Infrastructure for Alternative Fuels

Report of the European Expert Group on Future Transport Fuels

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1. THE NEED FOR ALTERNATIVE FUEL INFRASTRUCTURE

As stated in the first report of this Expert Group, transitions in fuel supply infrastructure and vehicles will be needed for all new transport fuels. These transitions may need to be encouraged or mandated throughout all EU Member States and coordinated at the EU level in order to drive the market forward.

Assuming a reduction of at least 60% of GHGs by 2050 with respect to 1990 in the transport sector, improvements in the energy efficiency of transport operations and vehicles will provide a period of several years to evaluate and develop the technologies for alternative fuel systems that will require major transitions in infrastructure and vehicle design. A timely decision on these major transitions can therefore be taken to ensure a long-term cost-effective and sustainable solution that is commensurate with adequate industrial lead-time.

In view of the scope of change required for a low carbon transport system, it would be recommendable to analyse the current regulatory framework and to identify the gaps and level of policy support required to enable this change, particularly with regard to infrastructure for alternative fuels.

There is a current lack of an EU-wide harmonised alternative fuel infrastructure due to differing levels of development in the Member States. Such fragmented development leads to high costs, hampers consumer acceptance, and prevents the economies of scale which the Single Market could provide. A specific strategy on alternative fuel infrastructure at EU level will be necessary for the short and medium term.

Member States have promoted different alternative fuel infrastructures, because they have opted for different priorities in their fuel choices with regard to the implementation of the Renewable Energy Directive and to the allocation of state support. But there is a clear lack of harmonized EU standards within the various types of alternative fuel refuelling equipment and storage systems.

During the last decade, policy actions have mostly addressed fuel and vehicle developments, neglecting an appropriate alternative fuel infrastructure build-up. Funding to build up alternative fuel infrastructure has also been insufficient. The initial costs for market-deployment of alternative fuel infrastructure are generally higher than for petroleum-based fuels due to i.a. the lack of initial economies of scale. Fuel suppliers (i.e. private spending) are investing in alternative fuels even if the revenue from fuel sold is not sufficient to pay back infrastructure and logistics costs.

The recently adopted White Paper "Roadmap to a Single European Transport Area – Towards a Competitive and Resource Efficient Transport System" announces that the Commission will develop "a sustainable alternative fuels strategy including also the appropriate infrastructure" (Initiative 24) and ensure "guidelines and standards for refuelling infrastructures" (Initiative 26).

An appropriate EU regulatory framework and financial instruments will be required to introduce clean alternatives to the market and provide the European citizen with a clean choice of transport, in the same way that it has been essential to bring renewable energy production to where it is today.

In addition, a comprehensive EU infrastructure roll-out plan engaging key industrial (OEM's, fuel production and supply industry), national and local stakeholders will have to be developed, as is currently happening in Germany (H2 mobility) aligned with the EU Trans European Network for Transport (TEN-T) Programme and relevant EU energy infrastructure programmes. This roll-out plan will need to be accompanied by adequate information to make key decision-makers aware about the different aspects of different fuel alternatives. For example the different aspects of electromobility, with regard to the synergies and characteristics of fuel cell electric and battery electric vehicles and their respective infrastructure needs should be widely communicated.

There is a clear need for supporting public and private sectors to put in place effective actions to accelerate the development of new refuelling infrastructure with the objectives to:

- establish EU-wide a minimum coverage of refuelling infrastructure for the main alternative fuels that have demonstrated their technological viability and their market potential, to facilitate economies of scale for market introduction;
- ensure implementation of harmonised standards for the main alternative fuels;
- align policy and public/private funding and taxation in the field of alternative fuel infrastructure.

However, the implementation of these objectives needs to be based on a complete lifecycle performance of fuels and propulsion systems. Hence, any assessment underlying future infrastructure decisions needs to:

- take into account the potential of alternative fuels;
- consider the capacity of alternative fuels and their infrastructure to actually improve energy security, become economically viable and reduce carbon emissions (and meet additional sustainability requirements) so that counter-productive and expensive lock-in is avoided;
- develop the necessary actions on energy infrastructure and on vehicles (in parallel) to ensure consistency and coherence.

2. THE STATE OF PLAY IN THE EU

Infrastructure requirements of the individual alternative fuels are very different, with regard to technological challenges, cost, complexity, coordination requirements and administrative implications. Alternative energy sources requiring dedicated infrastructure would need to prove their advantages over fungible fuels and biofuels which require only minor infrastructure changes. The development of fungible and biofuel products to industrial volumes may prove more economical. The technical and resource limitations of the different alternative fuels may, however, require taking both approaches. In this respect, national energy mix options could influence the existing development of infrastructure as well as the future build-up of infrastructure.

Building up and maintaining several infrastructure systems in parallel is a challenge but not insurmountable. In the past, different types of fuel infrastructure have been built in parallel a number of times, such as the full size area covering distribution systems for several quality grades of gasoline and diesel, and on a smaller scale also for LPG and methane. This parallel full roll-out of several systems has been mainly carried out by industry alone, without public support. As shifting to alternative fuels is not driven by consumer demand or performance issues but rather by several policy objectives, for example increased energy security, reduced GHG emissions and improved local air quality, the market introduction of new transport "fuels" could require public support to bridge investment gaps. For those alternative fuels / energy technologically proven and with market potential, it would be preferable to undertake as much as possible the creation of new appropriate infrastructure. This would be essential for the future security of energy supply and mobility and also in the interest of all sectors of economy, particularly those active in the fuel and vehicle sectors. An overall neutrality of technology should be ensured.

The state of play of infrastructure for the main types of alternative fuels can be summarised as follows:

2.1. Electricity

Present coverage, regulatory framework, technology and standards

The existing European electricity system already provides end-users with a very efficient infrastructure for the generation, transmission, distribution and commercialization of electricity. The equilibrium of this very complex system is managed in real time by transmission control systems, across all borders of Europe. Optimal integration of electric mobility is important in order to avoid technical bottlenecks and unnecessary investments in the electricity network.

Additional infrastructure is therefore still required for charging on-board batteries as intermediate storage in road transport vehicles or stationary batteries in charging ("filling") stations. Infrastructure build-up is also required for any further electrification of railways. Technological and operational experience with transport infrastructure providing energy via over-head line or third rail in different power classes for urban and long distance traffic has been refined over decades of development and application and there are no technical obstacles to future expansion.

Regarding electric vehicle infrastructure, a standardized grid-vehicle connection is necessary: a common hardware solution between socket, connector and charging point should ensure consumer convenience, enabling the electric vehicle user to plug a car to the electricity supply anywhere in Europe. It is important to standardise the technology, as this would provide a secure investment climate and remove market hurdles. However standardisation is not enough to ensure interoperability, as has been demonstrated in the past with the standardisation of domestic plugs.

The commercial success of electric transport will largely depend on the customer as much as on the offer. Common standards will help to ensure a convenient recharging solution across Europe, avoiding a multiplicity of different cables and adaptors and/or retrofit costs for adapting to new charging systems. Moreover consumers should be able to charge their vehicle at any publicly accessible charging station across Europe. The Commission mandate to the European standardisation bodies for a common interface between the distribution grid and electric vehicles, currently under development, should ensure interoperability and address the required safety and security level for the consumer.

Developments are already to be noted, in this direction, such as the recently announced connector's "Combo System" for the European countries supported by the major European car manufacturers. The next expected step will be an agreement for the standardisation of the communication protocol to use in the battery charging management and for the harmonisation of the on-board charger classification in some specific classes, regarding its electric specifications, which should be suitable to match the needs of the various sizes of the car's battery packs and the charging characteristics of the vehicle.

In the long term, commonly agreed standards will generate cost benefits and help to create economies of scale for both electricity companies and the automobile industry. Standards for both hardware (connectors and cables) and communication software are a prerequisite for a secure investment climate for the required infrastructure. As well as encouraging the sharing of development costs, such standards will help to avoid the risk of stranded assets resulting from interim solutions. However, these new standards should not make charging from domestic plugs more difficult, as this charging method facilitates the early market introduction of electric vehicles. In general, at the early stage of market development, it is important to leave room for further market improvements and refrain from overcomplicating market models and regulation.

2.2. Hydrogen and Fuel Cells

Present coverage, regulatory framework, technology and standards

The development of hydrogen and fuel cell technologies for transport will offer zero tail-pipe pollutant emissions at the point of consumption, a strong reduction of noise and a comfort and range potential similar to ICE vehicles.

Hydrogen can be produced from all types of primary energy sources, ensuring its almost limitless availability, its storage capacity for renewable energy, and contributing to energy security. Hydrogen is an energy carrier that can be transported and stored in gaseous or liquid form, depending on the end-users needs. The support of Hydrogen as alternative fuel could be a key driver to further develop the role of Hydrogen technology in the European clean and secure energy supply.

Infrastructure build-up for hydrogen and a comparison to the needs for battery electric vehicles has been assessed in the recent European power-train study1. During the first decades the infrastructure costs for battery electric vehicles will be lower than those for the production, distribution and retail of Hydrogen, as most of the charging will be done domestically and over night, using existing infrastructure. Costs for electrical and hydrogen infrastructure are comparable and both dedicated infrastructures can be developed in parallel. It may not be wise to pick one or the other since they both are complementary, as they serve different car segments. Battery cars are better suited for the small size segment and shorter range, whereas fuel cell cars can also serve larger cars and longer range.

Hydrogen as an alternative fuel for transport needs to build up the necessary refuelling infrastructure, in order to reach sufficient network coverage to enable fuel cell electric vehicles' market entry. The storage and distribution part of the infrastructure can, for the market introduction phase, build on existing facilities for the large scale industrial use of hydrogen.

The hydrogen refuelling infrastructure for passenger vehicles could gradually and cost-effectively be deployed in step with the development of the market demand by inserting hydrogen dispensing systems in existing refuelling sites, as has been done previously with other alternative fuels such as LPG or CNG, thus reducing initial investment requirements.

The strategic build-up of infrastructure could further be achieved by inter-urban linkage of urban hydrogen hubs accommodating a variety of users like (public) buses, taxis, LDVs, passenger cars, catering for a wide range of users and increasing cost-efficiency.

These hubs could also efficiently support the development of hydrogen production and distribution capacity through a combination of the needs of various transport functions: public transport, urban and inter-urban logistics, handling of materials (warehouses, airports, ports), maritime transport.

Hydrogen is currently mainly produced and distributed in large quantities in petrochemical plants. It is widely used in industry, which can be leveraged for a public infrastructure. A significant fraction of this capacity produces hydrogen that meets the quality requirements for hydrogen use in fuel cells. However, where this is not the case, additional purification will be added progressively beyond 2020 as the fuel cell electric vehicle fleet builds up. In terms of Hydrogen production, additional investments are therefore limited up to 2020.

Hydrogen infrastructure is at an early phase of development with some 200 filling stations across Europe expected by 2015. Currently an initiative of a number of important industry companies from different sectors is planning to kick start the build up of hydrogen filling stations in Germany over the coming months. Considerable extension and build-up of new distribution and fuelling infrastructure is required in order to reach a sufficient

1 'A portfolio of power-trains for Europe: a fact-based analysis. The role of Battery Electric Vehicles, Plug-in hybrids and Fuel Cell Electric Vehicles'; released November 2010. The full report can be found at www.zeroemissionvehicles.eu

geographical coverage to support the vehicles' market entry. In terms of geographical coverage, territorial spread is key and a gradual and coordinated build up of infrastructure across Europe would be needed.

Concerning hydrogen and fuel cell standards, they are well advanced for the transport sector with ISO and SAE standards, already providing globally harmonized requirements with regard to key items such as the hydrogen refuelling interface, hydrogen fuel quality, and hydrogen refuelling station safety and lay out requirements. Other topics needing further coverage include fuelling protocols, stationary storage of hydrogen, high pressure hydrogen trailers and delivery by trans-filling.

This work will continue with the objective of comprehensive coverage by finalized standards in place for commercialization by 2015. Thanks to agreements in place between ISO and CEN these standards can readily be adopted as European standards where needed for interaction with EC regulation, while keeping the benefits of global harmonization.

European industry led coordination is required to ensure that the needs of European stakeholders are well addressed by international standards and to support the establishment of an efficient regulatory framework specifying these standards.

Important steps have already been taken for the development of the regulatory framework, as a European regulation for EC type approval of hydrogen fuelled vehicles is in place (covering passenger cars, buses and trucks). An efficient EC framework regarding hydrogen fuelling stations needs to be developed as well.

2.3. Biofuels

Present coverage, regulatory framework, technology and standards

With the exception of ethanol which cannot be transported by pipelines, other than in the form of bio-ether, biofuels can be blended and distributed through the existing oil and gas infrastructure, as long as the blend-in concentration is compatible with the blends mandated by the Fuel Quality Directive and existing standard vehicle technologies.

In principle, higher blends than Ethanol-10 and Biodiesel-7 (e.g. E85: 85% ethanol / 15% petrol) require some modifications to existing infrastructure and a dedicated distribution system. These high-blends could require new infrastructure equipment, which is not yet available on a significant scale (except for Ethanol-85 in Sweden, Germany and Netherlands).

The suitability of existing pipelines and housekeeping practice must be kept under review to ensure that fuels delivered to the point of sale meet the intended level of quality.

To support this and, as a general issue, the present Fuel Quality Monitoring System (FQMS) provided for in the FQD should be improved so that in-field problems with any fuels (present and future) are dealt with quickly and effectively. The current FQMS system is too slow to react to in-field problems.

2.4. Synthetic Fuels

Present coverage, regulatory framework, technology and standards

Synthetic fuels can – by design – be used neat or be blended at any mixing ratio with conventional mineral oil based fuels. The existing re-fuelling petrol/diesel networks can therefore be used and no specific infrastructure is required. This applies for all main synthetic pathways: HVO, GTL, BTL and CTL. New pathways include synthetic natural gas produced from temporary surplus of renewable electric power (e.g. wind or solar produced electric power), using hydrogen from electrolysis of water, and CO2.

Customer acceptance has already been proven commercially in Finland for a 30% HVO blend and in The Netherlands for neat GTL in current vehicles. Moreover, today HVO and FAME are on an equal footing as regards sustainability and agricultural challenges, since they are made from the same feedstock pool. Based on the current capacity, the expected volume of HVO will require an extended feedstock base and production to contribute to meeting the 2020 deadline for RED/FQD compliance, which is possible without any technical barriers. The only hindrance to such an increase at the moment derives from the fact that it competes with FAME for the same feedstock supply pool. Some synthetic fuels can have higher emissions than conventional fossil fuels.

2.5. Methane and Liquefied Natural Gas

Present coverage, regulatory framework, technology and standards

Natural gas and biomethane are considered as a single fuel, since their molecular composition is the same —CH4, methane—. Biomethane can be derived from different production processes - upgrading of landfill gas or AD biogas. Synthetic biomethane is produced via gasification of lignocellulosic materials and reforming of produced synthesis gas, or synthetic biomethane produced from hydrogen and CO2.

Natural gas and biomethane can be used in existing internal combustion engines with no limitation to blending thanks to the same molecular composition. The CO2 savings will depend on the natural gas/biomethane ratio. With regard to other tail pipe emissions, methane vehicles have practically zero particulate matter and very low NOx emissions, but their CO2 emissions are comparable to those of conventional oil.

A methane infrastructure largely exists, since most of Europe is covered with an extensive natural gas distribution grid for residential, industrial and power plant applications. The gas grid could also be made available for bio-methane feed-in to allow for a smooth change-over from fossil to renewable methane gas sources.

The infrastructure needs for Liquefied Natural Gas (LNG) for ships and heavy duty trucks on long distance transport and Compressed Natural Gas

(CNG) for cars, vans, trucks and buses on medium distance and urban short-range applications are different, but have some points in common, especially with the approach followed by L-CNG stations, where both forms, CNG and LNG are offered. For CNG, the methane needs to be compressed and dispensed from the current grid. For LNG, the methane needs to be handled through the supply chain as a cryogenic liquid, and could be sourced from LNG terminals or produced in liquefaction facilities in other locations. In remote areas lacking access to the gas grid, LNG could be supplied via trucks to filling stations able to supply both LNG and CNG (L-CNG stations).

The infrastructure of CNG fuelling stations, gas upgrading plants and gas injection exists or is expanding in a few countries like Austria, Germany, Italy, Netherlands, Sweden and Switzerland. In other countries, refuelling infrastructure is rudimentary and has to be extended or still created. In some countries, like France and Spain, there is practically no public network of methane filling stations. Both countries have pushed the use of this fuel in urban trucks and buses, with infrastructure accessible only to these fleets.

The development of methane vehicles is strongly hampered by very high investment costs that are required for the build-up of the needed methane refuelling infrastructure (CNG and L-CNG stations). The network of methane refuelling stations needs to be further developed in a harmonised way. The main driver behind investments in the methane refuelling infrastructure has mostly been the natural gas industry, especially when it comes to the promotion and construction of public refuelling opportunities for passenger cars and vans. The expansion of private refuelling facilities for commercial fleets of light and heavy duty and public transport companies of urban buses and trucks mainly results from local initiatives between public authorities and industry.

The disparities in the level of development for using methane in transport in Europe are due to specific national investment strategies and to a certain extent also to the availability of economic resources. In addition to this, investments for the development of infrastructure take time, which is even more evident in the case of CNG and L-CNG stations where investments are at least five times higher than for conventional liquid fuels. More established NGV (Natural Gas Vehicle) countries needed more than 15 years to develop the infrastructure of today. It is therefore clear that countries like Greece, Ireland or Slovenia, which are now starting the construction of methane refuelling stations, will require time, at least until 2025 or beyond, to guarantee adequate refuelling. Political support and binding targets, incentives and subsidy schemes would certainly speed up the build-up of infrastructure. A coherent public policy (taxation) will also be crucial.

The strong position of NGVs in Italy, with 760.000 natural gas vehicles (75% of the EU market) and 810 public refuelling stations (as of June 2011) after more than 30 years of natural gas in transport, is the result of a very active retrofit conversion industry in the 70s and 80s when the emission standards were much less strict than today and from the 90s supported by popular small and medium-sized cars and their commercial ex-factory CNG versions.

The European NGV related industry has already made investments of around 2 billion € to establish the existing network of methane refuelling stations. More than twice this amount would be needed to provide adequate refuelling conditions. But the diversity of national strategies has led to a very fragmented development of methane refuelling (public filling stations or private fleet depot stations) across Europe.

In total there are around 3.000 refuelling points (public and private) in the EU and EFTA countries, of which 2.300 are public. Of these, 2.000 public refuelling stations are based in Austria, Germany, Italy, Sweden and Switzerland alone. So far there are 23 stations that are equipped with the L-CNG technology, mainly in UK and Spain (as of June 2011).

Methane delivered in the form of LNG is an increasingly important energy resource to Europe. Additional infrastructure, however, is required for supply and storage at filling stations and for possible filling from depot and private truck fleet filling stations. Limited LNG infrastructure has been developed so far. It is already available in a growing number of terminals on the European coast: approximately 16 marine terminals currently exist in ports, and another 52 are proposed or under construction. Additional re-fuelling infrastructure in ports and along roads ("Blue Corridors") would be required to make LNG an option for maritime and long-distance road transport. With an operating range of 600 to 800 Km for LNG fuelled trucks, there is no need for an area-wide coverage in order to build a satisfactory LNG refuelling network. Strategically well chosen sites at truck stops along the major European highways would open the market opportunities.

LNG required for supply to L-CNG or LNG filling stations could, via the choice of suitable technology, be produced at pressure reduction stations along the high pressure NG grid with a minimal use of energy thanks to the cooling effect when reducing the gas pressure. Up to some 20% of the gas leaving the pressure reduction station could be transformed into LNG without addition of energy. A suitable design of the pressure reduction technology should be considered in further developments of the NG grid.

Biomethane, after proper upgrading of the raw product -biogas-, should preferentially be fed into the general natural gas grid under sustainability criteria – in the same way as liquid biofuels. Methane powered vehicles should then be supplied from the gas grid. This can balance regional differences in biogas production and natural gas consumption by vehicles, and avoid double investment into a parallel bio-methane distribution network. Blending biogas with fossil natural gas, allows a gradual increase of non-fossil fuels without major investments in new infrastructure. However, where logistics and economics permit, captive fleets could be fuelled from close-coupled bio-methane facilities such as sewage treatment plants or landfill sites.

Concerning the market outlook of methane and LNG for transport, any significant penetration would require the availability of a minimum refuelling infrastructure. If the refuelling network of CNG and L-CNG were rapidly developed across Europe, the market for methane powered vehicles could grow significantly in Europe in the short, medium and long term, with the expectation to reach a total market share of 5% by 2020, 9% by 2030 and 16% by 2050, both in passenger and freight transport, combining all transport modes.

The application of Euro VI in 2014 reinforces the relevance of environmental and economic benefits via CNG and LNG, especially in HD trucks and buses. Today the natural gas combustion engine technology, with minor modifications, already meets the Euro VI standard, outlined in Regulation (EC) Nº 595/2009. In particular, for trucks and buses the Regulation foresees a reduction of 80% in nitrogen oxides (NOx) and 66% in particulate matter (PM) emissions compared to the Euro V standard, which was introduced in 2008. Today's main concern for city air quality is NO_2, a part of the total NOx. The percentage of NO_2 in NOx is much lower from methane than from diesel engines. The new requirements will result in major modifications and investments in the diesel technology. Hence, the price gap between methane powered HD vehicles and conventional diesel vehicles will consequently be reduced and could sooner or later disappear. In the light duty sector methane vehicles already have the same purchase cost as diesel vehicles, and will be even cheaper than the respective diesel version in the future when stricter emission regulations will come into force. This combination of having a cost-effective fuel and advantageous vehicles available in the market will ensure customer acceptance if an appropriate refuelling infrastructure is put into place.

State-of-the-art heavy duty trucks with dedicated engines running on methane, on a tank-to-wheels basis, give a CO_2 saving of about 3% versus diesel vehicles, but the next generation of NG heavy engines with inlet valves' electronic control will improve the saving up to 8%. Dual fuel/heavy engines will also result in significant CO_2 emission reductions.

2.6. Liquefied Petroleum Gas

Present coverage, regulatory framework, technology and standards

Liquefied Petroleum Gas (LPG) is a blanket denomination covering propane and butane, two naturally occurring gases which are easily converted to liquid form through the application of moderate pressure. LPG is primarily derived during the exploitation of natural gas/oil fields (60% of global LPG supply), and is also produced in refineries. LPG can also be obtained as a by-product from the production of synthetic fuels.

Besides the fact that LPG can easily be liquefied and transported, it is also important to note that the security of its supply is ensured by its very diverse origins. Transporting LPG across the whole distribution chain, from the production site to the refuelling stations can include a combination of pipelines, deep sea/coastal tankers, rail tank cars, and bulk road tank cars. This ensures a high degree of flexibility of LPG supply routes, which can easily be modified depending on changing circumstances.

Autogas[2] infrastructure is relatively well-developed with a significant number of filling stations already present in the EU (approximately 27,500). European countries where the LPG filling station network is the most developed are Germany (6,150), Poland (5,900), Italy (2,350), and the Netherlands (1,900). However, the distribution of filling stations is somewhat irregular with infrastructure in some Member States under-developed (e.g. Spain, Denmark, Austria, and Sweden). Additional filling stations could close a few geographical gaps, and consequently enable autogas users to enjoy free mobility across Europe.

The industry has set out a voluntary standard (EN 14678) which outlines technical and safety requirements for autogas filling stations. A key objective for this standard was to increase user friendliness and apply similar standards to those used for conventional fuels, thus facilitating integration into national legislation. The LPG industry is currently in the process of revising the standard to include specific requirements for un-manned stations and multi-dispensers. The development of these two forms of LPG filling stations, which are currently subject to unnecessarily stringent regulations in some Member States, may represent a crucial opportunity for the further growth of this alternative fuel in Europe.

Including the Euro connector (EN 13760) which was created in 2003 but has only shown limited uptake, four types of filling nozzle are used across Europe. The types of nozzle and their respective geographical distribution are as follows:

- Dish filling unit: Portugal, France, Sweden, Poland, Italy, Greece, Austria, Hungary, and Romania
- Bayonet filling unit: UK, Norway, Denmark, Netherlands
- ACME filling unit: Ireland, Belgium, and Germany
- Euro connector: Spain

Although the coexistence of several filling units in Europe can possibly create inconvenience for autogas users, this does not prevent travelling across Europe as adaptors can be used. Autogas users can either buy such adaptors or borrow them at the filling stations.

The use of a single standardised connector across Europe would certainly enable the autogas market to grow further. However, such a move would have a considerable cost that could only be justified if the wider EU legislation was ensuring legal certainty for the longer term development of the sector. Obvious examples of such critical pieces of legislation are those dealing with the taxation of energy products or safety requirements concerning the installation of LPG filling stations in urban areas.

2 Autogas: Denomination of LPG used as a transport fuel

3. THE SCOPE OF INFRASTRUCTURE BUILD-UP

3.1. Fuels and transport modes

The first report of this Expert Group3 of 25 January 2011 concludes that the main alternative long-term options for substituting oil as an energy source for propulsion in transport are electricity, hydrogen, and liquid biofuels; synthetic fuels as a technology bridge from fossil to biomass-based fuels; methane (natural gas and biomethane) as a complementary fuel; and LPG as supplement.

Single-fuel solutions covering all transport modes would only be possible with liquid biofuels and synthetic fuels. However, feedstock availability and sustainability constraints limit their supply potential. It is therefore unlikely that there will be a single solution for the fuel for future mobility. The precautionary principle would then already advise to base projections for future mobility on multiple options. Fuel demand and GHG challenges require the use of a great variety of primary energy. Therefore, all environmentally and economically sustainable fuels will be needed to reduce the existing 96% oil dependency of the European transport sector.

The individual transport modes require different options of alternative fuels. A mix of several different fuels, with possibly increasing complexity, will therefore most likely determine the energy supply to transport for the foreseeable future. In a first approach, the following coverage of alternative fuels per transport mode can be expected in the long-term:

- Road transport could be powered by electricity and hydrogen for short distances, hydrogen, methane and LPG up to medium distance, and biofuels/synthetic fuels and LNG up to long distance. However, out of the mentioned alternatives, only biofuels/synthetic fuels and methane (CNG and LNG) are viable options for the heavy duty sector.

- Railways could be electrified wherever feasible, otherwise use biofuels and/or hybrid solutions to bridge gaps in the electrified network. Non electrified trains or locomotives can also use LNG.

- Aviation could be supplied from biomass derived kerosene. LNG might also be a possible option and there are also some examples where CNG has been used in short distance traffic.

- Waterborne transport (maritime and inland waterways) could be supplied by biofuels (all vessels), hydrogen (inland waterways and small boats), LNG, (short sea shipping and inland waterways transport), and nuclear (maritime).

3.2. Possible options

The following options were developed during the last meetings of the Expert Group. They will serve as the basis for recommendations by the Group.

3 http://ec.europa.eu/transport/urban/vehicles/directive/doc/2011_01_25_future_transport_fuels_report.pdf

Possible options may include incentives, self-regulation and regulatory actions. They should lead to the achievement of a minimum coverage of alternative fuelling infrastructure in the EU using harmonised standards in order to trigger a significant volume of take-up by the market. The final objective is to provide the minimum infrastructure coverage for those fuels /energy which are technologically proven and with market potential, which should enable the market to pick up and develop further.

Option 1: No additional EU action

This option takes into account all current legislative and policy initiatives in the field of alternative fuel infrastructure, as well as the current and announced industry developments. It includes the continuation of previous action programmes and incentives, such as:

- Funding Research and Technology Demonstration (RTD) projects to promote alternative fuels.

- Possibility of state aid for the construction of alternative fuel infrastructure.

Option 2: New funding schemes and non-legislative measures

This option includes *inter alia* the following non-legislative actions:

- Reinforcing RTD funding mechanisms and large-scale projects facilitating the introduction of alternative infrastructure in certain EU regions.

- Optimising the use of the existing funding schemes for the construction of alternative fuel infrastructure (Structural and Cohesion Funds and EIB loans).

- Creating new financing schemes for the construction of alternative fuel infrastructure (e.g. PPPs)

- Extensive monitoring and data collection on the use and operations of fleets running on alternative fuels to allow for fact based policy making.

- Online platforms providing information on alternative fuel filling stations in the EU.

These actions will complement or reinforce the actions which are already considered in policy option 1.

Option 3: Harmonisation of standards for alternative fuel infrastructure

This option entails the adoption of common standards for alternative fuel infrastructure, which is necessary to allow the free movement of Alternative Motor Fuels (AMF) vehicles, vessels, locomotives and aircraft. These standards will also contribute to the completion of the internal market in this field.

It should however be noted that the adoption of these standards is in the remit of the European Committee of Normalisation (CEN). In this respect, the Commission could provide a mandate to the CEN requesting them to adopt certain standards for alternative fuel infrastructure and then impose these standards in EU legislation. Many of these standards could be international standards (ISO) adopted by CEN under the Vienna agreement[4].

Option 4: Harmonisation of standards for alternative fuel infrastructure coupled with self-regulation by the industry based on common EU goals

In addition to the standards, some common goals could be set up at the EU level to be achieved by industry for the deployment of alternative fuel infrastructure, taking into account relevant characteristics of individual Member States such as geographic position, topography, population, number of vehicles registered, main transport modes used, etc. The industry would be required to ensure, in a first stage, a certain minimum build-up (i.e. coverage) of infrastructure for alternative fuels. Increase of the requirements, in a second stage, will follow after a period of time, subject to a review of the alternatively fuelled vehicles' market development.

This option would consider development perspectives for all main alternative fuel options, and takes into account resource limitations, market developments, and the long-term potential to contribute to achieving the objectives of the White Paper in particular with regard to greenhouse gas emissions.

Option 5: Binding targets on alternative fuel infrastructure

This option includes imposing the goals described in policy option 4 as binding targets for Member States. The same three sub-options listed in Option 4 would be considered.

These five possible Options represent a first approach which can be further developed or complemented with additional options.

In order to allow the market to operate freely, flexibility on the development of the different alternative fuels shall be left. This can be addressed by means of a differentiation between the different fuels, according to their development curves and a two-stage implementation approach, and by including an intermediate point for a review of technical and economic developments and possible correction of the requirements for the second stage.

3.3. Discussion on needs and possible options

The call for shifting to alternative fuels should be driven by a clear societal and political choice to significantly reduce transport's carbon footprint in order to facilitate consumer demand and meet a wide range of EU policy objectives. Today's established market for conventional fuels will not cater

4 ISO draft standards already provide globally harmonized requirements with regard to key items such as the hydrogen refueling interface, hydrogen fuel quality, and hydrogen refuelling station safety.

for the necessary change by itself until a point when the new fuels/ energy options have proven their potential. Furthermore, it seems unlikely that the current EU legislation, such as the Renewable Energy Directive and the Fuels Quality Directive, will provide the necessary stimuli to bring about the required infrastructure facilitating the uptake of alternative, low-carbon transport fuels; nor were they designed to do so.

On the other hand, existing incentives have proven too weak to bring about advanced sustainable biofuels (with little/no need for additional infrastructure beyond potential fuel-engine compatibility issues) or electric mobility, even though more than 90% of the renewable energy in transport target is anticipated to be met by conventional biofuels.

Hence the current legislative framework is unlikely to bring about the radical infrastructure changes that would be needed, e.g. for larger-scale electric mobility uptake. As a consequence, Option 1(no additional EU action) would not be effective.

Public aid for infrastructure investments is most likely needed. This is envisaged by the proposed Option 2 (new funding schemes and non-legislative measures). Option 3 (harmonisation of standards for alternative fuel infrastructure) is necessary to solve the lack of EU standards for alternative fuel refuelling equipment and storage systems. Option 4 (Option 3 coupled with self-regulation by the market) would represent setting-up common goals to be achieved by industry to bring about new infrastructure. Option 5 represents a step forward by imposing these goals as binding targets for Member States.

A potential advantage of Options 2 to 4 over Option 5 is that these leave more room for the market to decide on a sustainable fuel mix while accompanying this development by granting harmonised standards, direct investments and aids to build up the infrastructure needed to deliver these future fuel mixes. This is under the assumption that the EU will put in place appropriate legislation to take all externalities into account and have fuel prices reflecting the true costs of transport, including its impact on the environment and public health.

Furthermore, some members of the Expert Group would strongly reject the recommendation of establishing binding targets on fuel infrastructure resulting from Option 5. According to their view, existing legislation, standardization and RTD funding mechanisms constitute the appropriate framework to remove barriers to commercialization. They believe that developing infrastructure that is not in line with market development would not be cost effective, and that the legislation should only aim at creating a level playing field for those fuels and energies that have proven their technological and market viability.

One additional justification of the opposition to Option 5 is that any statutory requirement to enforce the implementation of the further introduction and expansion of alternative fuels would mean an unreasonable intervention in the freedom of exercise of occupation. If the market players (currently petroleum traders) were placed under an obligation to make available the network financed by themselves (filling stations) and to market alternative fuels, this could conflict with existing European and national laws.

There was further scepticism regarding uncertainties about the effectiveness of alternative fuel options to decarbonise the transport sector, the main goal put forward by the Transport White Paper. The most compelling example is electric vehicles that will only be effective in reducing emissions with a parallel decarbonisation of the electricity mix as a result of large-scale renewable energy deployment. A similar example is biofuels that might lead to additional emissions due to indirect land use changes that are currently being addressed by the Commission.

Most members of the group however share the opinion that Option 5 could become a real driver for the alternative fuel market, as increased visibility of and better accessibility to alternative refuelling is key to attract clients and steer market demand for those fuels. An appropriate refuelling infrastructure has to exist before producing and promoting more alternative fuelled vehicles on the OEM side. However, before promoting alternative infrastructure, there should be certainty on the availability of sufficient quantities of cleaner fuels that can reduce emissions.

Infrastructure mandates could prevent the market from selecting the most cost-efficient solutions, as they would lead to technology mandates. Technology mandates could remove the incentives for cost-optimisations by the representatives of a given fuel/drive-train option. A goal orientated legislation, for example the 6 % GHG reduction target of the Fuels Quality Directive, would also be in line with policy choices such as the reduction of oil-dependency, as the GHG reduction will be largely met by the substitution of diesel and gasoline by low carbon alternative fuels. The choice of those low carbon fuels will be based on their cost-efficiency thus enabling CO2 reduction at the lowest cost to society.

But when assessing new disruptive technologies in the energy sector, we have to consider the lack of coordination rules between energy supply and energy use in the market as they are independent segments.

For example, car manufacturers are already facing goal oriented regulations for tail pipe emissions in order to reduce negative impacts on the environment and health. And it would be a logical step to add legislative provisions which allow for the introduction of even cleaner and more efficient drive train technologies with market potential and one part of this is the necessary infrastructure to enable market-introduction.

Mandates on infrastructure are mainly objected by some members for the above reasons. But the other members of the group believe that public intervention may be necessary to break deadlocks between potential market growth for new alternative vehicle technologies and non-existing alternative fuel supply. Public intervention could be justified by overriding the objectives of security of energy supply in a sustainable way ensuring decarbonisation. Some members question using public money on the building of infrastructure, which should primarily be paid for by transport users, for example through higher charges on petrol.

These members see merits in having binding targets on alternative fuel infrastructure apply to Member States as a path forward for ensuring the availability across Europe of the alternative fuels that contribute to achieving the EU's targets. They observe that goal oriented binding targets have already been very effective in reducing the tail pipe emissions of vehicles, with benefits well exceeding additional costs and going far beyond what was previously achieved when only non binding targets were defined. It would be a logical step to complement this regulation supporting the introduction of even cleaner and more efficient drive train technologies with regulation supporting the deployment of the necessary infrastructure to enable their market-introduction.

Country-based deployment projections shared by the involved vehicle manufacturers commercializing the vehicles and infrastructure providers could be requested to base binding infrastructure deployment targets for a particular fuel. These would provide a timeline indicating areas of deployment, number of vehicles, number of fuelling points, and the breaking point for the economical viability of the technology.

The choice to reduce oil-dependency and CO2 emissions in transport is a clear societal and political choice which should be done at the lowest possible cost to society and is not only driven by individual or market needs. There are various possible schemes that Member States can adopt, including public-budget-neutral monetary incentives and energy taxation policy, to ensure that their targets are reached through market pull.

In conclusion, according to the statements from some members of the Expert-Group rejecting Option 5, any requirement regarding charging/fuelling points should be driven by market demand and not by legislation. However, most members believe that it is not realistic to expect the market to cater for the transition to more expensive low carbon alternatives alone, and that, therefore, important interfaces should be defined by legislation to allow and encourage this market demand. As a few countries, such as Sweden have shown, where an obligation was established for larger filling stations to sell at least one alternative (renewable) fuel, the petroleum industry is ready to make an additional step helping to increase the renewable fuel market. Binding conditions could be in the form of a quota for all alternative fuels. Then the market would decide which fuel to favour.

.New fuels like electricity and hydrogen, being energy carriers, will need to be produced from primary energy sources. Intelligent links with strategic energy technologies in the SET Plan together with strategic transport technologies in the Strategic Transport Technology Plan (STTP), as indicated by the White Paper are urgently needed to leverage funding and ensure an efficient use of energy. Horizontal programming of the SET Plan's European Industrial Initiatives in relation to the impact on transport, should further enhance the coordination of RD&D topics put forward within the framework of public calls for tender.

Additional incentives could usefully come from future increased fuel quality targets, more stringent vehicle emission performance targets or energy taxation rules. Action should be required from a number of different actors, e.g. fuel providers, vehicle manufacturers and users. No policy instrument can effectively target all these actors and, therefore, different policy instruments are needed to affect their behaviour.

Industries involved in mobility are already working on many potential technologies (advanced fossil fuels and combustion engines, fuel cells, batteries, advanced biofuels) none of which are commercially viable today. To overcome barriers to commercialization, support measures will need to cover the full innovation cycle spanning from investments in Research and Technology Demonstration (RTD) to commercialization. It is generally accepted by the group that funding RTD projects to support the harmonisation and homologation of alternative fuel equipment and storage systems is crucial, as well as specific financing schemes for the construction and operation of alternative fuel infrastructure, in order to successfully overcome the barrier of high investment (e.g. for pilot projects) and high initial operating costs. Investment costs would even risk to be climbing progressively, if such support measures were delayed, as more stations would have to be substituted.

Concerning green procurement and pre-commercial procurement schemes, they have not been very effective so far, mainly due to the lack of technical expertise at the local level. In particular, the application of Directive 2009/33/EC on the promotion of clean and energy efficient vehicles would need to be accompanied by an intensive technology dissemination programme to accelerate clean decision making. For instance, supporting a clean vehicle offer by leasing companies would be effective to that end by limiting the technological risk taken by early adopters as well as by creating hubs of technical expertise in the evaluation of new technology offers.

In relation to the timeframe for building up infrastructure, it cannot be the same for fuels with different commercial maturity. Hydrogen, for example, requires high initial investments to establish a basic refuelling network and sufficiently upscale the fleet, but if investments are well coordinated over the next 10 years (e.g. geographically and with regard to public buses and users), experts estimate that fuel cell electric vehicles could be fully commercial by 2025.

Methane infrastructure is also facing higher investments, but benefiting from a more mature technology could lead to a rapidly growing market reaching a 5% market share in the total vehicle market by 2020 (15 to 16 million vehicles). Another option is to use the natural gas network as a bridge for hydrogen: mixing hydrogen into the natural gas grid (up to 10% has already been demonstrated in small-scale projects) which in turn would facilitate the gradual development of production units.

Finally, for railways, it should be emphasized that a blending-in of biofuels must not lead to loss of performance nor lifetime, nor to a decrease of safety. Due to the long life-cycle of rail vehicles, fuel diversity will be necessary over decades. State aids will be needed in certain cases for the further electrification of railway lines.

3.4. Alternative fuelling infrastructure coverage

Definition of Coverage and Location:

Coverage: defines the intensity of fuelling stations/charging points that would offer the alternative fuels. The parameter depends on the type of alternative fuel to be considered. Member States must ensure an appropriate geographical spread of the fuels with proven potential.

For biomethane it is equally important that enough upgrading plants and grid injection points are erected. Therefore, a balance has to be found for the support of electricity and biomethane production. For hydrogen, high-blend biofuels, methane, and LPG, a minimum number of filling stations could be defined per km2 of inhabited urban areas or driving time/distances in remote areas; for electricity, coverage of charging points could be linked to the amount of newly installed and/or existing parking spaces (residential and non residential), or to the registered vehicles at national level; LNG may be required at harbours/ports and at truck filling stations having a certain minimum annual turnover. Other criteria could be to link the station coverage to the population density or to the number of vehicles registered in a Member State.

Location: defines the place where the alternative fuels will be offered. As electric vehicles are most suitable to be used in urban areas, a distinction could be made between urban and non-urban roads (e.g. highways). The infrastructure location for electric vehicles determines to a large extent the technical specifications of the charging infrastructure (see Annex 4). For fuels more suitable for long-distance transport, one could consider to offer them on the main highways, in particular within the TEN-T Network, at certain distance intervals. A corresponding logistics system would also need to be supported: gas injection into NG grid where possible, transport in high-pressure swap bodies for short and medium distances, or as LNG/LBG for longer distances.

Possible sub-options to be considered:

The main goal is to ensure EU-wide mobility for alternative fuels and to make this mobility economically viable. Options 1 to 5 previously discussed should lead to the achievement of a certain coverage of alternative fuelling infrastructure within the EU. The following sub-options, linked to the main options, focus on the coverage of each transport mode by the different alternative fuels that should enable the market to pick up.

Sub-Option a): Minimum coverage of each transport mode by the most appropriate and economically viable fuel. This sub-option would ensure a minimum market development for alternative fuel infrastructure.

Sub-Option b): Optimum coverage of each transport mode by appropriate and economically viable fuels. This sub-option would support the most suitable fuels for each transport mode to provide optimum coverage, following the recommendations provided by the Group.

Sub-Option c): Coverage of each transport mode according to fuel economic viability and development perspectives. This sub-option will consider development perspectives for all main alternative fuel options, and takes into account market developments and limitations of resources.

The following chapters contain a first approach to a policy assessment of the different options per alternative fuel, including possible associated environmental risks and benefits.

4. RECOMMENDATIONS FOR ELECTRICITY

Appropriate to include the fuel?

The commercial use of electric road and rail vehicles offers several major benefits for sustainable mobility

- Helping to attain major EU energy-environment policy goals: replacing conventional internal combustion engines by electric vehicles would result in major reductions in CO_2 emissions (particularly if the electricity mix is decarbonised) and in air quality improvements at the point of consumption, especially in cities. Electrifying road transport would also boost Europe's security of energy supply by breaking the growing dependence on imported fossil fuels.

- Electric vehicle technology offers an opportunity to take the lead towards a sustainable green economy which would contribute to the competitiveness of Europe: it offers the opportunity for the EU to become a front runner in producing electric vehicles.

- Given the technology and infrastructure levels currently in place, grid-connected road vehicles can become a reality and are already a reality for rail. Moreover, a large-scale rollout of electric vehicles would have an impact on the electricity system, load and foster the development of more intelligent distribution grids ('smart grids') capable of moderating such impact.

- Electric vehicle technology contributes to a multi-modal shift in the transport sector, in line with the more recent EU policy goals. Innovative mobility concepts are possible when combining electric vehicles with public transport. The concept of the electrification of the first and last urban mile should receive full attention, as this is one way towards a truly sustainable transport system (low-carbon and less congestion).

However, significant challenges (driving range limits, cost/weight/volume of batteries, disposal of used batteries, availability of lithium) still need to be resolved. Some progress has been already made, more specifically on the range issue.

Fast chargers, range extenders and the combination between private vehicles and public transport (multimodal transportation) are already available solutions for the driving range limit.

Which transport modes should be covered?

Electricity can power road transport vehicles in urban areas and for short distances. The further electrification of railways should not be included in eventual legislative measures since the minimum build-up of infrastructure is already in place.

Furthermore, there should be an assessment of electrifying services at harbours and airports. Public transport should also become more sustainable. To this extent future possibilities need to be assessed in order to make public bus transport sustainable. Public bus transport should also be included: there is a need for an assessment which possibilities are economically viable for electrifying the public bus fleet: further hybridisation of the bus fleet, battery swapping, or quick recharge at each bus stop. Additional trolley buses should also be investigated.

What policy options would be most suitable?

Slow charging from existing electric sockets is already possible. This type of charging will be mainly installed in private homes, commercial buildings and companies. A number of fast vehicle charging[5] points with higher voltages for public access may be also needed in order to facilitate and extend electromobility and address range anxiety issues of consumers. In a reasonable number of Member States a fast charging solution using the given infrastructure is already possible.

In all cases communication between the vehicle and the electricity grid should be provided and this requires a dedicated plug and socket as well as a standardized communication protocol, which needs to be standardised/selected at the EU level to ensure interoperability. The Communication between the charging infrastructure and consumers will also be crucial for public charging and, therefore, should also be considered in the standardisation process.

Harmonisation of standards for alternative fuel infrastructure coupled with self-regulation by the industry based on common EU goals (Option 4) is supported by the electricity industry. Other members of the group believe that EU measures on infrastructure build-up for electricity in vehicles should be no less stringent than for other alternative fuels. This is because electric vehicles are being introduced in the next coming years already, and are expected to make an important contribution to transport decarbonisation in the future.

At the moment market forces alone will not deliver the required public infrastructure due to the relative immaturity of the business process. During the transitory phase of market development, it might be advisable that the DSOs play a central role in this effort in order to ensure a minimum coverage because for the moment, given the relative immaturity of the business process no commercially viable market models are being identified. There are examples in some EU countries where a reasonable number of public charging stations are already in place led by the DSO. Once a certain market maturity is reached, the electricity industry calls

5 Fuelling an electric vehicle means charging the battery. Hence the fuelling of an electric vehicle will depend on the combination of: -charging power (i.e. the voltage/amperage and the number of phases of the plug); -battery characteristics. Hence High Power charging (Fast) means an AC or a DC connection higher than 32 amps. See Annex 4.

upon a careful assessment of the regulatory models across Europe to ensure an effective and efficiently functioning market for the charging infrastructure.

The situation is different for charging infrastructure in a domestic setting; private homes, commercial buildings and office buildings. Infrastructure (domestic sockets) is already installed available for use. It should also be noted that charging in domestic settings (home, office) may remain the dominant charging location.

In order to have a sustainable market safe and secure charging of EVs by consumers is an absolute priority. Therefore, it is necessary for mass market conditions to have one standardised dedicated e-mobility plug, in order to ensure consumer convenience, safeguard consumer safety, and integrate the increasing share of intermittent renewable energy.

Strict safety requirements have been put in place by legislation which may differ across EU Member States. The grid characteristics also differ significantly across Europe and regions. This different situation has complicated the decision on a dedicated e-mobility plug for AC charging infrastructure, although from a purely technical point of view, safety requirements are met. With regard to the charging mode, the electricity industry believes –in line with car manufactures and equipment manufactures– that Mode 3 in combination with type 2 plug is a safer and more reliable option to charge an EV in public locations and should be the preferred long-term infrastructure solution[6].

It is therefore recommended that the European Commission calls upon the Member States to harmonise legislation requirements and prescriptions, adapted to e-mobility purposes.

Minimum coverage of publicly available charging infrastructure needs to correspond to customer needs. However it is difficult to foresee and provide an exact number of units per registered vehicle. It may prove more advisable to make a recommendation per number of km on main public roads (for example a high power station every 60km on main highways).

In addition, fast charging has to be defined. The electricity industry recommends expressing the charging process in terms of power (normal, medium and high power), which is more accurate than in time-related terms (see Annex 4).

Do other policy options have to be considered?

Large scale electromobility demonstration projects, preferably including several EU countries and providers, are recommended to assess usage patterns and consumer behaviour and to test charging interface technologies and standards. The Green eMotion project is already addressing these issues and mid-term results may already provide new insight over the coming months.

Information and Communication Technologies (ICT) has an important role to play for the adoption of electromobility by consumers and should be more integrated in combined Research & Development programmes.

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6 EURELECTRIC Position Paper *European electricity industry views on how to charge electric vehicles*, April 2011.

Specifications of the variables in the policy options, including, for example, the amount and method of funding; estimation of costs and which parties should bear these costs

Infrastructure for slow charging at home (home-refuelling), not facilitating communication to the grid, is not expensive, if using the standard household socket, where the cost of charging points is lower and should be supported by the users. Dedicated infrastructure for recharging electric vehicles at home or at offices will put additional cost on the solution. However this type of connection becomes more important under mass market conditions and when an increased share of intermittent renewable needs to be integrated smoothly into the electricity distribution grid thus enabling zero emission mobility. The development of smart grid electricity distribution systems will facilitate this integration.

Public High Power points are more expensive. Given the immaturity of the commercialization process and lack of common agreed standards there is a danger that the market will not deliver. This dedicated high power infrastructure will be installed in conventional filling stations and other publicly accessible facilities by electricity and fuel providers, network operators or commercial retailers with adequate return foreseen on investment perspectives.

Although the different actors (i.e. public administrations, transport consortia, integrators, DSO and electricity providers, industry - equipment, batteries, vehicle manufacturers, etc.) that can play an active role within the electro-mobility scheme have been identified, it is still too early to confirm who will remain as the major player.

It is expected that once EVs gain a certain market share, different market models can exist. However, current initiatives for implementing the various business and market models, in fact, vary from one region to the other, and are at an immature stage. During the critical launch period of a sustainable eco-mobility solution, the lack of a proven and reliable master market option (that could be widely implemented across the EU) could pose the risk that many of the proposed initiatives may fail. Furthermore, the multi-sectoral and disciplinary nature of the initiatives and of the promoters - public, private or mixed[7], facing high upfront investment costs with still uncertain returns, adds additional complexity to a definitive solution, particularly if the lack of a wide range of affordable EVs in the market prevails, at least until the middle of this decade. In order to contribute towards the mitigation of these risks, along with the financial market options, future funding schemes adopted in Member States should be coordinated at the EU level.

The electrification of railway infrastructure and the purchase and operation of electric railway vehicles can be done with proven technology and predictable prices.

What standards need to be developed?

Common standards should allow all battery electric vehicles to be charged and to communicate with the grid and with all types of charger anywhere in the EU.

7 PPP - Public Private Partnership.

As established in the European strategy on clean and energy efficient vehicles8, the standard shall take into account ongoing work at international standardisation bodies. The work of the European standardisation bodies is still on-going, under mandate of the Commission, for a standardised charging interface. This single interface solution should be adopted by all industry players, including vehicle manufacturers, electricity providers and electricity distribution network operators, in order to ensure interoperability and connectivity between the electricity supply point and the charger of the vehicle. It is recommended that any binding target for a minimum coverage of charging points would be based on this common interface.

A decision on a standardised plug for both AC and DC has to be taken immediately because any delay in these decisions may hamper the market up-take. In addition the work for standardising communication protocols, enabling data communication, safety issues, billing/payments, plus information to drivers on the availability of nearby charging stations, needs to be continued and intensified in order to reach consensus as soon as possible.

5. RECOMMENDATIONS FOR HYDROGEN AND FUEL CELLS

Appropriate to include the fuel?

Fuel cell electric vehicles (FCEVs) provide a clean alternative and clear advantages widely acknowledged for passenger mobility, (including cars, taxis, motorbikes and (public) buses). There are no performance compromises to be made by the user in terms of size, driving range or speed, refuelling time or other driving comfort in comparison with traditional cars. Moreover, FCEVs have no tail-pipe emissions at the point of consumption, are silent and hydrogen can be produced from all (renewable) feedstock. FCEVs offer the opportunity for zero-emission transport and provide a clean alternative for all individual driving-patterns, urban, intercity and longer-distance. As with all electric car variations, a dedicated refuelling infrastructure, in this case for hydrogen, needs to be built up.

Which transport modes should be covered?

Hydrogen and fuel cells have been successfully applied and demonstrated over the past years in passenger (road) transport, public transport buses, the logistics sector and light duty vehicles. More research has been conducted on applications in the maritime and aviation sector, in the latter case as an auxiliary power source but also as a fuel as illustrated by recent speculation on the development of hydrogen powered airplanes.

The wide range of applications in transport allows for a more cost-effective introduction of hydrogen infrastructure at locations where various applications come together. For example in urban areas the location of hydrogen stations can be chosen to accommodate the refuelling of buses, light trucks, taxis, passenger cars, etc.

What policy options would be most suitable?

8 COM(2010)186 final

The choice to reduce oil-dependency in transport is a clear societal and political choice and is not driven by individual or market needs. Decision-makers need to be made aware of the impact of the choice of support for specific alternative fuels on local energy and transport systems, especially with regard to the impact on co-modality. Therefore it is not realistic to expect the market to cater for this transition to more expensive low carbon alternatives alone. In the absence of economic viability, an appropriate regulatory framework and financial public support, as well as public budget neutral incentives, will be required to introduce clean alternatives to the market and provide the European citizen with a clean choice of transport, in the same way that economic support was essential for bringing renewable energy production to where it is today

In view of the scope of change required for a low carbon transport system, it would be recommendable to dedicate a study to analyse the current regulatory framework and to identify the gaps and level of policy support required to enable this change.

To establish a European hydrogen refuelling network, the most effective approach will be to combine measures developed at the European level, defining in particular targets and obligations for Member States, with measures adopted by Member States and at the regional level to achieve these targets.

A European roll-out study is foreseen by the FCH-JU in 2012, in order to identify the most cost-efficient and appropriate EU Roll out Roadmap

An indicative timeline for hydrogen refuelling build-up, along the typical three stages towards commercialisation would be:

By 2015	Pre-commercial phase; Around 200 to 300 refuelling units in various urban regions across Europe, accommodating passengerand light duty mobility locally (5000 FCEV passenger cars, 500buses) RCS framework in place for commercialization
By 2020	Early commercial phase; market penetration by linking existing pre-commercial hydrogen infrastructure networks to build up a European network connecting strategic corridors. Up to 2000 (minimum 1000) fuelling stations, 500 000 FCEV passenger cars, 1000 FC buses
By 2025	Commercial phase; sufficient scale and coverage to be market-competitive with traditional and other alternatives and for further organic growth.

Do other policy options have to be considered?

Public/private partnership is key for the successful commercial deployment of clean alternatives, like hydrogen infrastructure and FCEVs. Special attention should be given to the development of appropriate risk-sharing mechanisms to bridge the pre-commercial deployment phase. This high risk and low return period before the actual commercial competitiveness begins, needs to be overcome. To attract sufficient private investment a predictable and long-term framework should be put in place, allowing for the pooling of resources from various funding/support schemes and targeting equity based funding and modern financing mechanisms.

Furthermore public budget neutral monetary (e.g. energy tax funded tax credits for alternative fuel retailing) and non-monetary measures are needed to cover the initial operational cost gap.

What standards need to be developed?

The development of standards is well advanced in the area of hydrogen and fuel cells for the transport sector with SAE and ISO draft standards already providing globally harmonized requirements with regard to key items such as the hydrogen refuelling interface, the hydrogen fuel quality, and hydrogen refuelling station safety. Other topics needing further coverage include fuelling protocols, stationary storage of hydrogen, high pressure hydrogen trailers and delivery by trans-filling.

European industry led coordination is required to ensure that the needs of European stakeholders are addressed by international standards and to support the establishment of an efficient regulatory framework encompassing these standards.

6. RECOMMENDATIONS FOR BIOFUELS

The chicken-and-egg-problem needs to be overcome successfully in order to achieve a considerable market share of alternative fuels. To this end, the issue needs to be addressed holistically and consistent EU action in the form of legislation and financial support is required, avoiding contradictory policy signals.

Appropriate to include the fuel?

Biofuels have the potential to curb GHG emissions in the transport sector as long as they satisfy all the sustainability criteria. Higher blends of those biofuels might be needed to fulfil the climate and energy targets. Only comparatively marginal adaptations to the distribution system are needed. Advanced biofuels offer additional benefits and coupling biofuels production with CCS could eventually lead to a net reduction in atmospheric CO2. No adaptation in consumer behaviour is needed (driving range, refuelling habits, look and feel of the car).

Like any other fuel all biofuels need to meet the sustainability criteria as established by the EU legislation in force, including those biofuels present in the market and future advanced types that might be developed. A broad discussion has been taken place on the Indirect impact of Land Use Change (ILUC) with a wide spectrum of contributions put forward within various initiatives undertaken by the Commission. This issue should be addressed within the framework of the Renewable Energy Directive and the Fuel Quality Directive. The Commission will report on the ILUC effects of biofuels and if appropriate present a legislative proposal to the Council and the Parliament. The issue should be settled before moving to a broad market introduction of higher blend biofuels.

Which transport modes should be covered?

Biofuels can be used in all main transport modes, including road (light and heavy duty) transport, public transport, maritime, railways and aviation. Given the limited potential expansion for sustainable biofuels, however, they should be allocated preferentially to those modes where no other alternative exists.

What policy options would be most suitable?

Constructors of Flex-Fuel-Vehicles (FFV) are currently not entitled to a CO2 credit for their FFVs because there are not enough E85 filling stations available. Sweden is a good example of how fuelling infrastructure for high-blends can be successfully built up by obliging pump owners to provide at least one alternative fuel per filling station. The alternative fuel of choice in Sweden was mostly E85. The USA recently announced that it has set itself a goal of installing 10,000 flexible fuel pumps (or blender pumps) within 5 years from now, in combination with financial incentives.

In the event that the sustainability of biofuels can be assured, i.e. their potential to reduce GHG emissions as well as their conformity with wider environmental and social sustainability considerations, the EU could consider elaborating a coherent plan for the roll-out of higher blend pumps across its territory in step with the development of the market demand, by means of the introduction of a European-wide pump law with common EU goals. Most members of the group believe Option 5 would be the most suitable option for this law, including binding targets for Member States on alternative fuel infrastructure. Other members, notably the environmental NGOs, think that it is not timely to consider this option since the sustainability of the biofuels sold at these pumps is by no means guaranteed.

Do other policy options have to be considered?

- Fully implementing the Fuel Quality Directive (FQD): Only a few Member States have so far introduced E10 into the marketplace but B7 is more widely available. Steps must be taken to support and encourage the EU-wide roll-out of E10 and B7 biofuels. On the basis of the roll-out being completed successfully, the Commission should prepare an impact assessment to see what more might need to be done by the Member States in order to help achieve their targets for 2020 renewable energy use in transport. If more is seen to be necessary, the Commission should establish a timetable for actions to be taken to achieve common and harmonised general market fuels across the EU27.

- Amending the Fuel Quality Directive (FQD): Relevant environmental and health-related parameters for petrol and diesel general market fuels in the EU are set by the FQD. In order to be coherent with the RED-requirements and to allow higher blends to be placed on the market, the FQD needs to be changed. Experience shows that this process can take time, which is why the issue needs to be brought onto the agenda as soon as possible. The FTF Expert Group underlines the importance of the Commission's assessment of the feasibility, need and cost-benefits of increasing the maximum permitted biofuel content of petrol and diesel (taking into account the sustainability impacts of biofuels), in its review of the FQD that is due by the end of 2012.

- Issue of CO2 emissions through Indirect Land Use Change: The EU should assess the impact of indirect land-use change due to biofuels on CO2 emissions and take appropriate action to reflect this in the Renewable Energy and Fuel Quality Directives.

- Reviewing the Energy Taxation Directive (ETD): the Commission recently published a proposal for amending the existing ETD. The Commission proposes to end the volume-based taxation of energy products and replace it with a tax consisting of two elements: a CO2 tax based on the emissions and a general energy consumption tax based on the energy content of the product. This adoption is absolutely necessary to solve the paradox of clean renewable fuels being taxed at a higher rate than polluting fossil fuels. It is also a prerequisite for the successful market introduction of higher biofuel blends.

- Agreement with the automobile industry on vehicles that are compatible with higher biofuel blends.

What standards need to be developed?

Harmonised standards should be developed by CEN allowing for the possibility of higher incorporation rates of biofuels into fossil fuel blends in case they prove to be technologically suitable, cost effective and in order to be accepted by the consumers. Member States and the Commission should coordinate a timetable for the implementation of possible new standards and identical biofuel blending EU-wide to provide consumers and industry with a proper common market.

A review should be undertaken to consider the merits of moving to higher levels of low-blend biofuels in general market fuels (i.e. beyond E10 and B7). Higher-level blends (e.g. E25 and B30), if their sustainability can be assured, may be needed in the mid-term to achieve the EU's climate and energy targets. If appropriate, standardization work should start as soon as possible.

A common approach should be taken across the EU on future biofuel blends. Countries outside the EU through which commercial transport moves, should be encouraged to provide the same quality of fuels along those commercial routes. The goal should be to establish worldwide standards in order to avoid market fragmentation and to reduce costs by economies of scale.

7. RECOMMENDATIONS FOR SYNTHETIC FUELS

The market deployment of synthetic fuels in neat form or blended with diesel, rail gasoil, marine gasoil and aviation kerosene does not require any technological investments as regards fuel infrastructure and vehicles. This makes the introduction of such fuels a relatively easy option, provided high enough volumes of synthetic fuels are available that lead to GHG emissions reductions.

There are indications that minor engine adjustments will allow further performance advantages when synthetic fuels are applied neat or in higher blending ratios.

8. RECOMMENDATIONS FOR METHANE AND LNG

Appropriate to include the fuel?

Worldwide Methane-fuelled vehicles are annually increasing at a two digit rate in percentage. About 13.5 million vehicles are in operation, 1.1 million units thereof in Europe (EU/EFTA). Natural Gas vehicles cover all types of vehicles from light to heavy duty. Biomethane can be successfully applied in short and long distance transport. HDV for public transport are increasingly used in cities aiming to reduce emissions and noise.

LNG/LBG trucks for long-distance transport (dedicated and dual fuel) are already offered by several OEMs and new versions with a range of up to 800-1000 km are being introduced into the market.

There is a high density natural gas grid available throughout Europe, which can also be used for the distribution of biomethane. Currently about 200 biogas upgrading plants and injection points are operational.

Which transport modes should be covered?

Methane is a fuel suitable for all transport distances either as compressed CBG/CNG or in liquid form as LBG/LNG. The liquefied form is particularly well suited for long distance hauling and increasingly for maritime transport. But methane is also well suited for trains where tracks are not yet electrified.

Methane can help to improve local air quality in cities and urban areas, especially in heavy duty applications and big fleets. It can be used in public transport buses, taxis, garbage and other municipal service trucks and vans, and in trucks used for urban freight distribution. Therefore methane will make an important contribution to achieve the White Paper targets. NO2 as a major cause for concern of air quality in cities will give a new push for methane powered urban vehicles.

What policy options would be most suitable?

A combination of Option 2 (New funding schemes and non-legislative measures) and Option 3 (Harmonization of standards for alternative fuel infrastructure) is considered to represent minimal measures to ensure the further positive development of the (bio-) methane sector as the initial cost for project developments are still high. The two options would stimulate the market demand towards a long-term cost effective production.

Option 4 as a stand-alone measure will not bring additional stimulus to Options 2 and 3. Industry will always follow its own interests, and therefore, it is not to be expected that Option 4 would lead to a harmonized alternative fuel strategy, which is evident for developing a Europe-wide market and increased customer acceptance. In the case of methane, a minimum coverage of CNG stations (whether public or private) has already been ensured in a few countries in Europe by the natural gas industry. Refueling coverage for methane is currently fragmented and self-regulation may exacerbate this problem. However, the approach to consider relevant characteristics of individual Member States such as geographic position, topography, population, number of vehicles registered, number of filling stations, main transport modes, etc. will be essential when considering any of the options to develop the refueling infrastructure for alternative fuels.

If Option 5 is moderately applied it might become a real driver without stifling market freedom and development. A quota for alternative fuels might be a good instrument to allow market and/or national politics to choose the preferred type of fuel. This has been successfully applied in Sweden. A fuel quota might also be an option because they would automatically require the build-up of the corresponding infrastructure to achieve the goal. In Switzerland there is a quota of 10% biomethane in natural gas for vehicle fuel that also obliged the gas industry to invest in injection and fuelling infrastructure in order to achieve this. The measure was successful as there is currently about 20% biomethane in the fossil gas. However, it would be necessary to increase further public support. A comparable quota (20% but not binding) was also formulated in Austria. As another example, the German natural gas industry has been setting self-binding targets for the injection of biomethane into the gas grid. Such self-binding targets by the industry in combination with a coherent public policy set by the legislators, which will make biomethane injection into the natural gas grid an attractive option, could be the most promising and most likely option to guarantee success.

What policy options would be most suitable?

To establish a European methane refuelling network several scenario's can be considered:

(a) Taking a European driven approach

(b) Taking a concerted approach between the EU and the Member States

(c) Taking a national PPP driven approach within a supportive European framework

Since PPP actions are already in place in several countries, a combination of scenarios (b) and (c) would probably be the most promising route to take. However, it is clear that Option (a), a European driven approach, also needs to be considered, as the level of knowledge with regard to the availability and benefit of alternative fuels in Member States is often very poor – meaning that any European driven approach could make a real difference.

An indicative timeline for methane refuelling build-up, along the typical three stages towards commercialization would be:

By 2015	Extending the existing 2,300 CNG filling stations in the EU, to 4,000 refuelling points, in order to guarantee adequate minimum refuelling Europe-wide. Extending the 23 LNG stations to 200 in pilot regions. Significant increase of the number of port/harbour LNG fuelling stations. Biogas upgrading plants and injection points increased to 400
By 2020	Consolidate a basic pan European CNG (light vehicles) and LNG (heavy vehicles) stations network, allowing limitless circulation across Europe achieved by facilities in all countries at least along highways. Start of full commercial phase. At least 800 upgrading plants in operation producing some 6 billion m3 of biomethane
By 2025	Commercial phase; sufficient scale and coverage to be market-competitive with traditional and other alternatives and for further organic growth

Do other policy options have to be considered?

Public/private partnership is key for successful commercial deployment of methane infrastructure. Special attention should be given to the development of appropriate risk-sharing mechanisms to bridge the pre-commercial deployment phase

Other than for renewable electricity or liquid biofuels, for gas, i.e. biomethane - whether compressed or liquid - there are more hurdles to be removed to achieve an open European market. Import and export (mainly through the gas grids) is often hindered by administrative hurdles like exchange of carbon (CO_2) credits, accountability of renewables, right of grid access and transport, etc. Rules on how to handle accountabilities are required. Acceptable sources of biogas should also be defined. In some countries biogas from waste water treatment or landfills is not accepted, in others it is even an obligation.

What standards need to be developed?

With the opening of the European gas market in 2007, harmonisation of standards for biomethane use became a priority issue. Harmonised standards will have to ensure flexible technical specifications in order to become a driving force, rather than excessive regulation. EU standards for biomethane will lead to a distinct reduction of investment and operation costs.

A harmonised filling station standard for CNG and L-CNG refuelling stations and also a harmonised type approval procedure for dual fuel applications need to be developed. Some of these issues are currently being dealt with at UNECE and ISO level, but a clear position from the European standardisation side in coordination with the industry is of outmost importance. Another important open issue is to regulate the possibility to install CNG and L-CNG stations all across the European territory including urban areas in general.

Legislative actions: timeframe, optimal coverage, etc.

Considering infrastructure investment costs of approx. 300.000 € for public methane stations and 1.000.000 € for private depot stations, the establishment of an European infrastructure fund in combination with a European Directive requiring Member States to implement a minimum refuelling infrastructure, would ensure that more CNG and LNG vehicles are put on the market in the future.

A distinction must be made between the infrastructure needed for light duty and heavy duty vehicles. The following minimum infrastructure needs for LDVs and HDVs would be required:

- LDVs: methane for private passenger cars and commercial fleets using cars and vans requires availability in 10 % of the urban filling stations, and at 25 % of the filling stations along the motorways. This stipulation of introducing a percentage threshold should be linked to the availability of methane filling stations at least every 150 km along the motorways (or major highways where motorways are not available), and a logical distribution inside the cities. Methane refuelling should be possible everywhere across Europe by driving to the next refuelling station located at an affordable distance. Geographical gaps in remote areas could be closed via the possibility of home refuelling, where a small compressor unit is linked to the domestic gas connection.

- HDVs: the infrastructure needed for HDVs depends on whether about it relates to the urban transportation of persons and goods, or to heavy duty trucks used for long distance haulage:

The LNG refuelling infrastructure for transport of goods ought to be developed in a dialogue with major trucking companies and operators of major truck refuelling facilities near truck terminals and along the major European motorways and transport routes. Refuelling of LNG should be possible every 400 km in L-CNG filling stations, able to provide both CNG for LDVs and LNG for HDVs.

The CNG refuelling infrastructure for HDV urban fleets (mainly buses and refuse trucks) is not yet established all over Europe, although cities are increasingly in favour of methane heavy duty vehicles in their urban fleets.

In conclusion, all the above mentioned measures to link the filling station network development for methane to percentages should always refer to the total number of existing filling stations. Complementary measures to new EU funding schemes could be supported by the following legislative measures in phase with the development of market demand:

– Linking permits for new multi-fuel stations to the inclusion of CNG or L-CNG refuelling facilities.

– A requirement that stations above a certain total volume of fuel sales must offer methane refuelling facilities if this is economically viable.

Independently it should of course still be possible to open dedicated methane filling stations outside the existing filling stations if the opening of a new location for methane only would be required for private or public use. Due to the L-CNG filling station concept, which does not necessarily require a connection to the pipeline, all European filling stations qualify to offer methane in all locations. If methane/LNG is fully covered, no limitations are foreseen with regard to methane resources. In addition, bio- and synthetic methane could gradually substitute fossil methane.

9. Recommendations for Liquefied Petroleum Gas

Appropriate to include the fuel?

Autogas is currently the most widely used alternative fuel, with approximately 6,5 million LPG vehicles on the EU market and close to 10 million in the wider European continent. The availability of LPG as an alternative fuel for spark ignited engines in small vehicles and as a secondary fuel in dual fuel vehicles provides great potential to effectively lower CO2 emissions across Europe on a broad scale using existing infrastructure.

Autogas is also used extensively in a number of other countries across the world, in particular in South Korea and Australia. However, the development of autogas has been heterogeneous in Europe, leading to a fragmented market and varied geographical distribution of the autogas filling infrastructure. As an example, while Poland and Germany do not require specific legislative measures, as an extensive network of filling stations is already in place, it is clear that countries like Austria, Spain or Denmark are characterised by a high degree of unexploited potential.

In spite of the relatively well established infrastructure in Europe, the LPG industry clearly needs targeted policies to support its development.

Which transport modes should be covered?

Autogas has a wide scope of possible uses. It is ideally suited as a strategic support for existing fuels in light duty vehicles and passenger cars at moderate investment levels providing a true alternative to diesel. It lowers operational costs in gasoline powered vehicles to the level of diesel without necessitating complicated after treatment systems to maintain a lower pollution level. It is also well suited for heavy-duty vehicles substituting diesel with only little additional investment necessary. A long term suitability can also be seen in short-sea shipping.

What policy options would be most suitable?

New funding schemes (as suggested in the policy option 2) would certainly play a crucial role in the further development of the LPG filling infrastructure. This could take the form of grants or fiscal incentives to help autogas distributors to cover the upfront cost of extending the filling station network.

An important hurdle related to increasing the number of LPG filling stations is the existing restrictions on minimum distances between LPG storage tanks or dispensers with other sites or structures (e.g. other fuel dispensers/storage tanks, kiosks, individual houses, etc.) Some EU Member States apply relatively high safety distances which create unnecessary obstacles to the installation of filling stations in urban areas, where available space is limited. While appropriate safety standards are obviously indispensable, a number of national authorities have developed such safety legislation without commissioning proper risk assessment studies and without consulting relevant stakeholders. The EU could certainly help in addressing this issue through the suggested policy option 4.

As regards the definition of objectives for the geographical coverage of filling points, the most suitable sub-option appears to be sub-option c (coverage according to fuel development perspectives). Predefining such objectives based on possibly arbitrary factors could indeed prove a very uncertain exercise, in particular because stimulating supply through the opening of filling stations will not automatically result in the expected level of market demand. An extensive network of filling stations is indeed not the only factor that would enable the take up of alternative fuels. This is illustrated in Germany for example, which hosts the most developed autogas infrastructure in the EU, but has however seen the growth of LPG vehicles slow down for other reasons in recent years.

Regarding the definition of coverage targets, it would first be necessary to empirically determine and then integrate the geographical zones of development of alternative fuels. Although LPG is suitable for long-distance transport, a sufficient coverage of filling stations is obviously also necessary in urban areas. Green vehicles using alternative fuels such as LPG are, in the context of air quality issues in cities, particularly well-adapted to urban use. A significant share of autogas users live in urban zones which means that for LPG to be attractive, it needs to be available at a reasonable distance from their place of residence/place of work.

Prior to reaching conclusions on coverage targets for filling stations, the European Commission should, therefore, consider conducting a survey aiming to assess more accurately, for all alternative fuels, where filling stations can best meet their respective potential demand. Such a gap analysis study could be based on representative samples taken at the regional and sub-regional level, drawing comparisons between demographic maps (showing the distribution of consumers/potential consumers) and the current distribution of filling stations.

Do other policy options have to be considered?

A number of regulatory obstacles at the EU and national levels are impeding the further development of the LPG filling infrastructure and should therefore result in appropriate policy responses:

- A wide variety of national legislation on safety distances between LPG dispensers/storage tanks and other premises (problematic for extending the coverage of LPG stations in urban areas).

- In the context of the revision of the Energy Taxation Directive, the considered phasing out of exemption of excise duties for LPG would be a dramatic obstacle to the medium to long term development of autogas. Favourable fiscal treatment is a crucial lever for the emergence and development of alternative fuels

What standards need to be developed?

Additional standardisation for the filling unit is not required as a Euro connector already exists. The uptake across Europe of the standardised connector is subject to debate within the LPG industry due to the costs involved in switching from the currently used filling unit to a new standardised connector. In addition to the EU and national governments ensuring favourable regulatory conditions for the growth of LPG, further coordination with the automotive industry would also be required. Car makers would indeed also have an interest in having all European markets switching to a single connector, whether it be the existing EN 13760 or another connector to be developed.

10. CONCLUSIONS

There is a clear need for enhancing public and private sectors to put in place effective actions to accelerate the development of new refuelling infrastructure with the following objectives:

- To establish EU-wide a minimum coverage of refuelling infrastructure for the main alternative fuels which are technologically viable and with market potential to facilitate economies of scale for market introduction

- To ensure the implementation of harmonised standards for the main alternative fuels.

- To align policy and public/private funding and taxation in the field of alternative fuel infrastructure.

An appropriate EU regulatory framework and financial instruments will be required to introduce sustainable low carbon alternatives to the market. Any infrastructure decision requires the development of the necessary legislation for energy infrastructure and vehicles in parallel, in order to ensure consistency and coherence.

A comprehensive EU infrastructure roll-out plan in cooperation with key industrial (OEM's and fuel production and supply industry), national and local stakeholders will have to be developed, aligned with the TEN-T Programme and relevant EU energy infrastructure programmes.

The capacity of alternative fuels and their infrastructure should be continuously reviewed to allow for the improvement of energy security and for the reduction of carbon emissions.

What fuels to include?

All alternative fuels are viable options for the future fuel mix, high infrastructure investment needs would, however, only be required for electricity, hydrogen and methane in the short and medium term. Special support measures for the build-up of the required infrastructure are, therefore, only necessary for these fuel options.

What transport modes should be covered?

All transport modes (railways, aviation, maritime and inland waterways) and non-road mobile machinery must be included in future fuel scenarios. For road transport, a special focus should be placed on the establishment of sufficient alternative refuelling possibilities along major motorways, which would enable long distance travelling in LDVs and HDVs. There are only very limited alternative fuel options to Diesel (biodiesel/diesel mix and LNG) in heavy duty trucks.

What policy options are most suitable

Public aid is most likely needed for infrastructure investments. It doesn't seem realistic to expect the market to cater for the transition to more expensive low carbon alternatives alone and, therefore, important interfaces should be defined by legislation to allow and encourage this market demand.

Public intervention is necessary to break deadlocks between potential market growth for new alternative vehicle technologies and non-existing alternative fuel supply. Public intervention can be justified by overriding objectives of security of energy supply in a sustainable way ensuring decarbonisation.

Binding targets on alternative fuel infrastructure could become a real driver for the alternative fuel market, as increased visibility of and better accessibility to alternative refuelling is the key to attract the final customer and steer market demand for those fuels. However, imposing an infrastructure mandate for solutions that still need to prove their technological viability, sustainability and /or their market potential could result in high costs for society and industry.

Appropriate refuelling infrastructure is necessary for producing and promoting alternative fuelled vehicles on the OEM side. The establishment of targets applicable to Member States with regard to alternative fuel infrastructure is considered a feasible path forward for ensuring the availability across Europe of the alternative fuels that contribute to achieve the EU's targets. However, the EU must avoid early, arbitrary selection of any given technology which might prevent the development of other technologies that perform better in terms of CO2 emission reduction and cost.

Funding schemes and non-legislative measures, harmonisation of standards and self-regulation by the industry based on common goals are judged necessary for achieving a minimum coverage of alternative fuelling infrastructure in the EU. The establishment of binding targets is considered as a recommended complementary measure for those alternative fuels technologically viable and with market potential. In this context, a first approach to quantified coverage goals per alternative fuel has been provided by the Expert Group.

Country-based deployment projections, with a timeline indicating areas of deployment, number of vehicles and number of fuelling points, breaking point for economical viability of the technology, shared by the involved vehicle manufacturers commercialising the vehicles and infrastructure providers could be requested to base binding infrastructure deployment targets for a particular fuel.

Overall strategy

The combination of requirements for a minimum coverage, supported by binding targets and a well-coordinated strategy between the EU and Member States is recommended by most members of the Expert Group. Other members emphasise that developing infrastructures that are not in line with market development would not be cost efficient, and that the legislation should only aim at creating a level playing field for all fuels and energies that have proven their technological and market viability and sustainability.

Customer acceptance may result from the visibility of and accessibility to alternative fuels. A sound legislative framework linked to the harmonisation of standards and supported by innovative funding schemes will lead to an optimum coverage of alternative refuelling over time.

11. RECOMMENDED ACTIONS

General

- Transport develops slowly, it is therefore important to start investing and supporting the build-up of alternative, sustainable low carbon refuelling already in 2012 wherever possible, also in order to reach the 2020 targets.

- It will be crucial to link the alternative fuel infrastructure strategy of the EU to the TEN-T programme in the first place, which can be used to provide the needed investments, but also to investigate EIB loans and other ways such as PPPs for allocating the needed capital to support the construction of alternative refuelling possibilities across the EU in a harmonised way.

- Some alternative fuel options need more time before entering the market. A coherent and sustainable investment policy is important, in order to avoid investments into technologies where the vehicles are not yet commercially available for the end users.

- Recognition of the challenge in the transport sector of parallel development of a fuelling network and availability of any type of vehicle designed for alternative fuels.

- Encouraging the definition of long-term targets, critical for all market stakeholders, including vehicle and equipment manufacturers, fuel retailers, infrastructure developers and end customers.

- Underlining the importance of coherent public policy and the harmonisation of standards in the area of alternative low carbon fuels and the required infrastructure.

- Member States shall not be prevented from implementing incentives for the compensation of higher alternative fuel infrastructure capital and operating costs during the transition period, in order to establish the conditions of a market-driven uptake of alternative transport fuels.

Fuels

- Implementation should be promoted of different projects on alternative fuels by the private sector, including the "LNG Blue Corridors" concept and other initiatives.

- Improving local air quality in urban areas should be supported by promoting viable alternative fuels and the refuelling infrastructure needed for captive fleets (e.g. taxis, municipal fleets) and heavy duty vehicles (buses, garbage collection trucks, city logistics).

- Common charging standards for all BEVs to communicate with the grid anywhere in the EU and also with all types of chargers. Any binding target for a minimum coverage of charging points would be based on this common interface.

- Public/private partnership is key for FCEVs and methane infrastructure. Special attention should be given to the development of appropriate risk-sharing mechanisms to bridge the pre-commercial deployment phase

- For hydrogen, standards should give further coverage to fuelling protocols, stationary storage, high pressure trailers and delivery by trans-filling.

- Mid-level blends of sustainable biofuels could be needed in the mid-term. A detailed review should be undertaken to consider the merits of moving to higher levels of biofuels in general market fuels. If appropriate, standardization work in CEN should start as soon as possible. The potential of biofuels to reduce GHG emissions, when land use change is included, should be part of the review.

- The EU should assess the impact of indirect land-use change due to biofuels on CO2 emissions and take appropriate action to reflect this in the Renewable Energy and Fuel Quality Directives.

- Fungible paraffinic fuels offer a seamless path forward in terms of vehicle compatibility but their sustainability must be assured. Among them, HVO (in the case of biofuels) and GTL (for other alternative fuels) are already available on a large commercial scale and should be also taken into account and better promoted by policy makers. To this end, remaining issues such as ILUC must be concluded so that all actors know the right sustainable routes to follow.

- The convenience of amending the Fuel Quality Directive and reviewing the Energy Taxation Directive should also be considered to ensure that those fuels with a high CO_2 content attract the highest level of tax.

12. ANNEX 1A: COMMISSION EXPERT GROUP FTF: MEMBER ORGANISATIONS

	Road	Rail	Airborne	Waterborne
Mineral oil products	EUROPIA CONCAWE ASFE UPEI	EUROPIA CONCAWE ASFE UPEI	EUROPIA CONCAWE ASFE UPEI	EUROPIA CONCAWE ASFE UPEI
Biofuels (liquid, gas)	EBTP EBB EBA ePURE ASFE EFOA	EBTP EUBIA EBB ePURE EFOA	EBTP EBB ASFE ePURE EFOA	EBTP EBB ePURE EBA ASFE EFOA
Natural gas	NGVA Europe	NGVA Europe	NGVA Europe	NGVA Europe
Electricity	EURELECTRIC CEDEC EUROBAT AVERE	EURELECTRIC CEDEC	EURELECTRIC CEDEC	EURELECTRIC CEDEC
Hydrogen	FHC-JTI NEW IG N.ERGHY EHA AVERE	FHC-JTI NEW IG N.ERGHY EHA	FHC-JTI NEW IG N.ERGHY EHA	FHC-JTI NEW IG N.ERGHY EHA
LPG	AEGPL			AEGPL
Manufacturers	ACEA EUCAR		Clean sky JTI	CESA
Suppliers	CLEPA	UNIFE	Clean sky JTI	
Research	ERTRAC EPOSS EARPA		ACARE Clean sky JTI	
Operators, users	UITP IRU FIA EUROCHAMBERS EUROCOMMERCE CEDEC ECG	UITP CER UIC EUROCHAMBERS EUROCOMMERCE CEDEC ECG	AEA ACI Clean sky JTI EUROCHAMBERS EUROCOMMERCE CEDEC ECG	UITP EBU EUROCHAMBERS EUROCOMMERCE CEDEC ECG
Civil society	T&E WWF GREENPEACE IEEP COPA-COPEGA	T&E WWF GREENPEACE IEEP COPA-COPEGA	T&E WWF GREENPEACE IEEP COPA-COPEGA	T&E WWF GREENPEACE IEEP COPA-COPEGA

Commission Expert Group FTF: ACRONYMS OF MEMBER ORGANISATIONS

ACARE	Advisory Council for Aeronautics Research in Europe
ACEA	European Automobile Manufacturers' Association
ACI	Airports Council International
AEA	Association of European Airlines
AEGPL	European LPG Association
ASFE	Alliance for Synthetic Fuels in Europe
AVERE	European Association for Battery, Hybrid and Fuel Cell Electric Vehicles
CEDEC	European Federation of Local Energy Companies
CER	Community of European Railway and Infrastructure Companies
CESA	Community of European Shipyards' Associations
Clean Sky JTI	Joint Technology Initiative for Aeronautics & Air Transport
CLEPA	European Association of Automotive Suppliers
CONCAWE	The oil companies' European association for environment, health and safety in refining and distribution
COPA-COGECA	European Farmers; European Agri-Cooperatives
EARPA	European Automotive Research Partners Association
EBA	European Biogas Association
EBB	European Biodiesel Board
EBTP	European Biofuels Technology Platform
EBU	European Barge Union (inland navigation)
ECG	Association of European Vehicle Logistics
EFOA	European Fuel Oxygenates Association
EHA	European Hydrogen Association
EPOSS	European Technology Platform on Smart Systems Integration
ePURE	European Producers Union of Renewable Ethanol

ERTRAC	European Road Transport Research Advisory Council
EUCAR	European Council for Automotive R&D
EURELECTRIC	Union of the Electricity Industry
EUROBAT	Association of European Storage Battery Manufacturers
EUROCHAMBERS	Association of European Chambers of Commerce and Industry
EUROCOMMERCE	Retail, Wholesale and International Trade sectors in Europe
EUROPIA	European Petroleum Industry Association
FCH-JTI	Fuel Cells and Hydrogen Joint Technology Initiative
FIA	Federation Internationale de l'Automobile
GREENPEACE	Greenpeace
IEEP	Institute for European Environmental Policy
IRU	International Road Transport Union
N.ERGHY	European Research Grouping on Fuel Cells and Hydrogen
NEW IG	European Industry Grouping for a Fuel Cell and Hydrogen Joint Technology Initiative
NGVA Europe	Natural & bio Gas Vehicle Association Europe
T&E	Transport & Environment (European environmental organisation)
UIC	International Union of Railways
UITP	International Association of Public Transport
UNIFE	European Railway Industry
UPEI	Union Pétrolière Européenne Indépendante
WWF	World Wildlife Fund

13. ANNEX 1B: COMMISSION EXPERT GROUP FTF. STAKEHOLDER PARTICIPANTS.

MEMBER ORGANIZATION	REPRESENTATIVE	BACK-UP
ACARE	Uwe MOELLER	
ACEA	Paul GREENING	Anders ROJ
ACI		
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AVERE	Karine SBIRRAZZUOLI	
CEDEC	Marc MALBRANCKE	
CER	Steffen JANK	Jerome LABARRE
CESA	Lanfranco BENEDETTI	
CLEAN SKY JTI		
CLEPA	Tim VINK	
CONCAWE	Ken ROSE	
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EARPA	Peter PRENNINGER	
EBA	Arthur WELLINGER	Rita RAMANAUSKAITE
EBB	Raffaello GAROFALO	
EBTP	Birger KERCKOW	Jean-Francois GRUSON
EBU	Robert TIEMAN	
ECG	Tom ANTONISSEN	
EFOA	Sunanda BANERJEE	Walter Mirabella

MEMBER ORGANIZATION	REPRESENTATIVE	BACK-UP
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EUCAR	**Anders ROJ**	
EURELECTRIC	**Thomas THEISEN**	Gunnar LORENZ
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FIA	**Wilfried KLANNER**	
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T&E	**Nusa URBANCIC**	
UIC		
UITP	**Ulrich WEBER**	Paul ARENTS
UNIFE		
UPEI	**Bernard SCHNITTLER**	Anahita ARYAN
WWF		

14. ANNEX 1C: COMMISSION EXPERT GROUP FTF. COMMISSION-EU PARTICIPANTS.

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MOVE	Franz SÖLDNER (Chairman) Carlos GARCIA BARQUERO (Technical Coordinator) Antonio TRICAS AIZPUN Clemence CAVOLI Hugues VAN HONACKER Piotr RAPACZ Hoang VU DUC Victoria BUTLER Janeta TOMA Maria Cristina MOHORA	
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EEA	Peder JENSEN	David CLUBB
EIB	Juan José FEBLES ACOSTA	Mario AYMERICH

15. ANNEX 1D: ACRONYMS AND ABBREVIATIONS

BEV: Battery Electric Vehicle
BTL: Biomass-To-Liquid
CCS: Carbon Capture and Sequestration
CEN: European Committee for Standardization
CNG: Compressed Natural Gas
CTL: Coal-To-Liquid
DSO: Distribution System Operator
EIB: European Investment Bank
ETD: Energy Taxation Directive
EV: Electric Vehicle
FAME: Fatty Acid Methyl Ester
FC: Fuel Cell
FCEV: Fuel Cell Electric Vehicle
FFV: Flex Fuel Vehicle
FQD: Fuel Quality Directive
FQMS: Fuel Quality Monitoring System
GHG: Greenhouse Gas
GTL: Gas-To-Liquid
HDV: High Duty Vehicle
HVO: Hydrotreated Vegetable and animal Oils
ICE: Internal Combustion Engine
ILUC: Indirect Land Use Change
ISO: International Organization for Standardization
ICT: Information and Communication Technologies
JTI: Joint Technology Initiative
NGV: Natural Gas Vehicle
LDV: Light Duty Vehicle
LNG: Liquefied Natural Gas
LPG: Liquefied Petroleum Gas
NGV: Natural Gas Vehicle
OEM: Original Equipment Manufacturer
PPP: Public-Private Partnership
RCS: Regulations, Codes and Standards
RED: Renewable Energy Directive
RTD: Research and Technology Demonstration
SAE: SAE International standards
SET: Strategic Energy Technology
STTP: Strategic Transport Technology Plan
TENT-T: Trans European Network for Transport
UNECE: United Nations Economic Commission for Europe

16. ANNEX 2: IMPLEMENTATION STAGES FOR SUB-OPTIONS

Due to the uncertainty with regard to the maturity of the different alternative fuels and vehicles, a distinction can be made between two implementation stages.

- Stage 1: Minimum coverage allowing EU-wide mobility (start in 2015). A basic minimum coverage of alternative fuel infrastructure is required, appropriate to the maturity of the technology of each alternative fuel. This coverage would allow users with vehicles running on alternative fuels to have access to the specific fuel across Europe within their vehicle action radius.

- Stage 2: Coverage allowing a transition to a self-sustained market (milestone 2020). The requirements regarding coverage of alternative fuel infrastructure will increase, depending on the expected development of each fuel after the first stage. Refuelling infrastructure of the most promising fuel(s) needs to be sufficient to facilitate a transition to a self-sustained market.

Between the first and the second stage, a review should take place in 2017, assessing the market development of each of the alternative fuels and their potential for stage 2. This review may lead to amending the legislative requirements for stage 2.

<u>Sub-Option a)</u>: Minimum coverage of each transport mode by the most appropriate fuel

This option considers the requirements to ensure a minimum market development for alternative fuel infrastructure taking into account the advantages and disadvantages of each fuel.

Sub-Option a) **Minimum coverage of each transport mode by the most appropriate fuel**		
Alternative Fuel	**Stage 1 (start 2015)**	**Stage 2 (milestone 2020)**
Electricity	Harmonised standards	Certain percentage of new urban public parking places
Hydrogen	Harmonised standards, various smaller pre-commercial deployment projects across Europe	Coverage of selected urban areas and of highways interconnecting these initial hubs
High-blend biofuels	Harmonised standards (E-25, E-85, B-30)	Boost higher blending ratios in traditional fuels and the optimised use as such in cars warranted for the use of these fuels (keep a protection grade for older cars)
Synthetic fuels	Boost higher blending ratios in traditional fuels and the use as such in fleets	Boost higher blending ratios in traditional fuels and the optimised use as such in fleets with adapted drivetrains
Methane	Public transport and dedicated fleets in cities	Coverage in urban and non-urban areas along gas grids (high and medium pressure)
LNG	Harmonised standards Pilot regions for non-urban transport	Ports/harbours with coastal ship transport. Dedicated truck fleets (blue corridor).
LPG	Harmonised standards	Minimum certain coverage in urban and non-urban. Ports/harbours with an annual fuel turnover of >xx litres.

<u>Sub-Option b)</u>: Optimum coverage of each transport mode by appropriate fuels

This option will combine the most suitable fuels for each transport mode to provide optimum coverage, following *inter alia* the recommendations of the Expert Group:

- Road transport will be powered by electricity and hydrogen for short distances (in cities, including public transport), hydrogen and methane up to medium distance, and biofuels, hydrogen, LPG and LNG up to long distance. Synthetic fuels will be applied for all distances.
- Maritime and short-sea-shipping transport will be supplied by LNG.

Sub-Option b) **Optimum coverage of each transport mode by appropriate fuels**		
Alternative Fuel	**Stage 1 (start 2015)**	**Stage 2 (milestone 2020)**
Electricity	Certain percentage of new urban public parking places	Certain percentage of all public parking places
Hydrogen	Harmonised standards , initial infrastructure in selected cities, regions and corridors	Full coverage of certain (starting) regions, and of interconnections between all covered urban areas, - in expansion with objective of being able to drive across Europe to most places (population based criteria) by 2025
High-blend biofuels	Certain coverage in urban and non-urban	Boost higher blending ratios in traditional fuels and the optimised use as such in cars warranted for the use of these fuels (keep a protection grade for older cars)
Synthetic fuels	Boost higher blending ratios in traditional fuels and the use as such in fleets	Boost higher blending ratios in traditional fuels and the optimised use as such in fleets with adapted drivetrains
Methane	Certain coverage in urban and non-urban	Increased coverage in urban and non-urban
LNG	Ports/harbours with an annual fuel turnover of > xx litres.	Full coverage for coastal shipping and for all maritime transport. Ports/harbours with an annual fuel turnover of >xx litres. Truck refuelling stations with an annual fuel turnover of >xx litres.
LPG	Minimum certain coverage in urban and non-urban. Ports/harbours with an annual fuel turnover of >xx litres.	Increased coverage in urban and non-urban. Ports/harbours with an annual fuel turnover of >xx litres.

<u>Sub-Option c):</u> Coverage according to the fuel development perspectives

This option will consider the market driven development perspectives for all main alternative fuel options, and takes into account resource limitations and the market developments. It may depend on modelling studies and could mean:

- Electricity will be covered due to the wide supply potential from different energy sources.
- Hydrogen infrastructure will be limited in line with the expected market development of the vehicles.
- Biofuels infrastructure coverage will be limited due to expected constraints in feedstock availability. In addition, future fungible biofuels could use the same infrastructure as conventional fuels.
- Methane/LNG will be fully covered as no limitations are foreseen with regard to methane resources. In addition, bio-methane could gradually substitute fossil methane.
- Synthetic fuels application will not require any technological investment in infrastructure.

Sub-Option c) * Coverage according to the fuel development perspectives		
Electricity	Certain percentage of all public parking places	Increased percentage of all public parking places
Hydrogen	Harmonised standards, initial infrastructure in selected cities, regions and corridors	Full coverage of certain (starting) regions, linking strategic hubs along identified corridor
High-blend biofuels	Harmonised standards.	Boost higher blending ratios in traditional fuels and the optimised use as such in cars warranted for the use of these fuels (keep a protection grade for older cars)
Synthetic fuels	Boost higher blending ratios in traditional fuels and the use as such in fleets	Boost higher blending ratios in traditional fuels and the optimised use as such in fleets with adapted drivetrains
Methane	Certain coverage in urban and non-urban	Increased coverage in urban and non-urban
LNG	Ports/harbours with an annual fuel turnover of > xx litres.	Ports/harbours with an annual fuel turnover of >xx litres. Truck refuelling stations with an annual fuel turnover of >xx litres.
LPG	Minimum certain coverage in urban and non-urban. Ports/harbours with an annual fuel turnover of >xx litres.	Increased coverage in urban and non-urban. Ports/harbours with an annual fuel turnover of >xx litres.

* Some members of the Group do not consider Sub-Option c) as an adequate measure

17. ANNEX 3: ASSOCIATED INFRASTRUCTURE COSTS

- **CNG/L-CNG associated infrastructure costs (NGVA Europe)**

The following associated costs when installing methane refuelling stations should be taken as average reference figures. First of all, it should be taken into account that two different approaches can be faced when talking about a new methane filling station:

– CNG filling Station: this type of infrastructure can be fed from the existing natural gas grid. In this case, it would be necessary to install a compressor with the capacity of reaching a final pressure of 200 bars, and the dispensers. The total cost of this kind of facility would be around 200.000 - 400.000 € depending on the compression capacity of the installation (normally 300÷500 m3/h.)

– L-CNG filling Station: this type of infrastructure capable of supplying both, liquefied and compressed natural gas and biomethane, has to be fed with liquefied natural gas via HD transport tankers. This LNG transport by road tanker is already well established in some countries like in Spain, where there are more than 40.000 movements of road tankers per year, being used mainly to bring LNG to cities not connected to the grid. It would be necessary to install a stationary LNG tanker to accumulate and feed the installation, a transfer pump to convert LNG into CNG, and the dispensers. The cost of the stationary tanker and the transfer pump is similar to the cost of a compressor. The total cost of this kind of facility would be similar to the investment of a high capacity CNG facility. The maintenance would however be expected to be lower.

Additional information on costs:

- Difference between gasoline and CNG version of a LD vehicle: 1.500÷2.500 € depending on vehicle size/engine complexity. Similar costs CNG versus diesel.
- Difference between diesel oil and CNG version of a HD vehicle: +13÷25% of CNG compared to Diesel version, depending on vehicle type.
- Laying of natural gas pipeline (if not available to connect to the filling station): 300÷600 €/metre; depending on land characteristics.

- **Electricity associated infrastructure costs**

AVERE

The costs of public charging infrastructure should be separated in 2 elements: the actual costs of the charging stations and the costs of installation of the charging stations which are variable depending on location, availability of power, conduit size and labour.

1) The current average price for a 2-plug charging station can vary from 4.000€[9] to €5.000 depending on where in Europe and how smart the station is. A fast charging station costs around €25.000, but Nissan offers some at €10.000.

[9] In Slovenia, the price for one smart charging station (2 x (IEC61851-1) plugs) is slightly above €5.000 (excluding VAT).

2) The installation costs of a charging station will vary depending on:

   - "building" costs (for example if digging is necessary)
   - costs of the parking space, road signs, marking, communication etc[10]…

Regarding the cost related to the parking space in city centres, this could be quite substantial, for example in Slovenia it can be up to €15.000. The connection fees to the grid will also have to be paid to the DSO[11] and again this can be up to €1.000 per plug.

Therefore the cost of the charging station itself is very often 1/2 or 1/3 or even 1/4 of the overall costs. After installation, maintenance costs should also be taken into account and these could be up to €2.000 per charging station per year.

The costs for Domestic charging infrastructure:

To project those costs, the number of predicted EVs should be multiplied by at least 2 to get the number of plugs needed (at home, at work…). There are currently 2 possible solutions.

1) CEE16A-plug: The estimated total cost for a simple installation with a CEE16A-plug including a protection device and a simple electronic device for communication lasting for 10 years is € 100.
2) Home Charge Device (Wall box solution): The estimated cost for a Home Charge Device / Wall Box solution is a bit more expensive: around €400.

This installation would probably have to be replaced after 5 years following the technological cycles.

EURELECTRIC

2 Plug Station (2x max. 22kW AC, Smart Charging compatible) ~ 5.300 €

2 Plug Station (2x max. 11kW AC) ~ 2.500 €

1 Plug Box (1x max. 22kW AC, Smart Charging compatible) ~ 1.900 €

1 Plug Box (1x max. 11kW AC) ~ 500 €

DC Fast Charging Station ~ 40.000 €

Connection Costs:

AC Range: 1.850 € - 5.200 € (Depending on max. capacity and cable length up to 10m)
DC Range: 4.000 € - 13.300 €

[10] For comparison with the US, the cost of installation of a charging station can be on average of $1.606, but can vary from $860 to $7400: http://projectgetready.com/resources/infrastructure/charging-station-installation-costs

[11] Data from Slovenia for a power source of cca 2x3,5 kW or 2x22kW.

- **Hydrogen and Fuel Cells associated infrastructure costs**

Between 2014 and 2020 a total estimated amount of €1,731 million is needed to build up the initial infrastructure. The cost per filling station will gradually reduce from 1.6 € million to €0,6 million per refilling station, depending on the size and volume.

The first 200 to 300 refilling units are likely to be added on to existing refuelling-sites. In the phase after 2015, more hydrogen refilling stations should be built in line with the scaling up of the car-volume.

When	What	Estimated cost
By 2015	Between 200 and 300 refuelling units (optimal case of FCEV rollout) in station/unit various urban regions across Europe, accommodating passenger and light duty mobility locally (5000 FCEV passenger cars, 500 FC buses)	0,6-2,5 M€ per filling station
By 2020	About 2000 fuelling stations (|500 000 FCEV passenger cars, 1000|per filling station/unit FC buses), in the optimal FCEV (depending on size of rollout case, minimum 1000 fuelling filling station) stations in the worst case	0,6-1,6 M€ per filling station
TOTAL estimated cost (up to 2020)		€ 1,731 million

- **Liquefied Petroleum associated infrastructure costs (AGPL)**

General infrastructure data

- LPG vehicles

Number of LPG vehicles in EU 27 (2009): 5,564,725

Number of LPG vehicles in EU 27 (2010): 6,027,650

Top 3 EU countries:

Poland (2010): 2,325,000
Italy (2010): 1,700,000
Germany (2010): 430,000

- LPG filling stations

  Number of LPG dispensing sites in EU 27 (2009): 26,891

  Number of LPG dispensing sites in EU 27 (2010): 27,526

Top 3 EU countries:

Germany (2010): 6,000
Poland (2010): 5,900
Italy (2010): 2,773

While the density of LPG filling stations may vary significantly across Europe, the cost for installing an LPG dispenser can also be subject to variations, depending on national safety regulations, commercial practices of local distributors, level of technology, etc...

It can be concluded that on average the associated cost for installing an LPG filling station usually ranges between €70,000 and €150,000. It should be noted that these amounts remain an average, and as an example this cost in Italy can go up to around €200,000 with underground tank of 30m3, which represents 90% of the newly installed filling stations in this country. The higher spectrum of the average cost generally includes the following items: civil work, underground tank (of varying capacities), underground piping, electric and data connection (e.g. wiring to the terminal at the cashier's desk in the station), gas detection devices, etc...

While the above description is the general standard in most EU 15 countries, the cost for setting up LPG dispensing sites can be significantly lower in some eastern European countries. This however generally concerns less sophisticated dispensing sites, e.g. relying on skid-mounted tanks (above-ground tanks embedded in a metal structure) of relatively low capacity. Such dispensing sites tend to be now phased out and replaced by more costly underground installations.

18. ANNEX 4: CHARGING TYPES FOR ELECTRIC VEHICLES

Fuelling an electric vehicle means charging the battery. Hence the fuelling of an electric vehicle will depend on the combination of:

- charging power (i.e. the voltage/amperage and the number of phases of the plug)
- battery characteristics

Power nomination	Mains connection	Power in kW	Power in Amps	Recharge range/hour[12]
Normal power[13]	1-Phase AC connection	≤ 3.7kW	10-16 amps	<20 km
Medium power	1- or 3-phase AC connection	3.7 -22 kW	16-32 amps	20 – 110 km
High power	3-phase AC connection	> 22 kW	> 32 amps	>110 km
High power	DC connection	> 22 kW	> 32 amps[14]	>110 km

The charging method of electric vehicles will depend on where EV customers want to charge their vehicles. A strict, future-proof categorization is difficult. However, a general, simplified picture of usage could be imagined as follows:

Normal power charging would generally take place in domestic settings like home and office buildings, but could also take place in public locations like curb-side charging poles and public car parks. Again it is difficult to foresee the future market developments but this normal power charging may suit a lot of EV customers' needs due to the fact that many of the daily trips range within today's battery capacity and when vehicles are charged while they are parked at the office, or at home. Medium power with a one or three-phase AC connection would be used by customers who park their vehicle while shopping or in a parking lot in a city area. A high-power 3-phase AC infrastructure can be erected on public roads to be used by EV customers who park their car on a public street. A high power DC connection would satisfy customer expectations for longer journeys, for instance when they would like to continue a motorway journey after a relative short recharging stop. Basic coverage is here needed but early experience in this matter requires less of these investments than expected (based on Irish experience).

[12] Assuming an average consumption of 20 kWh/100km.

[13] This single phase connection corresponds to the typical domestic plug connection dependent on country specific characteristics.

[14] With a DC connection the power to the vehicle is fed at the vehicle battery DC voltage, which normally ranges from 150-350 volts, so the amperage is related to the DC power and voltage.