	Electricity production: 4,047.8 GkWh (2013)
Urban share: 82.4 % (2014)	Electricity consumption: 3,882.6 GkWh (2013)
Rural share: 17.6 % (2014)	Oil production: 12,352.2 kbbl/day (2013)
Geography	Oil consumption: 18,886.8 kbbl/day (2013)
Land area: 9,826,675 km^2	Oil, proved reserves: 30.5 Gbbl (2013)
Economics:	Natural gas production: 687.6 Gm^3 (2013)
GDP: 16,720 G$ (2013)	Natural gas consumption: 737.3 Gm^3 (2013)
GDP per capita: 52,800 $/year (2013)	Natural gas, proved reserves: 8734.0 Gm^3 (2013)

Alternative transportation market overview

Electricity	Hydrogen	Biodiesel	Ethanol	Natural gas	Bio-methane	LPG

National status (colour)	*International status (size)*	*Trend (shape)*
: high attention	*: leading market*	*: strong/consistent growth*
: on the agenda	*: medium market*	*: growth trend*
: minimal consideration	*: small market*	*: stable market or inconsistent trend*
		: decreasing market

Policies & measures

Name	Target	Timeline	Description
Clean Cities	**Competent authority:** US Department of Energy (DOE) **Timeline:** Founded in 1993 as a result of the 1992 Energy Policy Act forcing certain fleets to use Alternative Fuel Vehicles. **Target technology:** Electric (advance electric drive technology, provide information and training to stakeholders, support planning of infrastructure), NG (expand market, provide technical assistance and training), LPG (expand market and develop infrastructure), E85 (expand market, develop infrastructure and encourage greater availability), B20 (address technical barriers, develop market and infrastructure, increase vehicle compatibility). **Geography:** National **Mechanism:** Market uptake **Type:** R&D, indicative target **Aim:** Reducing petrol use in the US transportation sector by 2.5 billion gallons per year by 2020 with alternative/renewable fuels and technologies. **Practice:** Coalitions of almost 100 cities involving 18 000 stakeholders worldwide such as private businesses, fuel suppliers, national and local government agencies, community organisations, laboratories and vehicle manufacturers. Funded 500 transportation projects, distributed $377 million in awards. **Impact:** Mostly for trucks, buses and municipal vehicles. Saved 4.6 billion gallons of petroleum, placed 400,000 AFV on road, saved 6.6M tons of GHG emissions. Petroleum		

Policies & measures	
	savings: 13.8% EV, 8.7% E85, 11.1% biodiesel 45.8% NG and 5.5% LPG.
Renewable Fuel Standards RFS	**Competent authority:** US Environmental Protection Agency (EPA) **Timeline:** Elaborated in 2005 as a result of the Energy Policy Act and revised in 2010. **Target technology:** Biofuels **Geography:** National **Mechanism:** Demand Management **Type:** Law/regulation, Binding target **Aim:** Increasing the volume of renewable fuel to 36 billion gallons by 2022. **Practice:** Elaborated in collaboration with refiners, renewable fuel producers, and others. Requires that a certain percentage of transportation fuel provided in a given geographic area is replaced by renewable fuels. Based on volume of total fuel sales and directed at specific points all along the supply chain. **Impact:** RFS1 (2005) required 7.5 billion gallons of renewable fuel to be blended into gasoline by 2012. RFS2 (2010) introduced new measures (included diesel in addition to gasoline, established new categories of renewable fuel, set separate volume requirements, required EPA to apply lifecycle GHG performance threshold standards) and increased the volume of renewable fuel required to be blended into transportation fuel to 36 billion gallons by 2022. 19 billion gallons saved since the implementation.
American Recovery and Reinvestment Act	**Competent authority:** US Department of Energy (DOE) **Timeline:** Enacted on 17 February 2009, commonly called "the stimulus". **Target technology:** All **Geography:** National **Mechanism:** Incentive to supply **Type:** R&D **Aim:** Promoting investments in energy independence and renewable energy technologies. **Practice:** Acceleration of the commercialization of Alternative Fuels. $17 billion of grants to NREL for renewable energy technologies, $387 million electrical efforts, $400 million to support vehicle electrification efforts, $2 billion advanced battery manufacturing, $590 million advanced biorefinery projects, $800 million on biofuel R&D programmes, $107 million advanced biofuels research and fueling infrastructure, $300 million toward competitive grants in alternative fuels. **Impact:** In 2009 alone, $8 billion in loans released by US government to Ford, Nissan and Tesla for electric developments.
Energy Policy Act EPAct	**Competent authority:** US Department of Energy (DOE) **Timeline:** First agreed on 24 October 1992 then revised in August 2005. **Target technology:** All **Geography:** National **Mechanism:** Market uptake **Type:** Law/regulation, R&D **Aim:** Reducing dependence on oil imports and improving air quality. **Practice:** Requires that certain fuelled fleets (federal, state, alternative fuel provider fleets) build an inventory of alternative fuel vehicles. Electric ($40 million R&D program to advance commercialization of hybrid flexible fuel vehicles requiring vehicles to achieve at least 250 miles per petroleum gallon). In 2005, calls for the development of grant programs, demonstration and testing initiatives, and tax incentives that promote alternative fuels and advanced vehicles production and use. $200 million for advanced

Policies & measures	
	vehicle demonstration and pilot programs, $40 million for HEV, Fuel cell and hydrogen systems $15 to $65 million a year.
CO_2 and Corporate Average Fuel Economy (CAFE) standards	**Competent authority:** National Highway Traffic Safety Administration (NHTSA) and US Environmental Protection Agency (EPA) **Timeline:** First enacted in 1975, latest revision in August 2012. **Target technology:** Electric, Hydrogen, CNG **Geography:** National **Mechanism:** Market uptake **Type:** Binding target **Aim:** Reducing energy consumption by increasing fuel economy of cars and light trucks for model years 2017 through 2025. **Practice:** NHTSA developed two phases of these standards: 2017-2021 (from 40.3 to 41.0 mpg on an average industry fleet-wide basis) and 2022-2025 (augural standards from 48.7 to 49.7 mpg). EPA established standards of 163g/mile of CO2 (equivalent to 54.5 mpg if solely through improvements in fuel efficiency). Applicable to passenger cars, light-duty trucks and medium-duty passenger vehicles. Include incentives for EV, PHEV, FCV and CNG vehicles by EPA (incentive multiplier for CO2 emissions compliance purposes to promote increased application of these technologies), incentives for use of advanced technologies including hybridization for full-size pick-up trucks. **Impact:** 2012 and 2013 experienced increase of 1.0 mpg and 0.9 mpg. CAFE performance improved by 4.3 mpg or 16.9% from 2008 to 2013 from 25.5 to 29.8 mpg.
Biomass Crop Assistance Program	**Competent authority:** US Department of Agriculture (USDA) **Timeline:** Created as a result of the 2008 Farm Bill, revised in February 2014. **Target technology:** Biofuels **Geography:** National **Mechanism:** Incentive to supply **Type:** Financial incentive **Aim:** Providing incentives in the agricultural sector for production of biofuels. **Practice:** Provides incentives to farmers, ranchers and forest landowners to establish, cultivate and harvest biomass for heat, power, bio-based products and biofuels. Reimbursements to crop producers and bioenergy facilities of up to 75% of the cost of establishing a bioenergy crop. $25 million of mandatory funding for 2014-2018. **Impact:** 13 major programs cost taxpayers $1.1 billion in 2008-2012.
H_2USA	**Competent authority:** US Department of Energy (DOE) **Timeline:** Launched in 2013 **Target technology:** Hydrogen **Geography:** National **Mechanism:** Innovation support **Type:** R&D **Aim:** Coordinating research and identifying cost-effective solutions to advance hydrogen infrastructure. **Practice:** Public-private partnership with automakers, government agencies, national laboratories, gas suppliers, fuel cell and hydrogen industries. Identifies actions for early adopters of FCV, conduct technical and market analysis, evaluate alternative fuelling infrastructure.

Policies & measures	
	Impact: Has reduced automative fuel cell costs by more than 35% since 2008 and by more than 80% since 2002. Fuel cell durability has doubled and the amount of expensive platinum needed has fallen by 80% since 2005.
Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP)	**Competent authority:** California Energy Commission **Timeline:** Considered in 2007, extended until January 2024 **Target technology:** All **Geography:** Regional (California) **Mechanism:** Incentive to supply, Market uptake **Type:** R&D **Aim:** Develop and deploy alternative and renewable fuels and advanced transportation technologies. **Practice:** Provides financial incentives for businesses, vehicle and technology manufacturers, workforce training partners, fleet owners, consumers and academic institutions. PEV ($25.3 million awarded in infrastructure projects, funding of approximately 6,200 EV charge points), FCV (funds in strategically located fueling stations and infrastructure, $36 million for construction of hydrogen fueling stations, $4 million for standards for quality of hydrogen fuel, in addition to metering, dispensing, and sale of hydrogen, $46.6 million granted in May 2014 to 8 different applicants for 28 new hydrogen refuelling stations in California), NG ($37.1 million for developing and deploying heavy duty NG trucks and installation/upgrades to fueling stations), Biofuels (plans to fund over 180 new E85 locations by 2016, $6 million to encourage California ethanol producers in new and retrofitted production technologies, feedstocks and facilities, $49 million on 13 biomethane feasibility, demonstration and production projects). **Impact:** Has invested more than $531 million to date, funded more than 462 clean transportation projects, provided $100 million annually.

Markets & infrastructure	
Electricity BEV vehicles sold per year: 14,592 (2012) Share of global BEV market: 26 % (2012) PHEV vehicles sold per year: 38,585 (2012) Share of global PHEV market: 70 % (2012) EV in circulation: 71,174 (2012) Charging stations: 15,192 (2012)	**Hydrogen** Fuelling stations, in operation: 58 (2014) Fuelling stations, planned: 26 (2014) Fuelling stations, out of operation: 44 (2014)
Biofuels Biodiesel production: 3,609.8 kt (2012) Biodiesel consumption: 3,002.0 kt (2012) Global share of biodiesel consumption: 14.1 % (2012) Ethanol production: 39,816.0 kt (2012) Ethanol consumption: 41,448.5 (2012) Global share of ethanol consumption: 59.7 % (2012)	**Natural gas** Consumption, reported: 77.5 MNm3 (2012) Consumption, theoretical: 97.5 MNm3 (2012) Light duty NGVs: 231,400 (2013) Medium & heavy duty NG Buses: 14,600 (2013) Medium & heavy duty NG Trucks: 4,000 (2013) Other NGVs: 0 (2013) Share of NGVs worldwide: 1.4 % (2013) Share of L-M-HD vehicles in country: 0.1 % (2013) CNG stations: 1,438 (2013) Share of CNG stations worldwide: 6.5 % (2013)

Markets & infrastructure
LPG Consumption: 578 kt (2010) Share of global LPG consumption: 2.5 % (2010) Vehicles in circulation: 199,000 (2010) Share of LPG vehicles worldwide: 1.1 % (2010)

Technological developments	
Technology	**Description**
Electricity	• **Available models**: Chevy Volt, Nissan LEAF, Tesla Model S • **ARPA** Batteries for Electrical Energy Storage in transportation BEEST (High risk and high-reward projects on ultra-high energy density, low-cost battery technology, lithium ion batteries) • **DOE** Hydrogen and Fuel Cell Interagency Task Force with 10 federal agencies, International Partnership for Hydrogen and Fuel Cells in the Economy with 17 countries and EU members, EV Everywhere Grand Challenge • **Coalitions** Better Place, Coulomb Technologies, A123 systems (Battery storage and fast charging), Pepco Holdings, Southern California Edison, Austin Energy, Xcel energy, Duke Energy, Seattle city light (Smart Grids and PEV pilots) • The **US Department of Transportation** recently announced the provision of USD 13.6 million to support eight projects to advance the commercialisation of fuel cell buses
Biofuels	• **DLA Energy Certification** and commercialization of alternative aviation fuels for reliability of fuel supply in terms of resilience against supply disruptions, reduction in impacts of oil price volatility and increased options for fuel supply • **DOE Vehicle Technology Office** Research in fuels and advanced combustion engines for displacing petroleum derived fuels, for example benefits of higher octane centred on ethanol and engine downsizing for blends of ethanol in gasoline from 51% to 85% • **DOE Bioenergy Technology Office** Development of new fuels via R&D, pilot and demonstration plant phases. Research on feedstock, algae, biochemical conversion, and thermochemical conversion with an estimated potential for the conversion of 1 billion tons of biomass per year thus producing from 20 to 70 billion gallons per year of advanced biofuels by 2022. • **Commercial Aviation Alternative Fuels Initiative (CAAFI)** Deployment of alternative jet fuels • **Midwest Aviation Sustainable Biofuels Initiative (MASBI)** along with United Airlines, Boeing, Honeywell's UOP, the Chicago Department of Aviation and the Clean Energy Trust as well as 40 public and private organizations representing the entire biofuels value chain
Bio-methane	• 8 ongoing state projects for bio-methane from landfills, fuelling around 600 trucks

Market players		
Name	**Involvement**	**Notes**
Department of Energy (DOE)	Financial incentives, R&D programmes, support of government policies to promote energy technology.	**Type:** Government authority **Technology:** All **Sector:** All
International Civil Aviation Organization (ICAO)	Dissemination of information, database of activities, development of national standards, support of fuel producers cooperation and fuel supply agreements, initiatives and projects on alternative fuels for aviation.	**Type:** UN specialized agency **Technology:** Biofuel **Sector:** Air
Commercial Aviation Alternative Fuels Initiative (CAAFI)	Fuel certification, R&D programmes, environmental impact and financial analysis, workshops on alternative jet fuels.	**Type:** Coalition of manufacturers, private/public companies, researchers and US government agencies. **Technology:** Biofuel **Sector:** Air
National Renewable Energy Laboratory (NREL)	R&D programmes, particularly in fuel production and transportation.	**Type:** Government research laboratory **Technology:** All **Sector:** Land
Environmental Protection Agency (EPA)	Regulation enforcements, grants, partnership sponsorship, information, training in Alternative Fuels options.	**Type:** Government agency **Technology:** All **Sector:** All
Office of Energy Efficiency and Renewable Energy (EERE)	Initiatives and projects in transportation sector via Vehicle, Bioenergy and Fuel-Cell Technologies Offices.	**Type:** Government agency **Technology:** All **Sector:** All
American Alternative Fuel (AAF)	Research, testing, fuel supply infrastructure, vehicle conversion, O&M of alternative fuel vehicles.	**Type:** Private company **Technology:** Electricity, CNG, LPG **Sector:** Cars, Vans and SUVs
Tesla	Model S electric car and electric supercharger technology.	**Type:** Car manufacturer **Technology:** Electricity **Sector:** Land
Ford	Electric and hybrid vehicles, E15 and E85 biofuelled cars, CNG/LPG vehicles.	**Type:** Car manufacturer **Technology:** Electricity, Biofuel, Natural Gas
General Motors	Chevrolet Volt electric car, NCG/LPG trucks and vans, fuel-cell initiatives.	**Type:** Car manufacturer **Technology:** Electricity, CNG/LPG, hydrogen

Market players		
National Alternative Fuel Training Consortium (NAFTC)	Programs, activities and training on alternative fuels and advanced technology vehicles (the only training organization in this sector in the US).	**Type:** University body **Technology:** All

Standards	
Type	**Description**
Electricity	**Name:** SAE J2293 Energy transfer system for EV **Competent authority:** SAE International **Specific target:** Charging system **Description:** Domestic standard. Conductive AC charging. Specifies requirements for transfer of electric energy to an EV from an electric utility power system, defines all characteristics of transfer system to insure the functional interoperability.
	Name: SAE J2954 Wireless charger **Competent authority:** SAE International **Specific target:** Charging system **Description:** Domestic. Conductive DC fast charging. Introduced in 2013. Establishes AC Level 1, AC Level 2 and DC Level 3 charge levels, specifies a location for wireless charging. Working with IEC on harmonization.
	Name: UL 2251 Plugs, receptacle and couplers for electric vehicles **Competent authority:** Underwriters Laboratories **Specific target:** Equipment **Description:** Domestic. Conductive DC fast charging. Introduced in 2013. Specifies requirements for cover plugs, receptacles, vehicle inlets, vehicle connectors, and breakaway couplings, intended for conductive connection systems, for use with electric vehicles in accordance with National Electrical Code (NEC).
	Name: SAE J1772 EV conductive charge coupler and SAE J1772* EV conductive charge coupler-Combo Connector **Competent authority:** SAE International **Specific target:** Equipment **Description:** Domestic. Conductive Level 1 and 2 AC charging and conductive DC fast charging. Introduced in 2012. First official charging standard in North America. Combo Connector Standard for Electric Vehicle (EV) and Plug-In Hybrid Electric (PEV) Vehicle. Reduces charging time from 8h to 20min. DC fast charging using paired couplers for AC and DC, using same standard plug.
	Name: SAE J1773 EV inductively coupled charging **Competent authority:** SAE International **Specific target:** Equipment **Description:** Domestic. Inductive AC charging. First introduced in 1995 and currently being revised. Establishes interface compatibility requirements for EV inductively coupled charging. Manually connected inductive charging for Levels 1 and 2 power transfer.

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Standards	
	Name: UL 2580 Batteries for uses in EV **Competent authority:** Underwriters Laboratories **Specific target:** Battery **Description:** Domestic. Covers electrical energy storage assemblies such as battery packs for use in EV, evaluates the electrical energy storage assembly's ability to safely withstand abuse conditions and prevents any exposure of persons to hazards. Evaluates electric energy storage assembly and modules based upon the manufacturer's specified charge and discharge parameters.
	Name: Tesla Model S **Competent authority:** Tesla Motors **Specific target:** Example vehicle models **Description:** Introduced in June 2012. Available in 4 configurations (40kWh, 60, 85, P85), Model X planned for Fall 2015. All equipped with J1772 public charging station adaptor and standard household outlet adapter. Supercharger (optional) for half the charge in 20min with 119 stations today in North America, 76 in Europe and 26 in Asia.
Hydrogen	**Name:** SAE J2579 Standard for Fuel Systems in Fuel Cell and Other Hydrogen Vehicles **Competent authority:** SAE International **Specific target:** Fuel system **Description:** Domestic. Originally published in 2008, updated in 2013. Specifies design, construction, maintenance requirements for hydrogen fuel storage and handling systems in on-road vehicles. Includes recommended practices on integration of hydrogen storage and handling systems, fuel cell system, and electrical systems into the overall Fuel Cell Vehicle.
	Name: CSA America HGV2 Standard Hydrogen Vehicle Fuel Containers **Competent authority:** CSA America **Specific target:** Fuel tank **Description:** Domestic. Published in 2014 as ANSI standard. Specifies design, manufacture, marking and testing of serially produced, refillable containers intended only for the storage of compressed hydrogen gas for vehicle operation. To be permanently attached to the vehicle.
	Name: SAE J2719 Hydrogen Fuel Quality for Fuel Cell Vehicles **Competent authority:** SAE International **Specific target:** Fuel specifications **Description:** Domestic. Originally issued in 2005 and revised in 2011. Specifies hydrogen fuel quality standard for commercial proton exchange membrane (PEM) fuel cell vehicles.
	Name: SAE J2600 Compressed Hydrogen Vehicle Fuelling **Competent authority:** SAE International **Specific target:** Refuelling/dispensing **Description:** Domestic. Published in 2002, second edition in 2012. Specifies design and testing of Compressed Hydrogen Surface Vehicle (CHSV) fueling connectors, nozzles, and receptacles.
	Name: SAE J2601 Fuelling Protocols for Gaseous Hydrogen Surface Vehicle **Competent authority:** SAE International **Specific target:** Refuelling/dispensing **Description:** Domestic. Published in 2014 as an official standard. In 3 parts for light duty vehicles, buses and industrial trucks. 1-Protocol and process limits for hydrogen fueling of light duty vehicles, especially the station's dispensing equipment cooling capability and the resultant fuel delivery temperature rating. To be

Standards	
	used in conjunction with SAE J2799. 2-Performance requirements for hydrogen dispensing systems used heavy duty hydrogen transit buses and vehicles. Boundary conditions for safe heavy duty hydrogen surface vehicle fueling, such as safety limits and performance requirements for gaseous hydrogen fuel dispensers used to fuel hydrogen transit buses. 3- Safety limits and performance requirements for gaseous hydrogen fuel dispensers used to fuel Hydrogen Powered Industrial Trucks (HPITs).
	Name: SAE J2799 Hydrogen Surface Vehicle to Station Communications Hardware and Software **Competent authority:** SAE International **Specific target:** Refuelling/dispensing **Description:** Domestic. Published in 2014. Intended to be used in conjunction with SAE J2601 and SAE J2600. Features guideline for communications hardware and software requirements for fueling a Hydrogen Surface Vehicle (HSV), or heavy duty vehicles and industrial trucks with compressed hydrogen storage.
	Name: : SAE J2578 Recommended Practice for General Fuel Cell Vehicle Safety **Competent authority:** SAE International **Specific target:** Safety **Description:** Domestic. Originally set for 2002 and third edition published in 2014. Specifies the safe integration of the fuel cell system, hydrogen fuel storage and handling systems into the overall Fuel Cell Vehicle. For vehicles for use on public roads.
	Name: : HydroGen4 **Competent authority:** General Motors **Specific target:** Example vehicle models **Description:** First FCEV in 1998. Launched in 2007. More than 120 test vehicles deployed since 2007, more than 2 million vehicles on the road. Co-development agreement with Honda in 2013 for next-generation fuel cell systems and hydrogen storage technologies.
CNG	**Name: :** ANSI NGV3/CSA 12.3 Fuel system components for CNG powered vehicles **Competent authority:** CSA America **Specific target:** Vehicle fuel system **Description:** Domestic. Implemented in 2012. Establishes requirements for newly produced compressed natural gas fuel system components, intended for use on NG powered vehicles (Fuel System Components, Check Valve, Manual Valve, Manual Container Valve, Automatic Valve, Gas Injector, Pressure Indicator, Pressure Regulator, Gas Flow Adjuster, Gas/Air Mixer, Pressure Relief Valve, Pressure Relief Device, Excess Flow Valve, Gas Tight Housing and Ventilation, Hoses, Rigid Fuel Line, Flexible Fuel Line, Filter, Fittings, Relief Line Closures)
	Name: : ANSI/IAS PRD 1 Pressure Relief Devices for NGV Fuel Containers **Competent authority:** American National Standard Institute **Specific target:** Vehicle fuel system **Description:** Domestic. First implemented in 1998, last updated in 2013.
	Name: : ANSI NGV2 CNG vehicle fuel containers **Competent authority:** American National Standard Institute **Specific target:** On-board cylinder **Description:** Domestic. First in 2007, revised in 2012. Establishes requirements that vehicle fuel storage container manufacturers must design, manufacture, test and certify their containers for sale. All vehicle fuel storage containers manufactured to the ANSI NGV2 Standard must have a label indicating among other things the expiration date of the container.

Standards	
	Name: : ANSI NGV1 CNG vehicle fuelling connection devices **Competent authority:** American National Standard Institute **Specific target:** Fuelling station **Description:** Domestic. First in 2006, revised in 2012. Specifies examination, testing and certification of compressed Natural Gas Vehicle (NGV) fuelling nozzles and receptacles.
	Name: : NFPA30 Safeguards for dispensing liquid/gaseous motor fuels into the fuel tanks of automotive vehicles and marine craft **Competent authority:** National Fire Protection Association (NFPA) **Specific target:** Fuelling station **Description:** Domestic. Last updated in 2012, under revision for 2015. Lists safeguards and guidelines.
	Name: : ANSI NGV4/CSA 12 Natural gas dispensing system **Competent authority:** CSA America **Specific target:** Fuelling station **Description:** Domestic. First introduced in 1999, 8 parts updated till 2014. Specifies hoses for NG dispensing systems, NGV dispensing systems, valves for NGV dispensing systems, NGV reciprocating compressor. NGV 4.1 to NGV 4.8
	Name: : SAE J1616 Recommended practice for CNG vehicle fuel **Competent authority:** SAE International **Specific target:** Safety **Description:** Domestic. Implemented in 1994. Establishes recommendations on vehicular fuel composition for CNG motor vehicle fuel
	Name: : NFPA52 Vehicular gaseous fuel systems code **Competent authority:** National Fire Protection Association (NFPA) **Specific target:** Quality **Description:** Domestic. Current edition of 2013. Specifies requirements that mitigate the fire and explosion hazards associated with compressed natural gas (CNG) and liquified natural gas (LNG) engine fuel systems and fuelling facilities.
LNG	**Name: :** BSR/CSA LNG -201x Standard for LNG fuel connection devices **Competent authority:** CSA America **Specific target:** Vehicle **Description:** Domestic. Under development. Is linked to Fuel Connection devices, fuel containers, fuel system components, valves, hoses and devices for dispensing systems.
	Name: : SAE J2343 Recommended Practice for LNG Medium and Heavy-Duty Powered Vehicles **Competent authority:** SAE International **Specific target:** Vehicle **Description:** Domestic. First version in 1997, last updated 2008. Provides guidance for the construction, operation, and maintenance of LNG powered medium, heavy-duty vehicles and all LNG vehicles used for public transit or commercial applications.
	Name: : SAE J2645 LNG vehicle metering and dispensing systems – Truck and Bus **Competent authority:** SAE International **Specific target:** Fuelling station **Description:** Domestic. Latest revision in 2009. Constructing, operating, and maintaining LNG vehicle metering and dispensing systems.

Standards	
	Name: : SAE J2699 LNG Vehicle Fuel **Competent authority:** SAE International **Specific target:** Quality **Description:** Domestic. Implemented in 2011. Requires LNG producers to provide the required information on the fuel composition.
Biofuel blends	**Name:** ASTM D7467 Standard Specification for Diesel Fuel Oil, Biodiesel Blend (B6 to B20) **Competent authority:** American Society for Testing and Materials (ASTM) **Specific target:** B6-20 **Description:** Introduced in 2008. Fuel blend grades of 6-20% in volume biodiesel (conform to ASTM D6751) within a light middle or middle distillate diesel fuel (conform to D975). Designated as B6 to B20.
	Name: ASTM D6751 Standard Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels **Competent authority:** American Society for Testing and Materials (ASTM) **Specific target:** B100 **Description:** Introduced in 2002. Standard only for blending purposes. Constantly revised. For pure biodiesel used in blends of up to 20% with diesel fuel under D975 standard. Biodiesel shall be mono-alkyl esters of long chain fatty acids derived from vegetable oils and animal fats.
	Name: ASTM D4806 Standard Specification for Denatured Fuel Ethanol for Blending with Petrol for Use as Automotive Spark Ignition Engine Fuel **Competent authority:** American Society for Testing and Materials (ASTM) **Specific target:** E100 **Description:** Introduced in 1990. Standard only for blending purposes. Adjusted seasonally and geographically. Intended to be blended with unleaded or leaded gasoline at 1 to 10% in volume. E10 and E15 not considered as alternative fuel under EPAct. Known as E100.
	Name: ASTMD5798 Specification for Fuel Ethanol (Ed75-Ed85) for Automotive Spark-Ignition Engine Fuel **Competent authority:** American Society for Testing and Materials (ASTM) **Specific target:** E75-85 **Description:** Introduced in the mid-1990s. For specially designated vehicles as a petrol substitute. E75-E85 produced from ethanol complying with ASTM D 4806. 75 to 85% in volume denatured ethanol.
Biofuels	**Name:** ASTMD4806 Standard Specification for Denatured Fuel Ethanol for Blending with Petrol for Use as Automotive Spark Ignition Engine Fuel **Competent authority:** American Society for Testing and Materials (ASTM) **Specific target:** Ethanol **Description:** Latest revision in 2014. Intended to be blended with unleaded or leaded gasoline at 1 to 10% in volume.
	Name: ASTMD7806 Standard Test Method for Determination of the Fatty Acid Methyl Ester (FAME) Content of a Blend of Biodiesel and Petroleum-Based Diesel Fuel Oil **Competent authority:** American Society for Testing and Materials (ASTM) **Specific target:** Biodiesel **Description:** Established in 2012. Determination of content of biodiesel (FAME) in diesel fuel oils. Applicable to concentrations from 1 to 30 volume %.

Standards	
	Name: MDA Social Duel Stamp **Competent authority:** Agrarian Development Ministry (MDA) **Specific target:** Biodiesel **Description:** Created in 2004 as a result of the PNPB. Standard for biodiesel producers to receive certificate and benefit from tax breaks of PNPB. Specifies requirements for biofuel producer to purchase minimum % of feedstock from family-owned farms, enter into agreements with family farms, concerning prices, schedules and terms of delivery for raw materials, and provide them with technical assistance.
	Name: Aerospace Material Standards ASTM D7566 Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons **Competent authority:** National Biodiesel Accreditation Commission **Specific target:** Aviation **Description:** First in 2009 then revised in 2011. Specifies property and compositional requirements for synthetic blending components that can be mixed with conventional, petroleum-derived jet fuel at specified volumes. Already approved Fischer Tropsch (FT) and Hydroprocess Esters and Fatty Acids (HEFA), that can blended at up to 50% volume with petroleum derived jet fuel.
	Name: Aerospace Material Standards ASTM D4054 Standard Practice for Qualification and Approval of New Aviation Turbine Fuels and Fuel Additives **Competent authority:** National Biodiesel Accreditation Commission **Specific target:** Aviation **Description:** First in 2009 then revised in 2011. Providing guidance on composition and performance testing and property targets to evaluate alternative jet fuel and prove fit-for-purpose for use on turbine engines and aircraft when blended with conventional fuel.
	Name: ISCC Standard **Competent authority:** International Sustainability and Carbon Certification (ISCC) **Description:** Created in 2010 and open for stakeholder contribution (around 250 international associations, corporations, research institutions and NGOs). Examines operational sustainability based on ISCC system by members. Developed the first internationally recognised certification system for biomass. Provides proof of compliance with environmental, social and traceability criteria, and qualifies biomass or biofuel companies for legal recognition. Covers entire supply chains, all kinds of biomass, provides audits on ISCC system documents, offers unique tool of GHG calculation. More than 4800 certificates issued worldwide.
	Name: ISO/PC 248, Sustainability Criteria for Bioenergy **Competent authority:** ISO Technical Management Board (TMB) under initiative led by Associação Brasileira de Normas Técnicas (ANTP) **Description:** First published in 2009. Revision under way for April 2015. Providing international expertise and best practice, identifying criteria that could prevent bioenergy from being harmful to the environment or leading to negative social impacts. Based on consensus of countries. ISO 13065: Standard as a result of ISO/PC 248 meeting in 2010 to meet alternative fuel targets providing transparent basis for all market actors to comply with legal requirements. Regarding production and use of bioenergy in relation to biodiversity, reduction of GHG emissions and promotion of economic and social development in areas where bioenergy is produced.

Standards	
	Name: RSB standard – Biofuel certification **Competent authority:** Roundtable on Sustainable Biomaterial (RSB) **Description:** Refers to social and environmental assurance through certification to the Roundtable for Sustainable Biomaterials (RSB) standard. Applies to the production, processing, conversion, trade and use of biomass and biofuels, and can be sought by feedstock and biofuel producers and processors, as well as biofuel blenders.