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UN ECE – United Nations Economic Commission for Europe



NATURAL GAS FOR VEHICLES (NGV)

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and

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JOINT REPORT



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2. INTRODUCTION

Continuity of the study

Global NGV market keeps growing. Each year new technologies, regulations, government strategies and business scenarios are developed and introduced. The purpose of this Report is to investigate these recent developments achieved during the 2009 – 2012 Triennium, draw conclusions, prepare recommendation and present them to the world gas industry. However, global, regional and national NGV markets have a range of constant inherent features that should be traced back into history in order to examine near and mid term future trends. These trends are a reliable indicator of the future NGV business course. Due to this link between past and future readers may find in this Report certain repetition of the previous 2003 – 2006 and 2006 – 2009 NGV Study Group Reports. This is unavoidable, although all data are updated as of December 2011. Thus continuity of the study is assured.

The specificity of this new study is represented by the fact that it is a result of the joint effort of two international organizations: International Gas Union and Economic Commission for Europe of the United Nations.

Such joint effort was due to the following. In January 2010 the 20th session of the UN ECE Working Party on Gas has decided to prepare a study on use of natural gas in transport in the UN ECE region. To an extent this study was meant as a follow-up of the study on the Blue Corridor Project published in 2002.

The first coordination meeting of participants was hosted by Gazprom VNIIGAZ in Moscow in spring 2010. Taking into account that almost identical topics are considered within the International Gas Union by basically the same groups of NGV experts, participants of the Moscow meeting have proposed to make one joint NGV study instead of two. Such synergy would allow avoiding an ineffective duplication of work as well as saving time and resources. This proposal has also been supported by the IGU Working Committee 5 and by the Chairman of the IGU Coordination Committee.

This explains some emphasis made in the present study on the CNG/NGVs situation and the market prospects in the European countries and in the UN ECE region in general, e.g. the description of the state and prospects in the countries participating in the GasHighWay project, as well as the NGVA Europe position paper on Minimum infrastructure needs for methane (ng/biomethane) refuelling across Europe.

Scope of the report

Unless otherwise specified the term Natural Gas Vehicle (NGV) in various combinations (NGV market, NGV legislation, NGV equipment etc.) in general is related methane-based fuels: compressed and liquefied natural gas and bio-methane as well as associated technologies, politics and business.

Geographical division of the world

For the purposes of this Report geographical sub-regions of the World are purely geographical – not political – areas of macro-regions divided so by the United Nations Statistics Division of the United Nations Department of Economic and Social Affairs (DESA).



Geographical Sub-Regions of the World

Countries subject to this report

Only those countries are subject to this report where natural gas vehicles and NGV related infrastructure are available NGV according to the best knowledge of the S.G 5.3 Study Group Members and Partners as of December 2011. If some countries are missed in this Report, it is a matter of nothing but simple unawareness of the team. NGV related infrastructure is understood to mean filling stations, mobile refueling units, conversion shops, cylinder requalification facilities, training centers and other integral elements of the national NGV market.

The following geographical sub-regions and countries are subject to this report:

AFRICA

Northern Africa	Eastern Africa	Western Africa
Algeria	Mozambique	Nigeria
Egypt	Tanzania	
Tunisia	United Arab Emirates	

AMERICA

North America	South America	Central America	Caribbean
Canada	Argentina	Mexico	Dominican Republic
USA	Bolivia	Panama	Trinidad and Tobago
	Brazil		
	Chile		
	Columbia		
	Ecuador		
	Peru		
	Venezuela		

ASIA

Central Asia	Southeastern Asia	Southern Asia	Western Asia	Eastern Asia
Armenia	Indonesia	Bangladesh	Turkey	China
Georgia	Malaysia	India		Japan
Kazakhstan	Myanmar	Iran		South Korea
Kirghizia	Philippines	Pakistan		
Tadzhikistan	Singapore			
Turkmenistan	Thailand			
Uzbekistan	Vietnam			

AUSTRALIA & NEW ZEALAND

Australia
New Zealand

EUROPE

Northern Europe	Eastern Europe	Southern Europe	Western Europe
Estonia	Byelorussia	Bosnia and Herzegovina	Austria
Finland	Bulgaria	Croatia	Belgium
Great Britain	Czech Republic	Greece	France

Northern Europe	Eastern Europe	Southern Europe	Western Europe
Iceland	Hungary	Italy	Germany
Ireland	Moldavia	Macedonia	Lichtenstein
Latvia	Poland	Montenegro	Luxemburg
Lithuania	Russia	Portugal	Netherlands
Norway	Slovakia	Serbia	Switzerland
Sweden	Ukraine	Spain	

3. EXECUTIVE SUMMARY

Eugene Pronin, Andrey Andreevsky, Gazprom, Russia

The present Final Report has been prepared due to valuable contributions of the members and partners of IGU Study Group 5.3 listed above.

The aim of the publication is to reflect the changes in the field of use of natural gas in its different kinds occurred in the world since the last Report published in 2009.

The peculiarity of this document is represented (as it was mentioned in the Introduction) by the fact that this is a joint effort of two important international organizations and their experts: International Gas Union and the United Nations Economic Commission for Europe (UN ECE).

This reason explains the structure of the Report.

The main part of it is represented by the “Market Profile”, i.e. a global overview of NGV situation in different continents and countries of the world.

The world statistics show the 12 times growth of NGVs compared to 2000, i.e. from 1.2 million to 14.55 million of vehicles. During the period considered in this Report the leadership in NGVs development has passed from Latin America to Asia. Pakistan leads in the world with 2.85 M NGVs and large governmental program supporting the development in the field.

The more spectacular dynamics showed Iran, India and China.

Iran with more than 17% share of natural gas resources in the world has superior condition for substituting common liquid fossil fuels by natural gas. Partially unexpectedly it has caught up with the leading group and takes the world’s second place with 2.85 M NGVs and 1800 filling stations.

In India the use of gaseous motor fuels receives a large governmental support. The government has made a list of 201 cities where CNG and LPG facilities would be installed in the coming years. Due to this support India takes now the 5th place in the world with 1.1 M NGVs. Although many of NGVs are converted after-market vehicles.

China also can be considered as one of the “newcomers” of the NGV market. The availability of natural gas in China is growing year by year due to the completion of significant domestic pipeline infrastructure projects that connect to neighbouring countries’ pipelines. Likewise, the amount of imported LNG in coastal areas of Southeast China is steadily increasing. This relatively recent abundance of natural gas provides the backdrop for the development and growth of NGV usage in China. Now there are in total 600.000 NGVs and 2.500 natural gas

refuelling stations in China. These figures are increasing rapidly each year, encouraged by more than 60 NGV car makers (OEMs) that have developed in China.

The Market Profile presents a wide picture of legal conditions and governmental support (or lack of support) of NGVs development existing in different countries. It shows the main technological trends in production of methane vehicles, high pressure cylinders, refueling and other equipment.

If compared to the previous Final Reports, this one contains some material showing the use of natural gas in transport under a new aspect. In Chapter 7.3 there is an article: "LNG as a bunkering fuel", which describes the ships refuelling technologies, infrastructure development and environmental effect. In Chapter 7.2: "Best practices: NGV refuelling stations" there is a detailed analysis of CNG refuelling stations operation prepared through questioning the experts working in this field in different countries.

Some space of the Report is dedicated to substantial analytical materials concerning the main conditions and prospects of NGV market development. In large part they are represented by position papers provided by NGVA Europe, such as: *Minimum infrastructure needs for methane (ng/biomethane) refuelling across Europe*; *EU emissions policies and its impact on the European NGV market*.

The first article is based on the premise, that taking into account the great environmental benefits being related to natural gas and biomethane and despite the fact that more and more ex-factory methane driven vehicles are being introduced to the European market place, the market share of CNG and LNG vehicles is still rather small, now making up close to 1 million vehicles in the EU, which is making up a market share of only 0.4 % of the total running fleet. And it offers some ways of improving the situation.

The second concerning the EU emission policies stresses that a market share of 20% of natural gas in transport fuels would allow a 5% reduction of the CO₂ emissions from all European vehicles. Assuming that 20% of the gas used would be made up of biomethane, the CO₂ reduction would increase to 7%. European emission policies are clearly and increasingly supporting NGVs and will remain the main driver for further market development of CNG and LNG vehicles.

The Report contains some important materials concerning new technologies, especially biomethane and hydrogen: Synergy of biomethane and natural gas; Natural gas blends technology gas – hydro; From concept to reality: smart transition to clean alternative fuels; Promising NGV related technologies to enhance efficiency and safety.

By 2030 natural gas consumption in the European Union should increase by around 16%. With the supply of natural gas becoming ever more dependent on imports, the papers evaluate the possible contribution that substitute products such as biomethane could make to satisfy the future demand for natural gas.

Today, natural gas and biomethane represent the most practical, realistic and easiest way to reduce pollution coming from road transportation. At the same time, Hydrogen as a vehicle fuel certainly is an interesting solution taking into account its environmental benefits. However, to be realistic, fully propelled hydrogen vehicles still remain an insecure long term option facing various obstacles, which must be solved first: open questions include e.g. production pathways with regard to coherent pollution, energy and cost dimensions; the organization and realization of a dedicated distribution network; the complexity and cost of hydrogen vehicles and their main components, etc.

As a consequence, the presented papers are intended to present the huge potential that methane/hydrogen blends can bring for the transport sector, as an ideal bridge to a more sustainable mobility, by using the existing NG/biomethane distribution infrastructure.

Some interesting examples of use of natural gas in transport are shown in the case studies: *Lille and the French case* and *First public LCNG filling station in Sweden*.

The main conclusions and prospects for the future are summarised in Chapter 8 entitled 'Natural Gas Vehicle Market In 2010 – 2020: Development Trends'.

The Appendices of the Report include some special information.

Due to the UN ECE cooperation within the preparation of the Final Report some emphasis is made on the situation in the UN ECE countries. That is why the first Appendix is dedicated to the European GasHighWay project and contains a detailed description of situation in the participating countries as well as the prospective location of filling stations.

The project is co-financed by the European Commission under the Intelligent Energy – Europe, a part of the EU's Competitiveness and Innovation Framework Programme (CIP). The aim of the project is promoting the uptake of gaseous vehicle fuels, namely biomethane and CNG, and especially the realization of a comprehensive network of filling stations for these fuels spanning Europe from the north, Finland and Sweden, to the south, Italy.

The main objectives of the project are: increase of the general awareness of target groups in the use of natural gas vehicles (NGVs), increase the supply of NG/biomethane by boosting the investments in distribution systems for these alternative fuels and in biogas production and biogas upgrading to enhance NGVs demand.

Due to the fact that the Blue Corridor concept becomes reality the second Appendix is dedicated to examples of the functionality of the concept. Its vitality is shown first of all by NGVs rally organized in different parts of the world: in Europe, in Latin America and Asia. Their aim was to attract the attention of local authorities, car manufacturers, mass media and general public to the benefits of introducing natural gas into engines.

The last Appendix is dedicated to the world NGV statistics traditionally provided by NGV Communications Group.

In general the experts of the joint IGU / UN ECE study have come to the following conclusions concerning the prospects of NGV market development.

Natural gas – with its environmental, economic and availability advantages – will remain the only alternative to oil and diesel in the short and medium prospective. Only natural gas is fully technically and economically applicable in any transportation means: on-road vehicles, scooters, heavy duty vehicles, ships, aircrafts, locomotives, etc.

The average rate of the world NGV fleet growth reached 15% in the last decade of the past century, and 26% in the 21st century. With the average growth of 18% the world NGV fleet will reach 60 million by 2020. According to the conservative energy development scenario, by 2020 the methane share in the bulk of motor fuels will reach 11% in Asia, 12% in Americas and 14% in Europe. The world gas consumption in transport is expected to increase from 20 bcm in 2010 up to 40-45 bcm in 2030. The coming decades will show the dramatic growth of use of liquefied natural gas and liquefied biomethane.

The alleged deficit of natural gas is not really foreseen. The World Energy Outlook 2011 published the last November by the World Energy Agency states that the Gold Age of natural gas is coming. The total recoverable reserves of natural gas will last for about 250 years with the present rate of consumption. Such forecast opens wide prospects for natural gas as a motor fuel.

4. MARKET PROFILE: WORLD, COUNTINENTS, COUNTRIES

Collected by: Mr. Davor Matic, OMV Adria, Croatia; WOC 5.3; UN ECE NGV Expert Group (with updates by WOC 5.3 / UN ECE NGV Expert Group members and partners)

The purpose of this chapter is to provide description of national and regional market developments since 2009. In other words it should provide an insight to the market profiles since end-2009 (when previous WOC 5 report was published) onwards with an aim to cover:

- key drivers affecting the market(s),
- availability of OEMs and increased conversions,
- new supportive measures (or counter-supportive) introduced,
- new programs / plans / projects of interest realized / under development / announced,
- new legislation issued,
- strategic documents issued etc.

Statistics, economics and technology is described more in details in the other chapters.

For the purposes of this Report geographical sub-regions of the World referred to in this Report are purely geographical – not political – areas of macro-regions divided so by the United Nations Statistics Division of the United Nations Department of Economic and Social Affairs (DESA).



Geographical Sub-Regions of the World

Only those countries are subject to this report where natural gas vehicles and NGV related infrastructure are available NGV according to the best knowledge of the S.G 5.3 Study Group Members and Partners. If some countries are missed in this Report, it is a matter of nothing but simple unawareness of the team (or the data unavailability regarding latest developments).

EUROPE

The European Commission adopted in March 2011 a comprehensive strategy (Transport 2050) for a competitive transport system set out to remove major barriers and bottlenecks in many key areas across the fields of: transport infrastructure and investment, innovation and the internal market. The aim is to create a Single European Transport Area with more competition and a fully integrated transport network which links the different modes and allows for a profound shift in transport patterns for passengers and freight. To this purpose, the roadmap puts forward 40 concrete initiatives for the next decade.

The Transport 2050 roadmap sets different goals for different types of journeys – within cities, between cities, and long distance.

- For intercity travel: 50% of all medium-distance passenger and freight transport should shift off the roads and onto rail and waterborne transport.
- For long-distance travel and intercontinental freight, air travel and ships will continue to dominate. New engines, fuels, and traffic management systems will increase efficiency and reduce emissions.
- For urban transport, a big shift to cleaner cars and cleaner fuels – 50% shift away from conventionally fuelled cars by 2030, phasing them out in cities by 2050.
- Halve the use of “conventionally fuelled” cars in urban transport by 2030, phasing them out in cities by 2050, and achieve essentially CO₂-free movement of goods in major urban centres by 2030.

Methane is part of the EU strategy for the future of transport outlined in the final draft of the report of the European Expert Group released on January 2011. After the “efficient vehicles” strategy, the European Commission has sketched out for the second time in a few months the advantages that natural gas vehicles can bring in the attempt to make transport cleaner and less dependent on oil. To reach this target, the expert group says that alternative fuels, such as electricity, hydrogen, natural gas and biomethane, biofuels and LPG, “should be available EU wide with harmonised standards, to ensure EU-wide free circulation of all vehicles” and should benefit of harmonised and EU-wide incentives. Concerning methane, the document underlines that building additional refuelling stations to ensure widespread supply and that setting “harmonised standards for bio-methane injection into the gas grid” are absolute priorities. In particular the expert group underlines “the need for an infrastructure development plan” and stresses how investments in the sector can pave the way for further environmental improvements: “The gas grid can be made available also for bio-methane feed-in to allow for a smooth change-over from fossil to renewable methane gas sources”. In a 2030-2050 perspective, bio-methane could account for a considerable part of the total volume of methane used in Europe and “the total potential of bio-methane supply is comparable to the total present natural gas consumption of the EU”. According to EU experts, “methane gas vehicles can play an important role in urban and medium distance transport in the medium term” and natural gas and biomethane “should be promoted as one of the main fuels in heavy urban transport”. This is one of the many elements suggested by and inserted into the draft report.

Thanks to the strong intervention of NGVA Europe, the European Commission proposal for raising minimum taxation levels for natural gas already in 2015, has been modified. It now allows member states to apply exemptions in taxes for natural gas used as a vehicle fuel until 2023, and according to the proposed amendment to Article 15 (i), the member state can,

but is not obliged, to make use of this possibility. This in part means that one of NGVA Europe main political postulations not to raise any taxes at least for 10 years from now has been accepted. Nevertheless and at the same time, it should be noted that this new approach is not enough coherent under NGVA Europe point of view, taking into account that natural gas vehicles are still a niche market in most European countries, and also the strategic and environmental benefits associated to its use. The environmental impact of each fuel and the fact that natural gas is the cleanest alternative is therefore being disregarded and also the consideration of the market share aspect as suggested by NGVA Europe has not been picked up. The Commission appreciated NGVA Europe concise contributions, including its final statement.

Following the main recommendations from the Expert Group of Future Transport Fuels, the European Commission officially introduced the 5th FP7 call for 2011/2012 research, innovation and demonstration projects. One of the transport related calls is on the “Demonstration of heavy duty vehicles running with liquefied methane” to promote LNG Blue Corridors on medium and longer distances. The project will be part of the European Green Cars initiative, which is one of the three PPP (Public Private Partnership) included in the Commission’s recovery package, and is designed as a large scale project having a total EU funding of 8 million Euro (total funding for road transport related calls is 37 million out of 150 million allocated to FP7). In this partnership 50% of all related costs will be refundable. NGV Europe has been encouraged to come up with a concrete proposal to carry out and co-ordinate the LNG Blue Corridors project and is inviting interested partners (manufacturers, fuel suppliers, operators, cities/regions as well as possible end-users; transport and logistic companies).

The main objective of the project is to initiate a European network for sustainable road transport by tackling non-technological barriers to the production of Liquefied BioMethane (LBM), expansion of supply routes for LNG, and the use of LNG in heavy goods vehicles. This will be done through an analysis and development phase, followed by pilot projects and the initiation of a European network of production/refuelling facilities. The high autonomy (600 to 800 km) of the long distance LNG trucks will reduce the number of the minimal necessary filling stations to a relatively small number. Going to real numbers, the aim would be to install in Europe a minimum of 10 new LNG/LBG filling stations, strategically situated, and able to give service in the different main routes to not less than 50 to 100 LNG heavy trucks. The analysis will be aimed at determining the member state and European market barriers. In addition, the differences in legislation, taxation and subsidy programmes will be investigated throughout Europe by the project partners. Moreover, recommendations will be formulated for European policy makers. Finally, an effort will be made to normalise and standardise the various technologies related to both, LMB production and application in methane vehicles using LNG.

Taking into account that today the Iberian Peninsula is the part of Europe with more LNG terminals, imagined are three initial LNG Blue Corridors:

1. Portugal, Spain, France, Belgium, The Netherlands and UK
2. Portugal, Spain, France, Germany, Denmark and Sweden
3. Portugal, Spain, France, Italy, Slovenia, Croatia

A fourth transversal corridor could link UK, The Netherlands, Germany, Austria, Russia; taking advantage of the filling points for the previous ones. An additional inland waters corridor going up the river Danube will link Romania up to Vienna.

Within the pilot projects, LBM production and identifying strategic supply routes of LNG for application in heavy goods vehicles will be demonstrated in partner countries and several regions being interested to apply the LNG concept in heavy goods transport, functioning as a connector to other regions and big European cities using the same principle, thus creating the LNG Blue Corridors. All pilot projects results will be monitored and disseminated to potential users.

The EU has set out an ambitious strategy to reduce CO₂ emissions from road vehicles and much has been achieved already. Regulation (EC) No 443/2009 setting emission performance standards for new passenger cars requires a fleet average emission of 130 g CO₂/km for new passenger cars to be fully achieved by 2015. Industry will need to invest even more in emission reduction technologies, including smart traffic management technologies, and further improve engine efficiency. This requirement could be achieved much sooner, however by increasing the proportion of natural gas vehicles. This was revealed in a recent study carried out by the CAR-Center Automotive Research at the University of Duisburg-Essen. According to its results, NGVs provide the ideal bridging technology into the age of electric vehicles; no other technology will allow us to reduce overnight the harmful CO₂ emissions of the vehicles at such a low cost due to the low emissions of natural gas fuel, which can be reduced even further by the addition of bio-methane. According to the authors this would enable the target for 2020 to be achieved five years earlier.

Moreover a Commission proposal to reduce CO₂ emissions from light commercial vehicles (vans) is currently being discussed by the Council and Parliament. It proposes a fleet average emission for all new vans of 175 g/km as of 2016.

The EU has also reduced emissions of pollutants such as particulate matter and NO_x by setting ever stricter standards. Euro 6 limits for cars and vans and Euro VI for heavy-duty vehicles will apply as of 2014. Even though petrol and diesel combustion engines will become less dominant in the 2020 perspective, every means available must be used to reduce their negative environmental impact.

Type-approval for road vehicles has been extended to cover all propulsion systems with the aim of removing potential regulatory barriers and to ensure that alternative propulsion vehicles are at least as safe as conventional ones. Therefore, common rules have already been set out for hydrogen powered vehicles, gas fuelled vehicles and biofuels. Common requirements are needed for electric vehicles too.

Regulation 2009/33/EC requires contracting entities and public and private operators to take into account lifetime energy and emissions impacts (costs) when purchasing road transport vehicles for fleets. It does not prevent the choice of retrofitted vehicles upgraded for higher environmental performance. As an additional instrument to help the implementation of this directive, European Commission launched a new website, <http://www.cleanvehicle.eu>, to help consumers and public authorities to choose the cleanest and most efficient vehicle, so to make the best choice that can help to save money in the medium and long term. Beyond all the information on the costs and the emissions of vehicles, from passenger cars to light and heavy duty vehicles to buses, the Portal provides information on public procurement rules and incentives schemes for clean and energy-efficient vehicles on EU level and in all Member States. The increase of sales will help reduce costs through economies of scale and will result in progressive improvement in the energy and environmental performance of the whole available fleet.

Regulation 2009/28/EC on the promotion of the use of energy from renewable sources is setting mandatory share of energy from RES in transport; at least 10% of the final consumption of energy in transport of member state by 2020. It includes also biomethane injected into the grid. Member states were obliged to prepare National Renewable Energy Action Plans (member states national targets) until June 30th 2010.

Regarding the off-shore applications, use of LNG in ships is gaining momentum.

The European Commission has published a report, in mid-July 2011 saying that sulphur dioxide emissions have to be cut by as much as 90 percent and particle emissions by 80 percent before January 2015. In particular, the decrease in the allowed maximum level of sulphur content of maritime fuels should be stronger in “sensitive areas” such as the English Channel, the North Sea and the Baltic Sea, from 1.5% to 0,1%. In other areas the reduction in sulphur contents will be from the current levels of 4.5% to 0.5% by January 2020. According to the report, projections made in 2005 showed that without further regulatory action, the continued growth in emissions of sulphur dioxide and nitrogen oxides from the maritime sector will surpass total emissions of these pollutants from all land-based sources by 2020. The Group of experts indicated the way forward explaining how achievement of these standards can be via purchase and use of low sulphur fuels, and also through alternatives fuels and stressing that there is an increase interest in LNG as a fuel, especially for those ships carrying cargo across short distances. In particular, using LNG would enable such ships to comply with the requirements and also remain competitive with other modes of transport.

The Danish Maritime Authority (DMA) is heading an EU project with the aim to make recommendations for creating a framework for the establishment of a maritime LNG infrastructure in the Baltic Sea, the North Sea and the English Channel. The framework, involving the fulfilment of a feasibility study and test of recommendations, is to be considered along two dimensions: a “hard” dimension with maritime LNG filling stations and a “soft” one with regulation, classification rules and industrial standards and cooperation, etc. The project has been formed in response to the recent IMO (International Maritime Organization) regulation on shipping sets limits on sulphur and nitrogen oxide emissions from 2010, 2015 and 2016 (the 2016 provisions). The recommendations are to target central stakeholders for the establishment and use of an LNG infrastructure encompassing technical as well as economic issues. Central stakeholders mean ship-owners, ports, LNG providers, industry organizations, states, the EU and the IMO, etc. The EU project description states that the use of LNG seems an obvious alternative to meet the environmental demands in a competitive way. But the absence of an LNG infrastructure for supplying LNG to ships that is supported by regulation, industry standards, etc. does not make this alternative viable. The recommendations will address LNG infrastructure from a supply chain point of view, from the reception of LNG and/or liquefaction of natural gas from the natural gas grid, via storage and distribution of LNG to the use of LNG in ships for propulsion. The project is co-financed by the EU and is strategic in relation to the implementation of Motorways of the Seas according to article 12A of the TEN-T (Trans-European Network) Guidelines on Motorways of the Seas.

Country by country overview (based on the available data) is presented below.

NORTHERN EUROPE

DENMARK was until recently country without any NGVs or CNG stations (a very late piece of positive news is the advent of the first public CNG station). Danish situation is a problem considering refuelling needs in NGVs trying to travel between other Nordic countries to continental Europe. The background is the Danish taxation of natural gas used as a vehicle fuel which makes CNG as expensive as diesel and petrol.

ICELAND is the only NGV country fully dependant on biomethane. New laws were passed by the Icelandic parliament in December 2010 and enforced on 1st January 2011 that reflects a systematic change in taxation on motor vehicles and fuels. No longer will motor vehicles in Iceland be taxed based on engine size or total weight of but instead based on documented emission of CO₂/km of fossil origin. Both the excise duty and VAT have been placed on motor vehicles in Iceland in the past but the %-range for the excise duty have been widened placing an added cost on vehicles releasing GHG, of fossil origin, over 160 gr/km. Bio-fuels will carry a VAT of 25.5% as before but the new law confirms that a special fuel fine that is placed on petrol and diesel will not be placed on bio-methane or bio-diesel for some years to come. The new law provides for the ability to import vehicles, capable of using bio-methane as a primary fuel, without paying an excise duty up to the maximum deduction of 1,250,000 kr (app. 7,900 EUR). The deductions apply for all bi-fuel vehicles with two fuel tanks, a methane tank and a petrol tank, as well as dual-fuel cars (methane/diesel). Also, the new law places a bi-fuel car and a dual-fuel car in the lowest category for the annual vehicle-fee, 5,000 kr/year (app.31 EUR/year), as opposed to a high as 73,800 kr/year (app. 466 EUR/year) for each passenger car. This will apply regardless of how the car became registered as a bi-fuel or dual-fuel car. Finally, the new laws confirmed that the government has no intent in placing a special fuel fee on bio-fuel usage in transportation in Iceland.

In **IRELAND** national gas company, Bord Gáis has launched a report on The Future of Renewable Gas in Ireland. The report outlines how grass and waste can be converted into natural gas that can then be used locally or piped into the national grid for distribution around Ireland. The report estimates that 7.5% of Ireland's natural gas demand could be met by renewable gas. Bord Gáis, which is currently trialling OEM NGVs in its fleet, uses Sweden's biomethane industry to show what is possible for natural gas vehicles.

The situation and prospects of CNG/NGVs in **LATVIA** are considered in the Chapter concerning the European GasHighWay Project. The main statistic data look as follow. With the total number of on-road vehicles of about 700 thousand units the number of NGVs amounts only to 18, with one CNG filling station in the country. The major CNG filling station operator is Latvijas Gaze. The average prices for motor fuels: CNG (EUR/m³) – 0.38; oil RON95 (EUR/l) – 1.32; diesel (EUR/l) – 1.28.

In **LITHUANIA** with the total fleet of on-road vehicles exceeding two million units it has 195 NGVs and 3 CNG filling stations. No incentives are offered by the state, and the fuel prices do not differ so much: CNG: 0.88 €/Nm³; gasoline-95: 1.32 €/l; diesel: 1.24 €/l.

Recent developments in **SWEDEN** are targeted primarily in the direction of use of liquefied methane and especially biomethane in heavy-duty applications.

Clean Air Power (CAP) reported to deliver eleven dual-fuel systems to Volvo Bus Corporation under a new supply agreement. The agreement follows on from the development agreement signed with Volvo Bus Corporation in July 2010 which stated that the companies would jointly develop the installation of dual-fuel systems on existing bus engines. These eleven dual-fuel systems will be fitted directly onto the buses on the Volvo

production line and these buses are expected to be in service in Sweden by July 2011. Due to this positive environmental impact, this project is receiving considerable support from the Swedish government who are contributing almost SEK 24 million (US\$ 3.54 million) of funding towards the project through the Swedish Energy Agency. Further to this agreement, the company is in follow-on discussions with Volvo Bus Corporation regarding the joint development of dual-fuel engines for the next generation of Volvo Buses and bus chassis. This supply agreement is separate from the supply agreement signed with Volvo Powertrain in July 2010, and represents a further extension to the relationship which began in 2007.¹

In parallel, Volvo Trucks initiated testing of the dual fuel trucks developed under the agreement with CAP. Field tests started in 2010 with a mixture containing 70 percent methane gas. Series production was scheduled to get under way in August 2011. The Volvo FM MethaneDiesel will initially be sold in Europe. First off the mark will be the Netherlands, Great Britain and Sweden, where the gas infrastructure is best established. At present there are plans to build about 100 trucks in 2011. The new Volvo FM MethaneDiesel is offered with a 13-litre engine producing 460 horsepower. The fuel consists of up to 75 percent liquefied gas and the rest diesel, but the proportions can vary depending on how the vehicle is used. When liquid methane and diesel are used in a ratio of 75-25 percent, a truck performing long haul or intercity duties has an operating range 500 to 1.000 km, depending on driving conditions. Volvo Trucks has also started retailing in Sweden of refuse trucks and distribution trucks using a 7-litre engine fitted with a Hardstaff QVM dual fuel solution 80 units had already been sold in November 2011..

Business Region Göteborg, together with industry and transport authorities, has received SEK 23.95 million (US\$ 3.3 million) in Energy Agency funds for demonstration projects for long-distance biomethane trucks and bus. The project aims to produce a strong market-rate alternative to diesel-powered heavy vehicles. AB Volvo and Volvo Buses are the OEM project participants. The project uses the term “BiMe” – a reference to methane gas engine (MDE) technology using compressed and liquefied biomethane. Liquefied biomethane infrastructure is being expanded to allow the use of LNG trucks. The projects will develop biogas technology in all its various stages – production, distribution and automotive part – thereby allowing for heavy vehicles to meet the tough environmental standards being set for them now and in the future. This development of BiMe trucks and buses is described as having a unique potential to develop a market for heavy duty vehicles powered by liquid biomethane in Sweden and open up environmental technology export opportunities. SEK 19 million will be invested in the development of an energy-efficient MDE truck engine. The project’s goals include 67 long-distance heavy duty trucks being powered by liquid biomethane and at least three filling stations, one each in Göteborg, Stockholm and Malmö. Truck project participants are AB Volvo, along with the leading biogas suppliers in Sweden, AGA, Eon and FordonsGas. Business Region Göteborg, which includes Energas Sweden and Biogas West, is the project manager. The project is co-funded by the Västra Götaland region. SEK 4.95 million will be invested in the development of an energy-efficient MDE bus engine suitable for regional transportation, aiming to have 20 biomethane-powered buses on the road by project end.

¹ CAP has formally signed a Supply Agreement with Volvo Powertrain and a separate Development Agreement with Volvo Bus Corporation. The new Supply and Development Agreement, initially for five years, has been signed with Volvo Powertrain, a subsidiary of AB Volvo. It follows 3 years of close cooperation on a product development partnership and supersedes the Letter of Intent signed in January 2009. CAP’s OEM product will be marketed and supported by Volvo Truck Corporation. The testing in commercial operation was set to begin in 2010 and initially take place in UK, Sweden and Thailand.

Three filling stations for liquefied methane gas have been planned in Sweden to date. Besides the completed one in Göteborg, Aga will open a filling station in Stockholm, and Eon will open one in Malmö. Volvo Trucks is a partner in all the projects (there are tentative plans to build some 20 additional stations to provide an adequate nation-wide coverage)..

Scania has been granted SEK 30 million (US\$ 4.4 million) by Sweden's Strategic Vehicle Research and Innovation Initiative (FFI) to develop a biofuel (alcohol and/or methane based) engine intended for heavy commercial vehicles. The company will focus on developing an engine using sustainable biofuels that will combine the high energy efficiency of diesel (compression ignition) technology with the more efficient exhaust after-treatment system of Otto (spark ignition) technology.

In the LDVs segment, some three years after the withdrawal in 2006 of Volvo's popular bi-fuel CNG/gasoline range, a Volvo bi-fuel model again became available. The company is backing conversions from Alternative Fuel Vehicles (AFV), a privately-owned Gothenburg based company, which has started converting the Volvo V70 model into a bi-fuel version. Canadian Westport Light Duty in the autumn of 2011 purchased AFV. The Volvo V70 2.5 Bi-Fuel, is based on Volvo's current V70 model. The converted Volvo will be insured and financed the same way as other Volvo cars in Volvo and Volvo Financial Services. The buyer will also receive the usual 24-month new car warranty. The only difference is that AFV will take over responsibility for the product after the conversion. The Nordic branch of Japanese carmaker Subaru plans to produce vehicles in Sweden. Subaru Nordic plans to convert its midsize Legacy" and crossover "Outback" models to CNG system. Although the company is confident that there is interest for more than 2.000 units of these vehicles, it has not yet determined the number of cars that will be manufactured because it is awaiting a government decision on company car income tax privileges after 2012. The cars would be sold in Finland and the rest of European market.

Latest status concerning incentives and supportive measures (end 2011) for methane use in transport sector in Sweden is as follows:

- 40% reduction of taxable value of benefit via the free use of company cars is for NGVs typically worth Euro 900 annually in tax savings.
- Priority lanes for gas fuelled taxi-cabs at airports, railway stations, and ferry terminals means much reduced time waiting for a new passenger and thus higher earnings.
- A number of municipalities offer free or reduced cost parking for NGVs.
- Annual road tax is about one third of the tax on petrol fuelled vehicles.
- Previous large annual road tax advantage (some 3-400 EUR) compared to diesel vehicles now, unfortunately, only valid when comparing with diesel vehicles older than five years.
- Many municipalities (also various private companies looking to improve their green image) give priority to CNG cabs or other NGVs when ordering taxi services or other transportation jobs.
- Various incentives in support of new bio-methane production units, not only conventional AD plants, but also projects aiming to gasify forest industry waste and reform into bio-methane.

Fuelling cost advantage for Otto engine NGVs on average up to 24% in comparison with use of petrol and up to some 10% in comparison with more fuel efficient diesel vehicles. Fuelling cost advantage for methane used in dual fuel trucks above 20%.

Technology development in **NORWAY** and **FINLAND** is lately concentrated on the off-road marine applications using LNG. The overview below is tackles also marine developments in other countries.

Norwegian Torghatten Nord has ordered four LNG ferries from the Polish Remontowa shipyard in Gdansk. This order is additional to four earlier ordered ferries now being built by Remontowa. Two new Fjord Line cruise ferries, to be built at Bergen, may be fitted with dual-fuel LNG engines. LNG/LBG considered for future ships plying the Gotland to Swedish mainland routes. GDF Suez subsidiary Cofely develops use of LNG/LBG fuelled ferry for use on Dutch Harlingen-Terschelling/Vlieland route. Norwegian NSK shipping has ordered an LNG fuelled coastal general cargo vessel to be built in Tersan (Turkey) with delivery in 2012. Viking Line on October 25th, 2010, announced the intention to order a € 240 million LNG ferry for delivery in early 2013 from the STX Finland shipyard in Turku. The ship will be used on the Stockholm-Turku route. The ferry has an overall length of 210 metres and a gross tonnage of 57.000. The top speed is 23 knots, and the ship will hold 2.300 passengers, and a crew of 200. The deal also includes an option on a sister ship. The Indian Baharti Shipyard will build two LNG powered RoRo vessels for Norwegian Sea-Cargo. Norwegian shipbuilder Kleven Maritime has signed a new contract with Rem Offshore, fishing and supply shipping company based in Fosnavåg, for delivery of a LNG-powered offshore vessel, scheduled for delivery in December 2012. STX Norway Offshore has entered into three separate contracts in recent days to build LNG-powered platform supply vessels (PSVs) scheduled for delivery in 2012.

Finland's Wärtsilä Corporation, a ship power solution provider, has received an order from Eidesvik Offshore for LNG Platform Supply Vessel (PSV) to be Eidesvik's fifth LNG-powered PSV. The vessel will be fitted for use in arctic waters with 'winterization' and de-icing solutions, and is to be built at Kleven Verft in Norway. The dual-fuel units enable, in addition to heavy fuel oil (HFO) and marine diesel oil (MDO), the use of gas as a main fuel for marine applications. Furthermore, Wärtsilä is cooperating with Korean Samsung Heavy Industries, the world second largest shipbuilder, concerning a new LNG powered container vessel design. The intention is to jointly develop next-generation ships with efficient and competitive propulsion machinery concepts that meet or exceed the demands of future environmental regulations, especially relevant in Emission Control Areas (ECAs). In gas mode, this dual fuel engines already complies with the IMO's Tier III regulations which come into force in 2016. Wärtsilä earlier on November 2010 signed an MoU regarding future cooperation with the Russian United Shipbuilding Corp. for joint developments of ship designs and propulsion systems. Wärtsilä and Deltamarin (designers of cruise ships and ferries) in a joint press release on October 2010 announced their co-operation concerning dual fuel powered ferries intended for traffic in the North American coastal waters.

The Norwegian transport corporation Fjord1 has entered into a contract with Norwegian-registered Fiskerstrand BLRT AS to plan and construct what is said to be the world's largest gas-powered ferry. The run for the records in this segment (see the section on France below). The ferry will run on LNG and will be delivered on 30 November 2011. The new LNG-powered ferry is designed by Multi Maritime AS in Førde and will have a total length of 130 metres and a capacity of 242 cars and/or 22 lorries in combination with cars. It will hold 600 passengers including staff. Maximum speed is to be around 20 knots. Following the success of the world's first ferry to run on natural gas with MF Glutra in 2000, Fjord1 is still the only company using natural gas ferries for vehicle and public transportation with five

more large vessels operating the busy links along the busy coastal roads of Norway. Fjord1 will by the end of 2011 have 12 gas ferries in operation along the Norwegian coast, making the company a world leader.

The 25,000 dwt product tanker 'Bit Viking' was the first vessel ever to undergo a conversion by Wärtsilä from heavy fuel oil to liquefied natural gas (LNG) operation. The unique fuel conversion of the product tanker 'Bit Viking', from heavy fuel oil to gas operation, has been finalised and in October 2011.

As regards the on-road situation in Finland, detailed overview can be found in the Gas Highway project report in the Appendix of this report.

In Norway, a comprehensive report entitled Biogas as Fuel for Buses, prepared by HOG Energy and signed off in December 2010, proposes that for climate and environmental reasons Norway should focus on biogas as fuel for buses. An interim report resulted in the City Council in Bergen deciding to build a biogas plant with sewage sludge as raw materials, and build up an extensive infrastructure for natural gas. Over 80 buses now operate on natural gas in that city. New gas buses are used in Trondheim (third largest town in Norway), and biomethane is in use as a fuel in Oslo.

In the **UNITED KINGDOM** Iveco is extending its line-up of natural gas powered heavy duty trucks in the UK and Ireland with the launch of a new range of Stralis rigids and tractor units designed to run on LNG. Clean Air Power has received a purchase order from a global manufacturer of construction equipment to develop a dual-fuel Snow-Blower demonstrator to be delivered to Stockholm airport, Sweden. Under the terms of the agreement, CAP will convert two 9 litre engines with the purpose of demonstrating the efficiency and cost saving capabilities that its technology offers end users. To this effect, the target is to reach a 50% substitution level, which is the measure of energy substituted by gas. The demonstration was due to be completed by May 2011. End 2009, Optare plc, a bus designer and manufacturer based in the United Kingdom, has reached an agreement with the Hardstaff Group giving it exclusive rights to the Hardstaff OIGI (Oil Ignition Gas Injection) dual-fuel conversion system for use in both new and existing passenger service vehicles. Buses using the injection system will achieve carbon reduction levels in excess of 50% of those from a conventional diesel only bus when utilising biomethane derived from landfill gas or anaerobic digestion. These buses would also be eligible for the Government's "Green Bus Grant".

Coca-Cola Enterprises will be delivering its branded soft drinks to the London 2012 Olympic Games (of which it is an official sponsor) on trucks fuelled by biomethane as part of a drive to cut carbon emissions within its fleet operations.

WESTERN EUROPE

In **AUSTRIA** the CNG network saw a fast growth of public CNG network since 2009. Based on a "Five Point Action Program to Promote Natural Gas/Biomethane as Automotive Fuel" signed by OMV and Austrian Minister for Environment in June 2006 Austrian gas industry invested heavily in the needed infrastructure. Whereas in March 2008 the opening of the 100th public filling CNG filling station had been celebrated, only one year later, in November 2009 the number of public CNG sites reached 150. Per end of 2011 in Austria 171 public CNG sites cover the whole country, with focus on major cities (19 CNG site in Vienna) and main roads.

Incentives for NGV are still limited: for new cars a tax reduction up to 600 € can be achieved

and some gas companies support new NGVs with a one time incentive.

M. Stohl has been driving his CNG rally car very successfully in Austrian Rally Championship. With 1st, 2nd and 3rd place in overall results in the last 3 competitions sponsored by FGW Austria he showed a great performance. FGW as Austrian association of gas industry had his 2010 image campaign fully dedicated to NGV's.

Some companies starting tests with HD NGV to reduce the CO₂-footprint in delivery.

For more details see also report on “Gas Highway” project in the Appendix of this report.

Additional information is also available on FGW homepage (<http://www.erdgasautos.at/> in German language only, but with lot of information including maps).



BELGIUM is improving natural gas fuel highway connections with its neighbours Germany and the Netherlands. Two of planned four unmanned CNG refuelling facilities (provider Dats24) have been opened in 2010, in the Antwerp port region, and two more were planned for completion by the end of 2010. Additionally there are plans for another four stations in the near future. Currently, Belgium has only a handful of CNG filling stations, but soon it should be possible to refuel NGVs in Antwerp, Anderlecht, Ninove and Halle.

In **FRANCE**, a joint ministry (Ecology, Economy and Budget) statement in France has declared several changes to the 2011 ecological bonus-malus scheme which sets incentives for purchasing low-emission vehicles. The government says the bonus-malus, which was initiated in 2008, has fully met its objectives by encouraging buyers of new vehicles to choose low CO₂ models. Declaring their goal achieved, the government has removed the bonus for buying a natural gas vehicle from 1st January 2011. Reduced bonuses remain in place however for purchasers of low-emission vehicles in general, including any NGVs that fit within the approved emission brackets. The average CO₂ emissions per kilometer for new vehicles changed from 149 grams in 2007 to 131 grams in 2010, representing a 12% reduction of CO₂ emissions from automobiles, placing France at the top of European countries according to the ministerial statement. This improvement was also accompanied by a significant decrease in fuel consumption.

Renault Trucks is continuing to expand its Clean Tech Natural Gas offering. As a complement to its refuse collection version (RCV) introduced in autumn 2010. Renault Premium Distribution NGV is now available in France, Spain, Switzerland, Italy, Belgium, the Netherlands and Norway. Renault Trucks is also planning to update its NGV offering on the Midlum. The Renault Trucks NGV range is mainly designed for urban or suburban applications by captive fleets in distribution activities (of fresh or dried goods), street cleaning, industrial or domestic waste transport as well as for the collection of waste requiring a boom arm, such as glass. With reduced noise level, which can be as much as 2 dB, fleet managers can extend their vehicle's operating hours, using it earlier in the morning and later in the evening.

In the off-road segment, French ferry operator, Brittany Ferries, and shipbuilder, STX France, are embarking on a joint project to develop a new generation of environmentally-friendly passenger ferries. Powered by dual-fuel engines, which will burn LNG combined with a high efficiency electric propulsion system, the new vessel will reduce energy consumption and CO₂ emissions by 15 – 20% compared to current ferries. Furthermore, pollution by nitrous and sulphurous oxides will be almost eliminated. The new ship is planned to be able to accommodate 2,400 passengers, 650 cars and 40 lorries and have a maximum speed of 25 knots. The vessel's structure will make use of lighter compound materials and high strength glues, together with advanced hull design.

The Government of **LUXEMBOURG** has set up the premium CAR-e and the premium CAR-e plus funding schemas aiming to promote the CO₂ reduction of car traffic. The premium e-CAR is a financial support of the state of 750 EUR, and is aimed at people who have purchased a car that fulfils the following CO₂ emission limits/standards:

- 120 g/km (160 g/km, under certain conditions, i.e. for NGV) when the car from 31st July 2010 is registered for the first time.
- 110 g/km (160 g/km, under certain conditions) when the car from 1st August 2010 is registered for the first time.

To get the benefit of the premium e-CAR the first registration of the cars in the following periods has been held:

- Between the 1st June 2007 and 31st December 2010, when the owner is a "personne physique".
- Between the 1st June 2008 and 31st December 2010, when the owner was a "personne morale de droit privé".

The premium is doubled to 1,500 EUR if the car's CO₂ emission limit of 100 g/km does not exceed and is registered in the course of 2010 for the first time. A latest modification on the schema reduces the threshold of CO₂ emissions from 120 g/km to 110 g / km as from 1st August 2010. The amount of 750 € will continue to apply, as the threshold of 160 g/km for large family cars, electric cars, hybrid or gas cars.

In **NETHERLANDS** the Ministry of Infrastructure and Environment, has set aside € 2.6 million (US\$ 3.79 million) in grants for the purchase of new company cars that run on green gas, biogas and higher blends of biofuels. The program starts July 1st 2011 and is an initiative of the ministry to encourage companies, water authorities and research institutions to use of clean fuels while reducing CO₂ emissions and the use of fossil fuels. The pilot grant program for sustainable mobility: biogas and higher blends of biofuels, will run from July 1st to December 30rd, 2011. A minimum of three new commercial vehicles (passenger cars or

vans) per application. The grant is € 3.000 (US\$ 4.370) per car and up to € 100.000 (US\$ 145.700) per project. The cars must be purchased ready to operate on clean fuels or be converted to operate on clean fuels immediately upon delivery. In the Netherlands Fiat Natural Power vans are being offered at the same price as diesel models and with free green gas (biomethane) in collaboration with regional gas supplier OrangeGas, for the first 10.000 km.

In the heavy-duty LNG segment, Vos Logistics, together with Mercedes-Benz Nederland, LNG Europe, Van Gansewinkel and Indox CryoEnergy Spain, has taken the initiative to enable trucks in the Netherlands to run on LNG. The group has collaborated on the first LNG filling station in mainland north-west Europe. Vos Logistics is planning to replace a significant part of its distribution fleet with LNG trucks if economically feasible, beginning with 50 to 100 trucks. Rolande LNG B.V. (Rolande), a Kaatsheuvel-based specialist in supplying LNG and liquefied biogas (LBG) for road transport applications, has facilitated in early 2010 what could be the first heavy-duty mono-fuel truck in Europe to run on liquid biomethane. Working in close cooperation with IVECO in the Netherlands, Rolande brought the concept to reality by converting an IVECO Stralis CNG to run on LNG/LBG. It is currently being used to demonstrate and convince the transport industry of the many advantages of using LBG as fuel. In July 2011, Volvo Trucks has delivered the first FM model dual fuel trucks to logistics transporters (Wezenberg Group and Dasko Group) and Jumbo Supermarkets.

LNG fuelled river boat transport is paving the way in Netherlands. In end 2011 a 5,600 dwt motorized barge was delivered in the Netherlands. This ship will travel up and down the Rhine river as far as Basle in Switzerland.

In **GERMANY** the government has outlined its new long-term energy strategy for the promotion of natural gas and biomethane as a fuel for vehicles. Under the title of “The Challenge of Mobility”, the government clearly states: “The Federal Government supports the growing sales of natural gas vehicles”. It plans to continue indefinitely the tax concession for natural gas as part of its drive to reduce greenhouse gas emissions. The strategic commitment by the federal government is intended to provide long-term planning security for gas suppliers and vehicle manufacturers and will further boost the market. Also for gas station operators, this is seen as an important signal to continue to invest in alternative fuel.

Deutsche Energie-Agentur (DENA – German Energy Agency) has released the results of a study entitled Enhancing the role of natural gas and biomethane in transport: concept for a roadmap process. Amongst an array of findings it recognises that in Germany transport is still over 90% dependent on oil, while CO₂ emissions from transport have only been reduced by about 6% since 1990. The study contains recommendations for several courses of action, aimed at greater uptake of natural gas vehicles and recognition of the potential contribution of natural gas and biomethane toward achieving Germany’s CO₂ reduction goal over 40% across all sectors by 2020. Recommendations for action focus on vehicle offers, fuel supply infrastructure, taxation, and price display, ending with a strategy for development of a Roadmap process.

Since January 2011, Daimler AG offers a natural gas version of the E-class, following on from the very successful B-class. The 4-cylinder engine produces 120 kW (or 163 hp) and reaches a top speed of 224 km/h. The developers have managed to reduce gas consumption compared to its predecessor. On average, the Mercedes E 200 NGT BlueEFFICIENCY only requires about 5.5 kilograms of natural gas per 100 kilometres. This not only results in lower fuel costs but also in a much improved carbon footprint. According to the manufacturer, CO₂ emissions are 149 grams per kilometre. Around 360 kilometres can be covered with natural

gas without a need to refuel. A petrol tank is also included for emergencies, thus extending the range to around 1.100 kilometres.

Daimler and the Linde Group plan to construct an additional 20 hydrogen filling stations in Germany over the coming three years, ensuring a supply of hydrogen produced purely from renewable resources for the steadily increasing number of fuel-cell vehicles on the roads. Construction and commissioning of the new filling stations will already start in 2012. The aim is to use existing sites belonging to different petroleum companies that are strategically located in the traffic network. This will make it possible to drive anywhere in Germany with a fuel-cell-powered vehicle for the first time.

Daimler AG and Robert Bosch GmbH have in July 2011 completed their negotiations and signed agreements on the establishment of a 50:50 joint venture for electric motors. The preparatory activities for the establishment of the joint venture have already begun, and the production of motors is due to commence at the start of 2012. From that same year, the traction motors will be used in the electric vehicles of both the Mercedes-Benz and smart brands, starting with the new generation of the smart fortwo electric drive, which is to go on sale in early 2012.

Volkswagen has produced a new re-styled Passat. Promoted as a long distance touring car for business or private use, the Passat is once again offered with with a bi-fuel (gasoline/natural gas) EcoFuel engine. VW says all ten engine options for the new Passat, including the 110 kW / 150 PS (TSI EcoFuel), have achieved up to 18% fuel reduction over the previous model.

Furthermore, Volkswagen has launched its new “up!” small car range, which will include a natural gas engine variant. The basic bi-fuel engine (petrol/natural gas), with output of 50 kW / 68 PS, has a combined fuel consumption of 3.2 kg/100 km (natural gas), equivalent to a CO₂ value of 86 g/km. As a BlueMotion Technology version the natural gas-powered “up!” attains a low CO₂ value of 79 g/km. The natural gas “up!” will be launched on the European market after the petrol versions (due in December), so should be available in 2012. With its 3.54 metre length and 1.64 metre width, the “up!” is one of the smallest four-seat cars; it is 1.48 metres high.

Audi will begin series production of CNG models that will be powered by e-gas, which is synthetic methane created via the methanation of hydrogen produced by electrolysis with renewable electricity, starting in 2013. Although no official announcement has been made, a spokesperson from Audi’s Product and Technology Communications has confirmed that Audi is developing a natural gas variant of the next generation A3 (2013) named A3 TCNG and the next generation A4 (2014). No technical details or image for the A4 TCNG are available at this stage.

The new generation Opel Combo is available with six engines: four diesel, one gasoline and a CNG Compressed Natural Gas unit. The CNG version delivers 88 kW/120 hp. The new Opel Zafira Tourer will be unveiled in September 2011 and, according to Opel, it will once again be available in a natural gas version not long after this initial launch.

Although not the primary topic of this chapter, which has an emphasis on market development and key drivers, several technology developments are worthwhile mentioning.

Meta Motoren-und Energie-Technik GmbH (Meta) developers are working on a concept for a compact class natural gas engine that produces 66 kW (90 hp), consuming 2.5 kilograms of natural gas per 100 km only. This would correspond to CO₂ emissions of just 69 grams per

kilometre on CNG and almost nil using biomethane. It is anticipated the Meta engine will emulate the performance and running smoothness of comparable diesel and gasoline engines. Based on the Meta-owned technology the 2-piston-engine will be about 25-35% lighter compared to conventional combustion engines of the same performance; it will be highly charged and optimized regarding efficiency.

In end-April 2010 German automotive technology company MBtech Group showcased an innovative natural gas combustion engine for medium-duty commercial vehicles. The company is developing a CNG driven in-line combustion engine with a 6 liter capacity and turbocharging especially for medium duty commercial vehicles. The engine must fulfill particularly strict requirements: in comparison to other current six cylinder diesel engines for MD vehicles it should be considerably more compact and lighter while also offering significant advantages with regard to mechanical friction loss. At the same time MBtech's engineers have set themselves the goal of achieving at least the same power and torque ratings despite running on CNG and having two cylinders less. The four-cylinder CNG engine is also prepared to fulfill the upcoming, stricter exhaust gas regulations.

Opel, Robert Bosch, IVK (Internal Combustion Engines and Automotive Engineering) and FKFS (Forschungsinstitut für Kraftfahrwesen und Fahrzeugmotoren Stuttgart) have been working on a natural gas hybrid vehicle, aimed at developing an NGV prototype emitting less than 90 grams CO₂/km emissions. The primary goal is developing a prototype of a CNG-fueled parallel hybrid based on an Opel Astra Caravan with less than 90 grams CO₂/km emissions. In recent years two methods, namely downsizing and downspeeding, were established on the market to reduce CO₂ emissions while maintaining the driving performance of engines with identical effective power but a larger displacement. Characteristic for both methods is the shift of engine operating points towards higher loads and therefore to areas of better brake specific fuel consumption.

In the biomethane segment positive examples can be recorded as well. The German waste collection operator BSR has started the construction of a biogas facility in Berlin. The new site will be capable of displacing 2.5 million litres of diesel per year. So far, the company has put into operations 93 CNG powered Daimler trucks, and plans to expand its fleet up to 140 vehicles.

In **SWITZERLAND** (status March 2011) 23 different models of cars and 13 models of delivery vans and minibuses with natural/biogas engines were available. The number of natural/biogas fuel stations has grown to 126 and the total number of NGVs amounts to about ten thousand. The average Swiss filling-station price for natural/biogas is around 30 percent cheaper than petrol.

On the 2010 and 2011 Geneva Motor Shows Swiss Gasmobil exhibited concept car: the Fiat 500 1.4 Natural Power Turbo with efficient engine technology and natural gas/biogas fuel. It delivers higher performance coupled with extremely low CO₂ emissions and optimum efficiency. The 5-speed, 2-cylinder turbo delivers 62 kW/85 HP at a natural/biogas consumption of only 2.9 kg/100 km and a climate-relevant CO₂ output of 72 g/km.

Environmental Car List of the VCS Traffic Club of Switzerland for the first time placed a natural gas vehicle (Fiat 500 natural gas-turbo MTA) on the first place.

EASTERN EUROPE

BELARUS with the total number of on-road vehicles of about 3.3 million has about 4600 NGVs filled by 26 mother and 16 daughter stations. No incentives are offered by the state. The development of NGVs in the country is supported by low prices for CNG: 0.19€/ncm compared to gasoline-95: € 0.66/l and diesel: € 0.59/l.

In **BULGARIA** LPG is already in saturation phase and has some tendencies to decline as a car fuel (opening the option for CNG as far as CNG is still not excised). 2% of total number of registered vehicles are NGVs (reached in 7 years), 99% retrofits but with increasing OEM models import. Oil and gas companies are introducing CNG at its petrol filling stations. The total number of NGV is 61.2 thousand, the total number of CNG refuelling stations is 87.

CZECH REPUBLIC is well covered with the OEM CNG manufacturers and models present, both in the Light and Heavy Duty segment with the Tedom, SOR and Irisbus Iveco CNG buses also manufactured locally. The Czech Republic's government passed a resolution in 2005 for the promotion of natural gas as an alternative fuel. The resolution aims to build natural gas up to 10 percent or all transportation fuel consumed by 2020, in line with European White Paper on transport policy in effect at that time. That target would see 400.000 CNG vehicles and 400 CNG stations in operation by 2020. Currently the Czech Republic operates 50 CNG stations.

Skoda auto presented CNG prototypes in May 2007, but unfortunately, with no further steps towards commercial production until now.

Police in Ostrava, the Czech Republic's third largest city, have decided to switch half of their 36 patrol vehicles to CNG operation. Skoda models, the Octavia and Fabia, have been selected for conversion.

For more detailed information on the Czech Republic situation see Appendix I concerning the GasHighWay Project.

In **HUNGARY** gas distributor for Hungary's capital city of Budapest, Fővárosi Gázművek Zrt. (FŐGÁZ), has entered into a strategic agreement with MOL Hungarian Oil and Gas Company to install the city's first CNG dispenser at a public filling station. The first dispenser was scheduled for opening in summer 2011 and may be followed by installations at other MOL stations. The company is aiming to increase public awareness of CNG as a vehicle fuel following a successful pilot project launched in 2008. The initiative forms part of the FŐGÁZ corporate citizenship strategy for environmental improvements. The total number of NGV is 300, the total number of CNG refuelling stations is 16.

The total number of on-road vehicles in **MOLDOVA** is about 540.495. The total number of CNG filling stations is 24. The main operator of CNG filling stations is Moldovagaz. The gas realization per year is about 5 mil nm³. The exact number of NGVs is unknown. No incentives are offered by the state. The development of NGVs is supported by prices for CNG: 0.45 €/nm³, i.e. about half price of gasoline (1,047 €/l) and diesel (1 €).

In **POLAND** crucial aspect of the use of NGVs is public transportation and vans that operate on a limited area. On February 2010 the Board of Directors Polish Oil and Gas Company decided to accept the strategy for the POGC Capital Group for the development of the natural gas market for the propulsion of vehicles. Currently (spring 2011) there is intensive work on the accepted document. Activities for support CNG sector in the regulatory area: application to the Ministry of Economy on maintaining a zero rate of excise duty; lobbying activities undertaken by the Chamber of the Natural Gas Industry in order to maintain a zero

rate of excise duty; participation of representatives of POGC in the Inter-ministerial Group for the competitiveness of the automotive industry at the Ministry of Economy; introduction of flexible CNG price by reference to wholesale price of diesel (order and acceptance with complicity with the Chamber of the Natural Gas Industry); a study of legal and fiscal environment in the CNG segment; obtaining a decision from Transportation Technical Supervision for allow unattended fuelling CNG and application to the Ministry of Infrastructure for creation a CNG road sign. Actions to support CNG sector in the marketing area includes cooperation with importers of cars (Fiat, Iveco, Mercedes, Volkswagen) and cooperation with the media in the promotion of CNG as a fuel. Characteristics of the main strategic objectives for future years: the increase in operating profitability in POGC framework in order to ensure long term viability of CNG segment within the Company in terms of creating economic value; construction of new CNG stations for corporate clients in order to ensure the strategic development of infrastructure for CNG in Poland, which international experience has shown that in the long term can lead to increased use of CNG as fuel in road transport and increase the volume of sales of compressed natural gas and CNG sales volume growth to drive revenue POGC either directly for the segment (CNG sales) and in the other areas (distribution).

In **RUSSIA** the following documents regulate NGV Market:

- Resolution of the Government of Russian Federation № 31 of January 15, 1993
- Concept of Long Term Socio-Economic Development of the Russian Federation Till 2020' Approved by the resolution of the Government of Russian Federation № 1663-r of November 17 2008;
- Principal Directions of Work of the Russian Federation till 2020' Approved by the resolution of the Government of Russian Federation № 1662-r of November 17 2008;
- Federal Law 'On energy Saving and Building Energy Efficiency, and Amendment of Associated Legislative Acts' № FZ 261 of November 23, 2009.
- Directives of the Chairman of the Government of the Russian Federation
- Directive of the President of the Russian Federation № Pr-1923 of June 27, 2011
- Order of the Federal Service for Tariffs № 412-э/2 of December 10, 2010 'On Wholesale Prices for Natural Gas produced by JSC Gazprom and Its Affiliated Entities, Traded to Consumers in the Russian Federation (except for private citizens).

NGV advocates in Russian industries, Government and Parliament are drafting the federal law on the use of gaseous transportation fuels to support natural gas and LPG markets. The Government Resolution of 1993 sets the upper limit for the retail price of CNG at the filling station. It shall not exceed 50% of the regional retail price for the lowest grade gasoline A-76. It is a very encouraging incentive: In August 2011 natural gas for vehicles costs 2 – 3 times cheaper than diesel or gasoline. No other economic or administrative incentives are enforced in Russia.

In the Russian Federation there is no single document that would regulate projection, construction and operation of CNG or LNG filling station. There are about 400 plus norms, standards and code of practice that have to be taken into account during the construction of natural gas filling facility.

The lack of national Law and appealing incentives is one of the reasons why Russian vehicle manufacturers are not very much encouraged to invest into OEM supply of NGVs. However, KAMAZ – Russian leader and champion in commercial truck production (10 times winner of Paris-Dakar Rally in trucks category) – has designed a CNG chassis that is used for a broad range of NGV applications: trucks, garbage collecting, buses and other.

The key players on the Russian NGV market are: Ministry of Energy, JSC Gazprom, National Gas Vehicle Association (NGVRUS).

Billionaire Mikhail D. Prokhorov introduced Russia's first electric car with gas system in December 2010. The car, named after the Russian letter "ё" (Yo) uses a small petroleum engine powered by petrol or natural gas which should run nearly continuously (therefore, at its most efficient rate at all times) to generate electric power. Then the electricity is used to directly move the engine/car or fills a bank of capacitors that can hold only a small charge. The two electric motors are the ones that will propel the car. The Yo consume about 67 miles per gallon (about 28.5 km per litre). Mass production will begin in St. Petersburg plant (by Yo-Avto, joint venture between the Prokhorov's Onexim Group and Yarovit-Motors, producer of multi-axial highway trucks and cargo capacity for working in difficult road and weather conditions) in mid-2012 with initially 10.000 cars a year at a cost of US\$ 12.000 to US\$ 15.000. Annual production should achieve 45.000 units and by mid-June 2011 122.800 vehicles were ordered. Yo has a maximum speed of 120 km per hour with a driving range of almost 1.100 km if both its natural gas and petrol tanks are filled (400 km on methane). The average fuel consumption is 3.5 liter/100 km. Two of the Yo-mobile models were showcased at prime-minister Putin's Novo-Ogaryovo residence and prime-minister Putin drove the CNG hybrid Yo-mobile from his residence to President Dmitry Medvedev's country house outside Moscow, and hailed it as an example to the government's innovation commission.

Company AvtoVAZ commenced development of a test model Lada Priora which runs on gasoline and CNG. Expectations are that by late 2011-early 2012 this car will leave the conveyor line. Russia also has three major truck manufacturers that sell NGVs: ZIL, GAZ and KAMAZ.

KAMAZ recently introduced Farid Minipac MK2 garbage truck. The medium-tonnage rear-loading garbage truck powered by CNG is designed for mechanical and manual collection of solid wastes in cramped urban environments. The vehicle is equipped with an imported Euro-5 compliant engine and is especially useful for cities where large-size machinery is denied access.

On the infrastructure development side, Gazprom has raised the possibility of a CNG corridor, to run from Moscow to Kaliningrad on Poland's north-eastern border. The subject was reportedly discussed during a recent visit by President Medvedev and government officials to the region. Additionally Gazprom has expressed interest in the further development of Poland's natural gas fuelling infrastructure. In Russia, Gazprom plans to double the number of natural gas filling stations in the country (it aims at the installation of 200 of these stations). 90% of all CNG sold in Russia was taken from Gazprom's filling stations. The firm has already started cooperation with the Nizhny Novgorod, Novgorod, Kaluga, Tambov, Oryol, Kaliningrad regions and cities of the Moscow region and Nadym.

Russia updates its national standards and harmonises the norms with the ISO. Apart from revising outdated national standards, today Russia wishes to eliminate regulatory gaps in areas where there are no standards at all. The main area that got a lot of attention is the standardization of the rules for the production and supply of LNG. It was resolved to develop a regulatory framework for small-scale production, storage and utilization of LNG. This project has been funded by Gazprom. Many of the firm's corporate standards are adopted into the national norms. There is a possibility that some Gazprom standards would be used to form the basis of ISO standards.

The city council of Moscow passed in June 2010 Resolution: "State of the Works and Further Measures to Promote the Use of Compressed Natural Gas as a Motor Fuel for the Automotive transport of Moscow". The Resolution aims to reduce the harmful effects of

transport on environment and health of the population of Moscow by expanding the use of CNG as a motor fuel in the city. Practical implementation is underway, facilitated by an earlier decision by the Moscow government which introduced alternative motor fuels for road transport to the city. Areas for potential investment are: building CNG/LNG filling stations; assembly / construction of OEM NGVs; manufacturing high pressure cylinders and setting up transportation companies (taxis, buses, trucks) that use NGVs. The key points of the Resolution are: social facilities (hospitals, kindergartens, schools) shall be served by Euro-4 vehicles or CNG vehicles; electrical and CNG trucks vehicles will be exempt from the ban to enter the central area of Moscow; communal vehicles in the central are of Moscow shall use alternative fuels (CNG, electric power), multifuel filling stations in Moscow, where CNG make no less than 30% of the overall fuel sales, and automotive companies, where no less than 50% of the fleet are vehicle powered by alternative fuels (CNG and electric power) may get at least 5-year land tax holidays; six Moscow bus companies will switch to CNG; 21 sites are approved for construction CNG filling stations; filling stations without CNG options will not be allowed in Moscow; a Moscow law on the Use of Alternative Transportation Fuels will be developed; electrical and CNG trucks vehicles will be exempt from the ban to enter restricted traffic zones; Government of Moscow intends to begin OEM production of NGVs in the city; Moscow NGVs will be used to serve the XXII Olympic Winter Games in Sochi, in February 2014 and biomethane from sewage water and landfills will be produced in Moscow.

Stavropol Krai, a federal subject located in Russia’s south-west is running a regional program called “The use in the Stavropol region of CNG as motor fuel in 2011-2013”, implemented under federal law in 2009. The program aims to have 6.000 vehicles start using CNG during this time (the predominant focus on KAMAZ products). The administration of Stavropol Krai plans not only to gradually transfer vehicles to the use of CNG, but also to construct and put into operation new CNG filling stations and other measures for transferring vehicles to natural gas.

Table 1 -Characteristics of the Russian NGV Market

COUNTRY PROFILE	RUSSIA
Last update	Janury 2012
RUSSIAN NGV MARKET IN THE WORLD	
Share of Russia in the world NGV fleet	0,9%
Share of Russia in the world filling station population	1,4%
Share of Russia in the world NG consumption by NGVs	1,5%
TOTAL NGV FLEET (fleet composition)	
LD buses & trucks	43 500
MD & HD trucks	10 400
Cars	19 300
Special purpose vehicles	11 400
MD & HD buses	1 400
Agricultural tractors	50
Rail road locomotives	2
Aircraft	-
Sea and river ships	-
Three-wheelers (auto rickshaws or (tuk-tuks)	-
Two-wheelers (motorbikes, scooters)	-
Retrofitted (converted) NGVs	90%
OEM NGVs	10%
OEM NGVS AVAILABLE ON THE MARKET	
Cars	

COUNTRY PROFILE	RUSSIA
Last update	Janury 2012
RUSSIAN NGV MARKET IN THE WORLD	
LADA Priora – bifuel, ready for marketing by mid 2012	
Gasoline version price (expectation)	
min	7 400 €
max	9 600 €
NGV version price (expectation)	+ 1 000 €
Buses	
LIAZ Solo	105 000 €
LIAZ Articulated	170 000 €
NEFAZ	€
PAZ	€
Trucks	
KAMAZ	43 000 €
NATURAL GAS (BIOMETHANE) FILLING STATION	
Filling stations in operation (total)	245
Including:	
Filling stations (public)	204
Filling stations (private)	41
Biomethane filling stations	-
LNG filling stations	1
LCNG filling stations	1
Mother – daughter stations	-
Mobile refueling units	40
Vehicle refueling appliances	4
Filling stations (planned or under construction)	26
FUEL PRICES:	
Gasoline super premium – Oct 98, €/l	0,76
Gasoline super – Oct 95, €/l	0,72
Gasoline regular – Oct 91, €/l	0,67
Diesel, €/l	0,56
LPG, €/l	0,36
CNG, €/m ³	0,25
KEY DRIVERS AFFECTING THE MARKET	
Bulk price of NG for end users is fixed by the government.	
Retail price of CNG (at the pump) is limited by the government and shall not exceed 50% of the price of low grade gasoline.	

Source: Gazprom

In **SLOVAKIA** main CNG consumers are bus transportation companies with the share of around 95% of total CNG consumption. Majority of big CNG FS are located in bus transporter depots or in local centres of the SPP Company (most of them are public). At the end of 2010 was opened the first CNG filling station located at a petrol service station, under agreement between SPP and fuel refiner and supplier SLOVNAFT (which operates 209 filling stations across the country and sees the potential for adding more CNG facilities). Adjustment of excise tax legislation which came into effect on 1st January 2011 brought cancellation of tax exemption on CNG; increase of excise tax on diesel, petrol and LPG and increase of VAT from 19% to 20% resulting in change of relations among motor fuels prices.

Excise tax put on CNG is 0.141 €/kg equal to minimal tax rate of EU (2.6 €/GJ). Increase of CNG price by 20 – 30% in comparison with average CNG price in 2010 occurred.

SOUTHERN EUROPE

In **ITALY**, the Ministry of Economic Development (Ministero dello Sviluppo Economico – MSE) has continued the program for the conversion of motor vehicles to natural gas and LPG into 2011, through MSE incentives via specialised workshops and dealers. The amount of the contribution is € 500 for conversion to LPG and 650 € for the natural gas (approx US\$ 700 and US\$ 900 respectively), made available from March 2011. Conversion prices for cars range from € 1.400 for vehicles with carburettors to € 2.400 for vehicles with sequential injection systems. The funds available for the year, confirmed by the Ministry of Economic Development, amounts to € 24.8 million (US\$ 34.5 million). MSE contributions will be deducted in the form of a discount directly in the invoice by the installer workshop or dealer. To obtain them, entitled persons should go to a participating workshop or dealership, which will take care of all the procedures involved, simply asking the beneficiary to display a few documents. A list of these documents is available at www.ecogas.it, under MSE Incentives (Incentivi MSE). Vehicles eligible for the incentives include category M1: “passenger transportation vehicles with a maximum of eight seats in addition to the driver” and N1: “freight transport with a maximum weight of no more than 3.5 t” in any Euro category. Vehicles purchased new from dealers already fitted with LPG or natural gas systems but not already approved for use with gas by the manufacturer are also eligible for conversion incentives. The participating workshops agreed at the commencement of the scheme not to exceed a list of the maximum prices applicable for conversion to LPG or natural gas. These prices remain unchanged.

On the technology development side Landi Renzo SpA has been working on the dual fuel CNG/diesel conversion kit for light-duty vehicles. The cost will be similar to standard CNG kits. The kit has also been designed to increase the life of older diesel engines. In Europe homologation of dual fuel vehicles is currently problematic as existing rules do not cater for fuels with variability. Efforts are now underway to address this issue, both in the light and heavy duty arenas.

On the OEM side Fiat offers the complete line up (Qubo, Panda, Punto, Doblo...) with Natural Power Euro 5 CNG models (achieving market share in Italy of around 15% in first quarter of 2011).

The new Iveco Daily, a light range commercial vehicle, will be launched during September 2011. The updated version includes all Natural Power versions operating on CNG EEV certification. In terms of model availability, the new Daily retains full coverage from 2.8 tonnes to 7.0 tonnes maximum permitted mass, allowing a useful payload of up to 4.7 tonnes.

Since 2009 the situation in **PORTUGAL** regarding NGV has not changed significantly. Number of CNG stations remained the same (5) and 32 new garbage trucks has been added to the overall fleet. Previous government (which finished its mandate in June 2011) provided huge subsidies to electric vehicles, but none for NGVs. The present government issued the new Strategic plan for transport sector development for 2011 – 2015 period (“Plano Estratégico de Transportes 2011-2015”) which doesn't mention NGVs. The main focus of this Strategic plan is the financial situation of some public enterprises in transport sector (buses, metros, ferry-boats). As regards fiscal aspects, on 1st October 2011 the government

increased VAT on natural gas from 6% to 23%, thus reducing the favorable price difference of natural gas in relation to other combustibles that had already the 23% rate.

According to local expert opinion, companies that distribute and retail both natural gas and petroleum products show absence of enthusiasm for NGVs in order not to “cannibalize” petroleum products market. On the other hand, small regional natural gas distributors (without links with petroleum products) show enthusiasm for NGV. This is the case, for instance, of Sonorgas installing a new station in Mirandela municipality - the North Interior Natural Gas Complex (NINGC). The LNG complex will be constructed bearing in mind creation of CNG and LNG filling station for vehicles, taking into account the future growth in the number of vehicles using this fuel. The consumption of vehicular natural gas in liquid and compressed form is estimated at approximately 700,000 Nm³/year. The NINGC project, the first of its kind in Portugal, is currently under construction. It is anticipated that all components of the Complex will come into operation at the middle-end 2012.

Since 2011 the economic situation in the country is in process of shrinkage under financial measures of IMF/EU/ECB. Theoretically, a situation of crisis would be a good opportunity for transport sector to try to reduce operational costs changing from diesel to CNG or LNG. However, the financial situations of Portuguese transport enterprises are not bright this moment or have not dimension enough for this initiative (fleets with little number of trucks). This is an opportunity for foreign enterprises to penetrate in Portuguese market to install public CNG/LNG stations and to convert existing fleets of trucks to dual-fuel or dedicated engines.

In **ROMANIA** development of national CNG filling station standard was underway with discussions between industry and ANRE. CNG tax exists but lower than equivalent tax for LPG (5% lower), diesel (70% lower) and petrol (75% lower). Dacia (Renault) Logan CNG is available as OEM product but for markets in India and Iran (not available in Europe till now).

In **SPAIN** Transports Metropolitans de Barcelona (TMB) and Gas Natural Fenosa are trialling a new hybrid bus prototype with electric and natural gas engines, a pilot scheme under an agreement signed between TMB and Gas Natural Fenosa to reduce emissions from buses, with the aim of improving air quality in Barcelona and the metropolitan area. Gas Natural Fenosa estimates that hybrid technology will enable a 20% to 30% reduction in energy consumption and emissions, compared to a non-hybrid bus of similar characteristics. The agreement between TMB and Gas Natural Fenosa anticipated an increase in the CNG fleet by 204 buses by 2015. This will take the number to 500, almost half of the total, which is 1.080.

Gas Natural Fenosa and Carrocera Castrosua SA, builder of buses and coaches, work collaboratively in the development of hybrid (CNG and electrical) vehicles and LNG-fuelled prototypes suitable for long intercity trips. Its first CNG-electric hybrid bus, named Castrosua Tempus has been tested in both Barcelona and Madrid cities. Madrid's EMT (Empresa Municipal de Transportes) has passed a first order for 13 units, now under construction. Also TATA HISPANO, the Spanish branch of the Indian manufacturer introduced in Spain the TATA Starbus CNG-electric hybrid. EMT also passed an order for other 11 units of this CNG hybrid.

Spain's HAM Group, a LNG distributor and transport company was in development of four more LNG fuelling facilities facilities scheduled for finalization until mid-2011, one of them near the Autovia A-2 (Madrid-Barcelona).

Gas Natural Fenosa has launched its new operations center Sanchinarro (Madrid), designed to service the fleet of about 400 buses for the Municipal Transport Company of Madrid (EMT). It is said to be the largest European NGV refueling station, both by fleet volume and compression capacity, and one of the largest in the world, being the first one exclusive for buses running on CNG. The main characteristic and advantage of this installation is that the configuration permits to refuel and clean each vehicle within a total time of 3 minutes (with nine simultaneous refuelling lanes that can serve up to 180 buses per hour). The company is planning on refurbishing and adapting two its existing facilities in order to make them available for working with CNG and reach the figure of 645 CNG buses by the end of 2011, and even try to reach 1.350 CNG buses in 2015.

The Madrid City Council has approved an amendment to the Fiscal Ordinance which regulates the rate for parking in certain areas of the capital, thereby promoting alternative-fuelled vehicle usage and assisting in the reduction of inner-city pollution. Effective 1 January 2011, commercial vehicles up to 5.000 kg powered by CNG or LPG, and hybrid vehicles, will have their annual fee for parking in “Differentiated Areas For Commercial and Industrial Vehicles” reduced from € 362.60 (US\$ 482) to €272 (US\$ 362), a saving of 25%.

Endesa, an electricity and natural gas utility company in Spain has inaugurated the first CNG refuelling station in the Balearic islands to service 12 new buses belonging to Palma’s municipal transport company. The refuelling station is the first of its kind in Mallorca and coincides with the recent arrival of natural gas to the islands. This project could be extended to other vehicles (such as taxis, courier or delivery vehicles).

As regards the Light Duty segment it was announced that Seat would start production of the Mii City Car (a car using the same platform as the “Volkswagen up!”). The CNG version is expected to become available during 2012.

In the region of former Yugoslavia, key promoter of CNG as automotive fuel is still industry and private sector and CNG filling stations today are still mostly stand alone meaning (in general) not integrated into “classic” petrol stations. Situation for CNG filling stations standards is improving; **CROATIA** issued its national CNG filling stations standard based on Austrian standard and a draft European norm. In **SERBIA** development of national standard is underway and in the meantime it is possible to use official translations to Serbian language of: draft European norm, Italian, German and Swiss standard. In **BOSNIA AND HERZEGOVINA** official translation of German standard is available. In **FORMER YUGOSLAV REPUBLIC OF MACEDONIA (FYROM)** development of national standard is underway. Full integration option of CNG into classic petrol filling stations is (economically) required (LPG is fully integrated so it should be CNG to provide same comfort to the customer).

OEMs CNG offer still limited and OEMs are “waiting for the stations”, but three OEM HD CNG buses producers are operating in Serbia (Ikarus, FAP and Vulovic Transport). On the customers side recent activities in Bosnia & Herzegovina, Croatia and Serbia were primarily linked with the introduction of CNG buses (pilot project in Sarajevo, 60 CNG buses in Zagreb, CNG bus project(s) in Belgrade, Novi Sad and Kragujevac) also with the tender for 20 CNG buses in Ljubljana, capital of **SLOVENIA**. Furthermore, Slovenian company ENOS LNG with three other companies started demonstration project for use of CNG in Slovenia. Also, as part of the promotion campaign four largest cities installed VRAs and gain CNG vehicles. In FYROM, public transport company of Skopje is increasing number of its (mainly retrofitted) CNG buses while other private transport company operating OEM CNG buses in the city of Kumanovo is planning to increase its number significantly. National oil and gas company Makpetrol plans to open 3 public CNG filling stations (first to be open in Kumanovo by the

end of March 2011) having a long term plans to integrate number of CNG filling units at its petrol filling stations across FYROM.

AFRICA

Both North and South Africa in prospective will produce natural gas from shale gas fields. North Africa carried out its exploration in 2010, while South Africa will commence work by 2013, earliest. So far, seven African countries have conducted demonstration projects and adopted NGVs and CNG stations which include Algeria, Egypt, Mozambique, Nigeria, South Africa, Tanzania and Tunisia. All of these countries also have gas fields in their territories.

Although Kenya has no domestic gas, this nation tries to get pipelined gas from its neighbouring country Tanzania. Morocco, Rwanda, and Senegal are looking for the possibilities of having alternative energy source such as the “cheaper” natural gas to enrich their energy basket.

Africa has three OEM NGV manufacturers so far (status on mid-2011). Two of those are in Egypt while the other one will come from Ethiopia (a joint venture between Ethiopian and Dutch companies that assemble eco-friendly high-market cars for Ethiopia and export markets).

NORTHERN AFRICA

In **ALGERIA**, with a view to environmental protection, the development of the NGV market is a major axis of the Algerian energy policy, consolidated by the abundance of the gas resources and the development of the distribution network of natural gas. The national program of public distribution of natural gas envisages by the year 2020 a natural gas penetration rate of about 60%, which will result in a consequent development of the public distribution network of natural gas, facilitating at the same time the connection of CNG compressor services to the network. The national program of promotion and development of the NGV market, with the participation of big national companies such as SONATRACH (production, transport and marketing of natural gas), SONELGAZ (distribution of natural gas) and NAFTAL (domestic distribution company) includes: the acquisition of buses fuelled by natural gas, the conversion of existing vehicles and the investment in distribution equipment.

In **EGYPT**, around the 160.000 new natural gas vehicles plus 260 new stations was planned to be added in the two years period by 2012. Apart from the popular bi-fuel cars, taxis and LDVs, and thousands of buses and trucks, the Egyptian Government wishes to convert motorcycles into NGVs in the near future. Domestic and Canadian companies have been working together to study the potential of this conversion. Under the Egyptian traffic law which came into effect in August 2008, owners of 20 years old taxis had until August of 2011 to replace their vehicles with newer cars, preferably with more environmentally friendly cars that run on natural gas. The Minister of Interior stated that traffic authorities would no longer renew the license of any taxi older than 20 years. The government has approved five models of taxis assembled in Egypt to replace the old vehicles. Natural gas models consist of Daewoo Motor's Speranza CNG A516 and A113 and Hyundai Verna powered by gasoline or CNG. To encourage the owners of old taxis to replace their cars, the above-mentioned car manufacturers offer cheap cars plus LE 2.000-LE 5.000 (350 – 870 US\$, based on the exchange rate valid in the time this data source was written) discounts. The remaining cost of the new car – which is more than LE 50.000 (8.725 US\$) will be settled in the form of a bank loan. Banks offer fixed rate loans to finance the taxi owners, and the government waive sales

taxes for the purchase of the cars. The Ministry of Finance has granted LE 100 (17.5 US\$) monthly allowance to these taxi owners to help them pay the settlements in several instalments. Supported by MOF, local advertising agencies also have agreed to place advertisements in taxis at a rate of LE 550 (95 US\$) per month.

In **TUNISIA** because of the shortfall in gas production, the electricity and gas distribution company, Société Tunisienne de l'Electricité et du Gaz (STEG), is examining the diversity of gas supply sources. This requires the promotion of exploitation and the reinforcement of the transmission network for natural gas, on the national level and on the level of inter-connections with Maghrebian and European networks. Two CNG buses were delivered by Iveco to Tunis City in Tunisia and used to demonstrate the advantage of CNG technology. As per a cooperation agreement between the Italian Ministry of Foreign Affairs and the Tunisian Ministry of Transport, 100 CNG buses would be made available for Tunisia.

EASTERN AFRICA

In **MOZAMBIQUE**, natural gas annual production in 2008 reached 3.3 bcm. With gas consumption of only 100 mcm per year, Mozambique exports 3.2 billion cubic meters of its gas while importing almost all of its oil mainly from South Africa. Therefore, the Government sees the importance of switching to natural gas for all segments including transport (with an objective to reduce transport (petroleum) fuel cost by a third). Following the plan to replace diesel buses with the CNG ones, a prototype of Caio Induscar's urban bus Apache S21 is going to be demonstrated in neighbouring countries with Mozambique as final destination. The prototype is equipped with a Brazilian conversion kit. The government had promised to purchase 100 natural gas buses, local developer (company Autogas) promotes its services and hopes to get at least 40 more buses using their facility to allow the business to become profitable. Maputo Transport Company (TPM) also has 85 CNG buses (OEM Yutong buses imported from China). Not all of these buses are in operation because they do not fully meet the requirements in Mozambique (to hold around 100 passengers and travel along hilly areas). TPM has received in June 2011 the first consignment of 50 Tata CNG buses from India and 50 more buses were planned to arrive in July and the final 50 in August 2011.

In its effort to convert all 8.000 state vehicles to NGV technology, the government of **TANZANIA** has ordered Tanzania Petroleum Development Corporation (TPDC) to implement a mega NGV project in partnership with Pan African Energy Tanzania Ltd. Within this project, three CNG refuelling stations will be constructed. In due time, the authority will issue a mandate regarding the conversion (so far for state-owned vehicles only). Presently, the country has found four natural gas fields (all fields producing natural gas). Scientists from the Dar es Salaam Institute of Technology (DIT), known as the "Triangle", and those from the University of Dar es Salaam have established retrofit centres that convert gasoline cars with electronic fuel injection system to NGVs. All components used in the conversion are made in accordance with international standards to guarantee safety and the cars are inspected by experts both before and after the conversion. The focus is also on the safety of CNG cylinders and filling stations.

The Prime Minister of **KENYA** visited a CNG fuelling station and vehicle conversion workshop in Egypt in 2010. The aim of the visit was to introduce the economic and environmental benefits of the CNG project. It is expected that Kenya will use the fuel at a later date to power the transport sector.

WESTERN AFRICA

Although **NIGERIA** has oil and gas, the country imports oil from abroad to meet its 32 million liters of fuel demand. Nigeria's oil importation is also due to the continued closure of its four oil refineries. The government wants to see around 2 million after-market converted NGVs on Nigerian roads by 2015. The main actors in this field include a joint venture among Nigerian Independent Petroleum Company (NIPCO), Nigerian Gas Company (NGC), and Green Gas Limited. The three companies agreed to commence "Benin City CNG project". The joint venture is aiming to convert 50.000 vehicles to run on bi-fuel CNG/petrol system by 2013-2014, and to build 8-10 CNG stations, 2 conversion workshops, and lay around 50 km gas pipeline, all to be completed during the first 2 years after project commencement.

SOUTHERN AFRICA

Through research conducted by South African National Energy Research Institute (Saneri), **SOUTH AFRICA** plans to use compressed natural gas as transport fuel in the entire country. Saneri is trying to get a demonstration project off the ground. The Johannesburg based company, Novo Energy, has received a licence from the National Energy Regulator of South Africa (Nersa) to distribute gas in six areas. The company's plan is to compress the gas to CNG at central points and to transport it by road to clients, or to gas-refilling stations for vehicles.

AUSTRALIA & NEW ZEALAND

Today, **AUSTRALIA** has a number of OEM CNG vehicles on offer in its vehicles market from manufacturers like Mercedes and Isuzu and the expectation is that in a near future even more vehicles will be available. The conversion of existing or new vehicles is also available using the latest CNG technologies and authorized conversion workshops. Australia is also a progressive dual-fuel and LNG for vehicles market.

On the vehicles side, Clean Air Power launched its Volvo Genesis Euro 5 dual fuel product to replace its existing Caterpillar product. Kleenheat Gas, a provider of gas services in Australia, has entered an agreement with US-based GreenMan Technologies and its subsidiary American Power Group Inc (APG) to carry out a 90-day trial for a conversion demonstration of heavy-duty trucks to APG's patented dual-fuel diesel-LNG system. Subject to successful completion of the trial, Kleenheat Gas and APG wish to enter into a Strategic Alliance for the exclusive distribution of APG Dual Fuel Systems in Australia (according to the latest data (June 2011) this trial was successfully completed). Australian company iGas Energy has been toiling over a new solution for fuelling of heavy duty long-distance transportation in Australia, using CNG fuel storage instead of LNG. The CNG is stored in carbon fibre composite cylinders at 350 bar, and as the gas is used to fuel the engine the iGas process maintains high pressure in the cylinder by displacing CNG with a liquid, one CNG cylinder at a time, allowing gas to be injected into the HPDI engine. A fuel pack comprising four Australian-approved cylinders will give a truck the same range as a 450 litre tank of diesel using a conventional engine. Westport is working closely with iGas to integrate the Westport GX engine with the iGas system to optimise overall performance, range, and cost with the objective of developing a CNG fuel storage system to complement the Westport technologies. Perth-based Advanced Engine Components Ltd (AEC) with the assistance of an AusIndustry Commercial Plus Grant, developed the Sitec 295hp, Euro 4, diesel engine to operate on LNG. This enables AEC to convert the Isuzu 295hp diesel powered trucks to LNG. Isuzu has approximately 40% of Australia's urban return-to-base truck market. The Isuzu 295hp

vehicles, used for refuse collection, concrete delivery, urban delivery and general transport, represent approximately 17% of Australia's total truck market.

In the fuelling segment, Tas Gas has developed an alliance with Advanced Fuels Technology as its NGV Technology partner and together the parties are looking to provide a total CNG solution to commercial fleets in Tasmania. Plans are to focus on developing depot based refuelling for fleets such as concrete, courier, bakery, local council and bus fleets. At the same time, public refuelling stations are planned to be developed in several cities.

Tasmania has also embarked on an LNG expansion plan for larger articulated vehicles. Furthermore, Australian gas company BOC has opened the micro-LNG generating plant in Northern Tasmania to supply vehicle fleet operators on the island. The plant can generate up to 50 tonnes of LNG a day (equivalent to 70,000 litres of diesel). Presently, it supplies gas to six fuelling stations built by the Tasmanian company, LNG Refuellers Pty Ltd, five of them along major trucking routes. LNG Refuellers will also invest in new LNG-powered trucks and has signed an initial 15-year supply deal with the facility. The "clean fuel" project is supported by the government. Furthermore, Brisbane-based Blue Energy Limited has signed a Memorandum of Understanding (MOU) with Korea Gas Corporation (KOGAS) to investigate the feasibility of developing small scale LNG and CNG projects within Eastern Australia. A joint working group was announced to be formed to identify potential opportunities for the development and operation of micro LNG and CNG facilities.

LNG is also progressively makes way or secures its position in the customers segment: MGC, Australia's largest producer of dairy products has extended its existing LNG supply agreement for its 57 LNG prime movers (representing 57 percent of its total fleet). Wettenhalls Group, an Australian transport, warehouse and logistics company, has commissioned its first LNG heavy transport vehicle. Depending on the expansion of refuelling facilities and the success of the initial vehicle, Wettenhalls envisage that up to 60 LNG-powered trucks could be on the group's fleet within 10 years, providing a significant reduction in greenhouse gas emissions. The Noske Group, a Melbourne-based bulk transport logistics solutions service provider was to be complemented by the building of a LNG refuelling facility in Portland to supply its extra long trucks for transport of the woodchips to the Port of Portland.

Finally, in the home-fuelling segment, OES CNG, based in Melbourne, Australia has designed a range of compressed natural gas (CNG) home refuelling units capable of delivering 300 or 360 bar, drawing natural gas from the home supply. First field test units have been installed and the company expected to have the CNG refuelling unit approved as a domestic appliance in the second half of 2011 with the range of capacities scheduled for release in the first half of 2012.

In order to attract customers and create demand for its filling stations, certain companies are offering free fuel for a year for the first hundred conversion clients (OES CNG Pty Ltd, also with CNG filling station in Melbourne). The offer has been extended to private and business excluding taxis or courier companies.

New developments in the **NEW ZEALAND** observed lately are going into the way of utilizing domestic gas sources, biomethane and coal seam gas.

Transpacific Industries (TPI) since recently collect their waste in Auckland using waste-generated biomethane. It is also the first time that landfill gas has been converted to vehicle fuel in the country, as New Zealand emulates biomethane developments in Europe and the U.S.

L&M Energy Ltd. has signed an agreement with HW Richardson Group Ltd. (one of New Zealand's largest trucking companies) to investigate the feasibility of developing small scale LNG projects within New Zealand, beginning with investigating the potential for a project utilising gas from Coal Seam Gas (CSG) asset near Ohai in Southland.

NORTH AMERICA

In North America, four factors promise to make natural gas a viable alternative to oil-based fuels. First, revolutionary technology is unlocking enormous new supplies of shale gas. Second, unrest in North Africa and the Middle East has underlined U.S. oil-supply vulnerability. Third, there are clear environmental advantages to clean-burning natural gas (which emits 25 percent less carbon dioxide than diesel). Fourth, there have been major advances in natural gas fuel technology.

In **CANADA** the deployment roadmap report, sponsored by the government ministry Natural Resources Canada, highlights the competitiveness and environmental benefits of introducing natural gas for trucking along key corridors and for urban fleets in Canada. The report resulted from work undertaken by the members of the Natural Gas Use in Transportation Roundtable. The key finding of the report was that trucking fleets that operate along regional corridors and in urban areas can improve their competitiveness and reduce their environmental impacts by using natural gas. Canadian communities will also benefit: first, by the use of lower emission natural gas refuse collection trucks and other commercial vehicles; and second, from local jobs created by Canadian companies who are leading suppliers of innovative natural gas vehicle and station technologies.

On the technology development side, Westport Innovations Inc. announced (in May 2011) that it has entered into an agreement with Caterpillar, Inc. to evaluate direct injection, natural gas fuel system technologies for possible use on Caterpillar's large engines. Through this evaluation project, Westport and Caterpillar are seeking to demonstrate that the integration of their respective direct injection, natural gas technologies can deliver the high performance and high efficiency requirements which large engine applications will demand. Under the terms of the agreement, the evaluation is expected to be completed in 2012, with program expenses shared by both Caterpillar and Westport.

As regards off-road applications, Gaz Métro and Canadian National Railways Co. joined Westport Innovations Inc. to develop a new LNG technology for locomotives in Canada. A first in Canada, the venture will receive \$2.3 million in funding from Sustainable Development Technology Canada, a not-for-profit corporation created by the federal government. Gaz Métro is also involved in a venture involving LNG engines for heavy trucks. The new project aims to demonstrate the technical, economic and environmental viability of LNG engine technology for locomotives (offering greenhouse gas reductions of up to 500 tonnes per year for each natural gas locomotive relative to diesel locomotives). If all goes according to plan, the consortium expects the prototype to be in operation in 2013.

Details of the program include:

- Investigate the design and feasibility of high performance natural gas technology for high-horsepower applications such as mining, rail, and marine.
- Design, build, and test prototype hardware suitable for a high-horsepower application.
- Performance and durability testing of liquefied natural gas (LNG) fuel system with both fuel and test facility provided by Gaz Métro Transportation Solutions.

- Install prototype fuel system, test, and demonstrate in service using a Canadian National Railways locomotive.

Funding support requires that every project involves representatives of each part of the supply chain: researchers, product developers, manufacturers, distributors, retailers and end customers.

On the fuelling infrastructure development side, Terasen Gas, a wholly owned subsidiary of Fortis and principal natural gas distribution utility in British Columbia, has submitted an application to the British Columbia Utilities Commission (BCUC) to provide commercial fuelling services through Terasen Gas owned and operated CNG and LNG fuelling stations. If approved, commercial customers will be able to safely and economically refuel their fleet vehicles, such as buses and refuse trucks, on their own premises, using stations provided by Terasen Gas at rates regulated by the BCUC.

On the customers side several examples can be listed. Robert Transport from Quebec has issued a purchase order for 180 Peterbilt LNG trucks featuring Westport HD Systems. Robert Transport is one of Canada's largest for-hire trucking companies with an estimated 1.100 tractors and 2.300 employees. The new trucks will be used on line haul routes between Montréal and Québec City, and Montréal to Toronto. Fuelling the Robert Transport fleet is Gaz Métro, a distributor of natural gas in Quebec, who plans to install three refuelling sites along the corridor between Quebec City and Mississauga, Ontario. Currently, no LNG fuelling infrastructure exists in the area. Helping drive innovation and improve carbon footprints in Quebec, the government announced that the depreciation rate applicable to commercial trucks or tractors was increased from 40% to 60% for any new equipment acquired after March 31st, 2010. Furthermore, an additional 85% cut for amortization reduction is granted if the truck or tractor runs on LNG.

Pilot projects with waste collection truck started in the City of Toronto, and in Miller Waste Systems from Ontario (leader in the refuse industry in Canada). U.S company Waste Management was about to deploy 20 vehicles in January 2011 to serve businesses in the area surrounding Vancouver. The contribution from BC-based Terasen Gas is from their Energy Efficiency and Conservation Program, which will help offset the incremental cost of the CNG powered trucks versus their traditional diesel counterparts. Waste Management operates the largest fleet of clean air CNG recycling and waste trucks in North America (in July 2011, Waste Management added a 1.000th natural gas truck to its fleet).

End-2009, Westport Innovations Inc. has entered into an agreement with Volvo as a Tier 1 Development Supplier for its heavy duty natural gas engines and associated supply chain. Under the new agreements, Westport and Volvo share program development expenses. The agreement requires Westport and Volvo to work to negotiate further agreements regarding certain elements of the development program. It also requires Westport and Volvo to satisfy certain milestones in order for the development program to continue, including the completion of the relevant technological, engineering and cost requirements and the completion of the further agreements.

The main features of the long term relationship are as follows:

- Westport and Volvo will mutually agree on the priority for commercial launch of gaseous fuel engines and will share the risks of development.
- For products requested by Volvo, Westport will be reimbursed for engineering and related development costs at passage through each successful major development gate.
- Westport will arrange for or supply gas-related components.

(for more info see section on Europe – Sweden)

Overview of recently introduced / announced policy measures in the **UNITED STATES** is listed below.

The New Alternative Transportation to Give Americans Solutions (NAT GAS) of 2011 was introduced in April 2011. The bill, H. R. 1380, had 76 original co-sponsors when it was introduced. The NAT GAS Act would restore and expand the NGV tax credit that makes NGVs eligible for a credit equal to 80% of the vehicle's incremental cost subject to caps depending upon vehicle size. It would also extend for five years the 50-cent-per-gallon alternative fuel credit for the purchase of natural gas fuel, and would expand tax credit incentives for developing natural gas fuelling infrastructure.

The legislation provides:

- A tax credit for up to 80% of the incremental cost of buying a natural gas vehicle, with a maximum value ranging from \$7,500 for a light-duty passenger vehicle to \$64,000 for the heaviest trucks. Recognizing the innovations in vehicle engine technology, the bill includes incentives for both bi-fuel vehicles – those that run on either natural gas or gasoline – and dual fuelled vehicles – where there is a mixture of small amount of diesel fuel with the natural gas. There are no vehicle tax credits in place today.
- A 50-cent per gallon fuel tax credit that is in place in 2011.
- An infrastructure tax credit of 50% of the cost up to a maximum tax credit of \$100,000 per station. For stations built in 2011, there is an existing infrastructure tax credit of 30% with a maximum credit of \$30,000. These credits cover only a small portion of the cost of building a station. This credit would also extend to home refuelling units, where purchases would be eligible for a \$2,000 tax credit.
- A tax credit to the manufacturer for the production of natural gas vehicles. The bill also includes other provisions that will facilitate the production and use of natural gas vehicles.

President Barack Obama has issued a Memorandum requiring the Federal fleet, the largest fleet of light duty vehicles in America, to lead by example to help meet national goals of reducing oil imports by one-third by 2025 and putting one million advanced vehicles on the road by 2015. Federal government agencies are accordingly instructed to acquire alternative fuelled vehicles, including those operating on natural gas (CNG, LNG, biomethane), and to make sure vehicles with multi-fuel capabilities actually use alternative fuels. Investment in fuelling infrastructure is recommended where inadequate supply exists. The memorandum sets out measures, with time limitations for compliance, to help achieve Federal fleet performance goals first iterated in October 2009.

In summary:

- By 31st December 2015, all new light duty vehicles leased or purchased by agencies must be alternative fuelled vehicles. Those vehicles must use, and be able to readily source, the alternative fuel for which they were designed.
- Executive fleets are required to achieve maximum fuel efficiency and be sized in shape and performance to that essential to meet agency needs.

- The General Services Administration (GSA) shall develop and distribute to agencies a Vehicle Allocation Methodology (VAM) for determining the optimum fleet inventory, eliminating non-essential vehicles and assisting agencies in selecting vehicle options based on lifecycle cost analysis, including projected fuel costs, warranty, operations, mileage, maintenance, and disposal.
- Targets defined using the GSA VAM will be published on Agency websites. Plans approved by GSA must be achievable by end December 2015.
- Under strict guidelines certain vehicles may be exempted, as used for law enforcement, protective, emergency response, or military tactical operations.

Supportive measures can be seen on the regional, national and municipal level.

The Texas Senate sent a bill (which passed on August 2011) that will establish incentives for companies to buy natural gas-fuelled vehicles and help fund fuelling stations in the “Texas Triangle” between Houston, San Antonio and Dallas-Ft. Worth. Senate Bill 20 would redirect the funds (funded with \$41.7 million) from the existing Texas Emissions Reduction Program, which replaces or retrofits heavy-duty construction equipment and other vehicles that emit high levels of pollution with less noxious equipment, toward those that specifically use natural gas. This legislation will foster the development of a Texas Clean Transportation Triangle by increasing the number of natural gas-refuelling stations and replacing the heaviest diesel trucks with natural gas-powered trucks, thus improving Texas’ air quality and economy. At least 10 percent of the U.S. transportation sector travels through the Triangle each year, and the U.S. Department of Transportation estimates this number will increase significantly over the next 25 years.

The State of Oklahoma has signed into law the Oklahoma Energy Security Act. The Legislature hereby expresses its intent to take steps to increase the energy independence of the U.S by increasing the use of domestic energy and renewable energy sources in Oklahoma. Included are specific provisions for natural gas vehicle refuelling. The Legislature declares the intent of the State of Oklahoma to increase the number of public access CNG fuelling stations located along the interstate highway system in the state. There is established a state goal to have at least one public CNG fuelling station located approximately every one 100 miles along the entire interstate highway system in the state by the year 2015. The state goal shall increase to at least one public CNG fuelling station approximately every fifty 50 miles by the year 2025.

The City of Chicago has set up a \$1 million federally funded Green Taxi program to reimburse cab companies for using hybrid cars or those powered by natural gas. Companies will be reimbursed \$2,000 for buying hybrids, and between \$9,000 and \$14,000 for converting cars to CNG or LPG. Electric vehicles do not qualify under this program.

The California Governor signed into law a bill granting to solo drivers in natural gas or pure electric vehicles access to the high occupancy vehicle (HOV) lanes in the state until 1st January 2015. Drivers of hybrids and plug-in hybrids will lose their access to the HOV lanes at the end of 2011. In August 2011, in a document titled, The Investment Plan for the Alternative and Renewable Fuel and Vehicle Technology Program, the California Energy Commission updates current progress, and outlines a redistribution of funds related to alternative fuel vehicle technology. The scheme is focused on several key areas including new electric vehicle charging sites, demonstrating and deploying medium and heavy duty natural gas and hybrid electric trucks, Manufacturing facilities for electric vehicles, alternative

fuel vehicles, vehicle components and batteries, biofuels and biomethane production, hydrogen fuelling infrastructure, new E85 fuelling stations etc.

Overview of the results of collected conducted marketing surveys and studies in this triennium is presented below.

TechnoMetrica has been conducting its Alternate Fuel Tracker Survey in which added two questions regarding the use of natural gas as an alternative to gasoline. Surprisingly, more than 70% of those surveyed said they were familiar with natural gas as a motor fuel, and almost half said they would be interested in a natural gas powered car. Survey respondents were asked how likely they would be to consider purchasing a number of fuel saving and alternate fuel powered vehicles. Given below is the share of drivers who are interested ("Very" or "Somewhat") for each alternative powertrain:

- Natural gas powered car – 48%
- Gas electric hybrid – 27%
- Plug-in hybrid – 18%
- Pure electric – 15%
- Diesel – 9%
- Smaller size vehicle – 16%

This survey was the seventh wave of TechnoMetrica's Quarterly Alternate Fuels Tracking research. Approximately 900 interviews were completed yielding a margin of error of +/- 3 percentage points.

A survey carried out by the US National Association of Fleet Administrators (NAFA) presented end-2010 shows that more than 33 percent of public service fleets used vehicles running on CNG and 15 percent of fleets plan on procuring CNG vehicles in the next year. The majority of fleet managers expect the sustainability issue will gain in importance over the next several years.

In addition, the U.S. consulting and technical training firm Alternative Fuel Vehicle Institute (AFVi) has carried out in 2010 a phone survey of 135 companies with fleets ranging in size from 70 to 72,000 vehicles. The survey showed almost half of fleets plan to purchase alternative fuel vehicles (AFVs) in the next three years. By fleet size, these companies are in the top 10 percent of all commercial companies in the U.S. Important considerations included availability of right alternative fuel vehicle, fuel availability, return on investment and environmental concerns.

The Marcellus Shale Coalition has released a Gladstein, Neandross & Associates (GNA) authored report: "NGV Roadmap for Pennsylvania Jobs, Energy Security and Clean Air". GNA's NGV Roadmap report provides a development plan by which a comprehensive natural gas refuelling infrastructure can be successfully established in the Pennsylvania transportation sector to support the replacement of heavy-duty diesel fleet vehicles with ones powered by natural gas. The report primarily focused on return to base fleet operations such as refuse collection, transit bus and other that are the primary entry points for natural gas in transportation. By using a concentric circle approach, fueling infrastructure will eventually be linked in a corridor connecting the major metropolitan areas, including Philadelphia, Scranton/Wilkes-Barre, Harrisburg, and Pittsburgh. Founded in 2008, the Marcellus Shale Coalition (MSC) is an organization committed to the responsible development of natural gas from the Marcellus Shale geological formation and the enhancement of the region's economy that can be realized by this clean-burning energy source. Members of the coalition work with

partners across the region to address issues with regulators, local, county, state and federal government officials and communities about all aspects of producing clean-burning, job-creating natural gas from the Marcellus Shale.

The Massachusetts Institute of Technology has completed a two year study which examined the scale of U.S. natural gas reserves and the potential of this fuel to reduce greenhouse-gas (GHG) emissions. Undertaken by the MIT Energy Initiative (MITEI), the study concluded that natural gas will play a leading role in reducing GHG emissions over the next several decades. The findings were presented to lawmakers and senior administration officials in Washington. The U.S. has a significant natural gas resource base, enough to equal about 92 years' worth at present domestic consumption rates. Much of this is from unconventional sources, including gas shales. Environmental issues associated with producing unconventional gas resources are manageable but challenging. In the transportation sector, the study found a somewhat smaller role for natural gas. The use of CNG or LNG as a fuel for vehicles could help to displace oil and reduce greenhouse gas emissions, but to a limited extent because of the high cost of converting vehicles to use these fuels. By contrast, making methanol, a liquid fuel, out of natural gas requires much less up-front conversion cost and could have an impact on oil usage and thus improve energy security, but would not reduce greenhouse gases. From the report comes one recommendation directed toward the transportation sector: remove policy and regulatory barriers to natural gas as a transportation fuel.

A report released (mid-2010) in the US by Resources for the Future (RFF) and the National Energy Policy Institute (NEPI) concludes that expanding the use of natural gas trucks is the most effective and cost-effective policy option available to decrease reliance on petroleum. The report "Toward a New National Energy Policy: Assessing the Options" assesses 35 different policy options for reducing oil consumption and carbon emissions. Using assumptions concerning first-cost of vehicles, fuel savings, discount rates, and petroleum displacement, the report found that natural gas trucks could displace petroleum at a cost of about \$15 per barrel. From a cost-effectiveness standpoint, natural gas trucks were the most effective of all policy options evaluated. For its report, RFF and NEPI prepared a detailed background report on natural gas trucks. The report includes various assumptions regarding fuel costs, truck costs and discount rates. The assumptions above regarding cost-effectiveness show that for many fleets natural gas trucks are a cost-effective solution that provides real paybacks and lower net costs than diesel vehicles. However, the report also reveals that NGVs, like many other advanced technologies, could have longer pay-back periods than most businesses are willing to accept, and, therefore, require incentives to encourage their expanded use.

On the industry and customers side, major stakeholders are grouping and organizing together.

Leading U.S fleet operators announced the formation of the Natural Gas Vehicle (NGV) Fleet Forum, a new membership organization dedicated to advancing the use of clean, domestic, abundant and low-cost natural gas in the U.S. transportation sector. The NGV Fleet Forum will provide a members-only venue for fleet operators to share technical expertise, collaborate on product development and procurement, and support other members in the successful deployment of natural gas vehicles. Charter members in the NGV Fleet Forum include Sysco Corporation, Ryder System, Inc., UPS, PepsiCo/Frito-Lay, Paper Transport, Los Angeles County Metropolitan Transportation Authority, Sempra Energy Utilities, Border Valley Trading, HayDay Farms and Chesapeake Energy.

More than 50 producers and distributors of natural gas from America's Natural Gas Alliance (ANGA) and the American Gas Association (AGA) are working collaboratively to advance the

development and utilization of natural gas vehicles and fuelling infrastructure in the North American marketplace. The ANGA-AGA joint initiative will encourage stakeholder dialogue to advance greater use of North American natural gas for transportation. Specifically, the collective effort will focus on infrastructure development, greater fleet usage, vehicle production, and marketing and education for natural gas transportation. Natural gas producers and distributors recognize that the private sector must play a leading role. This joint work will continue important efforts to help manufacturers meet demands for vehicles that run on natural gas, and ensure that the infrastructure is in place to fill them up.

Following President Barack Obama's introduction of a Secure Energy Future blueprint on March 2011, the Whitehouse issued a Fact Sheet declaring "a key area of opportunity is the large commercial fleets that companies operate across our country every day, which with the proper incentives can offer significant potential reductions in fuel use." To that end a National Clean Fleets Partnership has been formed. The five inaugural charter members, AT&T, FedEx, PepsiCo, UPS and Verizon, used the opportunity to introduce various natural gas and other alternative fuel vehicles. In July 2011 six new corporate partners have joined the Partnership. The new partners: Coca-Cola, Enterprise Holdings, General Electric, OSRAM SYLVANIA, Ryder, and Staples operate a total of nearly a million commercial vehicles nationwide. This public-private partnership will help large companies to reduce diesel and gasoline use in their fleets by incorporating alternative fuel technologies and fuel-saving measures into their daily operations. The Department of Energy (DOE) will assist companies in their efforts to reduce fuel use and achieve greater efficiency and cost-savings by offering specialized resources, technical expertise, and support. The partnership is part of the DOE Vehicle Technology Program's "Clean Cities" initiative. These charter members represent five of the nation's 10 largest national fleets and collectively own and operate more than 275.000 vehicles. Their planned current and near-term petroleum reduction strategies will account for the deployment of over 20.000 advanced technology vehicles.

In February 2011 American Public Gas Association (APGA) Board approved the creation of NGV Task Force. The Task Force will focus on three key areas: to act as a clearinghouse of information on NGVs; to provide advice to APGA members on matters about NGVs; and to play the active and leading roles in APGA's NGV-related advocacy efforts.

The American Public Gas Association (APGA), NGVAmerica, and Hybrid Kinetic Motors Corporation (HK Motors) in April 2010 announced the formation of a strategic collaboration to promote the mass production and sales of natural gas-powered hybrid passenger vehicles. HK Motors plans to begin producing a family of light-duty natural gas hybrid-electric passenger vehicles at its plant in Alabama beginning in 2013. Development of the technology and availability of vehicles are, of course, an integral part of the equation for successful market development and opening of the new workplaces. State-of-the-art in this segment (based on the available data) is presented below.

On April 2010, the U.S. Environmental Protection Agency (EPA) and Department of Transportation (DOT) issued final regulations for new greenhouse gas emission controls and fuel efficiency requirements. The rules cover model years 2012–2016 and, when fully phased-in, will require that passenger cars, light-duty trucks, and medium-duty passenger vehicles meet a combined average emissions level of 250 grams of carbon dioxide per mile (225 g/mi for cars, 298 g/mi for light trucks), equivalent to 35.5 miles per gallon (MPG) (39.5 mpg for cars, 29.8 mpg for light trucks). The new rules (according to EPA) will add an average of \$950 to the cost of new vehicles. EPA also finalized several provisions in the rules that should provide an incentive for manufacturers to produce NGVs. The rule provides significant greenhouse gas emission credits for dedicated NGVs produced in model years 2012–2015. The rules also leave in place the current fuel economy credits for dedicated

vehicles. Bi-fuel vehicles also can earn greenhouse gas emission credits under the rule for years 2012–2015; for purposes of the credits the vehicles will be assumed to operate on alternative fuel 50 percent of the time. According to NGVAmerica, the new rules will generally not apply to aftermarket conversions. This is because there is an exemption for small entities (1.000 employees for vehicle manufacturers and 750 employees for engine and parts manufacturing). There also is a separate exemption for small volume manufacturers who produce less than 5.000 vehicles per year. It is likely that, at least for a while, that most conversion manufacturers will satisfy the Small Business Administration's definition of a small entity, or will have fewer than 5.000 annual sales. EPA intends to address coverage of these other companies in a later rulemaking.

In addition to the above, in August 2011 the state of California and 13 vehicle manufacturers had agreed on a proposal for more stringent fuel economy and greenhouse gas emissions standards for cars and light trucks. Under the agreement, which covers model year (MY) 2017-25 vehicles, industry average light-vehicle fuel economy will rise from 35.5mpg in MY 2016 to 54.5mpg by MY 2025. The Administration also agreed to industry requests for a mid-term review to determine whether the rules should be adjusted for MY 2022-25. Federal regulators indicated that a number of credits and incentives would help vehicle manufacturers to meet the new standards. These include “off-cycle credits” for stop-start and other technologies not properly recognised in current test procedures; special treatment for electric, plug-in hybrid, fuel cell, and CNG vehicles; incentives for technologies that make full-size pickups more fuel-efficient; and credits for air-conditioning improvements that reduce GHG emissions and improve vehicle efficiency.

The U.S. EPA decided to streamline the requirements for certifying aftermarket systems that are used to convert vehicles to run on alternative fuels such as natural gas. EPA is responsible for ensuring that all vehicles and engines sold in the United States, including clean alternative fuel conversions, meet emission standards. The new regulations will make it less burdensome and less expensive for companies that offer vehicle conversion systems for many existing cars and trucks. EPA's decision is particularly important in the case of heavy-duty fleets, since currently, because of cost, there are no EPA approved conversion systems for diesel vehicles. Because heavy-duty fleet vehicles are the biggest consumers of fuel, they have the greatest potential for reducing the country's dependence on foreign oil in the near term. Under the Clean Air Act, all new motor vehicles must meet stringent emission requirements, regardless of the fuel they use. Newly manufactured natural gas vehicles have been subject to EPA regulations since 1996. However, converted vehicles initially were exempt from the regulatory requirements but have been subject to the rigorous and expensive certification rules since 2002. Manufacturers encouraged the EPA to take steps to reduce the burden imposed by the regulations and to include additional flexibility for aftermarket systems. The revised regulations establish three new tiers: relatively new vehicles; vehicles more than two model years old; and vehicles beyond their useful life, the definition of which varies depending on the size and weight of the vehicles. The revised regulations codify existing flexibility for conversions intended for use on vehicles produced within the past two model years and extend more flexibility to vehicles that are more than two model years old. The new rules will continue to require that manufacturers demonstrate that their conversion systems maintain emissions performance of the vehicle.

Together, the U.S. Department of Energy (DOE)'s National Renewable Energy Laboratory (NREL), the California Energy Commission (CEC), and the South Coast Air Quality Management District (SCAQMD) will invest up to US\$13.5 million to support the development of natural gas engines and vehicles. As part of the cost-shared projects, companies selected for awards will invest nearly US\$8 million in additional funds to support US\$21 million in total projects. NREL will oversee the Natural Gas Engine Research and

Development projects to develop highly efficient natural gas engines that meet or exceed 2010 emission standards, integrate natural gas engines into different chassis and vehicle platforms, and verify fuel efficiency, petroleum reduction, and emissions benefits in real-world operation. The focus is on medium and heavy-duty trucks and buses, which currently represent 22 percent of the fuel used in on-road vehicles.

Clean Air Power, the developer of dual-fuel combustion technology has entered into a concept development agreement with Navistar, Inc. to develop a MaxxForce 13 Natural Gas/Diesel Engine Program for the North American market. The purpose of the development program is to utilize Clean Air Power's dual-fuel combustion technology to deliver a Class 8 engine that achieves the U.S Environmental Protection Agency (EPA) 2010 emissions standard. Subject to a successful Concept Ready Phase, the agreement will then enter a second stage known as the Product Development Phase which will deliver a U.S. EPA 2010 certified dual-fuel engine. Navistar and Clean Air Power will together seek U.S grant funding for full production. In October 2010, International Trucks announced a partnership with Emission Solutions, Inc. (ESI) to provide a new natural gas engine offering in the International WorkStar truck. The International WorkStar CNG 7300/7400, which is 2010 EPA and CARB certified, is now available. GreenMan Technologies, Inc. announced (in December 2010) that its American Power Group Inc. (APG) subsidiary has received a Vehicular Memorandum of Exemption and eleven initial Test Exemptions from the U.S EPA for the testing and verification of APG's non-invasive dual-fuel upgrade system for aftermarket diesel truck and tractor engines. Both CNG and LNG fuelling systems will be tested. The initial vehicles to be tested include nine Class 8 tractors covering various Caterpillar, Detroit Diesel, and Mack engine models ranging in age from 1994 to 2005 as well as a 2008 Ford F450 Pickup and a 2004 Sprinter Van with a Mercedes Benz engine. APG expects to apply for additional test exemptions for a wide range of third-party engine models classified as intermediate age or over full useful life due to age or mileage. Based on independent marketing research conducted by Power Systems Research, it is estimated that over four million vehicles or 80% of the five million medium to heavy-duty diesel vehicles on the road today, are model year 2006 or older therefore ideal candidates for upgrade technology.

Two heavy duty natural gas vehicle technology projects are included in the array of proposals approved for funding by "Drive", California's Alternative and Renewable Fuel and Vehicle Technology Program. The first seeks to demonstrate the efficiency of a natural gas engine for demanding applications, while the second will demonstrate a hybrid-electric drive system that uses a natural-gas-powered micro-turbine. The Gas Technology Institute and Cummins Westport, Inc. will demonstrate a unique, low-emission; high efficiency natural-gas engine designed for regional hauling and heavy vocational truck applications. The advanced ISX11.9 G natural gas engine fills an important market gap since there is currently no such engine option available for long distance class 8 trucking. Swift Transportation will demonstrate one of the engines in a highway tractor for 12 months. The project will complete all necessary development, testing, certifying, and demonstration needed to commercialize the ISX11.9 G natural gas engine, with a goal of achieving 20 percent market penetration for this class of engine. For heavy-duty class 8 trucks, the Kenworth Truck Company will demonstrate a hybrid-electric drive system that uses a natural-gas-powered micro-turbine. The goal of the project is to make cost and efficiency improvements to the hybrid system and its batteries. The system will use an intercooled recuperated (ICR) 350 kilowatt microturbine that will be run on natural gas because of the fuel's low emissions and low cost. FedEx will take delivery of the demonstration truck and integrate the vehicle into its on-going operations starting in 2012. The test vehicle will be equipped with data-logging equipment to record information on the vehicle's operation for analysis. The system will initially be designed for

class 8 trucks, but can be readily scaled to fit all class 6, 7, and 8 vehicles over a wide range of operations. Kenworth projects that this technology will be commercially viable in 2013.

The Port of Long Beach and Vision Motor Corporation of El Segundo, California entered into an agreement in November 2010, to develop and demonstrate a hydrogen fuel cell/plug-in electric class 8 on-road truck, the Tyrano Freightliner, and one hydrogen fuel cell/plug-in electric zero-emission terminal tractor (ZETT), to be produced jointly by Vision and Capacity of Texas. Tyrano Freightliner was delivered in July 2011 and will be tested to evaluate their suitability for short distance cargo-hauling (“drayage”) and terminal operations. The truck, using a 536 HP engine draws its power from a battery kept recharged with H₂ fuel cell.

Volvo Trucks is expanding its alternative fuel vehicle lineup with the introduction of a natural gas-powered (9L Cummins Westport ISL G engine, 320 hp, in LNG or CNG option) Volvo VNM daycab with first ten units being delivered in July 2011. The natural gas option is targeted toward port drayage, pickup and delivery applications, grocery and beverage haulers or any private fleet concerned about CO₂ emissions. Freightliner Trucks, a division of Daimler Trucks North America LLC, is to introduce a 114 Severe Duty (SD) set-back axle (SBA) truck with natural gas technology to the North American market. Designed for severe duty segments such as construction and other markets, the new 114SD SBA is a lightweight durable truck for heavy-duty vocational applications. Developed in collaboration with VAC-CON, Freightliner Trucks has also delivered the Freightliner Business Class M2 112V CNG truck, claimed to be the first the first turnkey natural gas truck in Northern America upfitted with a vacuum body. It will also be equipped with a CNG-powered auxiliary-mounted engine that powers the truck’s water system. Isuzu Commercial Truck of America, Inc., distributor of low-cab-forward trucks, is to commence production of gasoline-powered Isuzu N-Series trucks on April, 2011. Production is to include an engine option with modified CNG/LPG compatible (hardened) valves. U.S automotive retail group EVCARCO, Inc. has decided to sell CNG powered Foton MD 3000 medium-duty class 3-5 trucks at its green auto dealerships. The MD 3000 and LD 1000 are versatile for multi-use applications and are equipped with cargo delivery bodies. The vehicle’s chassis and Euro-style cab design allows for easy multi-conversions for uses such as street sweepers and refuse collection. Mack Trucks, Inc. has introduced a natural gas-powered version of its versatile TerraPro™ Cabover model for the refuse and construction applications. The MACK TerraPro Cabover model is available with heavy-duty natural gas engines supplied by Cummins Westport. The 9-liter Cummins Westport ISL G is rated at 320 hp, can use CNG or LNG, and has a three-way catalyst to meet EPA 2010 emissions standards. A growing number of municipalities mandate alternative fuel vehicles as a condition of contracts with refuse haulers. US-based Peterbilt, manufacturer of dump trucks, refuse (garbage) trucks and other commercial vehicles, presented the three variants of its CNG refuse truck (for waste management). All are equipped with Cummins ISL-G engines with a maximum output of 320 horsepower, with three-way catalytic converters in each model to significantly reduce emissions. Full production of the vehicles was scheduled for 2011. Enviromech Industries (EMI) joins hands with Gillig Corporation to reintroduce Gillig buses to the NGV market in California and to the rest of USA. EMI is a provider of advanced alternative fuel systems and propulsion technologies for heavy-duty trucks, buses, automobiles, and specialty vehicles while Gillig Corporation is a producer of heavy-duty buses for mass transit systems, mainly the Bus Rapid Transit (BRT) and the Low Floor buses. Kenworth Truck Company has expanded its green product line with the introduction of the Kenworth T440 natural gas model powered by the Cummins Westport ISL G engine, focused on local and regional haul and vocational applications, and becoming the latest Kenworth truck able to operate on both CNG and LNG, joining Kenworth’s W900S which began offering those options in the late 2009. Kenworth also offers the T800 LNG truck equipped with the Westport GX engine.

Altech-Eco Corporation, has obtained a Certificate of Conformity (COC) from the U.S Environmental Protection Agency (EPA) for their dedicated (100% natural gas driven) 2011 Ford E-Series CNG conversion system, and already holding COC for their 2010 Ford Fusion passenger sedan CNG conversion system and has also received EPA certifications for the 2010 Ford Transit Connect, the Ford F-250 and F-350, the Mercury Milan, and the Ford Focus. IMPCO Automotive, subsidiary of Fuel Systems Solutions, Inc. and a designer, manufacturer and supplier of alternative fuel components and systems has ramped up production of its CNG system designed for Chevrolet Express and GMC Savana Cargo vans. Each Chevrolet Express and GMC Savana CNG van is covered by GM's three-year, 36.000 mile new vehicle limited warranty and five-year, 100.000 mile limited powertrain warranty. All vehicles comply with EPA: BIN 5 and CARB: LEV2 – SULEV emission requirements, certified in all 50 states. One of the first major fleet orders received by GM and built at the IMPCO Automotive Union City Plant was an order of 101 Chevrolet Express 2500 Cargo vans for AT&T, to be used in its customer service fleet. AT&T had previously announced a goal to deploy 15.000 alternative fuel vehicles by 2018. Also, IMPCO Technologies has been issued 2011 model year Certifications for IMPCO dedicated CNG Fuel Systems for Ford Motor Company vehicles. Baytech Corporation (Baytech), a wholly owned subsidiary of Landi Renzo USA (Landi Renzo), has developed a 50-state CARB and EPA certified dedicated compressed natural gas (CNG) system for the 2011 Chevrolet Impala and Buick Lucerne. Since this CNG vehicle is rated as SULEV (Super Ultra Low Emission Vehicle), the CNG Impala and Lucerne will be eligible for the High Occupancy Vehicle Lanes in California as well as many other states. Baytech has also obtained 2010 U.S EPA and Californian Air Resources Board (CARB) emissions certifications for its dedicated CNG and bi-fuel (CNG or gasoline) 6.0L and 8.1L engines for General Motors, Isuzu and Workhorse medium and heavy duty vehicles. Vehicles covered by these new certifications include cab forward, cutaway van, chassis cab and custom chassis models. First CNG Conversion Provider in U.S. to Earn Designation by Ford – BAF Technologies, Inc., Clean Energy Fuels Corp. subsidiary, has been officially designated by the Ford Motor Company as a Ford Qualified Vehicle Modifier (QVM) for gaseous-fuelled vehicles. BAF's alternative fuel vehicle upfitting capabilities include aftermarket CNG conversions of Ford-manufactured vans, cutaway shuttles, taxis, pick-ups and light-duty trucks. Leggett & Platt Commercial Vehicle Products (L&P CVP), a Qualified Vehicle Modifier (QVM) of Ford vehicles in the USA, will install Landi Renzo alternative fuel systems at its Ford ship-thru facility in Ohio, in a new strategic partnership that will see more NGV choices available for fleet operators and vehicle owners. NatGasCar LLC, a U.S provider of natural gas vehicle conversion and refuelling systems, has developed and recently received EPA certification for a CNG conversion system for the Dodge Ram 1500, Dodge Dakota, and Mitsubishi Raider. The certification is for model years 2010 and 2011 and is available in CNG Dedicated or Bi-Fuel (gasoline/CNG) configurations. NaturalDrive Partners, LLC, has obtained model year 2011 certification from the California Air Resources Board (CARB) and the U.S Environmental Protection Agency (EPA) for its dedicated CNG system for General Motors full-size vans. This certification meets California's SULEV emission standard. The U.S Department of Treasury confirmed that 2011 General Motors Vehicles converted by NaturalDrive to operate solely on natural gas meet the requirements of the Qualified Alternative Fuel Motor Vehicle Credit, earning a tax credit of US \$8.000. NaturalDrive Partners has also previously obtained model year 2010 EPA emissions certification for its dedicated CNG retrofit of the General Motors 6 liter three quarter and full ton trucks, and retrofitted vehicles can also qualify for the maximum federal tax credit of US \$8.000 for vehicles in this weight class. Vehicle models covered by this certificate were originally produced by General Motors in model year 2010 to operate on gasoline and have been modified by the above named manufacturer to operate on CNG. Fleets can convert a wide variety of sedans, trucks and vans to CNG operation with certified NaturalDrive systems, including the Chevrolet Impala, Malibu, G6, HUMMER H3,

Silverado/Sierra, Express/Savana, Colorado/Canyon, in weight classes ranging from 4.000 to 10.000 GVWR (Gross vehicle weight rating).

Ford has developed and tested a CNG/LPG Gaseous Engine Prep Package to be installed by preferred upfitters, who install the CNG/LPG tanks and hardware. The engine comes with hardened exhaust valves and valve seats for improved wear resistance and durability for gaseous fuel systems, and Ford engineers work with the upfit companies to ensure consistent and reliable performance. The new engine calibration maintains engine operating limits as specified for cylinder pressures, piston temperatures and engine speed, among others. Ford maintains the engine and powertrain warranty (five years/50.000 miles) and the upfitter is responsible for the system component warranty. By 2012, half of all Ford vehicles will be capable of running on alternative fuel.

Chrysler could bring natural gas vehicles (NGVs) to the North American market in as little as two and a half years, but Fiat NGVs are unlikely despite their success in Europe. The U.S. has different prerequisites for vehicles entering the natural gas market than does Europe, ranging from crash testing to onboard engine diagnostics, so Fiat product adaptation is unlikely. The introduction of Chrysler-engineered bi-fuel NGVs is apparently the most likely option. American Honda Motor Co. Inc. has introduced its 2012 Honda Civic concept model, confirming the inclusion of the natural gas powertrain amongst the range of options. Promotion of the new Honda Civic natural gas sedan was announced in July 2011. General Motors signed in July 2011 an agreement with Westport Innovations Inc. to develop natural gas engine controls, emissions and performance strategies. Project will focus on light-weight engines as small as 0.5 litres, a size that would be used in small, passenger vehicles. Currently the only commercial, OEM natural-gas powered passenger car on the U.S market is the Honda Civic GX.

Several examples of utilisation of off-road applications are listed below.

Gaseous Fuel Systems, Corporation (GFS), a manufacturer and seller of equipment that enables diesel engines to operate on both diesel and natural gas, has successfully demonstrated its dual-fuel conversion system for mining vehicles in the United States. The CAT 777 operating at a commercial coal production facility in Harlan County, Kentucky operates with more than 60% gas substitution for diesel without loss of performance. GFS is preparing to launch its first commercial U.S. fleet conversion of mining vehicles in 2011 in Eastern Kentucky and Southern West Virginia where there are hundreds of mining trucks that could be converted to the GFS system. Large numbers of on-road 18 wheeler tractor trailer trucks hauling coal in this region can also be converted by GFS. The dual-fuel system will allow mining equipment to save more than 30% on fuel cost using U.S. produced natural gas while lowering emissions.

The Mississippi River and other inland rivers of the U.S are home to several thousand towboats, all facing current and future environmental restrictions on emissions. Wärtsilä and Ship Architects, Inc., USA, have cooperated to develop a new environmentally sound towboat concept that employs Wärtsilä dual-fuel engines for propulsion. The riverboat industry is facing challenges as the result of progressively severe restrictions being imposed on engine emissions. Further reductions will be needed in the future when the Emissions Control Area (ECA) regulations take effect in August 2012. There is a sense of urgency to the development of more environmentally friendly vessels. Mentioned dual-fuel technology enables the towboats of U.S.rivers to be powered by engines that comply with current and future environmental legislation, while creating operational cost savings for the operators (technology eliminates need for low-sulphur fuel). The key driver to this need for change is the U.S EPA lowering of sulphur content levels in the fuel used (EPA's limits are tighter than

the global standards). The bottleneck to the adoption of these new standards is the limited refining capacity for low-sulphur fuel (therefore potentially creating a shortage of supply and higher fuel prices due to increased demand).

The Staten Island Ferry will receive \$ 2.34 million in federal funding for a pilot program for conversion from diesel fuel to LNG (currently, the ferries run on ultra-low diesel). As the only ferry service between the Island and Manhattan, the Staten Island Ferry carries more than 21 million passengers per year, including 65,000 passengers every weekday. The boats make 109 daily trips during the work week. Because of heavy use, the ferries must be constantly fuelled and undergo maintenance work.

Naval architectural and marine engineering firm The Glosten Associates recently (August 2011) completed the feasibility study for Washington State Ferries on converting its 144-car ferry design to LNG propulsion. The study concluded that the conversion is both technically feasible and cost effective, although technical and regulatory challenges remain. The study examined design, economic, regulatory, and environmental issues. To support the study, Glosten developed a preliminary design for both dual-fuel and monofuel (LNG only) engines. This design was formally reviewed by the United States Coast Guard.

The fuelling infrastructure development projects and agreements, the unavoidable element of the “chicken and egg” equation are summarized here (based on the available data, several examples are listed below).

Natural gas fuel provider Clean Energy Fuels Corp. has signed long-term agreements with four major airport complexes in four states to design, build, own and operate new CNG stations to support ground transport vehicles and off-airport parking shuttles. The new stations, available 24/7 for public access, will be located in New York City, New York; New Orleans, Louisiana; Philadelphia, Pennsylvania and Tampa, Florida.

Clean Energy Fuels Corp., has also signed an agreement with Pilot Travel Centers LLC (Pilot) to build, own and operate public access CNG/LNG fuelling facilities at agreed-upon Pilot Flying J truck travel centres nationwide. Pilot Flying J, the largest retail operator of travel centres in Northern America, operates over 550 truck travel centres in 43 states and six Canadian provinces. With the availability of new, class-8, 2010 EPA-compliant natural gas trucks from several major manufacturers, major regional and national trucking operators are considering the move to natural gas for their fleets to add fuel diversity, lower emissions and reduce dependence on imported oil. This partnership will also enable to begin creating a nationwide goods movement corridor for natural gas trucks.

Clean Energy Fuels Corp. also issued plans to expand its existing network of LNG truck fuelling stations in Southern California in 2010 beyond its current two LNG stations. New or upgraded LNG fuelling facilities are planned for strategic points along truck transport routes in the California cities. This hub of stations will form the backbone upon which Clean Energy intends to expand its LNG fuelling efforts into the South-western region of the United States. Trucks will be able to transport goods from the Los Angeles and Long Beach ports, deliver them to distribution centres, and take the goods directly to stores in local communities. This augmented LNG truck fuelling capability plays a key role in the creation of a full-scale Southwest LNG truck-fuelling corridor and is planned to connect this group of LNG fuelling stations in Southern California to Northern California, Arizona, Nevada and Utah.

Clean Energy has received in total \$300 million in the past few months (summer 2011) to develop LNG fuelling stations across the country (see also section on Chesapeake Energy Corp. later in this chapter). Company’s plan is to expand its national fuelling network to 100-

plus more long-haul trucking (stations) over the next couple of years (in addition to existing 248 VNG and LNG stations including the first long-haul LNG station).

In August 2011, a group of alternative fuel activists is putting forward plans for “the Interstate Clean Transportation Corridor” (ICTC) which proposes a series of LNG and CNG filling stations connecting heavily trafficked interstate trucking routes between Utah, California, and Nevada. The land for the first ICTC station (a for-profit, privately-owned business) was donated by UPS.

On the customers side, across the United States, more than 11.000 transit buses, nearly 4.000 refuse trucks, over 3.000 school buses, 15.000 to 17.000 medium-duty vehicles and more than 30.000 light-duty vehicles in federal, state, local government and private fleets are already gas-fuelled (status mid-2011). What can be seen lately is the further introduction of natural gas into fleets (heavy-duty segment, delivery services and taxis) as the prime mover of market development. Several recent examples are listed below.

More refuse haulers in cities of Washington, New York and Vermont are strengthening their eco-conscious programs to help them save fuel and reduce carbon emissions. Leading refuse operators in Florida, New Jersey, Idaho and California have opened new CNG filling stations to support deployment of their growing fleets of CNG refuse collection trucks. Besides introducing more NGVs, firms like Waste Management, Casella Waste Systems and Allied Waste are planning to open new refuelling facilities to serve their fleets. Republic Services, Inc., a provider of recycling and solid waste collection, transfer and disposal services in the US and Puerto Rico, had decided to make 20 percent of its fleet renewals for 2010 with NGVs by adding 226 NGV trucks to 10 facilities in its Western region. Of the 226 NGVs, 173 are CNG and the remaining 53 are on LNG.

Dallas Area Rapid Transit (DART) has awarded Clean Energy Fuels Corp. a US\$40-million contract to design and build four new CNG stations to support the transition of DART’s fixed route and paratransit bus fleet to 100% CNG power. Over the next three years (starting in mid 2011), the agency plans to deploy 452 new CNG buses and 200 CNG paratransit vehicles as replacements for its current fleet of LNG and diesel-powered models that began service in 1998. The Board of the New York Metropolitan Transit Authority (MTA) has awarded a contract for up to 475 buses. These CNG buses will be operated by the New York City Transit Authority (NYCTA) and the MTA Bus Company (MTA Bus). Two pilot buses will be delivered to the MTA in the second quarter of 2011, with the balance of the base order delivered in the fourth quarter of 2011 and early 2012. The MTA is the largest transit agency in North America, and is responsible for public transportation in the state of New York.

U.S natural gas producer Chesapeake Energy Corporation has set goal of converting its entire corporate fleet of 4.200 vehicles to CNG by 2014. Also, on July 2011, Chesapeake Energy announced (as the first concrete step in its wider scheme) its intent to provide \$150 million in financial support to Clean Energy’s continued expansion. The funds will be dispersed over three years and take the form of convertible debt to be used for the construction of 150 LNG fuelling facilities along the interstate highway system. Chesapeake announced redirecting approximately 1 percent to 2 percent of its annual drilling cap-ex (capital expenditure budget) over the next 10 years, or at least \$1 billion in total, to stimulate market adoption of CNG, LNG and GTL (natural gas-to-liquids) fuels.

In a bid to cut costs and get front-of-the-line privileges at Dallas/Fort Worth International Airport, the biggest taxi company in North Texas plans to convert nearly all of its company-owned cabs from gasoline to CNG. Yellow Cab wants to take advantage of a program that D/FW Airport implemented allowing taxis fuelled by natural gas to jump to the front of the line

for fares. Furthermore, Taxi Affiliation Services (TAS), which operates Yellow Cab Chicago, the nation's oldest and largest continuously operating taxicab fleet, has awarded Clean Energy Fuels Corp. a 10-year contract to build and operate two new CNG fuelling stations and sell fuel to the company's growing CNG taxi fleet. Yellow Cab Chicago and its affiliates plan an initial deployment of 100 new CNG taxis. In addition to serving Yellow Cab taxis, the stations will be open 24/7 for public access.

The South Coast Air Management District (SCAQMD) awarded more than US\$40 million to help replace 146 diesel school buses across the Southland and about 400 older diesel trucks operating primarily at the ports and in other goods movement activities. 128 of the 146 school buses will be replaced with natural gas vehicles. Furthermore, the National Association of Pupil Transportation (NAPT), in conjunction with NGV Fleet Partners, has unveiled Operation Upcycle, a Stimulus program which aims to help school districts repower aging diesel engine school buses with new CNG engines, by subsidizing the costs of conversion with low interest loans, and funded by a grant awarded through the American Recovery and Reinvestment Act (ARRA). The program is open to any school district with access to CNG refueling stations. A typical CNG school bus conversion can cost upwards of US\$50,000.

Ryder System, Inc., a global transport and supply chain management business, and the San Bernardino Associated Governments (SANBAG) have moved into implementation phase on the first of its kind stimulus-funded natural gas truck leasing and rental project in Southern California. With the contracts in place, Ryder is about to purchase the first 70 LNG/CNG trucks. Ryder will purchase and deploy approximately 202 heavy-duty natural gas powered trucks for this project. These ultra low-emission trucks will be deployed into Ryder's Southern California operations network of 1,200 customers representing more than 6,000 commercial trucks, where Ryder's commercial customers will access them through short-term rentals, long-term leases, or through Ryder's dedicated logistics services.

In 2010 UPS has deployed 245 new delivery trucks powered by CNG to cities in Colorado and California. The trucks, built from scratch as CNG vehicles, joined more than 900 CNG vehicles already in use by UPS worldwide.

By the end of 2010 AT&T has deployed 2,000 CNG corporate fleet vehicles. This milestone is part of a US\$565 million planned investment announced in March 2009 to replace approximately 15,000 fleet vehicles with alternative-fuel models through 2018. Currently, the AT&T corporate fleet includes more than 75,900 vehicles. Through 2013, AT&T anticipates purchasing approximately 8,000 CNG vehicles at an anticipated cost of US\$350 million. AT&T expects to spend an additional US\$215 million through 2018 to replace approximately 7,100 fleet passenger cars with alternative-fuel models. Clean Energy Fuels Corp. has contracted with AT&T to supply CNG fuelling stations to support AT&T in its commitment to deploy above mentioned up to 8,000 CNG fleet vehicles nationwide. As part of a multi-year master agreement, Clean Energy will build, operate and supply CNG stations for AT&T's use.

SOUTH AMERICA

In **ARGENTINA**, the local Government is considering a new incentive program, called “Ecobuses” to convert heavy duty public transportation vehicles to natural gas or biomethane. In accordance with plans, this transition must be executed in the next 10 years. The National Congress is preparing a proposal to establish economical incentives to convert heavy duty diesel vehicles to cleaner fuels. The overall purpose of the program is to reduce the environmental impact of this operation, in metropolitan areas. The CAGNC (Argentine Chamber for CNG) underlines the importance of developing a pilot project for CNG heavy goods vehicles, for which purpose the association is promoting the offerings of providers and exponents of the fuel system. The benefits highlighted by this project will be promoted simultaneously by another enterprise, the blue corridor between Buenos Aires and Rosario, which will basically consist of three refuelling stations that will demonstrate the speed and efficiency of service provision for trucks. With this model, the hope is to optimize the Mercosur blue corridor. The route considered by Argentina and Brazil via Petrobras, for example, is between Rio de Janeiro and Valparaiso. This would provide a corridor to promote transportation in the region.

Peugeot Argentina introduced to this country and to Latin America, the new 408 (assembled in Argentina for distribution to Latin America).

On the vehicles conversion side, CNG has consolidated its technological lead regarding to the massive application of electronic technology equipment with injection of 5th generation. In 2010, the shares of sales of such equipment grew by 25 to 30 percent of the total vehicle conversions to NGVs.

Regarding off-road applications, it was announced from Australia that Buquebus had purchased the first ferry propelled by LNG, which will be operating between Argentina and Uruguay. Late in 2010, the shipbuilder Incat Tasmania Pty Ltd announced it had signed a contract to build what will be the first high-speed passenger ship powered by natural gas. The boat is under construction at the Incat shipyard in Prince of Wales, Tasmania, and delivery is expected in spring 2012, to be operational during the summer season. The ship, which can accommodate over 1.000 passengers and 153 cars, will have a speed of 53 knots allowing it to compete in terms of time with air traffic between Uruguay and Argentina. The use of LNG in the ship propulsion can allow savings of 45% in total operating costs compared with those involving the use of standard heavy fuel oil.

BOLIVIA is the country in Latin America (after Venezuela) with the second largest quantity of natural gas reserves.

The Bolivian Government has created the NGV Conversion Executing Entity (EEC-GNV) to stimulate the utilization of natural gas in transportation, through resources from an appropriate Government Fund that will be transferred to EEC-GNV, to cover conversion costs, which will be directly made by this entity. The Government of Bolivia will promote the creation of incentives for the import of NGVs. The purpose of the EEC-GNV is also to reduce the demand for LPG in the country by switching vehicles to natural gas. Vehicle operators on the LPG register have been given 90 days to enter conversion programs. Article 16 of the draft of the Transport Act states that the use of natural gas will be promoted through tax incentives for the importation of cars and via different fuel prices. In addition there will be facilities for the acquisition of transportation units and incentives for manufacturing and vehicle assembly and parts of the transport vehicles to NGV or other energy. The Oil Ministry has already authorized direct purchase of installation kits that can accelerate the conversion

process. The country's goal is the conversion of 80.000 vehicles per year, in conjunction with the construction of new CNG stations on the routes. In three years, there would be 240.000 NGVs and the plan for 2015 seeks to bring the number to one million. Through Restructuring Commission and the EEC-GNV, Bolivia aims to accelerate the shift of the energy matrix to decrease dependence on imported petrol and diesel – subsidized fuel last year claimed more than 660 million dollars from the government. Ministry of Hydrocarbons and Energy (MHE) is authorized to direct procurement of CNG conversion kits and cylinders, in addition to negotiating with conversion centres, to accelerate the shift of the energy matrix. According to MHE, natural gas filling stations would be placed approximately every 80 kilometers along the highways..

Under the Supreme Decree of January 12.2011, the MHE reached a preliminary agreement with the Chinese firm Eastern Petroleum & Gas SA, for the mass conversion of vehicles to use natural gas for vehicles, with emphasis on the fleet dedicated to public transport, commencing April. The company is offering to supply gas cylinders, installation kits, training of national manpower to perform conversions at an accelerated pace, and funding of all work in conditions suitable for Bolivia. Eastern Petroleum & Gas SA has offered to place three industrial workshops in the capitals of the country's central axis, which can convert up to 100 vehicles per day. The company also offered to bring a dozen technicians familiar with the equipment into the country, to train about three hundred Bolivian mechanics, who will be tasked with the conversion.

Aiming at the transformation of the energy matrix of the vehicle fleet, the government of Evo Morales launched a program of conversion to natural gas and free cylinders retest, with funds for around 70 million Bolivianos. Workshops enabled to do this do not pass the cost on to the user, but Yacimientos Petrolíferos Fiscales Bolivianos (YPFB) is responsible for making the payment to them. As a result of this, it is expected that in the short term at least 15.000 vehicles will be added to the existing NGV fleet. The cities of La Paz, Santa Cruz and Sucre are the starting locations for a new drive to convert LPG public transport vehicles to natural gas. The free conversion program, initiated by Bolivia's Ministry of Hydrocarbons and Energy, is carried out under the directives of relevant Supreme Decree. It also includes replacement and redevelopment of NGV cylinders. The first stage aims to convert 7.000 vehicles.

In Santa Cruz, the biggest city in Bolivia, conversion of diesel buses to CNG system will be activated. This programme is supported by the government as it plans to approve the purchase of 6.000 units of CNG engines from China. The conversion will be carried out with full funding (for free). Bolivia has about 65.000 buses that require change or conversion. Meanwhile, in La Paz City, 30.000 CNG engines are required for the conversion. Santa Cruz and Cochabamba were reported to have about 45.000 vehicles. Bolivia's National Hydrocarbon Agency (ANH) has given the green light for the start up of CNG conversion programme in Cochabamba.

The NGV segment in **BRAZIL** has been severely impacted by not very competitive prices of natural gas relatively to other transportation fuels such as ethanol and gasoline. Efforts have been made to stimulate the use of natural gas in heavy-duty vehicles, to replace diesel fuel, through the organization of workshops or conferences, in the last couple of years. Some efforts have also been made by OEMs to convince fleet owners, showing new developed technologies, such as dual fuel or bi-fuel utilization instead of diesel or gas only, but with limited success. There are indications that some governmental public policies and incentives are needed, to change the current picture.

The Rio State Government has worked recently to prepare Rio de Janeiro for the 2014 World Cup and the 2016 Summer Olympics. These preparations include creation of the Rio Sustainable Transport initiative, a public-private partnership designed to reduce emissions by using eco-friendly vehicles. State officials consulted with regional firms like Robert Bosch Latin America, MAN Latin America and Gas Natural Fenosa to produce a public transit vehicle that achieves lower emissions. The Volksbus prototype was developed having the injection system of natural gas in the vehicle, allowing the bus running up to 90% of its consumption with CNG. This dual fuel system was the first produced in Brazil. The next step of the project will be the inclusion of the vehicle on a normal operation to track emissions and noise. Volksbus will be tested over the next two years ahead of the 2014 World Cup.

Brazil expands natural gas use in the off-road segment with more than a hundred boats to be converted in the in the Amazon region. The first of these natural gas powered motorboats will cover the region of Tefé (523 kilometres from the capital city of Amazonas state). It will feature an Italian 5th generation kit with electronic fuel injection and six 20 kg cylinders that will be on the outside of the boat. It will also be able to run on gasoline. While the use of CNG is emerging in the state of Amazonas, the boat technology was already tested in the dual fuel “Ivete Sangalo” ferry, which operates in Bahia with 70 percent of natural gas and 30 of diesel.

COLOMBIA has the biggest heavy and medium duty NGV fleet of Latin America. In accordance with the local Government, the NGV segment will show an annual growth of 7% up to 2020. And the natural gas annual demand for this market will be growing at a level of 1.47% during the next 10 years. Still, based upon reliable sources, the country natural gas reserves are bigger than the oil ones. The country’s domestic market is mature and new attention is being given to natural gas for transportation, with collaboration between companies in the gas supply chain aimed at further developing the NGV market. One of the most recent was the release of 15.000 bonds in Bogota and municipalities in the centre of the country to finance 50% of the conversion cost of vehicles to CNG, using funds provided by supply chain companies such as Ecopetrol and Chevron Texaco (gas producers), TGI (gas transporters), Gas Natural (distributor and service stations), and GN Auto Gazel (service stations).

Chevron recently (summer 2011) launched a major initiative to integrate Chevron-produced natural gas into the Texaco brand and market it under the name Texgas in Colombia. Three Texgas natural gas fuelling stations are now open and the current plan calls for an additional 12 Texgas stations in strategic cities throughout the country. Chevron will also be offering Texgas to its current network of Texaco stations, some of which already provide an NGV alternative. Additionally, Chevron has submitted a proposal to place Texgas in all Metroplus vehicle facilities to meet the fuelling and lubrication needs of 200 new natural-gas-powered buses that will replace the city’s older, less energy-efficient vehicles. A decision on the proposal is expected by the third quarter of 2011. Currently, Chevron produces 65 percent of Colombia’s natural gas as part of a more than 30-year partnership with Ecopetrol, the national oil company.

The company Colombiana de Chasis has launched the country’s first articulated CNG bus, specially designed to run on this fuel. The vehicle will operate in Medellín (with expected selling of at least 60 units in the short term, while the target will be intermediate cities in the country). The 6-tons bus with capacity of carrying 120 passengers was built entirely in Colombia and has a Cummins natural gas engine which meets Euro 5 standards. In turn, the unit has a smaller turning radius and with its lighter axles the impact on the pavement is lower and avoids road damage.

Hyundai Motors Company has introduced its bi-fuel Hyundai Atos and Accent in the Colombian market. Local installers will install the CNG kits in these cars. Initially, the vehicles will be used in taxi fleets. Hyundai is the dominant taxi brand in the country with a target of 12.000 unit sales this year. It expects between 10 and 15 percent of its taxi sales will be natural gas. An alliance with Gas Express Vehicular and NGV Motori, with support from Gazel, will assist taxi owners meeting the higher cost of CNG taxis by financing, or via recharging arrangements when refuelling.

In **CHILE** the city of Punta Arenas presented its new fleet of CNG provided by Movigas. Trans-Andean companies are developing initiatives to convert urban public transport, and also planning to set up more CNG stations and even launch zero mileage CNG vehicles on the local market. The companies Gasco and Cidef reached a short-term agreement to begin selling vehicles that are ready to run on this technology and thus promote and reinforce the use of the gaseous fuel throughout the country. The main objective is to focus on the taxi segment and then expand the range of CNG models for private users. The only vehicles currently authorized to run on natural gas are those intended for commercial purposes, unless the vehicle was originally manufactured to run on natural gas. This project aims to overcome this obstacle and will develop gradually with the leading brands and models. Gasco intends to expand its presence in the country and is analyzing the possibility to exploit the presence of its partner gas companies (Unigas and Vidagas) which have experience in vehicle fuel segment.

The Ministry of Transport and Communications (MTC) of **PERU** reported that the value of Scrap Bond will reach US\$ 5.000, depending on the level of seniority of the vehicle to be scrapped, and that will be used to pay part of the cost of new units that use NGV. The Minister of Transport and Communications announced the issuing of a legal device to finalize the procedure for initiating the delivery of the Bond. The delivery was announced to start with the Provincial Municipality of Callao and the Bonds will be financed from the budget established by the national government, through the MTC. Depending on the age of vehicles, the Bond will be between 3.500 and 5.000 dollars.

On the fleet customer and infrastructure development side several examples are listed below.

The Lima Metropolitan System is currently operating 600 buses powered by natural gas, adding another 300 to circulate for three years in the traditional routes. And Lima Bus, which is one of the four operators of the Metropolitan, in the year 2011, plans to acquire another 350 buses.

Gas Comprimido del Perú (Gascop) is investing about three million dollars in the construction of a mega station in the province of Chiclayo, Lambayeque, to supply the energy for use in public service vehicles. Operations are projected to start during the third quarter of 2011, and the company will also invest 400 thousand dollars in the expansion of the current operations in Chiclayo. When the two stations become operational they will provide natural gas for 2.000 vehicles per day in the city of Chiclayo, and there are also about 550 public service vehicles converted to natural gas in Lambayeque, a figure which by year-end is projected to reach about 1.500 units. In addition, Gascop will also construct of its second refuelling station in Piura, which will serve a large number of customers.

NEOgás do Perú S.A (NGP) has offered a new system for refuelling urban and interurban buses in Lima and Callao in connection with the launch of Neobus. The new service offers carriers the opportunity to have CNG service stations on their premises. Provided that the bus company meets prescribed minimum fuel consumption levels, NEOgas says it will install

the system at zero cost to the carrier by assuming all installation and maintenance costs for the first five years. At the completion of the five-year period, ownership of some of the equipment is transferred to the carrier and, if they wish, they can assume the administration of the facility at a much lower cost, to be operated by their own trained personnel.

Based upon information released by the Ministry of Energy of **VENEZUELA**, 43.000 vehicles have been converted to natural gas in 2010. Still in accordance with this source, the objective of this program is to convert 400.000 vehicles until the end of 2012. The Government has also made agreements with some international OEMs to have 30% of their vehicles offered to the Venezuelan market, capable to run as a bi-fuel vehicle: gasoline/natural gas. The objective of the Program is to reduce 30% of the current gasoline consumption in the country.

Through the Autogas program, the government of Hugo Chávez since 2007 encourages the development of the CNG industry and the change of the energy matrix. The target is to stimulate a rational use of liquid fuels in the domestic market via a gradual switch to NGVs. For the reactivation of this plan, the government announced a resolution by which OEMs, manufacturers, importers and distributors of vehicles must produce at least 30 percent of its vehicles with bi-fuel system, a proportion that should rise to 50 percent in 2011.

Three vehicles models from General Motors and Ford Motor are leaders in Venezuela concerning the sales of CNG vehicles as a result of the Autogas program. According to the report for the first four months of 2011 from the Venezuela Automotive Chamber (Cavenez), the first place was held by the Aveo followed by the Optra and the Fiesta. The ranking also includes other models like the Corolla and Terios (Toyota), the Cherokee (Chrysler) and the Elantra (Mitsubishi)..

The official distributors of Peugeot vehicles and parts in Venezuela will offer the 408 Allure with a CNG (bi-fuel) option to taxi operators, a product aimed particularly at operators servicing the tourist sector. This model is assembled in Argentina for distribution in all of Latin America (see also section on Argentina).

Iveco Venezuela in June 2011 launched its natural gas powered Eurocargo truck (the first of a new series) for use in urban solid waste collection. After an evaluation period the truck will be transferred to various entities within the national territory, to evaluate its performance in different geographical conditions.

Another measure to attain large-scale implementation of the program is the free conversion service. That is, the users can install the NGV system for free, while the vehicle will be supplied with CNG in the stations authorized by the program at no cost. To consolidate the project, Venezuela also plans to use technology and experience from Argentina in what will be the possible formation of joint ventures between the two countries to produce locally the material needed for the expansion of the Autogas program.

CENTRAL AMERICA AND THE CARIBBEAN

Mexico, Dominican Republic and Trinidad & Tobago have initiated efforts to use natural gas in their vehicular fleets, to replace gasoline, diesel or LPG, depending on each region. Those programs are still at a very preliminary stage, and in most of the cases, under evaluation by their local Governments.

MEXICO City's Passenger Transport Network ('La Red de Transporte de Pasajeros' – RTP) has introduced 30 new CNG buses to the city. The 11-meter buses are dedicated CNG vehicles (Euro 5) from Hyundai in Korea, specially tuned for Mexico City's high altitude. Gas is supplied by Gazel, while the RTP considers the establishment of its own refuelling facility. RTP is also planning to introduce a larger scale of this technological innovation, taking into consideration the financial investment in infrastructure for fuel supply, the technical aspects of maintenance, operation and training of operational staff.

Hyundai also introduced in mid-2011 a new Class 7 truck model (HD120) for the distribution of goods, equipped with 195 hp CNG engine.

The CNG filling station operator Gazel from South America has announced that it will invest US\$ 50 million over the next five years in the construction and operation of 40 CNG filling stations in Mexico. The Grupo Dina company (a local OEM vehicle manufacturer) plans to expand its production of a CNG buses via a new model (using Cummins Westport engines). Dina aims to replace 20.000 units of more than 20 years old minibuses in the Mexico City. Already 30 Dina CNG minibuses are put on trial in Guadalajara.

In order to mitigate the adverse impact of volatile fuel prices, the Government of the **DOMINICAN REPUBLIC** in mid-2011 initiated the adoption of a set of measures to reduce oil dependency which includes the gradual transformation of the energy matrix and transport fleet to the use of unconventional fuels such as natural gas. The announcement was made by Minister of Industry and Commerce, who reported that the Government has allocated RD\$ 400 million (US\$ 10.5 million) for the start-up of the conversion plan via the first 1.600 units of public transport vehicles. In May 2011, new licenses were issued to operate 3 companies that import CNG equipments, 20 conversion centres, and 42 new fuelling stations. They will also develop four extended corridors with dispensing points, which will be set from Santo Domingo to all around the East, North, South and Northwest regions. Additionally, the Minister of Industry and Commerce, at that time announced, that the first stage of public transport fleet conversions to natural gas will start in June 2011 at the 35 workshops authorized for kits installations, where the first 5.000 units will be converted. The Government aims to achieve the conversion of 20.000 vehicles before the end of its current administration. In August 2011, a Reservas Bank fund of more than RD\$ 800 million (US\$ 21.2 million) was created to provide financing of natural gas kit installations to 17.000 drivers of passenger vehicles. The owners of the converted vehicles will repay the bank via discounts from the natural gas coupons issued to them. It is important to note that the Dominican Republic already has introduced laws and technical standards regulating conversions and the storage, distribution, and sale of natural gas.

In **TRINIDAD & TOBAGO** a CNG task force was in mid-2011 looking at a US\$ 20 million proposal to convert 400 buses operated by the Public Transport Service Corporation (PTSC) to operate with CNG instead of diesel. The conversion process should take six months. The Government would spend approximately US\$ 2.6 billion on the fuel subsidy and was actively moving to get more of the nation's motorists to use CNG as an alternate fuel to free up funds for development. The Government hopes that the various tax incentives offered to CNG

users would assist in attracting at least 15.000 new users in the following year, and around 100.000 users over a five year period.

Trinidad and Tobago's plans for increasing the use of natural gas vehicles are being translating into action with the establishment of the above mentioned government CNG Task Force launched in October 2010, and with the first of at least five new CNG refuelling stations being commissioned. The CNG Task Force is aimed at diversifying the country's transportation fuel mix as well as reducing the petroleum subsidy bill and the costs of transportation and vehicle maintenance through increased uptake of natural gas. The Government is now actively seeking to accelerate the development of CNG as a major transportation fuel.

The following incentives have been announced:

- Removal of Customs Import Duty on CNG conversion kits and cylinders required to convert vehicles from liquid fuels to CNG.
- Grant of a tax credit to individuals of 25% of the cost of CNG conversion kits and cylinders used in conversion to CNG up to a maximum of US\$ 10.000.
- Grant of Wear and Tear Allowance of 130% of the cost of CNG conversion kits and cylinders used in the conversion of fleets.
- Grant of Wear and Tear Allowance of 130% of the cost of plant, machinery and equipment, required for a conversion centre, excluding installation costs.
- Zero rating of value added tax (VAT) for 5 years on imports of factory outfitted private and commercial CNG vehicles which are no older than 2 years.
- Removal of motor vehicle tax (MVT) for 5 years on imports of factory outfitted private and commercial CNG vehicles which are no older than 2 years.

Trinidad and Tobago National Petroleum Marketing Company Limited has been requested to develop within 18 months, at least 5 new service stations with the capability of refuelling vehicles which use CNG. The task force is charged with the development and implementation of measures required to maximize the use of CNG. These will include updating of the Petroleum (CNG) Regulations, developing a Public education program, monitoring and control of the CNG industry and soliciting and addressing the concerns of the wider CNG stakeholders. Other goals include:

- Over the next five years, transform 15-20% (75.000 to 100.000 vehicles) of the vehicle population to CNG vehicles.
- Introduce a network of up to 20 dedicated and 40 multi fuel CNG filling locations as well as up to 20 CNG installation and inspection sites to provide state-of-the-art service to CNG users.

All new CNG service stations must have the technology to refuel vehicles within a three minute time frame, thereby removing the concern that many drivers have about the length of time it takes to fill the CNG kits.

ASIA

CENTRAL ASIA

Progressively rising natural gas production is transforming **KAZAKHSTAN** from a net gas importer to a net exporter. Natural gas development has lagged behind oil due to the lack of domestic gas pipeline infrastructure linking the western producing region with the eastern industrial region as well as insufficiency in export pipelines. However, the Kazakhstan-China gas pipeline will enable the transport of gas to Kazakhstan's industrial region, and will also enable increased gas exports when it comes online in 2014.

The U.S Department of Energy (DOE) will be working with stakeholders in Almaty to create an NGV roadmap especially for its project in Almaty. Almaty city officials, the Kazakhstani government, and gas company Kaztransgas are working to develop codes and standards for natural gas vehicles and infrastructure as well as training needs. The U.S DOE, Argonne National Laboratory, and Clean Fuels Consulting are using the experience of the successful Clean Cities program to develop a roadmap for these stakeholders. To develop the roadmap, DOE is compiling input from a range of stakeholders including the Almaty city government (the Akimat), KazTransGas, the national Kazakhstan natural gas company, British Gas Kazakhstan (which built the first CNG fuelling station), a variety of the NGV equipment suppliers engaged in the project, local research institutes, and the principal funding institutions, the European Bank for Reconstruction and Development and the United Nations Development Program. The roadmap will elaborate the stakeholders' various goals, opportunities and challenges in implementing a long term NGV program. Almaty Electrotrans (AET), the municipal bus company, will deploy 200 new CNG fuelled buses over the course of 2011, supported by a US\$ 35 million loan from European Bank for Reconstruction and Development (EBRD). The first 20 buses were delivered in December 2010. All 200 buses are anticipated to be in service during the second quarter of 2011. AET awarded the bus contract to Zhengzhou Yutong, a Chinese company that uses Cummins-Westport, Inc. C Gas Plus natural gas engines. The initial roll-out of 20 buses occurred in time to support the Asian Winter Games slated for the end of February 2011. British Gas completed a filling station for the buses in July 2010 capable of serving 240 buses. More stations are planned for the city by KazTransGas, a distribution-focused subsidiary of national oil and gas company Kazmuniagas, with the hope that private bus operators and other fleet operators see the benefit of this new, cleaner transportation technology. Once the pilot program is launched successfully in Almaty, the gas company plans to create a network of CNG stations (up to 100 CNG stations will be built across the country) ultimately supported by 50,000 NGVs. As part of this "Concept on Expansion of CNG as a motor fuel for 2010-2015" investments within this 5-year period will total US\$ 135.5 million. Cooperation between the U.S. and Kazakhstan in the transport sector is a new initiative of the U.S.-Kazakhstan Energy Partnership. Seeking to improve the country's environment and to encourage conversion of private car owners to CNG the companies are seeking to involve the government by offering to adopt an official state program, which envisages a number of preferences including changes into the taxation system in favour of owners of transport vehicles and bus/ taxi fleets using CNG as a fuel for their vehicles.

South Korean chemical and construction conglomerate Kolon Group has recently signed a preliminary agreement with the state-run KazTransGaz to build 100 compressed natural gas filling stations in the Central Asian country by 2015. Both Kolon and KazTransGaz will establish a joint venture for this project, which involves a US\$ 250 million contract to develop CNG fuelling infrastructure across Kazakhstan's major cities.

ARMENIA is the most developed country in the field of NGVs among the countries of the FSU. With the total vehicle fleet in the country of about 380 thousand it has about 100 thousand NGVs and 306 refuelling stations. Sales of CNG grow 5 to 8 percent annually. In 2010 Armenian NGVs consumed 318.3 Mcm of natural gas. Practically all taxi cabs and light duty buses (minivans) use CNG. For now no incentives are offered by the state. The fast development of NGVs in the country is explained mostly by economic reasons: natural gas for vehicles is the cheapest motor fuel: CNG: 0.38€/ncm; gasoline–95: 0.91€/l; diesel: 0.83€/l.

UZBEKISTAN started a CNG program in February 2007 through a wide-scale state conversion program. The country plans an expansion project to widen its CNG filling facilities. The state-owned gas corporation Uzbekneftegaz (UNG) will develop 100 CNG filling stations in three phases, beginning in March, May and July to October 2011. Officials estimate that 29 percent of total vehicle population in the country will be powered by natural gas by 2015. UNG has apparently announced a tender for purchase and supply of the stations, specifying installation in three phases starting March and ending October 2011 and a per station capacity of minimum 2.4 million cubic metres. By 2015, Uzbekistan plans to put into operation 352 compressed natural gas (CNG) filling stations.

In January 2011, Kolon Group announced it will spend US\$ 83 million over the next four years to build 50 CNG stations in Uzbekistan, as the company attempts to expand its global energy business in the Asian market.

U.S firm Honeywell will carry out a project to produce CNG conversion kits and fuelling components in Uzbekistan. Together with Uzbekneftegaz, Honeywell plans to execute several joint projects over the next three years (starting in 2011). At the first stage, Honeywell will organize the production of engine compartment equipment worth US\$ 7 million for the vehicle conversion project. Around 100.000 units of this product will be manufactured on annual basis. It will also be involved in the establishment of a facility to produce CNG fuelling components (automated systems, fuel injection). The US\$ 5 million investments will be used to generate 200 units of this product per year. This project is scheduled for 2012. Uzbekistan in early 2007 adopted an NGV program aiming for a gradual switch of traditionally-fuelled vehicles to NGV system. This project will last until end of 2012.

EASTERN ASIA

The availability of natural gas in **CHINA** is growing year by year due to the completion of significant domestic pipeline infrastructure projects that connect to neighbouring countries' pipelines. Likewise, the amount of imported LNG in coastal areas of Southeast China is steadily increasing. This relatively recent abundance of natural gas provides the backdrop for the development and growth of NGV usage in China. In mid-2011 there were a total of 550.000 NGVs and nearly 1.700 natural gas refuelling stations in China. These figures are increasing rapidly each year, encouraged by more than 60 NGV OEMs (car makers) that have developed in China. In relation to the number of NGVs, the capacity of the existing fuel stations is still insufficient. This raises the familiar “chicken or egg” problem found in many developing areas. Fortunately, both the government and the natural gas station operators realize the importance of building more refuelling stations. For example, Hainan Province plans to add 100 CNG and LNG stations by 2014, while Dongguan City in Guangdong Province plans to have 60 stations by the end of 2020. To encourage more vehicles to use CNG fuel, the Lianyungang and Xuzhou governments provide a subsidy of 2.000 Yuan to car owners for retrofitting. These policies and actions have delivered a positive signal indicating that the natural gas fueling market will be prosperous in the following years. Since late 2009, conversion of heavy-duty vehicles (HDVs) to LNG system has been very popular. In 2010, Xinjiang Guanghui alone, planned to produce/convert 3.500 LNG-powered vehicles and build

60 LNG filling stations. The target continues as 30,000 LNG vehicles and a total of 300 stations are expected to be operated within the next 3-5 years. Infrastructure expansions are also on the agenda. There are projects on installation of natural gas liquefaction plants (the Northwest projects) initiated. Meanwhile, the first LNG marine boat in China was operated in August 2010. The boat ran along the Yangzi River from the Western part of the country to East of China. For the marine routes, 10 LNG standard filling stations plus 80-100 mobile stations are planned along Yi Chang City – Wuhan Central, each covering 600 km long route. Apart from that, LNG is gaining momentum in China via public bus projects in some cities in the South of China, like SanYa, Haikou Hainan Island, Shengzhen, FeShan and Guiyang etc, which have been in operation since few years ago.

By 2015, three lines of natural gas infrastructure are expected to be completed:

- The first is the West-to-East Natural gas pipeline project which was initiated when the West-to-East line was built five years ago. It supplies 12 billion Nm³ of gas annually.
- The Second extension of this West-to-East line offers 30 billion Nm³ gas per year from Uzbekistan, Kazakhstan, and Russia to China.
- 20 billion Nm³ gas per year is transported through this pipeline from Sichuan to the East of China.
- The third extension of West-to East line is under consideration...
- There are LNG Terminals been operated in GuangDong, Fujian and Shanghai. More LNG terminals are soon going to be built up and operated in the Zhejiang, Jiangsu and Liaoning provinces.

The constructions of more LNG terminals along the coastal areas offer big opportunities for after-market conversion business, especially those in heavy-duty trucks and trailers segment. Presently, there are around 50,000 trucks used for transporting coal and raw materials to heavy industry areas for power plants and steel related factories which are considered to be powered by LNG. More and more LNG buses will be operated near these coastal areas. The cost of converting HDVs to LNG mode can be regained within very short time. The distribution of gas in areas nearby the existing (and future) natural gas pipelines is good. However, other surrounding areas outside this gas distribution network and pipeline system have no access to gas. This provides a good opportunity for LNG related businesses.

China plans to invest up to US\$ 1.5 trillion over five years in seven strategic sectors aiming at accelerating its transition from the world's supplier of cheap goods to a leading supplier of high-value technologies. The seven sectors include alternative fuel cars, biotechnology, energy saving and eco-friendly technologies (for power generation), alternative energy (to reduce oil import and coal usage), high-end manufacturing, advanced materials, and new generation information technology. Also, China is pledged to cut carbon emissions per unit of GDP by 2020 by 40-45 percent from 2005 levels. In the car sector, the chosen technologies include those using CNG, LNG, electric, hybrid, fuel cells, and LPG. Producers of NGV component from China are also expanding their market coverage overseas.

Currently China has self-developed pressure reducers, electronic control units and gas nozzles of NGVs. Those special components have entered the market. The annual production capacity of natural gas cylinders has reached 800,000 units. Type 1-4 CNG cylinders and also LNG cylinders are produced. Generally speaking, there are many manufacturers of equipment for natural gas filling stations, but the production scale is comparatively small. China has developed its own purification facilities, storage facilities, compressors and dispensers for stations. That equipment represents 90% of the domestic market shares, some of them even 100%. The locally-developed components and facilities largely reduce the cost of the vehicle production and station operation, and contribute to the large-scale operation of NGVs.

The State Council Development Research Center has released a “New Energy Vehicles in China Development Strategy Study” that gives a clear picture of the future path of alternative fuelled vehicles (AFVs) in the country. By 2020, car ownership in the country is expected to reach 140 million and around 200 million by 2030. According to target and projection, by 2025, only half of passenger cars will use gasoline as fuel source. The other half will use advanced diesel, gas, biofuels, and other new energy sources. It is expected that by 2020 biofuels and fuel cells will play an important role in replacing gasoline in cars.

Three new-energy vehicles production lines for dedicated electric vehicles, hybrids, plus CNG and LNG vehicles will be installed in six automotive plants in five cities in line with Sichuan’s provincial auto-industry development plan for 2010. Throughout China, the investment in new-energy vehicles is likely to reach 4.5 trillion yuan (US\$ 661.4 billion) for the period of 2011-2020. Various incentives like exemption from purchase tax and taxes on use of vehicles and ships are expected to be offered by the government.

Under the 2010 "Promotion Year" for the provincial auto-manufacturing sector, the province is to mainly focus on six auto projects, with a total investment of 17.7 billion yuan (US\$ 2.6 billion). The project involves the construction of six auto industrial parks in the cities of Chengdu, Ziyang, Mianyang, Nanchong and Neijiang, where the alternative fuel vehicles will be manufactured. In addition, Sichuan also aims to widen research and development of new energy-powered cars and practical applications, as well as technologies for batteries, battery charging systems, engines and electronic control systems. Soon the authority will release the final report of the development plan for China's energy-saving and new-energy vehicles industry in the period 2011 to 2020. The Declaration of China Automotive Technical Innovation (or “Changchun Consensus”) was agreed by representatives of 13 major domestic carmakers, including the producers of bi-fuel cars and/or dedicated CNG buses FAW Group Corp, Dongfeng Motor Group, Chery Automobile Co Ltd, etc. Among other aspects of the pact, the automakers agreed to set up a pan-industry platform to discuss standards, cooperation, technology, quality and sustainable development, as well as to develop new-energy technologies in the industry. Sinopec would also gradually begin to provide LNG and electric vehicle charging services in more than 29,000 units of its gas stations throughout China.

China’s NGV Light-Duty Vehicles selection consists of various types, amongst others, motorcycle, dedicated CNG or bi-fuel autorickshaws, bi-fuel tricycles for disabled persons, passenger cars, minibuses, light-duty trucks. The automakers consists of Astro Motor Technical Co., Auto Rickshaw, China Chongqing Big Science & Technology (Group), Chinese Motor Industrial Co., Chongqing Hengtong Bus Co., Ltd., Chongqing Rightway Industry Corporation Limited, Chongqing Tengzhou Moto Co., Ltd., Biyadi Automobile Co., Ltd, Chery Automobile Co., Ltd, Chongqing Chanan Suzuki Automobile Co., Ltd, China CNG Bus, Dongfeng Citroën, Dongfeng Automobile Co., Ltd, Dongfeng Peugeot Citroen Automobile Co., Ltd , Dongfeng Yueda Kia Automobile Co., Ltd, FAW, FAW Volkswagen Automobile Co., Ltd, Honda, JMC Brand, CQBUS – Kingtonliyang, Lifan, Mudan , Shanghai Volkswagen Automobile Co., Ltd, Shenyang Brilliance Jinbei Co., Ltd, Tianjin FAW Xiali Automobile Co., Ltd, Toyota, Geely, etc.

Shaanxi Auto will develop LNG heavy-duty trucks for long-distance transportation providers, while CNOOC Gas and Power Group will provide the necessary LNG filling stations along the operating routes of the trucks. The CNOOC Gas and Power Group is a wholly-owned subsidiary of the CNOOC Group, China’s biggest offshore oil producer, which is also the parent company of CNOOC Ltd.

The carmaker's proposal to industry regulators is to include LNG heavy-duty trucks in the central government's new-energy vehicle subsidy program. Shaanxi currently has technological cooperation with Germany's MAN AG to make heavy trucks. According to the vehicle industry prognosis, 30% of total vehicles in this country will be powered by natural gas by 2020. Local industry executives indicated that gas supply and future price changes would be the biggest challenges in developing the NGV segment in China, as under government control natural gas may lose its price advantage over petroleum.

The number of NGVs in **JAPAN** is almost saturated within a few years. To break this situation and to disseminate NGV, Tokyo Gas has developed gasoline/CNG hybrid vehicle as a concept car. The base vehicle is the Sai produced by Toyota. This gasoline/CNG hybrid vehicle was developed as a concept car to show the potentiality of natural gas as transportation fuel; however there is currently no plan to sell this vehicle. In spite of the above, Tokyo Gas will conduct; further modification, gathering and verifying several performance data such as fuel consumption, exhaust gas content etc.; demonstration in the several exhibitions to contribute further dissemination of NGVs. Recently two additional gasoline/CNG hybrid vehicles were manufactured, one is for Tokyo Gas and the other is for Hokkaido Gas Company, Ltd.

In order to reduce CO₂ emissions and increase NGV adoption and cost efficiency of CNG filling stations, the Japan gas industry has adopted a policy to support the development of "high-efficiency CNG trucks" for long distances. Major retailers and manufacturers are considering a switch to CNG trucks for long-distance intercity routes as well, but not much progress has been made in the development of CNG models by truck producers. The Japan Gas Association (JGA) has therefore decided to support this development and JGA conducts demonstration travelling project in which major freight companies in Japan participate. In taking this step Japan will also be following the example South Korea.

Thirteen Japanese companies have turned their attention to hydrogen. A joint press release (January 2011) included the following details regarding the launch of fuel-cell vehicles (FCVs) in the Japanese market in 2015 and the development of the hydrogen supply infrastructure necessary for the successful adoption of the vehicles. As development of fuel-cell systems progresses, Japanese automakers are continuing to drastically reduce the cost of manufacturing such systems and are aiming to launch FCVs in the Japanese market - mainly in the country's four largest cities – in 2015.

- Hydrogen fuel suppliers are aiming to construct approximately 100 hydrogen fuelling stations by 2015, based on the number of FCVs expected to initially enter the market, to ensure a smooth launch and to create an initial market.
- With an aim to significantly reduce the amount of CO₂ emitted by the transportation sector, automakers and hydrogen fuel suppliers will work together to expand the introduction of FCVs and develop the hydrogen supply network throughout Japan. The two groups are looking to the government to join them in forming various strategies to support their joint efforts and to gain greater public acceptance of the technology.

As a specific strategic initiative in the immediate future, the companies plan to approach local governments and other concerned parties to discuss strategies for creating initial consumer demand for FCVs and for the optimal placement of hydrogen fueling stations, targeting Japan's four major metropolitan areas (Tokyo, Nagoya, Osaka and Fukuoka). The companies include: Toyota Motor Corporation (TMC), Nissan Motor Company, Ltd., Honda Motor Company, Ltd., JX Nippon Oil & Energy Corporation, Idemitsu Kosan Company, Ltd., Iwatani Corporation, Osaka Gas Company, Ltd., Cosmo Oil Company, Ltd., Saibu Gas

Company, Ltd., Showa Shell Sekiyu K.K., Taiyo Nippon Sanso Corporation, Tokyo Gas Company, Ltd. and Toho Gas, Company, Ltd.

Kawasaki Kisen Kaisha Ltd. in July 2011 unveiled plans to develop a car carrier that uses LNG as fuel and is expected to cut carbon dioxide emissions 40% over vessels running on fuel oil. The marine shipper will develop the carrier with Kawasaki Heavy Industries Ltd. and the Norwegian body (DNV) that approves technological standards for ships. The carrier is expected to be 143 m long and be able to ship around 2.000 cars. It will be fitted with Kawasaki Heavy's gas engines. NO_x emissions also will be 80-90% lower than with conventional diesel engines. The ship is set to start operating in 2015. Kawasaki Kisen will use the carrier to meet tougher European exhaust standards and deal with surging fuel oil prices. Once complete, the ship will be operated by a company transporting cars in Europe.

SOUTH KOREA has secured sufficient gas supplies from all around the world, e.g. from Iraq, Saudi Arabia, and Canada (with shale gas). Additionally, South Korea has opted for bio-dimethyl ether (DME) or hydrogen fuel cells as well as biogas. In April 2011 Kogas signed a memorandum of understanding (MOU) with Malaysia's government-backed firm Biotechnology to produce compressed biogas.

This country started its NGV programme by adopting CNG medium and heavy duty (MD-HD) buses (as of December 2010, around 26.000 CNG buses and some 900 garbage trucks operate in South Korea) and later by adopting other CNG or LNG-powered HDVs. But they did not include cars and other LDVs due to concerns about the safety of having the fuelling facility within cities area (due to earlier explosion of an LPG car). By the end of the 1st quarter 2010, the Gangwon Province government presented an agreement that offers loans to convert taxis to bi-fuel technology in the Gangwon Province. The Gangwon government aims to increase the number of taxis operating on CNG. The agreement was signed in Chuncheon City. The pact was inked by the Gangwon Credit Guarantee Foundation (GCGF), Provincial Independent Taxi Drivers Council and NGVS, vehicle conversion subsidiary of NGVI. GCGF will secure loans to cover conversion expenses and drivers will be exempt from interest over a certain payback period. Around 4.500 independent taxi drivers in Gangwon Province could benefit from this agreement.

Further developments on the heavy-duty side include the first CNG hybrid bus fully developed in Korea by Hyundai Motor Company. The bus delivers fuel efficiency with lower emissions by using a CNG engine and an electric motor. "Blue-City" meets and even exceeds the performance and efficiency of existing CNG buses (despite cutting down the total number of fuel tanks to five from seven) and it can still operate 340 km on a single charge, which is equivalent to the existing CNG bus. Furthermore, while its climbing performance of 30 percent is similar to a conventional CNG bus, the maximum speed stands at 100 km/h, which is ideal for a metro bus. The fuel efficiency of "Blue-City" is about 30-40 percent higher than that of normal CNG buses, enabling metro bus operators to save costs. In terms of CO₂ emissions, the CNG hybrid bus emits over 24 percent less CO₂ than a conventional CNG bus and 35 percent less than a diesel bus. Hyundai will operate 30 test units of "Blue-City" in selected metropolitan areas from July, with plans to mass produce the vehicles in 2012.

SOUTH-EASTERN ASIA

To curb oil import, the Government of **INDONESIA** and the National Energy Council (Dewan Energi Nasional or DEN) will revitalise the use of CNG in transport sector. To promote the fuel, DEN announced its intention to launch the "Go Gas" program in mid-2011. The program will also include the inauguration of revitalisation of 20 CNG filling stations. About 20 percent

of all vehicles in Jakarta are expected to switch to CNG during the first year after the campaign. The Governor of Jakarta has ordered all city offices and public transportation vehicles to switch to CNG starting in 2012. The necessity to offer incentives for the purchase of vehicle conversion kits was highlighted. However, this topic still needs to be discussed with the Directorate of Land Transport and the Ministry of Finance. In the meantime, kits are bought with the support of a loan system, following an example from the neighbouring country, Thailand.

The government sees that the price standardisation is important to support the operation of 524 Transjakarta buses in the existing 10 corridors in Jakarta Province. With this pricing policy, CNG bus operators would refuel in any of the available stations instead of queuing at stations with cheapest gas price. Consequently, the buses would arrive at each bus stop with less delay.

Interesting activities can be observed in the off-road segment. The Ministry of Oceans and Fisheries of Indonesia will provide 200 CNG cylinders for fishing boats to help fish farmers reduce their operational costs. The fuel cost for fishing boats is about 60 percent of total expenses in operating the boats. Before the full implementation of diesel to gas boat conversion is carried out, a trial project needs to be arranged. Presently, fuel supply is still a challenge that needs to be resolved. The first trial will be done in Pasuruan City in the East Java Province. Several small gas fields in six different areas in East Java will be exploited and used as refuelling terminals. Should this pilot project succeed the ministry, through Directorate General Fisheries, will apply the programme to fishing centres in nine different locations all over the country.

In **MALAYSIA** presently, only taxis and rental vehicles are using NGVs. Private car owners have not converted their vehicles as the retrofitting costs are still considered to be high. The government has also been promoting CNG use in transport, for example by offering zero import duty (100 percent import duty exemption) for conversion kits. The Petronas NGV unit is responsible for monitoring the service centres that are eligible for the exemption. To date, 110 service centres for NGVs are in operation nationwide. A 25 percent discount on road tax is offered to owners of bi-fuel and dual fuel vehicles, while those operating dedicated CNG vehicles (to run on 100 percent CNG fuel), get 50 percent discount. Nevertheless, industry stakeholders expect that the price gap between CNG and traditional fuels will soon be large enough to motivate more and more people to switch to NGVs.

Malaysian NGV Sdn Bhd has reported its plan to open 200 CNG fuelling stations nationwide by end-2011. The scheme will be launched under the concept "One Gas Clean Energy For All". Under this concept, everyone is welcome to participate in the project. Participants should have land of more than 33.000 sq ft in a strategic location, within a main town. Malaysian NGV Sdn Bhd has the permit to market and distribute natural gas vehicles. The company was incorporated in Malaysia in January 2005. It is a distributor of natural gas under the brand GOGAS, specialist in conversion kits, re-powering diesel engines to NGV and a local manufacturer of NGV buses and lorries.

Hexagon Composites ASA's business unit, Lincoln Composites has signed a contract with Sime Darby Sdn. Bhd. for the supply of 30 foot TITAN^(TM) high-pressure tanks and storage modules for use within Malaysia. The high pressure composite containers for Malaysia will provide a capacity increase allowing transport of twice as much gas as conventional steel solutions, while reducing the overall gross vehicle weight by several metric tons. This payload increase will allow fewer trailers to transport more gas throughout the country, reducing road congestion and increasing gas transportation operating efficiency.

Public utility transport operators in the **PHILIPPINES** who want to use brand-new CNG buses in their fleets can now apply for franchises with the Land Transportation Franchising and Regulatory Board (LTFRB). Transportation Secretary has ordered the exemption of CNG-powered public utility buses (PUBs) from the franchise moratorium. The government imposed the moratorium to curb the rise in the number of buses plying Metro Manila roads, exacerbating traffic jams and pollution in the process.

Based on the revised Philippine Energy Plan (2005-2014), the government had planned for 200 CNG buses to operate along the Batangas-Manila route in 2006 expanding to 2,000 CNG buses on the road, supported by 10 CNG refuelling stations by 2007. It was originally intended that the initial 200 CNG buses would be fuelled by Philipppians Shell Petroleum Corp (PSPC); however the fleet size has reached just 60 units, of which only 17 are reportedly fuelled by PSPC. Although Shell and Chevron have apparently indicated their intention to give up the CNG refuelling facility, with negotiations mooted to be finalized as early as November 2010, operators of compressed natural gas buses in Luzon, the largest island of the Philippines, urged the Department of Energy (DOE) to reinvigorate the Natural Gas Vehicle Program for Public Transport (NGVPPT) requesting from DOE to look for alternative CNG mother-daughter facilities. Diversification of gas suppliers is also sought. It is hoped DOE interest in reviving the NGVPPT program will stimulate investment in natural gas refuelling infrastructure and buses. Lately, problems occurred with natural gas supply to buses at the peak season; also during the Holy Week time buses had to remain at the station for more than four hours waiting for supply to arrive. Positive developments in this aspect are underway. In June 2011 the pilot mother-daughter CNG facilities owned by the Shell companies were about to be taken over by the government through the Philippine National Oil Company – Exploration Corporation (PNOC-EC) although negotiations are still underway since Shell expressed interest in making additional investments and building CNG filling stations once the government has put in place the required gas pipeline infrastructure. PNOC-EC plans to invest into the construction of another CNG mother station and two daughter stations.

Bus operators are seeking relief in CNG with the continuous increase in prices of diesel and the recent increase in toll fees. In early April, the Department of Energy was reported to be finalizing its Fuelling Sustainable Transport Program (FSTP), aimed at converting public and private vehicles from diesel and petrol to CNG, LNG, LPG and electric power. Diesel jeepneys are also expected to be converted to the CNG systems and to electric power.

In relation to above, the DOE has signed a Memorandum of Agreement (MOA) with large transport groups, for an eco-jeepney program which will promote the use of CNG and LPG engines. As part of a Green Transport initiative the program will aim to convert as many diesel-run jeepneys as possible, helping to reduce the nation's dependence on oil, and has been given priority status.

Also, the DOE wishes to see around 1,000 CNG buses plying in the country (around Manila) in the short term.

Furthermore, it is worthwhile mentioning is that the Ministry of Transportation and Energtek have successfully completed a road test of a CNG tricycle in mid 2009. The result of this study shows that CNG system is safe. In this trial project, Energtek installed a CNG conversion kit (CNG Lite System) in the vehicle. The unique vehicle, commonly powered by diesel, is different from other Asian countries' three-wheelers although it has the same functions as a small passenger vehicle. So far, the lack of sufficient refuelling facilities caused a sluggish development in NGVs adoption in this country. Nevertheless, many NGV/station related companies see this country as a "potential market".

To support eco-friendly activities towards cleaner environment in **SINGAPORE**, the government (Ministry of Finance, Ministry of the Environment and Water Resources, Ministry of Transport, Land Transport Authority and National Environment Agency) has been granting a Green Vehicle Rebate (GVR) since 2001. The rebate offers refund and tax breaks for users of CNG, Electric, and hybrid vehicles. The government has decided to extend the GVR scheme to the three vehicle segments mentioned above. The scheme is applicable from 1 January to 31 December 2011. However, from 2012, CNG will be excluded from the scheme while the electric and hybrid vehicles owners will still benefit from it. CNG taxi fleet operators are seen as the most affected parties by the duty implementation. Presently Singapore has 2.700 CNG taxis. Nevertheless, even with the duty imposed, CNG will still be cheaper than petrol or diesel.

Trans-Cab Services Pte Ltd, a taxi operator in Singapore, will add 3.000 CNG-powered taxis in its fleet. One thousand out of 2.600 taxis owned by the company already run on CNG. The bi-fuel taxis are due for full delivery by mid 2011. Transcab have some 1.000 taxis currently operating on CNG and intend to increase this number by another 3.000 units in the next one to one-and-half-years. Singapore is home to the largest compressed natural gas (CNG) station in the world, the station is about to have 44 dispensers (22×2) for cars and 2 dispensers for buses and trucks.

With stricter requirements for environmental performance, and an expected increasingly competitive price for LNG as fuel for ships, a shift to LNG propulsion may have an exciting impact on Singapore as a bunkering hub. With the push towards cleaner fuel for ships, the results of this joint industry project are timely in evaluating the potential for LNG bunkering services in Singapore. The consortium is made up of 16 participants from all parts of the LNG value chain. Among the members are Gazprom, Rolls-Royce, Wartsila, Hanjin Shipping, I.M. Skaugen, Keppel, The Linde Group, Trans LNG, DNV, BW group, BBG, the Maritime and Port Authority of Singapore, the two Singapore universities, NUS and NTU.

As **TAIWAN** does not have sufficient gas pipeline infrastructure for CNG, the country is now considering the use of LNG in the transport sector instead. The CTCI Chemicals Corporation has been appointed by the Environmental Protection Agency (EPA) of Taiwan to conduct a pilot project on LNG vehicles and fuelling stations in a city in Taiwan. According to the plan, in about three years (starting mid-2010), 25 to 50 garbage trucks would be modified to use the LNG system. A fuelling facility will be constructed to facilitate this fleet. The station would be built near an LNG receiving terminal in Taichung City in the centre of Taiwan. Presently, Taiwan has two LNG terminals, in the south and centre of the country. Recently, the EPA submitted a project of 40 refuse trucks to all Environmental Protection Bureaus (EPB) of Taiwan. The interested EPB would get the financing from EPA as proposed in the plan. CTCI has conducted a study of the technical requirements for the implementation of this project. The proportion of OEM NGVs was prominently 90% for HDVs and 60% for LDVs.

There has been a tremendous, never-before experienced increase of OEM produced NGVs in **THAILAND**. Most LDV customers consider the safety and warranty from automobile manufacturers as highly important because the warranty of converted NGVs from local CNG workshops will be terminated automatically. Meanwhile the OEM NGVs will offer the warranty of chassis and engine like other automobiles from the factories. They mostly provide 3 years or 100.000 km warranty. Due to the hike in the diesel price in 2008, transport entrepreneurs became interested in using CNG during the period of economic recession, the aim being to reduce energy costs. The OEM HDVs (bus, truck and trailers) were pioneered by vehicle importation from China. A huge increase in the number of OEM NGVs is expected in the near future.

OEMs model presence started in 2005 with Mercedes Benz E200 NGT at first imported, then manufactured directly in Thailand. Chevrolet CNG started to enter the market in 2007 by working with local CNG conversion workshops (models Optra, Estate and Colorado pick-up). The Mitsubishi Lancer CNG variant is also developed by a local company followed by Mitsubishi Triton CNG pick-up fully manufactured in the factory. Toyota Hilux Vigo Pickup has been developed by a private local company (done by retrofit centre). Hyundai and Proton also penetrated the market with Hyundai Sonata CNG (retrofit) and Proton Persona CNG (retrofit). TATA Xenon Super CNG (OEM) entered the market at the end of 2008. As already mentioned above, the OEM HDVs in bus, truck and trailer segments were initiated via importing from China. At present, two manufacturing companies have entered the OEM HDV market: Hino and Isuzu with a variety of models. TATA is present in the medium-duty segment via one-tonne pick-up trucks and has announced its plans to introduce its tractor trucks to the market in September 2011.

On the other hand, Government is also providing support for the conversion sector which varies from road and excise tax reductions, conversion funding, as well as import duty exemptions for CNG conversion kits, new CNG engines etc.

The Transport Ministry of Thailand has successfully launched a CNG taxi conversion project in Bangkok City by the beginning of February 2011. The government aims to attract 15,000 more taxis to switch their vehicles to bi-fuel CNG/petrol system. Bangkok City has about 70,000 taxis. Half of those are powered by LPG and the rest by CNG. Following a decision to maintain subsidy on LPG in transport, the government wish to see LPG taxis owners switching their vehicles to CNG. The aim is to cut LPG demand and reduce the country's fuel costs. Without the conversion, LPG consumption would remain high and this would encourage the Oil Fund to continue with the subsidy. Financing scheme includes THB 5,000 for the installation of CNG conversion kit in each taxi. The ministry initially provides THB 1.2 billion for this program, with a budget per taxi of THB 40,000. The cylinders and conversion kits (under the financing management of the Oil Fund) were expected to cost THB 5,000 per taxi, while the remaining THB 5,000 is the cost of installation. Conversion centres are attracted to join the program. Also, CNG costs only half of LPG price. However, most LPG taxi drivers in Bangkok prefer not to convert their cars as long as LPG is subsidized.

In 2010, the CNG share of the total transport fuels reached 10 percent. PTT expects that the share will increase to 14 percent in the next five years (2015). To ensure the stability in the growth of NGV and CNG consumption, vehicles retrofitted to NGV system are banned from being switched back to diesel. Additionally, pipeline and station expansion programmes are also on the agenda. In 2011 the station number is expected to rise to 500, whereof about half in Bangkok and the Greater Bangkok area. This means that around 75 additional dispensing facilities would be constructed within this year alone.

Thai government incentives implemented to promote NGV:

Import Duty:

Import duty exemption for:

- CNG cylinder and conversion kit type 2-4 until December 2011.
- New engine for dedicated NGV system, exemption applies with no time limit.
- Imported CKD (Complete Knock-Down) bus chassis with engine with no time limit on the waiver, except for CBU (Complete-Bus-Unit) chassis with engine in which the waiver applies until December 2011 only.

- Imported CKD Passenger Van until Dec. 2012.
- Import duty for CNG refuelling facilities reduced to 1% (no time limit)

Excise Tax:

Reduce excise tax for:

- OEM passenger car and minibus not over 3.000 cc. engine from 30% to 20% (no time limit);
- NGV retrofit outside vehicle manufacturing plant from 30% to 22% but not exceed US\$ 1.500, applies until December 2011.

Others:

- Revolving fund through 11 Thai commercial banks for “all converted natural gas vehicles” with lower interest rate up to March 2011.
- Energy Conservation fund for “Public buses” that are operated in Bangkok City and surrounding areas which can be converted to CNG vehicles with a very low annual interest rate of 0.5% until December 2010.
- 50% reduction of road tax for dedicated NGVs and 25% for Bi-fuel or DDF (no time limit).

Thai Ministry of Transport will push forward the 4.000 CNG buses leasing programme as the result of Bangkok Mass Transit Authority’s (BMTA) survey shows a rising acceptance of NGV buses among the people. Around 81 percent of the 5.730 survey respondents (BMTA’s bus passengers) are positive about the idea of using new CNG buses. The majority of the respondents expect that the government will set a flat passenger fare at 30 THB/day.

Number of activities is also registered in the off-road segment.

Family Transportation Co. Ltd., a boat taxis servicer on Saen Saeb canal in Bangkok, has joined with PTT in using LNG by converting 72 boat taxis to run on LNG/Diesel (dual fuel).. The project started in November 2009. Until now, 12 boats were installed with LNG conversion equipments. LNG replacement is 50 percent. A ship can contain one 450 liter LNG cylinder and it can transport passengers for 1.5 days (around 160 kilometres) before refilling LNG.

In line with the government green initiatives, Jenjosh Group, a vessel (ship container) designer and builder from Singapore, plans to build a fleet of CNG-powered ships. CNG vessels would require a niche market to sell. Thailand is such a market as it already has an LNG supplying facility at the outskirts of Bangkok. The site is capable to dispense 50 tonne/day of LNG, enough to refuel 10 LCNG passenger boats that sail in Chao Phraya River in Bangkok since January this year. The boats were converted to dual-fuel CNG/diesel (dual fuel) technology. Each vehicle has an LNG tank onboard and a vaporiser transforming the LNG into gaseous phase before the fuel is injected to a dual fuel engine powering the boat. The opportunity in Thailand thanks to several factors: the retail price of CNG is about 2.5 times lower than diesel and there is sufficient demand for river transportation between inland factories and Thailand's main port of Laem Chabang. Thai partner believed that there is an opportunity to replace tugs and barges currently used to transport the containers with CNG ships. Currently, twelve of these ships are being built. The first two units are already plying in Thailand. When fully implemented, the twelve vessels would serve only 2% of container volume presently going into Laem Chabang. Another ambition is to build a regional

feeder 1.000-TEU container vessel capable to cover a large mileage of 1.500 nautical miles. The vessels could be used to sail between Asian countries. The company sees opportunities to offer its CNG product to Indonesia, Vietnam and other parts of Thailand.

Capital City of **VIETNAM**, Ho Chi Minh (HCM) will improve the service quality of its public buses. Transportation authorities in the city plan to replace some of its large buses with smaller ones to improve its mobility in crowded streets. Around 1.680 new buses will be incorporated in the fleet within the next five years. During 2013-2015, HCM will purchase 700 new 40-seater buses and 409 units of 55-seater ones. All buses must comply with the EURO 3 or higher emission norms, or have the CNG technology. As for the financing scheme, buyers of these buses will have to pay a 20 to 30 percent deposit of the total price. The rest of the cost will be covered by seven-year soft-loans. The government original plan, as announced in 2009, was to have 800 CNG buses in HCM City by end of 2011. By December 2009, there were only 2 buses, converted by the Koreans, running on this fuel. In August 2011 were introduced 21 new CNG buses to HCM City.

SOUTHERN ASIA

Until mid-2011, **BANGLADESH** invested in total Tk 15 billion during previous last seven years to establish 600 CNG filling stations and 150 conversion workshops. Bangladesh saves almost Tk 12 billion foreign currency on import of petroleum annually, since the country uses CNG in transport. The positive movement in NGV sector is not without challenge. First challenge is the gas and power shortage followed by temporary restrictions on the opening time of CNG filling station. Due to the crisis in the supply of gas, the Ministry of Power, Energy and Mineral Resources (MoPEMR) created zoning principals for the establishment of CNG filling stations across the nation. The government would not approve installation of CNG dispensing units in certain areas without special instruction or authority request. However, the regulation does not apply to Dhaka and Chittagong cities. The second challenge is the price gap between gasoline/diesel and CNG. The trend of increasing CNG price seems to hit South Asia. In Bangladesh, the government has increased the price of CNG in May 2011 to Tk 25 from the earlier Tk 16.75 per cubic meter. The BERG (Bangladesh Energy Regulatory Commission) officials, however, did not provide any estimates on the impact of the decision to increase CNG price by nearly 50 percent at one go would have in the mass transport sector. Currently 50 percent of all buses use CNG.

With the aim of battling traffic congestion in the Bangladesh capital, Dhaka City, the government is about to impose restrictions on cars plying the city streets and will construct a circular railway. The government is also considering passing a law to control the buying of cars and sports utility vehicles. Also, there will be an introduction of modern taxi service, stopping CNG conversion of non-commercial small vehicles, relaxation of loan conditions for the purchasing of large buses, restrictions on the setting up new CNG filling stations, and discouraging of the use of more than one vehicle by a single family. However, there is no restriction for conversions of small commercial vehicles and other types of vehicles to CNG propulsion. The ruling would apply in Dhaka City only. In the summer of 2011 a Dhaka City project focussing on improved waste management and environmental improvements led to a plan to convert 45 new diesel trucks used for refuse collection in Dhaka City to CNG propulsion. At least 13 cities in Bangladesh have CNG filling stations. Apart from Dhaka, Chittagong also has a big share of NGVs.

The Bangladesh Road Transport Corporation (BRTC) will soon add 175 CNG buses to its “eco-bus” fleet in Dhaka city. BRTC will use the balance of a previous funding program provided by the Nordic Development Fund, to import CNG buses. The Fund offered Tk 900

million financing but BRTC paid only Tk 325 million in February 2010 for 100 CNG buses. Now the bus corporation will use the balance to buy the additional buses. The corporation also plans to introduce more imported CNG powered school buses.

INDIA has more than 50 models of CNG cars, sedans, light commercial vehicles/mini trucks/pick-ups, mini vans, three wheelers, buses, and medium to heavy-duty trucks. Nevertheless, many of the NGVs are after-market vehicles. Considering the national gas infrastructure and the CNG station expansion plans, the number of OEM produced or converted NGVs is expected to grow even faster in the immediate future. It is anticipated that by 2015-16, one fifth of all cars in India will run on gas.

The Government of India in February 2009 unveiled a transport stimulus package intended to provide central funding on the purchase of buses for use in urban transport systems. The Ministry of Urban Development will provide financial assistance for purchasing public transport buses, as part of a national effort to reduce the use of private vehicles and control congestion. The Jawaharlal Nehru National Urban Renewal Mission (JnNURM), a government program, has allocated \$58 billion to 63 cities to help modernize and improve the quality of life. The New Delhi natural gas vehicle program is said to have halved the air pollution in comparison to ten years ago. Approximately 60,000 auto rickshaws in New Delhi, India, were required to convert to CNG for fuel.

The government has made a list of 201 cities where CNG and LPG facilities would be installed in the coming years. The Petroleum & Natural Gas MGL is about to spend Rs1 billion for expansion of gas distribution. The Regulatory Board (PNGRB) has held 2 rounds of bids where the private and public sectors were invited to participate. In Delhi, the government provides land for CNG station and guarantees a very low rate on VAT and other local taxes. The tax structure needs to be kept favourable to encourage motorists to switch from petrol and diesel to CNG.

GAIL projections for the five-year-12th-Plan period (2012-2017) are favourable, and supported via planned LNG imports. The company is also installing CNG stations along national highways. In the gas distribution sector, 200 cities have been earmarked to soon get gas supplies via pipeline. Agartala, the capital city of Tripura, plans to make all vehicles in this city run on CNG by 2013, aiming to become India's 1st green city. The transport Department was set to introduce 70 CNG public buses by end of March 2010. Around 60% of the autorickshaws and a big number of cars and buses are currently already using CNG technology. In Pune, the Regional Transport Authority (RTA) expressed its concern about the slow conversion rate of diesel autorickshaws to CNG mode. The Regional Transport Office (RTO) previously issued a mandate for all new rickshaws to have CNG or LPG kits from March 2010 onwards.

Indraprastha Gas Limited (IGL) plans to come up with 32 more stations by the end of the current financial year 2011-12, thereby taking the number of commissioned stations to 310. Thereafter, IGL plans to add around 35 stations every year. IGL has signed an agreement with Delhi Transport Corporation for the setting up of CNG facilities at their Depots. According to the agreement, IGL would be setting up CNG dispensers in all the existing (35 CNG fuelling stations have already been established) and planned new DTC Depots. IGL has also signed an agreement with Uttar Pradesh State Road Transport Corporation (UPSRTC) for the setting up of CNG facilities in their depots. Finally, in an agreement with Northern Railways, IGL has set up an exclusive CNG facility on premises owned by Northern Railways.

From April 1st 2010, gasoline and diesel vehicles must meet the Bharat Stage 4 emission norms in 13 cities. The rest of the country is still in the Bharat Stage 3 (for all four-wheelers). Bharat Stage 4 also has norms on OBD (similar to Euro 3 norm but less strict). This requirement and the mandatory use of NGVs for public transport are expected to make Delhi have a supply of the cleanest auto fuels in the world. The Delhi government recognises the importance of CNG as transport fuel in this largest metropolis area in India, as the entire public transport system in Delhi runs on CNG. In addition, the most populous city in India (5th in the world), Mumbai, presently (in mid-2011) has around 130.000 autorickshaws, and around 42.000 taxis running on CNG.

Regarding the vehicle segments, the most common size of CNG cylinder used in India is the 60 liter one and most of the demand consists of type-1 steel cylinder. Commonly, one cylinder is installed in each vehicle. Some use 4x 60 liters or 4x55 liters cylinders according to the OEM requirements.

Lohia Auto Industries has announced the intention to enter the three wheeler segment. The company is planning to launch its new three-wheeler model both in the diesel and CNG versions this financial year (2011). The models will be available both in the passenger and the commercial vehicle segments. New vehicles will meet the Bharat Stage 3 emission Standards. Regarding the Indian vehicle manufacturer TATA, the new Tata Magic Iris CNG is expected to replace the auto rickshaws in Pune's city transport and also be a safer, more comfortable, and more economical option compared to the ubiquitous three wheelers. The Magic Iris is a three-door minivan with five seats and a top speed of 34 mph (55 km/h). The standard variant is powered by an 11 hp (8 kW) diesel engine and it has been launched in some parts of the country. It is worth recalling that Tata Motors has recently tested another NGV version of one of its models, in that case the maxi van Winger. Winger is a multi utility vehicle that can be used as school van, Business Process Outsourcing pick and drop vehicle (for hotel and airport transfer, etc), hospital ambulance and a family car. Gail Gas, subsidiary of State-owned Gail India, is in talks with two-wheelers manufacturers to introduce CNG scooters in the country. India has more than 9.4 million motorised two-wheelers. CNG scooters are already available in other country such as China. Iran also has some converted CNG motorbikes (two-wheelers). In early May 2010, Bajaj Auto launched two new passenger three-wheelers; which will both be available in CNG and LPG variants. Bajaj Auto also aims to launch a new small-passenger-car within the class of Tata Nano by 2012 (TATA is also considering rolling the CNG version of this vehicles). Bajaj Auto will team up with global auto giant Renault Nissan to develop this vehicle. The target market is three-wheelers owners who would move up to four-wheeler vehicle. Mahindra and Mahindra have introduced in 2010 its Maxximo Light Commercial Vehicle (LCV) pick up in India including a CNG option. This vehicle is a new entry and rival of TATA Ace CNG mini truck (LCV) launched in January 2008. Mahindra & Mahindra is planning to introduce the CNG version of their half-tonne cargo carrier Gio in the local market. No deadline was yet announced for this scheme. The automaker HM continues promoting its HM Shifeng Winner 1.8 CNG Bharat 4 Light Commercial Vehicle in Delhi and the National Capital Region (NCR). This 3-tonne mini truck is the first CNG-powered LCV in India that meets the Bharat Stage 4 norm. Following the local government notification to convert all diesel commercial vehicles to CNG technology, it is expected that around 2.000 Winner CNG BS 4 will be sold in Delhi alone.

After rolling out five CNG models last year, India's largest passenger car maker, Maruti Suzuki India Ltd, plans to eventually offer all their models on a CNG platform (except for the Grand Vitara SUV and the Kizashi sedan which are Complete Build-up Units – CBU). Maruti Suzuki has the widest gas-run car portfolio with CNG-run Alto, Wagon R, Eeco, Estilo and SX4. Already, the CNG variants comprise nearly 10 per cent of the net sales of these models, which are available only in Delhi and the National Capital Region, Maharashtra and Gujarat.

The company plans to offer the CNG variants in other states as the network of CNG stations expands. GM's upcoming six joint venture products with China's SAIC will have 14 variants. Apart from the conventional diesel and petrol variants, they will have LPG and CNG versions. GM also launched the CNG version of its Chevrolet Aveo mid-size sedan with a 3-year/100,000 km standard warranty. Hyundai Motor India Ltd. (HMI) has made an exclusive arrangement with KNC of Korea (CEV India) to work together for its Santro and i10 model. KNC is responsible for the installation of CNG kits in the Accent, Santro and I 10 (1.1) models. The 0 km Hyundai cars will be fitted with CNG system and they will then be sold in Delhi, Mumbai, Ahmadabad and Kanpur, and some other cities. Mahindra & Mahindra Ltd. from India introduced the CNG variant of its complete family sedan, the Mahindra Logan. The 1.4 GLE/GLX versions of Logan are equipped with the Italian Landi Renzo's CNG kit. The kits come with a manufacturer approved instalment with original vehicle warranty of 2yrs/50000km. The sedans are currently available in Mumbai and Delhi. Fiat Grande Punto bi-fuel was announced to be introduced in India in the summer of 2011. Toyota Kirloskar Motors has also started retailing the bi-fuel gasoline/CNG variant of its popular sedan model Corolla.

Mahindra Navistar Automotives was about to introduce 15-18 seater and 32-42 seater buses in the 3.5 to 7 tonne category around May 2011, competing with other players like Tata Motors, Ashok Leyland, Eicher, etc. All variants of the mini bus will be Bharat Stage-III compliant. UK bus manufacturer Optare made an agreement with Indian auto manufacturer Ashok Leyland to add CNG buses to its eco-fleet. Ashok Leyland has delivered 6,000 CNG-powered buses to Indian bus operators, and has developed the country's first one-litre-per-cylinder six-cylinder CNG engine with multipoint fuel injection for buses. The firm forecasted that the CNG variant of EcoDrive will be successful in European countries with large supply of natural gas. HYBUS powered by hybrid CNG-electric drive made by Ashok Leyland, is India's first electric plug-in CNG hybrid. With this technology, the bus improves fuel savings by almost 30%. Volvo recently introduced the Volvo CNG City Bus, which will be built in its manufacturing plant in Bagalore, Hoskote. With this new CNG line Volvo is ready to expand its share in the bus segment. Currently Volvo holds over 50% share in the diesel AC segment and operates its buses across 10 cities in India.

So far, the CNG programme has not been extended to the large highway trucks. Only in Mumbai there is a court order that bans old trucks in the city unless they are on CNG. Some after market conversions of trucks have, however, taken place in Mumbai, but this is not yet an extensive practise. Nevertheless, Tata Motors India has revealed its plan to launch several models of dual fuel diesel/CNG vehicles. The trucks will be equipped with advanced fuel injection systems and three options of CNG cylinder capacity. The vehicles were announced to be ready around June 2011, and will be sold in specific markets such as New Delhi, parts of Maharashtra and the North-East. The CNG trucks will cost around 12.5 percent more than the diesel version. Tata Motors have also displayed a hybrid low-floor Tata Starbus intra-city bus concept powered with a series hybrid engine consisting of an internal combustion CNG engine and three lithium ion batteries mounted on the roof. The CNG engine charges the lithium ion batteries through a generator, and the batteries in turn power the driveline. The regenerative braking system also helps in charging the batteries.

As regards the off-road applications, presently, trials are in progress for running locomotives in dual fuel mode using CNG. The Indian Railway Organisation for Alternative Fuels has been established to conduct projects for introduction of alternative fuels like CNG and bio-diesel. Furthermore, in August 2011 the Indian Railways and the Indian Oil Corporation have signed a memorandum of understanding to explore the potential of LNG in a substantial manner in locomotives, factories and workshops.

On the customers (fleets) side, Andhra Pradesh State Road Transport Corporation (APSRTC) has received a directive from the Andhra Pradesh state government to ensure that at least one-third of the 6.000 buses which it intends to purchase over the next 36 months (starting February 2011) must operate on CNG. Presently, less than 100 CNG buses are being run in the state. The APSRTC runs a fleet of 19.000 buses, the largest in the world.

India in 2003 joined the International Partnership for the Hydrogen Economy (IPHE) as a founding member. By 2006, a National Hydrogen Energy Roadmap was created to plan for a gradual, practical transition to hydrogen energy and infrastructure, including power generation and transport applications. The Roadmap's Vision 2020, through the Green Initiatives for Transport (GIFT), calls for 1 million vehicles to be operating on hydrogen fuels by 2020. GAIL collaborates with the Australian Eden Energy (EDE) to work on a six-month trial project. Starting with 2 buses by the fourth quarter of 2010, it was announced that by year end, around 50-70 of these buses would be in operation. The fuel used would be CNG including a 15-20% hydrogen content, marketed as Hythane® and developed by the U.S branch of EDE. A Hythane® dispensing station and related infrastructure is expected to be built in a bus depot within 2010 or early 2011. The buses of a public transport operator, BEST Undertaking, will be used for this programme. Presently, BEST already has more than 2.000 CNG buses. It expects to convert the remaining 2.000 units of its fleet to the natural gas system by 2013.

In mid-2011 the Delhi Government has formed a joint-venture with the Swedish government for the purification of biogas to compressed biomethane (CBM). The project with the sewage plant in Delhi was announced to commence in September 2011. The CBM will be used to supply the Delhi Transport Corporation bus fleet (one of the largest in the world). The Swedish Development Corporation Agency will provide fifty percent of the funding.

As already mentioned in the case of Bangladesh, the trend of increasing CNG price seems to have hit South Asia. In India, Indraprastha Gas Ltd (IGL), the sole CNG supplier in Delhi, on April 2011 increased the price of CNG for vehicles. The increase was caused by a hike in operating expenses resulting from a revision of minimum wages by the government. Despite the increase, CNG would still offer nearly 64 percent savings towards running costs when compared to petrol vehicles at the current level of prices. When compared to diesel vehicles, the economics in favour of CNG at the revised price would be over 22 per cent.

IRAN with more than a 17% share of natural gas resources in the world has superior conditions for substituting common liquid fossil fuels by natural gas. So fuel switching to CNG in transportation sector was seriously considered in 2.000 by the government in order to control the sustainable contribution of petrol imports in the national budget. Iran is predicted to become self-sufficient in petrol by 2015 when it is expected to complete its upgrade projects at Arak, Abadan and Isfahan refineries as well as the construction of one of three condensate splitters at the Bandar Abbas refinery. The refinery upgrades is done in line with policies aimed at lowering domestic petrol consumption, thus, lowering petrol import and cutting the country's expenses. Within these policies, the government introduced petrol rationing (buying quota), withdrew fuel subsidies, and focused on efforts to promote and enhance the use of NGVs.

Iran has a great natural gas pipeline network all over the country with a total length of 26.000 kilometres, and reaching 800 cities and 10.000 villages. This wide gas pipeline network provides a high ability to supply natural gas to CNG stations.

Regarding production of kits, cylinders and compressors, technology has been transferred from abroad, and there is now local production of CNG kit components, cylinders and CNG stations equipment. At present, some local manufacturing companies are producing cylinders

with an actual production capacity of 520.000 cylinders per year. Around 35 percent of the CNG equipment for vehicles and stations is produced locally. The country is also moving towards being self-sufficient in production of CNG components not only to meet local demands, but also to be exported. In addition, 4 companies are producing kits and components for converting vehicles. Localized compressor manufacturing companies are producing major parts of CNG stations equipments with a production capacity of 400 compressors per year. National standards and regulations framework concerning NGVs is well developed. Iran is also looking at the potential for switching from petrol to LNG-fuelled engines.

State of the art and next steps in the NGV sector in Iran are:

- Designs and developments are CNG-based (OEMs).
- Increasing CNG stations all over Iran by public and private sectors up to 1.800 until 2011.
- Localization of completely CNG kit components, cylinders and compressors.
- Encouraging private sectors to invest in CNG field.
- Toward blue sky in metropolitans.
- Consumption pattern will be toward CNG base on CNG's program.
- Development of mid sized stations and then a suitable geographical spread of these stations (with a capacity to refuel 20-400 vehicles).
- Growth of the CNG share of the total fuel consumption basket (max 30%). Currently, about 18 percent of vehicles in Iran are using the CNG technology (2 million out of 11 million).
- Reasonable ratio of CNG stations and vehicles.
- Vehicles manufactures have to produce only CNG-based vehicles after 2011.
- With rapid market growth, safety has to be considered and this aspect includes very necessary notification for retesting of cylinders, inspection of stations and vehicles.
- Prosecution (?) and completion of comprehensive repair system in order to give a good service.

In the commercial sector, natural gas vehicles currently remain small due to low price of diesel. There are however 5364 CNG buses (mid-2011) operating in a number of cities.

Iran aims to become the world leader in terms of the highest number of CNG stations as well as in CNG consumption by 2015. This is supported by the facts that the government plans to continue supporting the segment, the availability of abundant natural gas supply, guarantee of high price gap between petrol and CNG, and the local production of NGV variants and related components. In early 2011, the Iranian government also urged ministries of petroleum, energy, interior, trade, industries, and road and transportation to help expand CNG stations across the nation. By early January 2011 there were 1.540 CNG stations operating in Iran (target was 1.800). It is expected that during the next Iranian year (21 March 2011- 20 March 2012) the number will reach 2.188 units. Iran's neighbouring countries, such as Qatar, are interested in using Iran's expertise in developing NGV programme for public transport, and in expanding their CNG filling station network.

Among the new products, development and investment were allocated for the Peugeot 206 class (production of 207i based on 206 platforms), upgrade of Suzuki Grand Vitara with a

new Euro 4 compliant model, and a new version of Soren of the Samand group. Peugeot Pars and 405 did well in the market so a new version of Pars has been unveiled. Iranian automotive manufacturer IKCO intends to produce 40.000 Renault-based Logan cars in 2011, of which 15% will be fitted with bi-fuel (CNG/gasoline) engines.

From January 2010, the Iranian minister of oil order has allocated Iranian Gas Khodro Co.- IFCO's tasks and responsibilities to manage national CNG plan to the National Iranian Oil Products Distribution Company (NIOPDC). NIOPDC has proved that it has successfully managed the construction of 800 dual purpose-CNG and gasoline fuels-stations, and operates more than 550 units of these stations. Nowadays, all duties related to the CNG sector such as development and instruction of filling stations and vehicles conversions to CNG system have been given to NIOPDC.

The most important issues that NIOPDC is working on are listed below.

- Within the new plan, the government offers up to 90% subsidies to cover the expenses of converting taxis and public vehicles to CNG system. The subsidy could cover the conversion of up to 150.000 vehicles. Furthermore, the government no longer finance car manufacturers for producing CNG (b-ifuel) vehicles and they should balance their selling prices and NGV production according to market demand. A specified plan/target for NGVs production is no longer available.
- In the CNG stations segment by private sector, as before, the NIOPDC will manage the provision of 100% subsidy for the stations' main equipment, which include dryers, compressors, dispensers, and priority panels. Furthermore, the government offers dual-purpose (CNG and liquid fuels) stations a long-term loan to cover over 70% expenses of gas and electric as well as civil costs. No interest is imposed on this loan.
- The Iranian parliament has issued a decree that forced the government to stop subsidizing fuel. This new regulation will cause a huge increment in fuel prices and price of CNG is expected to increase up to four times.
- After successfully using Smart Fuel Cards to lower the purchase of traditional fuels for transport that led to a decrease in consuming of more than 20 million litre gasoline and diesel per day, the NIOPDC is planning to create 'Energy Cards' for NGVs. With the issuance of Energy Cards, drivers, must use this card when refuelling in both CNG and gasoline stations. It can help the government to see the fuel distribution and check the share of consumption of each fuel. The good news is that the cards will be issued only to legally converted vehicles. This way, the authorities have a control on the safety aspects of the vehicles. Thus, safety for NGV drivers and passengers is better guaranteed. Nowadays, an NGV database, information net hardware and software system has been developed. Card reader devices are also being installed on CNG dispensers. The system is expected to become operational within the immediate future.
- One of the most important projects that NIOPDC is working on is the expansion of existing CNG stations in big cities especially in Tehran. As there is not enough space in Tehran and considering the land allocation rate in big cities, after an investigation on existing CNG stations' performance versus fuelling demand, 25 CNG stations in Tehran plus another 21 units in other 4 big cities were selected to be further developed.

SRI LANKA has finally explored the potential and benefits of using methane in transport. This country has carried out an experiment to produce biomethane from waste to fuel three-wheelers. The demonstration project of biomethane as a transport fuel is conducted by Department of Chemical & Process Engineering, University of Moratuwa and funded by Ministry of Science and Technology, Sri Lanka. Sri Lanka is now also looking at the building of an LNG importation terminal.

In **PAKISTAN** the NGV share in the total vehicle segment in mid-2010 was 80 percent of the total LDVs segment (cars, three-wheelers, and other LDVs). Pakistan chose also to produce CNG conversion kits locally. The Oil and Gas Regulatory Authority (OGRA) that oversees the implementation of NGV programme in Pakistan has issued permission to eight companies to produce and assemble CNG conversion kits and fuelling components such as priority panels, compressors, and dispensers. The country was reported to achieve self-sufficiency in producing these components domestically. Recently, the components are also exported e.g. dispensers to Argentina and Bangladesh.

It is yet to be established whether Pakistan will overcome the power (electricity), CNG supply and the decreasing petrol-CNG price gap issues. Recently, the country has been facing difficulties with CNG supply as many filling stations are closed-supposedly on a temporary basis. In fact, the NGV sector only uses 7% of the country's total gas consumption. So, closing some of those stations is unlikely to help reducing gas deficit (which recently went down further by 25%).

Recently, the government assigned OGRA to work with the Petroleum Ministry to create a rational policy to allow provisional licensees change of site and relocation of CNG stations. As per the draft of the new CNG policy, CNG stations owners/licensees can relocate their sites, among others, if the current site of the station has been declared risky for public safety. While there has been dense growth of CNG stations on either side of a road in the existing area of operation, a particular area has insufficient supply of CNG stations, etc. Yet, inter-provincial relocation of CNG station is not allowed.

In February 2011, the Pakistani government decided to deregulate CNG prices. With the implementation of the deregulation, Oil and Gas Regulatory Authority (OGRA) will no longer fix the price. The price will then be determined by the market forces. However, by March 2011, OGRA revised CNG prices based on the Gross Calorific Value (GCV) of the fuel. Each of the four provinces in this country gets different pricing policies, in which, some are raised and some are reduced. The government is working on policies to substitute liquid hydrocarbon fuels with natural gas to cut oil import costs and to improve the quality of the environment.

In early 2010, the government has re-activated the 8.000 CNG bus project in this country (the "Shaheed Benazir Bhutto CNG Bus Project"). With the support of the World Bank and the Federal Environment Ministry, the Clean Development Mechanism (CDM) for this project has been initiated. The CDM is an arrangement under the Kyoto Protocol allowing industrialised countries with a greenhouse gas reduction commitment (called Annex 1 countries) to invest in ventures that reduce emissions in developing countries as an alternative to more expensive emission reductions in their own countries. Being a United Nations Framework Convention on Climate Change (UNFCCC) programme, the CDM allows emission-reduction (or emission removal) projects in developing countries to earn certified emission reduction (CER) credits, each equivalent to one tonne of carbon dioxide. These CERs can be traded and sold, and used by industrialized countries to meet a part of their emission reduction targets under the Kyoto Protocol, according to the UNFCCC. There is a plan to extend this CDM programme to nine other major cities that will be involved in the

CNG bus projects. Therefore, ten major cities will get these eco-friendly buses and half of those will be assigned to Karachi City. The federal government is ready to provide Rs 2.5 billion as subsidy and an upfront grant for bringing 4,000 CNG dedicated buses over the time period of five years for Karachi. The total investment in the project is about Rs 21 billion. To offset the cost of the provision of one bus, the federal government will assign a total Rs 677.181 as subsidy over a five year time frame. An Rs 300,000 upfront grant will be given as part of the down payment and Rs 377.181 as interest subsidy payable in five years. The environment ministry has already allotted Rs 300 million to the State Bank of Pakistan for the implementation of the pilot project in Karachi. The buses will be operated and maintained by private sector under the government's regulatory framework and duly assisted by provincial governments in provision of routes and depots, land infrastructure and CNG refuelling stations. Regarding CNG retail price, the Oil and Gas regulatory Authority (OGRA) would fix difference between CNG and gasoline prices. It is very likely that the 55% difference, based on fuel economy, will be maintained in future. Apart from buying the buses, conversion of diesel-to-CNG buses would also be a part of the agenda to encourage local bus manufacturing industry.

The above mentioned project triggered further related development activities. The Hydrocarbon Development Institute of Pakistan that would lead the project has approached Sindh Transport Department for the establishment of a model mega CNG refuelling station at Karachi capable of refuelling 200-250 CNG buses. Around 15-20 such mega stations are expected to be built in Karachi City to facilitate the operation of 4,000 CNG buses. Authorities offer financial assistance/incentives to start the adoption of CNG buses and the provision of its fuelling and infrastructure facilities. A 15% subsidy will be offered to private transport companies willing to import Hino CNG buses. They will also be granted a loan for seven years. Owners of the buses will get 20% operational and 5% capital subsidies. In Lahore, the second largest city in the country after Karachi, the public transport company LTC plans to incorporate 2,000 natural gas-powered buses in the initiative supported by the local government that aims to encourage private operators to convert their fleets to natural gas.

The International Multi Group of Companies (IMGC), a Pakistani business house with interests in areas as diverse as edible oil and film imports, has expressed an interest in importing vehicles from India's Tata Group, including the Nano and CNG buses. IMGC's plans to import CNG buses from Tata have been held up due to restrictions in Pakistan's trade policy, which allows the import of only a limited number of vehicles and makes it mandatory for a majority of vehicles to be assembled within the country. At the same time, the policies of the Reserve Bank of India do not allow joint ventures and investments in Pakistan. In October 2010, Omnitek Engineering Corporation (OMTK) announced that it has signed an agreement with Karachi-based Xperts Technologies LLC to market and install the company's diesel-to-natural gas conversion technology for truck and bus applications throughout Pakistan. Landi Renzo Pakistan is planning to export its CNG conversion kits for four-wheeled vehicles. The company has yet to expand into the HDVs market, which includes buses, trucks and vans, and is considered to have a huge potential

In the OEM LDV sector, The new Corolla Ecotec, featuring a two year or 50,000 km warranty under the Japanese automaker's standards, was presented in summer 2011 by Indus Motor (local distributor of Toyota and Daihatsu vehicles), and was specifically designed and approved by Toyota Motor Corporation for Pakistan.

In the **UNITED ARAB EMIRATES** Adnoc Distribution had, in collaboration with the sister company Abu Dhabi Gas Industries Ltd (Gasco), nearly completed (status in March 2011) the project's first phase which entailed the construction of 16 CNG filling stations, 10 in Abu Dhabi, 2 in Al Ain and 4 in Sharjah, as well as 9 vehicle conversion centres, operated by

specialist companies. It is expected that by the end of 2012, around 25 per cent of the government vehicles will be converted to be run on CNG.

Some 500 taxis in Abu Dhabi will be converted to run on CNG in the first phase (by the end of 2020). The initiative is part of Abu Dhabi's mission to power 25 per cent of public transport and government vehicles by CNG. TransAD announced that the Abu Dhabi National Oil company (ADNOC) would be responsible to equip the vehicles with CNG kits, while the taxi operators would bear the cost. The Department of Transport (DoT) in Abu Dhabi has also announced to convert all its vehicles into CNG mode by 2020.

One of the largest transportation and services enterprises in the Middle East, the Dubai-based Emirates Transport plans to retrofit its entire fleet of 10,500 commercial vehicles to CNG and CNG hybrid engines in a partnership with ADNOC. The project is scheduled to begin in 2012. Around 6,500 buses, light and heavy trucks, and minivans, and 4,000 cars, will be involved in this scheme. Additionally, Commercial Vehicles Middle East, which is currently involved in partnership negotiations with Emarat and the Emirates Petroleum Products Company LLC, will build CNG filling facilities at fuelling stations across Dubai and Sharjah. Following the conversion, Dubai Police and Sharjah taxi, which own 2,000 cars and 5,500 taxis respectively, will also retrofit their fleets to CNG. Emirates Transport has already started a vehicle replacement program to convert 511 vehicles of Abu Dhabi police and 1,700 cars of the Abu Dhabi taxi fleet. By mid March 2011, 250 cars had been retrofitted. In early March 2011, Emirates Transport opened the first ADNOC-certified CNG transfer centre in Dubai.

Dubai Municipality has unveiled its pilot project of converting five of its vehicles to use natural gas. The second phase of the DM project will see a total of 438 commercial and medium-sized vehicles of the municipality switching to natural gas. Roads and Transport Authority (RTA) is planning to convert its entire fleet of buses into the CNG mode and a pilot project in this regard will start in mid-2011. RTA is said to be negotiating with service providers to convert the buses and the plan is to study the performance of a bus for a few months in a pilot study. Based on the results, recommendations would be made for the entire fleet. Conversion is expected to be completed by 2020. The RTA has earlier introduced a fleet of CNG-powered abras (water taxis) and hybrid taxis.

The government is targeting to build mother-daughter CNG filling stations in the Dubai state. The initial plan is to have 12 daughter stations to serve government fleets (later these could also be opened for private car owners). Emirates Gas (EMGAS) will provide the filling facilities and fuel throughout the UAE. The firm is a member of the ENOC Group wholly owned by the Government of Dubai. EMGAS will transport the gas from its mother stations to daughter stations using trailers. EMGAS has invested Dh110 million into the first phase of the CNG infrastructure expansion scheme. This funding will be used to finance the project between 2011 and 2014 in which two CNG mother stations will be constructed; two online (conventional) stations will be connected to the existing natural gas pipeline, as well as four to five CNG sub stations. Phase two will be started in 2016. Around 365 million financing will be used to enlarge the infrastructure to six mother-stations connecting two pipelines, 19 online-stations (fuels supplied through gas pipeline), and 11 daughter stations in Dubai and Northern Emirates. In 2011 the new filling stations will serve cars, taxis, light commercial vehicles, sport utility vehicle and multi-purpose vehicles. By 2012, stations will also be able to accommodate buses.

Local manufacturers expect that the UAE in a later stage will produce its own CNG components. It could lead to lower cost in vehicle conversions. At the time being, European CNG conversion kits are used in the Emirates.

For several years **SYRIA** has been considering entering the NGV segment. Tenders on procurement of CNG filling stations were issued twice and this year another attempt is made. Various suppliers from station segment were invited to join the tender. The tender is released by the Syrian government, Syrian Petroleum Company (SPC) who also acts as the owner of the station. Each station would require 750 Nm³/hour of compressed gas.

WESTERN ASIA

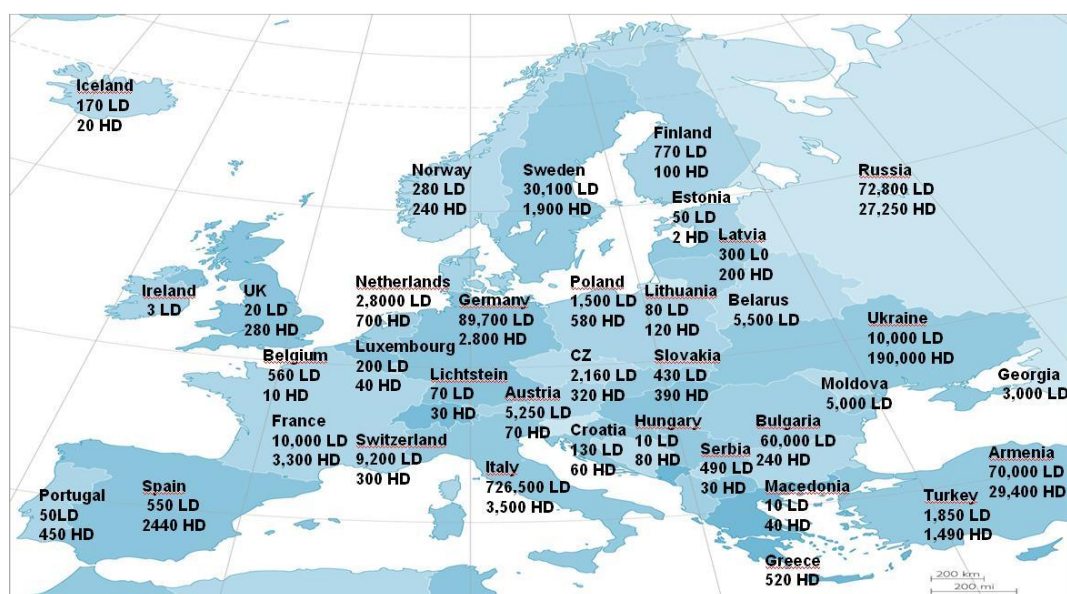
In **TURKEY** in September 2010, Karsan (Turkey based vehicle manufacturer) signed a partnership deal with Italy's BredaMenarinibus. As a result, Karsan opened a manufacturing plant in the North Western province of Bursa to manufacture buses since the beginning of 2011. According to the plan, the facility will initially produce 300-400 buses annually. Trial production was carried out in this facility in January 2011, with the production of BredaMenarinibus's CNG and diesel buses. The buses made during the trial were those ranging between 8 and 12 meters. The buses are also made for export.

At present, there are about 1.850 cars and almost 1.500 buses powered by CNG in this country. Most buses are OEM made while cars are all converted. Turkey has 14 CNG filling stations spread out in 5 cities. All stations are connected to gas pipelines. Apart from that, there are 7 L-CNG stations used for transporting gas to remote areas. There are three local producers playing in the CNG market in this country: Aldesa, Fema, and Voltran manufacture CNG kits for domestic cars, with exception of Aldesa which also export its products to Asia and Europe. Also, as mentioned above, in line with the agreement with Italian based Breda firm, Karsan assembles CNG buses in Turkey for export purposes. The Fiat Group's local partner, Tofas, also makes Doblo and the new Fiorino bi-fuel to be sent to Italy. Turkey uses all European (EU) regulations and standards. No local standards were introduced. Although the government has not yet imposed any mandate, special incentives, nor set target for the adoption of NGVs and its stations, the eventual transition to NGV technology is expected.

5. MINIMUM INFRASTRUCTURE NEEDS FOR METHANE (NG/BIOMETHANE) REFUELLING ACROSS EUROPE

Mr. Davor Matic, OMV Adria, Croatia; WOC 5.3; UN ECE NGV Expert Group

In response to the Expert Group Meeting on Future Transport Fuels on May 5th, NGVA Europe welcomes the Commission evaluation process of identifying possible measures for supporting the infrastructure build-up for certain alternative fuels. Taking into account the great environmental benefits being related to natural gas and biomethane and despite the fact that more and more ex-factory methane driven vehicles are being introduced to the European market place, the market share of CNG and LNG vehicles is still rather small, now making up close to 1 million vehicles in the EU, which is making up a market share of only 0.4 % of the total running fleet.



Today practically all vehicles using methane as a fuel are propelled by CNG (compressed natural gas and biomethane being injected into the gas grid). But LNG heavy duty trucks (dedicated or dual fuel) are becoming more and more popular as trucks are Europe biggest road polluters and only very few options to replace Diesel exist so far. LNG (liquefied methane) has a higher energy density than CNG and is therefore a real and affordable way to replace Diesel on medium and long distances (LNG Blue Corridors).

The slow development of bio natural gas vehicles is basically caused by very high investment costs that are required for the build-up of the needed methane refuelling infrastructure (CNG and L-CNG stations). Therefore the network of methane refuelling stations is still rudimentary and EU member states have decided to put a different strategy focus on national level, in terms of type of vehicles.

E.g. some big member states like France or Spain are so far mostly going for urban HDVs using CNG, but hardly have any LDVs on their roads.

The available vehicle options are:

- LDV using CNG
- HDV (urban buses and trucks) using CNG
- HDV (on medium and long distance haulage using LNG)

This diversity of national strategies has led to a very fragmented development of methane refuelling (public filling stations or private fleet depot stations). What it needs is a harmonised strategy to develop methane refuelling across the EU.

The following two concepts of methane refuelling stations apply:

- CNG station using a compressor connected to the pipeline
- L-CNG station with CNG and LNG dispenser where LNG is stored in a cryogenic tank

In total there are only 2.700 refuelling points (public and private) in Europe, whereof only 20 stations are equipped with the L-CNG technology.

This situation is not acceptable as bio natural gas is an available, clean and affordable fuel, which can significantly contribute to reach the 2020 emission reduction targets (Fuel Quality Directive and Renewable Energy Directive) and will also notably help to make European transport more sustainable in a 2050 perspective. Having said that, NGVA Europe believes that any technology neutral approach by the European Commission would be the wrong attempt to reduce both, oil dependency and emission reduction of pollutants.

There are certainly several power train alternatives theoretically available today, but some of these technologies, including electric vehicles and hydrogen fuel cells, are far from being mature and economically viable for the final customer. We don't have the luxury of time, mobility changes slowly, so we have to work with and use what we have got now, the natural gas combustion engine technology. Depending on the natural gas/biomethane ratio, CO₂ savings of 24-100 % can be achieved by using this clean immediately available technology instead of conventional oil derived fuels.

We believe in the future fuel mix in transport, different options can serve different applications. The next decade will be crucial to reach our emission reduction targets. Methane can therefore play a major role, provided political support for the further build-up of the methane refuelling infrastructure would be realised.

The decision to strongly promote electric mobility has been taken at political level. But EVs only give a partial solution for urban traffic on short distances. Methane however is, due to its excellent CO₂, NO_x (and particularly NO₂), PM and noise reduction performance, the ideal alternative in LDVs for covering longer distances, heavy urban buses and trucks, and HDVs for long distance haulage using LNG as a fuel.

NGVA Europe suggestions for a minimum Methane refuelling infrastructure:

In relation with the Expert Group discussion note, NGVA Europe supports Option 2 "Direct investments and subsidies for alternative fuel infrastructure" and Option 3 "Legislative actions on alternative fuel infrastructure".

When looking at Option 2 financing schemes and state aids to directly support the construction of the methane refuelling infrastructure (CNG and L-CNG stations) are essential. In addition to that funding research and technology demonstration project for the harmonisation and homologation is also needed with regards to LNG, LBM (Liquefied Biomethane), Methane/Diesel (dual fuel), NG/hydrogen mixtures and CNG hybrids. The European NGV (Natural Gas Vehicle) related industry already made investments of 1.5 billion € to establish the existing network of methane refuelling stations. More than twice as much would however be needed to guarantee adequate refuelling conditions. NGVA Europe therefore calls for a European investment fund to allocate this capital.

Option 3 "Legislative actions" should complement any funding scheme as reality has proven that regulatory measures are needed to rapidly implement alternative fuels. The market

cannot make this decision on its own which alternative fuel to give preference to. If we would just wait for a change in customer behaviour, this would mean a manifestation of oil in transport for a long time. The customer will always pick alternative solutions that are visible and affordable. CNG vehicles are affordable and the fuel is also still cheap, so what it needs is more visibility of and accessibility to methane refuelling.

The main bottleneck:

Considering infrastructure investment costs of approx. 400.000 € for public stations and 1.000.000 € for depot stations serving clean bio natural gas vehicles, it is clear that an European infrastructure fund in combination with a European Directive demanding member states to implement a minimum refuelling infrastructure is the only logic way to make sure that more CNG and LNG vehicles will be put in the market in the future.

For the specific situation of NG/biomethane, it should be noted that 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: talking about CNG/biomethane for private passenger cars and commercial fleets using cars and vans, we would suggest availability in 10 % of the urban filling stations, and at 25 % of the filling stations along the motorways. Though the exact figures should be verified, it should be noted that the essence would be to stipulate a % which would lead to the availability of filling stations capable of providing NG/biomethane every 150 km along the motorways (or major highways where motorways are not available), and a logical distribution inside the cities. Methane refuelling should however be possible everywhere across Europe by not using more than 15 minutes to drive to the next refuelling station.
- HDVs: the infrastructure needed for HDVs varies depending if its referred to the urban transport of persons and goods, or 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 European motorways. An initial target could be i.e. to offer refuelling possibilities every 400 km along the major roads used for international truck traffic. The L-CNG filling station concept would apply, able to provide both CNG for LDVs and LNG for HDVs.
 - The CNG/biomethane 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 vehicles in their urban fleets. The Expert Group report on Future Transport Fuels, published on 25th January 2011, says that “Methane (CNG) should be promoted as one of the main alternatives fuels in HDVs in urban transport”. European cities should therefore aim for at least 50% methane share in their public fleets. A city like Madrid is leading by example and has its entire refuse truck fleet running on CNG (670 trucks) and an additional 600 CNG buses out of 2000 (target of 1000 CNG buses for 2012).

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 an EU fund would be:

- Linking permits for new multifuel stations to the inclusion of CNG or L-CNG refuelling facilities.
- Demanding that stations above a certain total volume of fuel sales must offer methane refuelling facilities.

These two options have the advantage of not hitting the EU budget or national aids, but the fuel retailing companies. Independently it should of course still being possible to open dedicated methane filling stations outside of 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.

CNG/LNG associated infrastructure costs:

The next information intends to give a general overview of the associated costs when installing methane refuelling stations. The figures should be taken as average figures from different EU countries.

First of all, it should be taken into account that two different approaches can be faced when talking about a new natural gas filling station:

- CNG Fuelling 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 400.000 €. This average figure would be representative for an installation with a compression capacity of 300÷500 m³/h.
- CNG/LNG Fuelling Station: this type of infrastructure capable of supplying both, liquefied and compressed natural gas, has to be fed with liquefied natural gas via HD transport tankers. 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 also be around 400.000 €. 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.
- Difference between diesel oil and CNG version of a HD vehicle: +13÷25% of CNG compared to Diesel version, depending on vehicle type.
- Natural gas pipeline lying down: 300÷600 €/metre; depending on land characteristics.



Indox Cryo Energy, Spain

6. ENVIRONMENT AND EMISSIONS

6.1 EU EMISSIONS POLICIES AND ITS IMPACT ON THE EUROPEAN NGV MARKET

Matthias Maedge, EU Affairs Manager of NGVA Europe and Manuel Lage, General Manager of NGVA Europe

Strategic statements with a time perspective 2020 – 2050

In the next decades, transport faces the challenges of decarbonising and building up secure long-term sustainable energy supply. Transport is responsible for 32% of the EU's final energy use and 21% of GHG emissions. The decarbonisation of road transport will be a major challenge considering that it represents 80% of the energy used by all transport modes. In April 2010, the European Commission released a Communication on a European strategy on clean and energy efficient vehicles, which set out several policy measures to support the creation of a clean and energy efficient transport system that will contribute to achieving the Europe 2020 objectives with respect to reduction of GHG emissions and increase the share of alternative fuels and renewable sources in transport.

The 2011 White Paper "*Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system*", published on 28th March 2011, sets out a comprehensive strategy for a competitive transport system that will increase mobility, remove major barriers, drive growth and employment and decarbonise transport. For urban transport this means a big shift to cleaner fuels. By 2030 the use of conventionally fuelled cars in urban transport should be halved, while transporting goods in major urban centres should then be essentially CO₂-free. By 2050 the use of conventionally fuelled cars should be phased out in cities. Also included in the White Paper is the Clean Transport Systems initiative. The main objective of this important initiative is to develop a sustainable alternative fuel strategy for the EU, including the appropriate infrastructure.

NGVA Europe, the Natural & bio Gas Vehicle Association, supports the White Paper and the push to use more alternative and clean vehicle fuels. The Commission aims at dramatically reducing Europe's dependence on imported oil and cut carbon emissions in transport by 60% based on 1990 levels by 2050. Methane (NG/Biomethane) is mentioned as one of the

alternatives and can play an important role to help achieving the 2050 key goals. The White Paper for example points out the importance of CNG, LNG and biogas for medium and long distance road transport and the shipping sector (at least 40% cut in shipping emissions set as target). But Methane will also make an important contribution to achieve the predominant target to have no more conventionally fuelled cars in cities, in order to improve local air quality and reduce noise exposure. It will have to be complemented by the development of an appropriate refuelling infrastructure for new vehicles. Large fleets of urban buses, taxis and delivery vans are particularly suitable for the introduction of alternative propulsion systems and fuels, the paper says.

In this light, the European NGV market will grow significantly in Europe in the short (2020), medium (2030) and long term (2050) 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 (*source: NGVA Europe*).

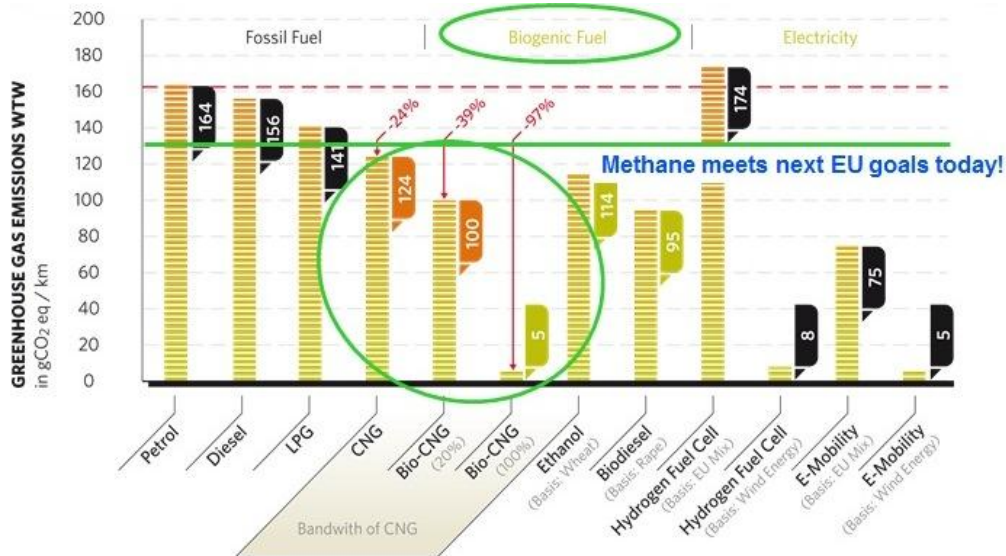
Current and future European key policies

Road transport contributes about one-fifth of the EU's total emissions of carbon dioxide (CO₂), the main greenhouse gas. While emissions from other sectors are generally falling, those from road transport have continued to increase since 1990. Eager to tackle climate change, the European Commission has a comprehensive strategy designed to help the EU reach its predominant objectives of promoting alternatives to oil derived fuels, limiting average CO₂, NO_x and PM emissions from newly registered vehicles, improving urban air quality and also significantly reducing noise exposure from transport.

The great potential of NGVs: CO₂ regulations, EURO VI, Air Quality

The European legislation setting emission performance standards for new passenger cars, adopted in 2009 by the European Parliament and the Council, is the cornerstone of the EU's strategy to improve the fuel economy of cars and ensure that average emissions from new passenger cars registered in the EU by 2012 do not exceed 120g CO₂/km. An average target of 130g CO₂/km must be reached by improvements on the vehicle itself and a further 10g CO₂/km reduction by additional measures. A so-called limit value curve implies that heavier cars are allowed higher emissions than lighter cars while preserving the overall fleet average. In 2012, 65% of each manufacturer's newly registered cars must comply on average with the limit value curve set by the legislation. This will rise to 75% in 2013, 80% in 2014, and 100% from 2015 onwards. If the average CO₂ emissions of a manufacturer's fleet exceed its limit value in any year from 2012, the manufacturer has to pay an excess emissions premium for each car registered. This premium amounts to €5 for the first g/km of exceedance, €15 for the second g/km, €25 for the third g/km, and €95 for each subsequent g/km. From 2019, already the first g/km of exceedance will cost €95. A target of 95g/km is specified for the year 2020. Details of how this target will be reached, including the excess emissions premium, will have to be defined in a review to be completed no later than the beginning of 2013.

Methane (NG/biomethane) vehicles already meet the next EU goals today



Source: German Energy Agency (DENA) Study 2010

As part of its strategy to cut CO₂ emissions from light-duty vehicles, in May 2011 the EU adopted legislation to reduce emissions from vans (light commercial vehicles), similar to that passed in 2009 for passenger cars. The Van Regulation will cut emissions from vans to an average of 175g CO₂/km per kilometre by 2017 – with the reduction phased in from 2014 – and to 147g CO₂/km by 2020. These cuts represent reductions of 14% and 28% respectively compared with the 2007 average of 203 g/km. Only the fleet average is regulated, so manufacturers will still be able to make vehicles with emissions above the limit value curve provided these are balanced by vehicles below the curve. The EU fleet average of 175 g/km will be phased in between 2014 and 2017. In 2014 an average of 70% of each manufacturer's newly registered vans must comply with the limit value curve set by the legislation. This proportion will rise to 75% in 2015, 80% in 2016, and 100% from 2017 onwards.

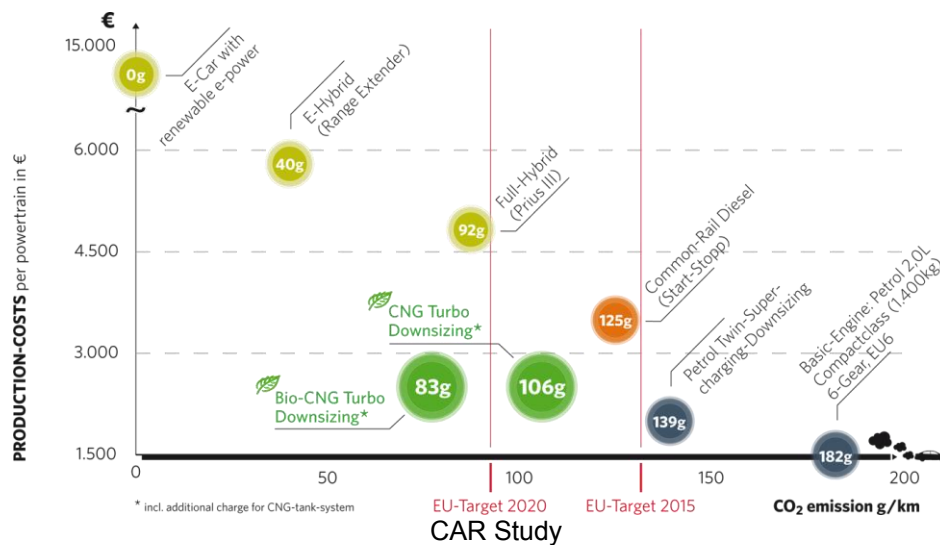
In the case of heavy duty vehicles, it is much more complicated for the European Commission to legislate on CO₂ emissions, as manufacturers still try to avoid releasing their emission data, also due to the fact that CO₂ emissions in a heavy duty vehicle are much related to the type of use, load factor and road profile, all very variable elements. State-of-the-art heavy duty trucks with dedicated engines running on natural gas and biomethane, on a tank-to-wheel basis, give a CO₂ saving of about 3% versus diesel vehicles, but next generation of NG heavy engines with inlet valves' electronic control (Fiat *Multiair* type technologies) will improve the saving up to 8%. Dual fuel heavy engines also announce important CO₂ emission reductions.

The whole picture changes completely when considering the entire life cycle on a well-to-wheel basis, which is not yet applicable for Europe, as European legislation is looking at tailpipe emission only. This is also the main reason why retrofitting in Europe does not make sense, because the CO₂ benefit, with respect to the engine setting, is much better for ex-factory produced NGVs instead of converting OEM petrol versions to gas.

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. Euro VI will mark an important step as the pollutant emission reductions required by this standard can only be met

by manufacturers if they will make a technological leap on the diesel technology, which will lead to additional costs for producing these vehicles that would also be heavier. The price gap between NGVs and conventional diesel vehicles will consequently be reduced and could sooner or later disappear. The price advantage of NGVs becomes even more obvious when taking a closer look at the productions costs per powertrain in relation to the CO₂ emission g/km.

Cost-benefit analysis in € of current GHG emission savings



Today the natural gas combustion engine technology, with minor modifications, already meets the Euro VI standard, outlined in Regulation (EC) N° 595/2009. In particular, for trucks and buses the adopted regulation foresees a reduction of 80% in nitrogen oxides (NO_x) and 66% in particulate matter (PM) emissions compared to the Euro V standard, which was introduced in 2008. These requirements will result in major modifications and investments in the diesel technology, which, as a consequence, is obviously not the cure for Europe’s first and foremost environmental goal: protecting air quality. Therefore, the European Commission will soon also present a proposal for the revision of the Air Quality Directive, which will give a further push for the market development of NGVs in Europe.

NGVs contribute to achieve the 2020 legislation – Fuel Quality & RES Directive

In April 2009, Directive 2009/30/EC was adopted which revises the Fuel Quality Directive [Directive 98/70/EC] as part of the EU’s Climate Change Package. It amends a number of elements of the petrol and diesel specifications as well as introducing in Article 7a a requirement on fuel suppliers to reduce the greenhouse gas intensity of energy supplied for road transport (Low Carbon Fuel Standard). Fuel suppliers should, by 31 December 2020, gradually reduce life cycle greenhouse gas emissions by up to 10% compared to the EU-average level of life cycle greenhouse gas emissions per unit of energy from fossil fuels in 2010. This reduction should amount to at least 6% by 31 December 2020, obtained through the use of biofuels, alternative fuels and reductions in flaring and venting at production sites. In addition to the 6% binding target, a further 2% reduction should be achieved through the use of environmentally friendly carbon capture and storage technologies and electric vehicles and finally another 2% reduction for reaching the indicative target of 10% through the purchase of credits under the Clean Development Mechanism of the Kyoto Protocol. A report

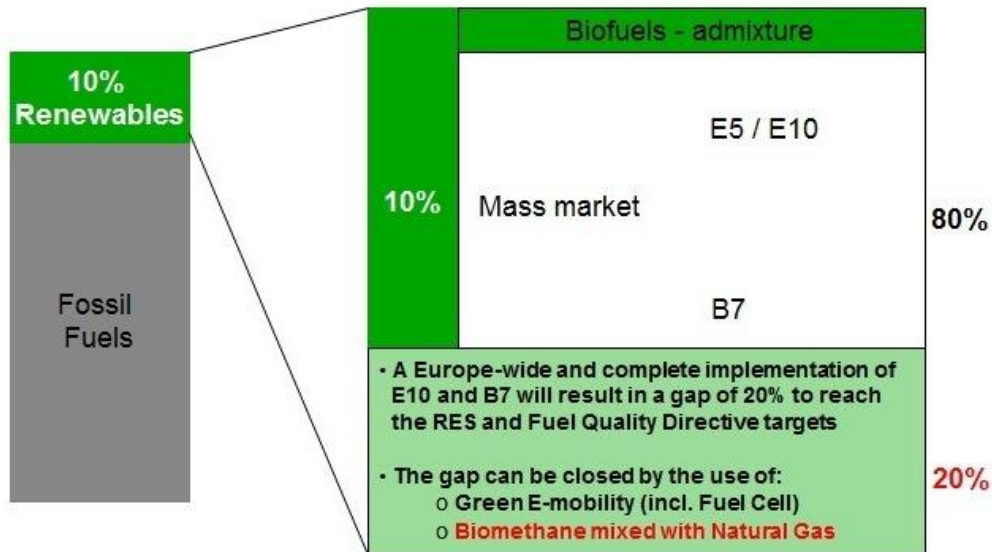
by Ludwig-Bölkow-Systemtechnik GmbH states that it can be seen that already one million CNG vehicles can contribute by 2.0 to 5.6% to the 6% target.

Biofuels used for compliance with the greenhouse gas reduction targets laid down in the Fuel Quality Directive have to be produced according to sustainability criteria, but a number of aspects of the Directive require further work. As a result the Commission has recently published a consultation on the implementation of various issues relating to Article 7a and has also carried out a pre-consultation in relation to policy options for addressing indirect land use change from biofuels, to which also NGVA Europe contributed as a stakeholder.

Directive 2009/28/EC on the promotion of the use of energy from renewable sources (RES Directive) is another European key policy asking for a 20% target for the overall share of energy from renewable sources and a 10% target for energy from renewable sources in transport. Biomethane is one of the main pillars to reach the mandatory 2020 target of 10% biofuels in transport, as the Directive states that “*biofuels means liquid or gaseous fuel for transport produced from biomass*”. Due to the same molecular composition, natural gas and biomethane can be used in existing internal combustion engines with no limitation to blending. The development of biomethane is therefore linked to that of Natural Gas Vehicles and biomethane should preferentially be fed into the natural gas grid, as also the Expert Group on Future Transport Fuels concluded. Article 4 of the RES Directive requests Member States to submit national renewable energy action plans by 30 June 2010. Now the EU Member States have to revise these plans by December 2011 has their renewable energy targets cannot be reached via the measures presented. With regard to transport, Member States have explained that 9,5% of the overall 10% RES target in transport would be reached by means of E10 (adding of 10% Ethanol to petrol) and B7 (adding of 7% Biodiesel to diesel). Today manufacturers and Member States confirm that this will not be possible and there will be at least a 20% gap to reach the target. Alternative options are however very limited, namely to green electricity, not yet available, and biomethane injected into the gas grid, which has a huge untapped potential Europe-wide.

How to reach the 10% RES and Fuel Quality targets in transport by 2020

Biomethane is, unlike electricity, always produced from renewable sources. The huge variety of feedstock that can be used to generate biogas (biowaste, manure, sewage sludge, landfill gas, etc.), avoiding that additional CO₂ would be released to the atmosphere, would require that any percentage of biomethane injected into the gas grid should be acknowledged. Therefore the CO₂ advantage of biomethane needs to be tied to the CO₂ intensity of the natural gas grid. Setting binding injection targets should however be avoided, as feedstock availability and production capacity differs from country to country (see NGVA Europe Fact Sheet on ‘*Biomethane production potential*’). OEMs producing and offering vehicles using a mix of natural gas and biomethane should be rewarded with CO₂ Super Credits, which would encourage them to produce more and promote stronger NGVs. In this light, also consumer information on fuel economy and CO₂ emissions in respect of the marketing of new passenger cars should be adjusted (Labelling Directive 1999/94/EC).



Conclusions

A market share of 20% of natural gas in transport fuels would allow a 5% reduction of the CO₂ emissions from all European vehicles. Assuming that 20% of the gas used would be made up of biomethane, the CO₂ reduction would increase to 7%. European emission policies are clearly and increasingly supporting NGVs and will remain the main driver for further market development of CNG and LNG vehicles. But there are currently several other political initiatives to be seen, including the revision of the Energy Taxation Directive, which aims at eliminating tax advantages for different fuels, including natural gas, by 2023. Another important aspect closely linked to a favourable tax treatment is the development of the methane refuelling infrastructure. Hence, the Expert Group on Future Transport Fuels, whereof NGVA Europe is a member, is currently preparing its report on policy recommendations for 2012. NGVA Europe has already been deeply involved in the elaboration of the first report of the expert group, which was one of the basic reference documents for the preparation of the transport White Paper, but NGVA Europe, amongst others, also actively contributes to the high level group CARS 21 (Competitive Automotive Regulatory System for the 21st century), in order to support the modification of existing and development of additional EU policies for the automotive sector in the best possible way.

6.2 CARBON FOOTPRINT MATRIX & POTENTIAL SUPPLY SCENARIOS OF ALTERNATIVE FUELS FOR TRANSPORTS

Dr. Antonio Nicotra, General Manager, Gasfin Investment SA

1) Introduction to Life Cycle Assessment (LCA) and Carbon Footprint Matrix

The Transport Industry is committed to sustaining its growth in a preserved environment, aiming towards a “low-carbon” and “carbon-neutral” economy, by eagerly searching for new fuels solutions, as complement or alternative to crude oil derivatives.

Hydrogen based Fuel Cells and Electric Motors appear to be the “cleanest” options as these systems do not release any CO₂ locally, where the engines operate.

Bio-fuels also appear to be very friendly to the environment based on the concept that all CO₂ released by their combustion is eventually re-absorbed during the growth of the relevant energy crop from which bio-fuels are derived (the bio-fuel “carbon neutral” principle).

However, Electricity and Hydrogen are not “primary sources” of energy, and relevant amounts of CO₂ and other GHG are released in the locations where these forms of energy are generated and distributed (depending on the primary source of energy being utilized).

Also, the preparation phase of bio-fuels (including crop planting, cultivation, harvesting, transporting & processing into final product and subsequent distribution to consumers) requires substantially higher amounts of energy in comparison to the preparation process of the fossil fuel to be replaced, consequently releasing much higher amounts of CO₂ and other GHG.

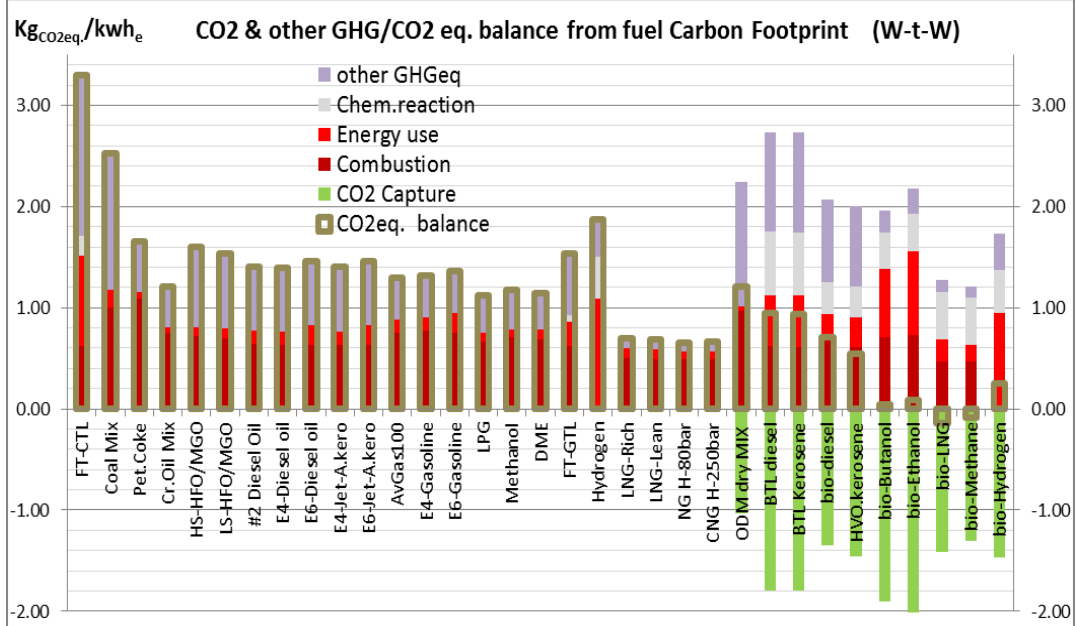
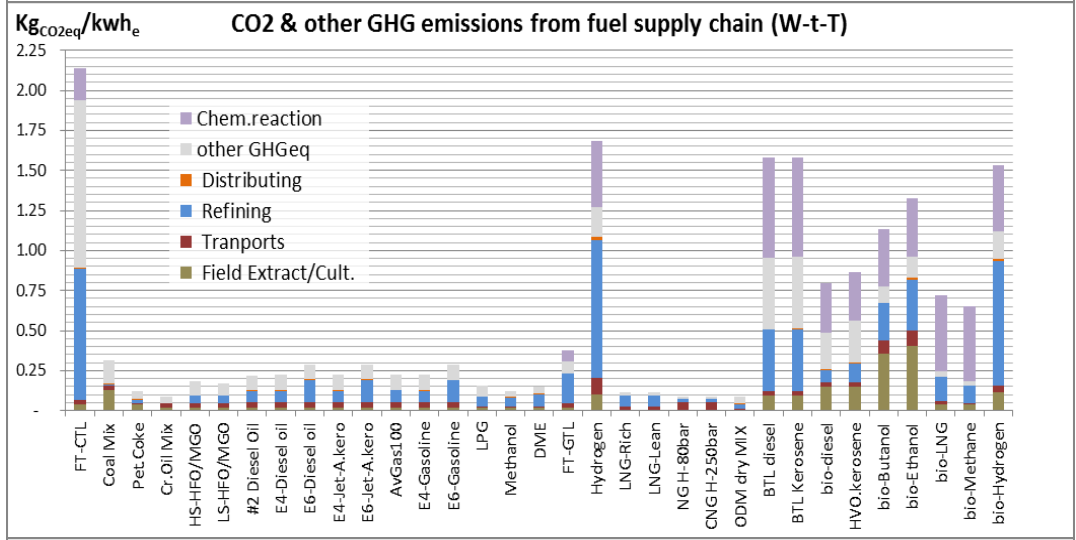
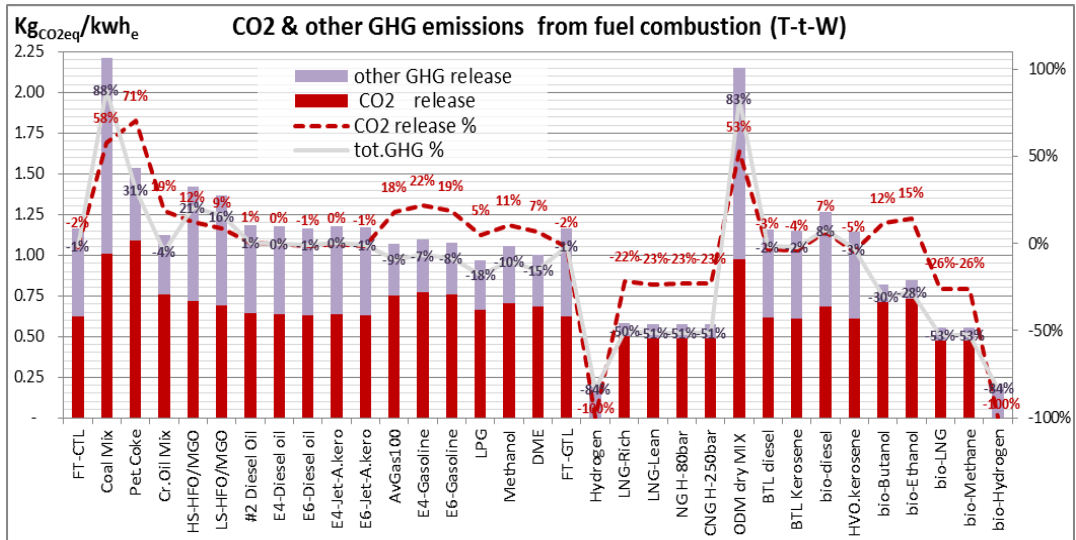
Consequently, the “cleanness” of each relevant fuel option cannot be defined only by the amount of emissions released during the work (motion) performed by the engine operation (this combustion phase is called “tank-to-wheel”), but it must also include all GHG released during the entire supply chain of the relevant fuel: including extraction from the source, upgrading, transport, refining process and distribution till the tank of relevant vehicle (this supply phase is called “well-to-tank”) and also include the GHG emissions relevant to all additives and by-products eventually utilized through the fuel supply chain.

This entire process is called “Life Cycle Assessment” or “well-to-wheel” or “cradle to grave” analysis of the relevant fuel and has the aim of assessing the entire “Carbon Footprint” of the fuel during its entire Life Cycle, in order to assess more correctly the overall impact on GHG emissions of the fuel under scrutiny and not only the local effects.

Even the electricity directly generated from solar or wind power has a Carbon Footprint that concerns the GHG emissions related to the production and transportation of all the component and equipment forming the related infrastructure.

Relevant approaches and calculations for LCA are strictly regulated by the ISO 14040/14044 standards.

Furthermore, when bio-fuels are investigated, the analysis should not be limited to the Fuel Life Cycle (as regulated by the “carbon neutral” principle of the EU DIR 2009/28/EC), but it should be extended by counting the carbon through the overall Carbon Balance between Atmosphere and Biosphere, as relevant amount of CO₂ remain suspended in the Atmosphere or sank into the Biosphere.



2) Carbon-Footprint-Matrix calculated by Gasfin under ISO14040/044

Gasfin has calculated LCAs under ISO 14040/044 and collected the data in a Carbon Footprint Matrix extended to most fuels used by transports. The comparative results of this Matrix are summarized in the following tables and graphs, (in the next page):

The above tables and graphs provide the following evidences:

Fuels combustion: Methane generates about 25% less CO₂ and 50% less total GHG/CO₂ equivalent emissions than oil derivatives. While coal releases 50% more CO₂ and 90% more GHG/CO₂ equivalent emissions than oil derivatives. The only GHG/CO₂ equivalent emissions generated from combustion of hydrogen are related to NO_x emissions.

Fuels supply chain: Traditional fossil fuels supply chains are most efficient and least polluting; reforming processes and Fisher-Tropsch synthesis are highly energy intensive generating substantial emissions; the bio-fuels supply chains release over 3 times more emissions than correspondent fossil fuels.

Life Cycle Carbon balances: bio-methane, in liquid or gaseous forms, appears to be the only option able to achieve a “negative carbon footprint” consisting in sinking into the Bio-sphere (roots) more Carbon than the amount sourced into the Atmosphere by the entire fuel supply chain and combustion processes.

3) Potential Supply Scenarios of Alternative Fuels for Transports

The “low carbon footprint” or even the “negative carbon footprint” of a new alternative fuel option is not a sufficient reason for the fuel to qualify as preferred option for sustaining the future growth of the transport industry.

This “environment friendly” alternative fuel must also be abundant in supply, able to cover the growing demand of fuel by all means of transports, and economically viable, with regards to its production & distribution costs and to the technologies & infrastructures required to allow the current transport industry to switch from current fuels to the new alternative/complementary fuel. Evidently the technologies of the new alternative fuel need to be proven, reliable, efficient and safe, (same or better than current fuels).

4) Alternative Bio-Fuels Potential-Supply Matrix elaborated by Gasfin

Gasfin has elaborated the potential productivity of the alternative bio-fuels considered “mature” by transports as complement (drop-in: **BTL [Biomass-To-Liquid]** and **HVO [Hydrogenated Vegetable Oil]**) or alternative (not-drop-in: **Bio-LNG/LBM [Liquid Bio Methane]**) to the traditional oil derivatives currently in use.

The bio-fuels potential-supply Matrix has been elaborated referring to the energy demand statistics provided by the 2010 EU STATS and US EIA and the 2009 FAO statistics on world agriculture & forestry. Results are shown in the following table and graphs (next page) and can be summarized as follows:

- ✓ **In EU-27**, the bio-Methane potential productivity reaches 75% of all EU-27 current energy demand (and it is 50% higher than all liquid fuel demand). BTL potential would only reach about 36% of all liquid fuel demand in EU-27. HVO potential would only be able to contribute to about 5% of all liquid fuel demand in EU-27.

- ✓ **Worldwide:** the bio-Methane potential productivity is about 60% higher than all World current energy demand. BTL potential would only reach about 50% of all energy demand. HVO potential would only be able to contribute to about 15% of all energy demand.

The main differences on productivity are related to the different qualities and quantities of substrate-bio-mass wastes from which the 3 different bio-fuels can be produced.

Fuel demand (EU & EIA Stats 2010)

LIQUID FUEL CONSUMPTION		EU27	WORLD	EU27 %	W %	E27/W%
Total Liquids	tot. M. tn	582	3,465	100.0%	100.0%	16.8%
All Transports	M. tn	377	2,064	64.9%	59.6%	18.3%
Aviation	M. tn	53	262	14.2%	12.7%	20.3%
TOTAL ENERGY	M. TOE	1,158	12,203			9.5%

BIO-FUELS RESOURCES (FAO Stats 2009)

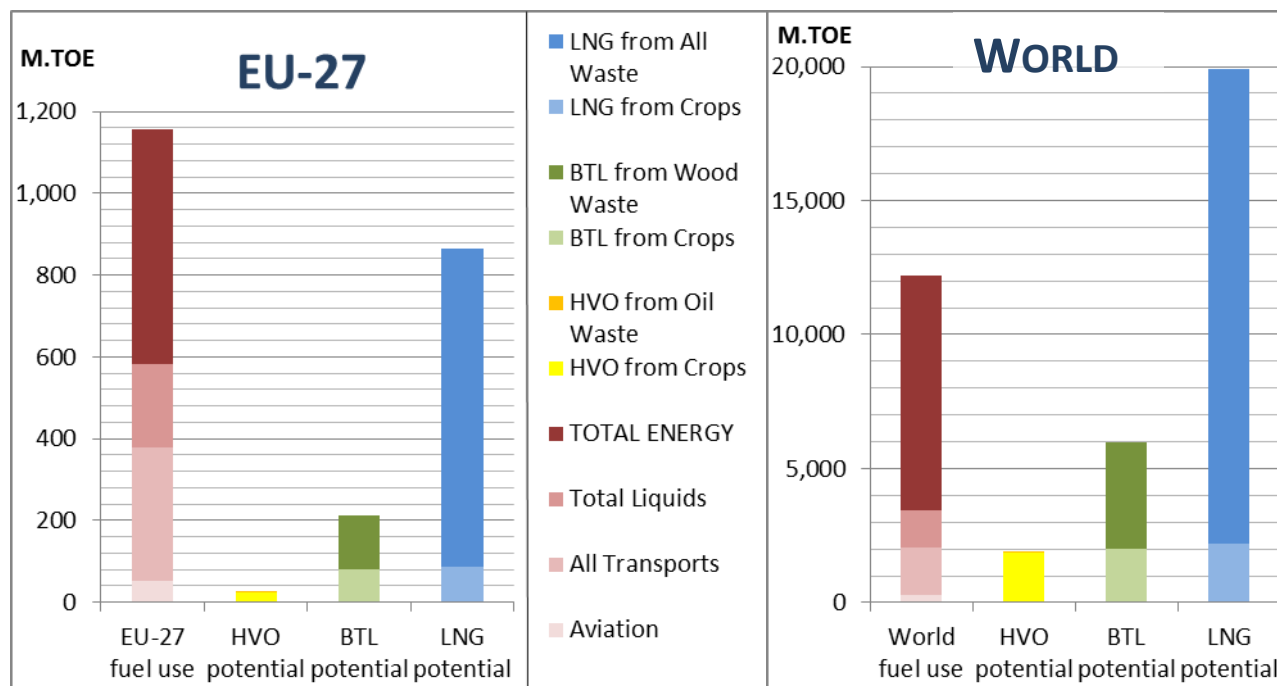
LAND total	tot. M. ha	433	13,459	100%	100%	3.2%
agriculture	M. ha	185	3,907	42.7%	29.0%	4.7%
pastures	M. ha	65	2,350	15.0%	17.5%	2.8%
forests	M. ha	156	3,640	36.0%	27.0%	4.3%
PEOPLE	M. Nr	500	6,775			7.4%
LIVESTOCK	tot. M. Nr	850	27,500	100%	100%	3.1%
Cattle	M. Nr	90	1,300	10.6%	4.7%	6.9%
Hens	M. Nr	500	23,000	58.8%	83.6%	2.2%
Pigs	M. Nr	160	2,000	18.8%	7.3%	8.0%
Sheeps	M. Nr	100	1,200	11.8%	4.4%	8.3%

BIO-FUELS RESERVES

CROP PRODUCTION	tot. M. tn	1,896	45,261			4.2%
VEGETABLES RESIDUES	tot. M. tn	3,206	68,090			4.7%
LIVESTOCK PRODUCTION	tot. M. tn	187	1,154			16.2%
ORGANIC DRY MASS WASTE	tot. M. tn	3,649	83,043			4.4%
from Veg-production	M. tn	664	22,630	18.2%	27.3%	2.9%
from Veg-residues	M. tn	328	5,074	9.0%	6.1%	6.5%
from Wood & paper	M. tn	795	28,971	21.8%	34.9%	2.7%
from Meat-production	M. tn	66	577	1.8%	0.7%	11.4%
from Livestock manure	M. tn	1,598	23,080	43.8%	27.8%	6.9%
from Municipal-Solid O.W.	M. tn	125	1,694	3.4%	2.0%	7.4%
from Municipal Sewage	M. tn	75	1,016	2.1%	1.2%	7.4%

Bio-FUELS POTENTIAL

LAND for ENERGY CROPS	tot. M. ha	25	626	10%	10%	4.0%
Cellulosic Residues	tot. M. tn	1,013	32,354			3.1%
All ODM Waste	tot. M. tn	3,649	83,043			4.4%
HVO potential	tot. M. tn	26.5	1,891			1.4%
from Energy Crops	M. tn	25.0	1,878	1.0	3.0	1.3%
from oil/fat Waste	M. tn	1.5	13.5			11.4%
BTL potential	tot. M. tn	211	5,975			3.5%
from Energy Crops	M. tn	80	2,003	3.2	3.2	4.0%
from cellulosic Waste	M. tn	131	3,972			3.3%
Bio-LNG potential	tot. M. tn	866	19,907			4.4%
from Energy Crops	M. tn	88	2,191	3.5	3.5	4.0%
from all ODM Waste	M. tn	779	17,716			4.4%



5) Economic Forecast of Potential Alternative Bio-Fuels Scenarios

Low carbon footprint and abundant availability of a candidate alternative fuel for transports would not be able to sustain the industry growth if its economics are not favourable, with regards of the fuel production cost and the relevant investments needed to implement the entire supply chain. “Drop-in” fuels that can be mixed with the current fuels in use have the advantage to sharing the same infrastructures, while “not-drop-in” fuels would require more investments for the logistics needed to implement new supply infrastructures parallel/next-by to the existing units.

6) Alternative Bio-Fuels Economic-Forecast Matrix elaborated by Gasfin

Gasfin has elaborated a Matrix able to indicate the economical sustainability of the alternative bio-fuels considered “mature” by transports as complement (drop-in) or alternative (not-drop-in) to the traditional oil derivatives currently in use. This bio-fuels economic-forecast-Matrix has been elaborated referring to the 2011 energy prices forecast provided by the US EIA and assuming best practice industry standards for CAPEX & OPEX of the various technologies selected for the entire supply chain of the alternative biofuels examined.

Results are shown in the graphs here below and can be summarized as follows:

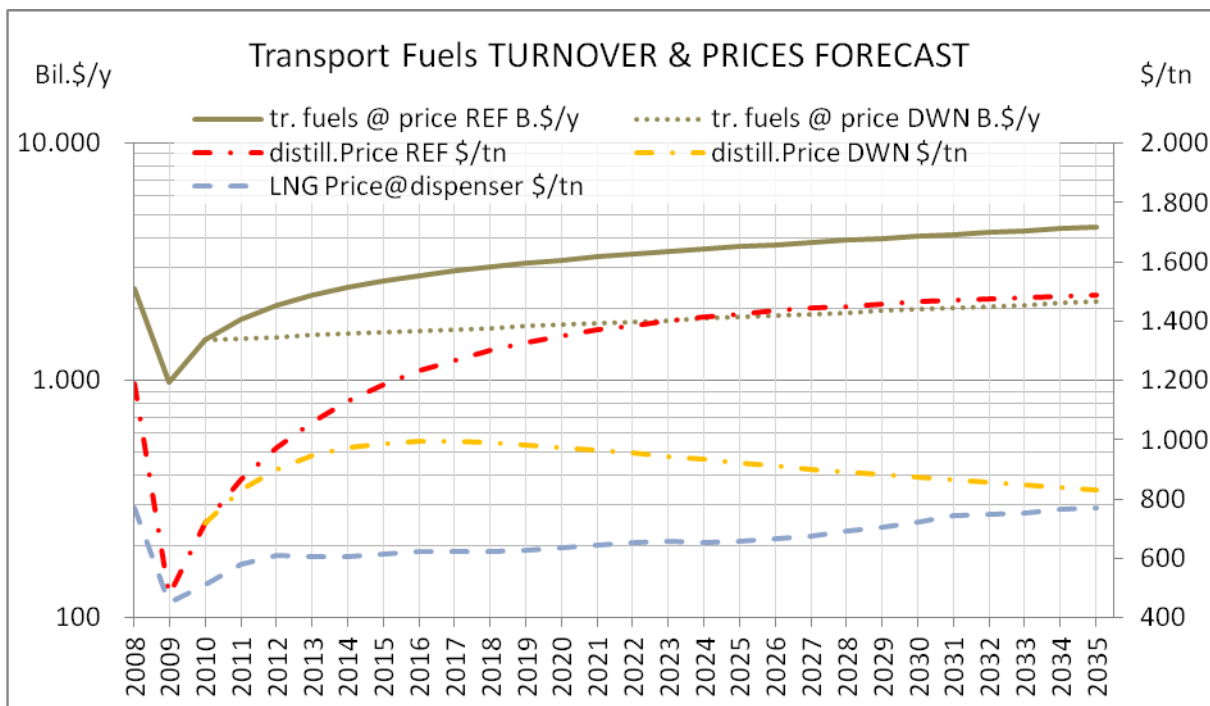
Transport Fuels TURNOVER and PRICES FORECAST:

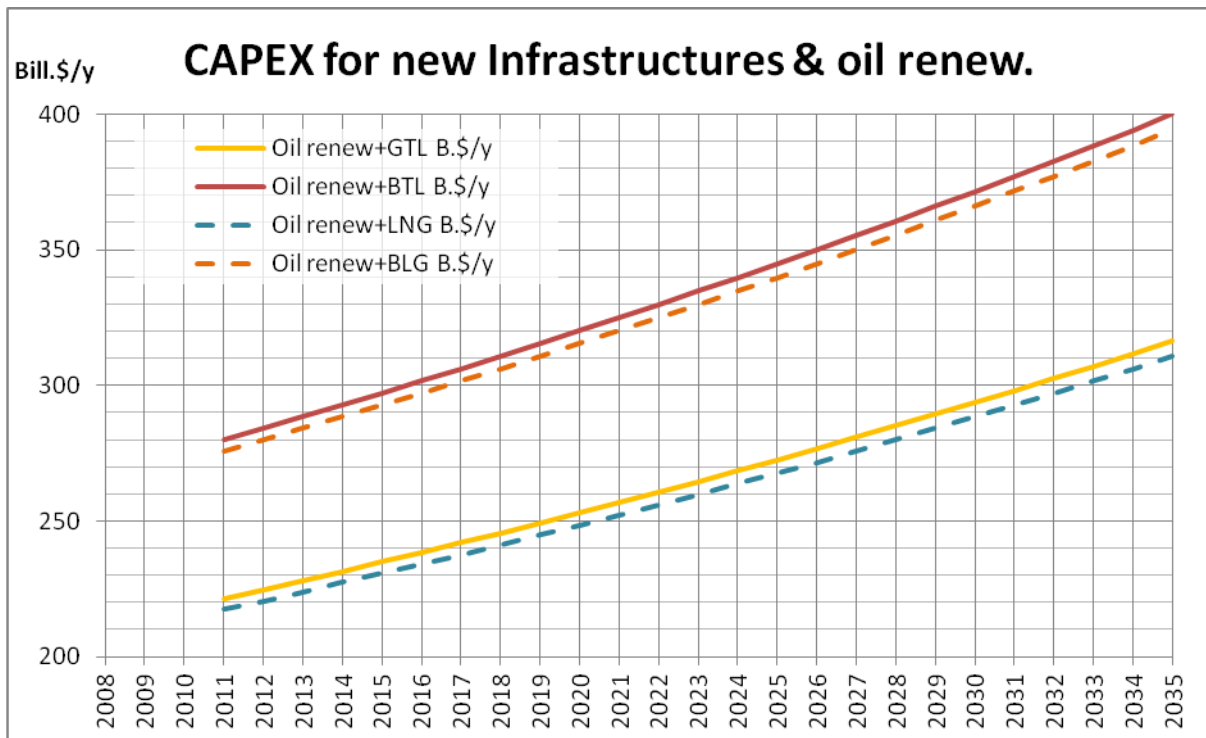
- ✓ Mid distillate oil price have quickly recovered after the 2008 financial crisis and are expected grow to about \$1,500/t_{FOB} in the next 25 years in the “reference” EIA 2011 forecast scenario (REF line in the graph); oil prices may return to the 2010 level of about \$800/t_{FOB} in the event of a new recession or a new fuel being established as main substitute to oil (DWN line in the draft).
- ✓ “Drop-in” new fuels such as GTL, BTL and HVO trade at a premium over distillate oil derivatives and do not show ability of reversing the prices upwards trend.
- ✓ Natural Gas prices have recently shown ability to decouple from oil prices with more moderate price increases.

- ✓ The establishing of Natural Gas (from both fossil and renewable sources) as a main substitute of oil also for transports would allow to relieve the pressure on oil prices and converge oil and gas prices to the envisaged average of about \$800/tn.
- ✓ The Worldwide TURNOVER of transport fuels is expected to grow from about \$1.5 Trillion in 2010 to \$4.4 Trillion in 2035 assuming the prices of the reference scenario. This Turnover would only grow to about \$2,2 Trillion should the price of fuel return to the \$800/tn target, **giving Industry Savings in the range of \$ 1-2 Trillion per year.**

CAPEX required for new alternative fuels infrastructures and oil revamping:

- ✓ The CAPEX required for renewing oil infrastructures and implementing either new GTL refineries and/or new LNG supply chains appear to be in the range of about \$220-320 Billion per year for either case.
- ✓ Should BTL and/or LBG programs be implemented in addition to renewing the oil infrastructures, the required CAPEX would range at about \$280-400 Billion per year for either case.
- ✓ The main key point is the consideration that investing in the drop-in alternatives (selling at a premium) do not help in lowering the oil prices and achieving the savings above indicated; on the contrary, investing in LNG and LBG would allow to achieve the indicated saving, from which they could be discounted (CAPEX =20-25%SAVINGS).





7) CONCLUSION

The author acknowledges that the overall assessment requires further investigations to verify, share and revise calculations and results.

However, the clear advantages (environmental, availability and economic) shown by adopting natural gas (fossil) and bio-methane (renewable) as main substitute to oil encourages to expedite their relevant programs at all levels.

7. FUELLING AND OPERATION TECHNOLOGIES

7.1 FUELLING OF LNG/L-CNG VEHICLES

Manuel Lage, Dr. Eng., NGVA Europe, General Manager

The concept of European LNG Blue Corridors

NGVA Europe is currently investigating a proposal that focuses on both the production of liquefied biomethane (LBM) and applications of Bio LNG in heavy goods vehicles on medium- and long-distance haulage. Since freight transport often starts and ends in cities the Bio LNG Blue Corridor proposal also aims at supplying NG/biomethane to urban areas and big European cities using the L-CNG filling station concept, able to provide both, Bio LNG to heavy-duty trucks and Bio CNG to light-duty passenger cars and commercial fleets of urban distribution vans and lorries. (The NGVA Europe LNG Blue Corridors concept and proposal in detail are presented in Appendix II of this Report and in the Chapter 5).

Experience

The experience of using LNG in heavy vehicles is not new. In some early cases it was applied to a captive fleet like the garbage collection urban trucks in Barcelona (Spain). In this case this experience lasted more than ten years, until the renewal of the fleet trucks. The gas consumption of this fleet, owned by the company CESPÀ, was of 2.7 million Nm³ of natural gas per year. The LNG was tank transported from the Barcelona port LNG terminal, nearby.

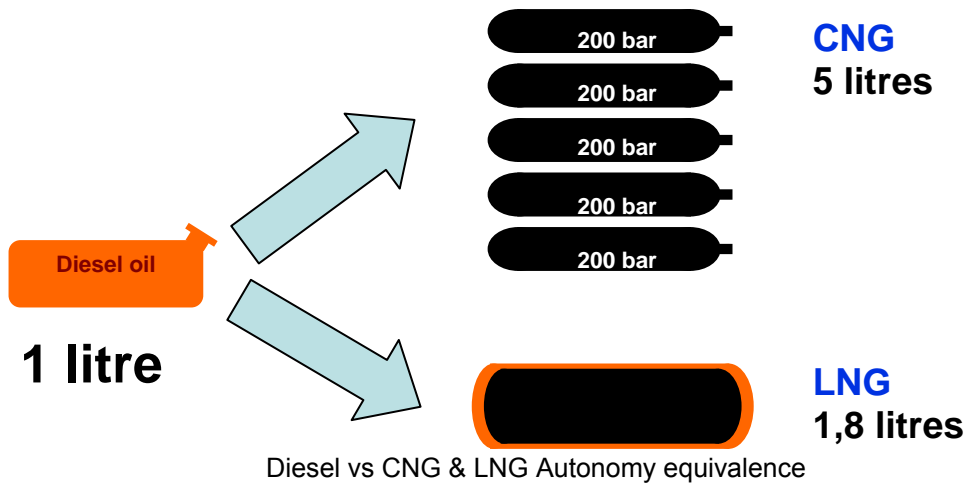


LNG (Liquefied Natural Gas) characteristics

Taking as a reference the widely used CNG, we can see that the autonomy equivalence of one litre of diesel oil is 5 litre of CNG, meaning that when we talk about heavy vehicles, CNG is mainly recommended for urban fleets, with daily refuelling by night.

LNG, by its condition of liquid, is the NG with a higher energy density, needing only a volume of 1.8 litre to give the same autonomy that 1 litre of diesel oil. This significant characteristic opens the way for the medium and long distance road transport using LNG.

Diesel vs CNG & LNG Autonomy equivalence



Comparison between CNG vs LNG tank configuration on the same truck chassis:



CNG (green truck): 8 tanks of 80 lt. 640 lt. CNG equivalent to 128 litre diesel LNG (white truck): 1 single LNG 360 lt. tank equivalent to 200 litre diesel (56% more)

In the last years it has been a limited offer of LNG tractor units for road transport in Europe, mainly from Mercedes Benz and IVECO, as dedicated engines, plus other dual fuel alternatives from specialised conversion companies.



IVECO Stralis 280 & 330 CV and MB Econic 280 CV

The Dutch company Rolande LNG B.V., a specialist in supplying LNG and LBG for road transport applications, has recently introduced the first truck running on Liquid Bio Gas.

Rolande LNG B.V. made this concept to work by converting, in close cooperation with the OEM, an IVECO Stralis CNG into a truck being capable to run on LNG/LBG. Rolande LNG

B.V. provided not only the know-how but also the special cryogenic tanks and heat exchanger.

LBG is made from gas coming out of a landfill. It gives better emission levels than EEV or Euro 5 diesel engines. LBG CO₂ emissions (Well to Wheel) are by far the best alternative to any other bio fuel currently available (up to 80% CO₂ reduction compared to diesel).

The truck is being used to show and promote the many advantages of LBG as fuel: It is cleaner (better than future Euro 6), quieter (5 dbA lower noise level than a diesel) and up to 80% CO₂ neutral! There is no better and economic alternative today. LBG can save between 2 and 5 €cents per km and run more than 1.200 km before refuelling.

The excellent results obtained by Rolande with the first 20 LNG/LBG units pushed the company to order 80 additional units, to be put in service by the end of the year 2011.

Dual Fuel technology

Dual fuel systems have been developed to substitute natural gas for diesel in light and heavy duty engines. The natural gas injection system is electronically controlled and can cater for multi-point, mono-point and sequential port injection.

A separate electronic control unit (ECU) is used for the natural gas fuel, providing a full closed loop feedback system that monitors existing variables alongside the diesel electronic control unit (ECU) and controls the gas injection based on the feedback from the various engine sensors. The ECU is fully programmable and can provide custom mapping for various vehicle applications, giving enhanced compatibility features.

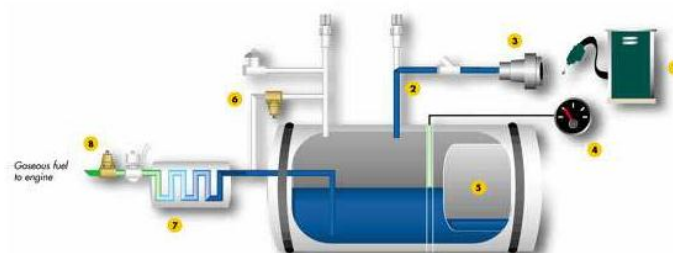


Volvo tractor unit with Hardstaff technology, dual fuel engine.

LNG in board tank system and connections

Under the point of view of tanks and component availability, installations, filling stations, etc, LNG technology is well established and everything is available commercially.

GENERAL WORKING DIAGRAM

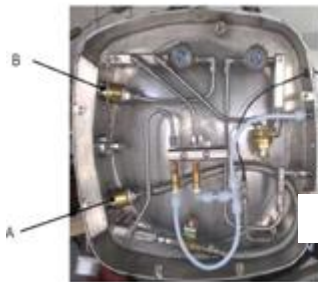




CONNECTIONS

- A) LNG FILLING CONNECTION
- B) RECOVERY GAS CONNECTION

CONNECTIONS



VENTING LINE

STANDARD LNG COUPLINGS



Some examples of Refuelling Stations L-CNG in Europe



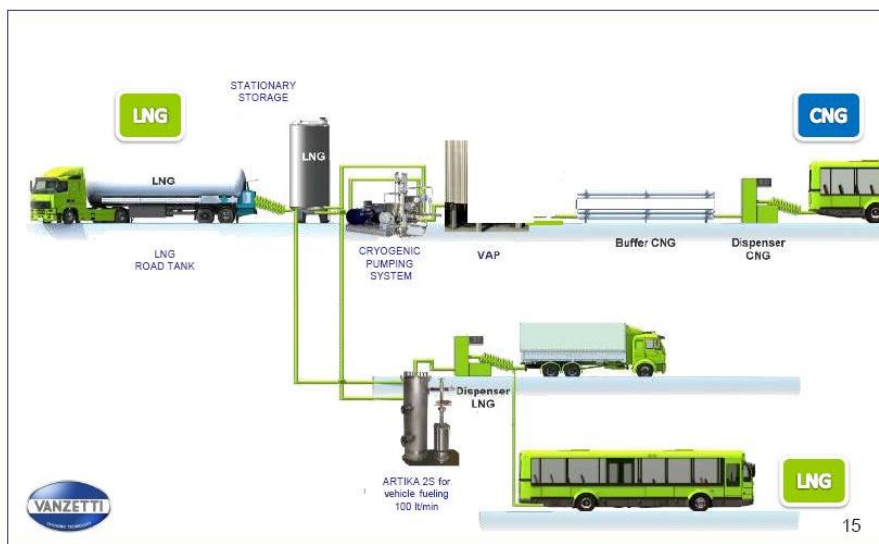
Liquefaction can also be used as a “refining” process for NG. In some cases the process of NG liquefaction is also used to improve the gas quality coming from well. This is the case of the LNG plant near Poznan (Poland).

NG comes from the well with 17% of nitrogen, making it unable to be used directly in NGVs. The liquefaction process eliminates most of nitrogen, enriching the methane content of the LNG and facilitating its transport.

LNG availability through road distribution will allow having filling stations able to supply both CNG and LNG. The new plant has a production of 100 ton/day of LNG.



Views of the Poznan LNG plant



Principle of L-CNG/LNG refuelling stations

7.2 BEST PRACTICES: NGV FUELLING STATIONS

NGV including all methane- and biomethane-driven vehicles

Peter Seidinger, Jeffrey Seisler Clean, Fuels Consulting.

The purpose of this section is to develop an understanding of some of the cost reduction opportunities and ‘best practices’ for the installation and operation of fuelling stations serving natural gas vehicles. The stations include the range of available technologies:

- compressed natural gas (CNG);
- liquefied natural gas (LNG);
- (although this was not the primary focus of the research);
- liquefied-to-compressed natural gas (L-CNG);

- mobile fuelling technologies and techniques and, also including the use of biomethane, be it added to the natural gas pipeline grid or used directly as a vehicle fuel upgraded from 'raw' biogas.

The information gathered is based on a survey of industry experts, both equipment suppliers and customers/users (who, in some cases, are the same) as well as some direct interviews with knowledgeable stakeholders.

The findings are based on interview and survey responses. Conclusions are those of the authors as well as a number of the survey recipients who made additional comments after the first results of the survey were collated and provided back to them for their input and additional feedback.

Summary of “best practices for NGV fuelling stations”

To ensure “best practice of refilling natural gas” as an automotive fuel:

- Use LNG, whenever possible, directly for L-NGVs and as L-CNG fuelling due to its relatively favourable energy efficiency, if:
 - Reasonably priced LNG is available (today coming mainly from local regasification terminals),
 - Pattern of demand of L-NGVs and CNG vehicles fits the pattern of customers' needs, AND
 - Sufficient NGV-fleet customers already exist (either existing customers or with a new local customer willing to use natural gas as a vehicle fuel).Note that L-NGVs predominantly are heavy duty vehicles (HDVs) (including buses), Light duty cars or commercial vehicles generally are fuelled by CNG. For the latter category L-CNG-stations are needed.
- In all other cases use CNG from the gas grid taking into consideration (in order of priority):
 - Using the highest possible inlet pressure from the gas grid into the CNG station;
 - Identifying the best retail location (considering customer travelling patterns as well as obtaining highest gas inlet pressure from the grid),
 - Ensuring there is enough initial demand for fuel from existing or new local fleets or private commuter NGVs.

A least two of the three conditions should exist, otherwise installation of an NGV fuelling station should be reconsidered. For LNG stations initial demand *must* be assured. (L-CNG stations will not be concerned with inlet pressure from the natural gas grid.)

Mother-Daughter (M-D) Stations

Mother-Daughter stations are a system whereby large tube trailers with CNG can be fuelled from a large-capacity compressor station and the gas is taken by truck to a fuelling station where there is no access to pipeline gas. The fuel truck is connected to a dispenser that enables NGVs to receive gas. When the pressure of the CNG in the truck is too low to deliver more gas, or the tanks is empty (depending on what technology is used) the fuel truck returns to the 'mother station' for another load of gas. Frequently a two-truck system is used in tandem so that the CNG station has a consistent volume of fuel available for customers. The layout/design for those M-D-stations has to be optimized for targeted supply/ demand within certain limits of flexibility. In the best case additional costs for logistics (factor 2) can be compensated by lower overall costs for a gas grid connection not needed at daughter sites. (Mother station should be receiving gas at the highest possible grid inlet pressure; daughter stations should be less than 100km from the mother station (and accessible via suitable

roads). Sufficient space at the daughter station should be available for two trailers (on incoming and the other outgoing.)

Slow Fill Stations (< 10-40m³ natural gas/h)

Natural gas “Slow Fill Equipment” may have its place, but only where costs are not among the top three issues (e.g. remote fuelling location with some NGV from a bigger fleet to be serviced within a network of stations). Cost of land and access to suitable land for a public slow fill operation often can be prohibitive (when those costs have to be covered by very small sales volume). For private slow fill (e.g. home fuelling) additional costs for installation and complying with local codes and regulations will add to the base price.

Biomethane stations without gas grid connection

NGV fuelling with biomethane directly to a station is possible when biogas is produced locally. Due to generally higher costs for biomethane (typically a factor of two-to-three times the cost of gas) this option is, by far, the most expensive overall. For some specific situations it may be reasonable (e.g. dedicated NGV fleets) or at places where sufficient biogas supply is available and the excess capacity can be supplied to a sufficient volume of local NGV customers.

Regulations and standards have “the major single impact” on costs

Although not directly linked to the direct cost of fuelling equipment, the biggest single trigger for cost reduction will be a worldwide harmonization of NGV refuelling standards. Producer and operators today spend too much money to ensure compliance with a lot of different regulations and standards (differences in national, or missing international standards). For NGV fuelling this missing harmonisation is seen today as the single most important cost component by producers/enablers. Respondents to the survey indicated that adopting the best practices for safety can reduce costs by as much as 30%.

Two main parts of this study

This chapter on best practice of NGV fuelling has two main parts:

- a. Best practices for NGV fuelling as gained from interviews with operators and suppliers/producers (i.e. turnkey suppliers, consulting engineers and equipment manufacturers) as well as from industry literature on “best practises”.
- b. Results from a survey using written questionnaires.
More than 60 experts worldwide were contacted, including:
 - Operators and customers of NGV fuelling stations (50% response rate and 15 reviewers)
 - Suppliers of NGV fuelling (48% response rate and 14 reviewers)(Note: The names and organisations participating in the survey appear in the appendix B to this chapter.)

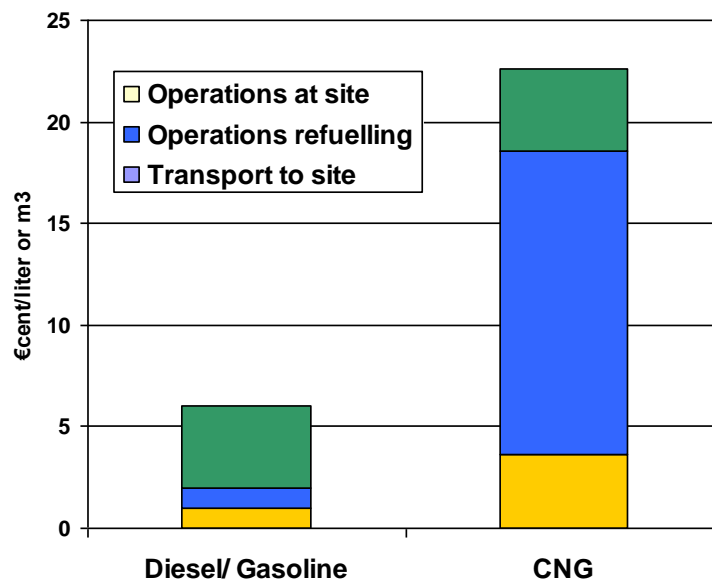
The feedback received from the survey recipients mostly focuses on qualitative information. Quantifiable results were difficult to obtain and comparisons of some elements across international boundaries is difficult to compare. Nevertheless the results of the survey provide significant findings and conclusions that have not been previously gathered in publically available surveys. The results have been compressed in the following chapters.

Gasoline/Diesel fuelling are setting “benchmarks/best practice” for NGV fuelling

Since gasoline and diesel are and will remain the dominant automotive fuels worldwide, the costs of fuelling gasoline/diesel are the benchmark for NGV fuelling. This includes:

- Direct costs of fuelling (equipment on site, costs of gas-/electric grid), as well as;
- Indirect costs of fuelling (costs for building structures, land, or provisions for automatic payment 24 hours per day/7 days per week).

Compares the costs of petroleum fuelling stations versus a CNG station, using European figures/data as examples.



Comparison between fuelling costs for gasoline/diesel vs. natural gas (CNG) (data for Europe). – LNG/L-CNG costs will be lower if the design is optimized exactly to fuel demands in the local market.
Source: calculations from several operators

Tax incentives for NGVs and fuelling stations have played an important role in reducing overall costs but these will be reduced as the CNG and LNG market shares increase.

Identifying “Next steps and benchmarks for best practices to reduce costs of NGV fuelling”

Survey respondents were asked to identify specific actions, techniques or initiatives designed to reduce NGV fuelling station costs worldwide.

Some of those are not specific to natural gas fuelling, but are needed by station installers to cut costs, such as continued development of standards and regulations and/or harmonization of existing international regulations. The specific issues concerning fuelling of NGVs differ substantially from country to country and region to region. Issues with the highest potential contribution to reduce costs and increase performance may be taken as “action program for step 2” and include:

- [Action A1](#): Collect best practices from today’s operated NGV fuelling systems (including safety), and define solutions with best cost-value ratio. Support initiatives to develop internationally harmonized standards.
- [Action A2](#): Collect and analyse best practices for technologies/systems to extend intervals for maintenance of NGV fuelling systems (times may differ for different components)
- [Action A3](#): Define LNG standards for L-CNG/LNG fuelling

Benchmark /best practices on NGV fuelling – Results and outlook

Overcoming the ‘chicken and egg’ problem will continue to be a challenge since experience shows that both fuelling stations and NGVs must develop in a balanced way more or less simultaneously. The existence of NGV fuelling stations alone does not necessarily cause NGV numbers to increase. But an adequate network of NGV fuelling stations is a prerequisite for NGV development; hence the notion of a ‘chicken and egg’ syndrome. Modes of mobility in general are changing “slowly”. Gasoline and diesel are “status quo automotive fuels” when it comes to economics, efficiency, and performance:

- Liquid fuels have an extremely high energy content in a small volume;
- Liquids are easy to store and to handle;
- Worldwide standards and regulations for liquid petroleum fuels are well developed and the existing infrastructure of fuelling stations already is paid off;
- Vehicle production capacities (OEM investments) are well-optimized for vehicles running on liquid petroleum fuels.

Every new alternative has to compete against the status quo fuels, and even with lower costs for alternatives it may take decades to establish new alternative forms of mobility.

Thus, political visions are needed to support every new alternative fuel. (Examples of “how to introduce new, alternative automotive fuels” are discussed in other chapters in this report.) It is clear, however, that governments and government-sponsored incentives in the short, medium and even longer term will be required to make at least some of the alternative fuels commercially viable. As such, each group of alternative fuel stakeholders – producers of vehicles and fuelling stations – need to focus on ways to reduce costs and improve efficiencies of scale as well as operation.

Broad variety of natural gas (NG) as automotive fuel to be covered

This short study on NGV fuelling focuses on all NGV fuelling technologies:

- Compressed Natural Gas (CNG) – gas supply from local gas grid,
- Compressed Biomethane (CBG) – renewable gas from landfills, anaerobic digesters (AD) or gasification plants (upgraded to quality that can be injected into the gas grid)

- Liquefied natural gas (LNG) and liquefied biomethane (LBG),
- CNG produced from LNG (L-CNG)

Worldwide NG retail markets differ in their needs and often are dependent on the phase of their development. Thus, it is difficult to provide complete quantitative benchmarks for a set of truly *universal* best practices.

Available results are project specific and qualitative, but quantitative benchmarks are generic

a. Service/performance standards for NGV fuelling (including self service)

CNG and LNG fuelling stations must meet the 'benchmarks' set by gasoline/diesel fuelling, i.e. refuelling times, availability of fuelling system and others. To be more specific, that means:

a.1 For “public NG retail sites”

Service benchmarks

- Open 24hours per day / 7 days per week;
- Acceptance of all credit cards/fuel cards;
- NG-dispensers placed at same locations as diesel/gasoline pumps;
- Additional non-fuel infrastructures must be provided such as shops, food and beverage services, car wash, etc.

Performance

- Unquestionable safety standards including identifying differences between CNG and LPG.
- Fuelling time comparable to diesel/gasoline (not more than twice as long)
- Best available CNG filling pressure to ensure the best vehicle range
- Availability of the gas at all times and under all times and conditions, to achieve 98-99% reliability including during peak times of fuelling. including

a.2 For “semi-/non public NG retail sites”

Same as under a.1, but with

- Less infrastructure needs (e.g. shop, restaurant, etc.)
- Longer filling times possible (e.g. possibility of slow filling NG buses during the night)
- Better availability of fuelling stations needed (i.e. up to 99% coverage, depending on urban or rural settings)

**b. “Stand alone NG retail sites” vs. “integrated NG retail with petrol/diesel”
(public sites)**

Average costs for (public) automotive fuel retail per site are defined by:

Average fuelling costs/liter for diesel/gasoline multiplied by the average diesel + gasoline sales per site

For a modern fuel retail service station in a mature market (e.g. in Europe) a typical figure may be:

$$5 \text{ €cent/liter} \times 4 \text{ Mio litre / year} + \text{site} = \text{€ 200.000 / site} + \text{year}$$

Remark: The costs in this calculation includes all site specific costs, such as rent of land (> 3.000 m²), personnel; 24/7 days open), operating costs (maintenance, energy, insurance, costs for shop/food sales), and depreciation (10 – 15 years). Specific direct costs for gasoline/diesel fuelling are very low (electricity for pumps, maintenance of dispensers (low costs) and tanks for liquid fuels.)

To ensure this “benchmark on best fuel retail service” for the NGV customer the same amount has to be spent for a dedicated, stand-alone NGV fuelling site, plus the additional cost for the NGV fuelling equipment which, typically, is much higher than for gasoline/diesel fuelling.

Calculations have to be made at specific costs/volumes in every country. Nevertheless it is obvious, that NGV fuelling stations during build up of the NGV market can not be operated as “stand alone sites (without gasoline and diesel” economically. This includes (public) L-CNG/LNG-retail sites as well.

For stand alone operations a well-running CNG station should achieve 2 to 3 Mio kg sales per year.

Option: Dedicated sites for (non-public) LNG fuelling

If only HD-NGV (e.g. long distance trucks) have to be refuelled, this may be done in non-public retail sites, as is done with many commercial road transport companies who maintain their own dedicated fuelling locations serving diesel fuel. This concept reduces investment requirements and operation costs.

c. Decide FIRST on which type of NGVs will be fuelled then build stations.

Diesel and gasoline are used in all types of cars/vehicles, from the smallest to the biggest with the highest possible fuelling performance for the vehicle owners (filling time, mileage per fill, etc.)

For natural gas as an automotive fuel the distinctions between fuelling light versus heavy duty vehicles differ, particularly if LNG is considered:

- CNG (including L-CNG) is most often used in personal cars (focus: fleets, including taxis) and commercial LD-NGVs;
- LNG will be most appropriate for HDVs (including buses).

The following illustrates the different considerations in terms of volumes of fuel per site and year for the different fuels and vehicles they best serve:

HD-NGV			LNG
LDV/Fleets		CNG	CNG / L-CNG
PC-NGV		CNG	CNG / L-CNG
	< 250	250 – 1.000	1.000 – > 5.000
	<i>NG sales volumes per site+year (in 1.000kg)</i>		
	Scenario for types of NGV and its best fuelling options		
	Range of fuelling size in 1.000 m ³ natural gas per year+sitesite		

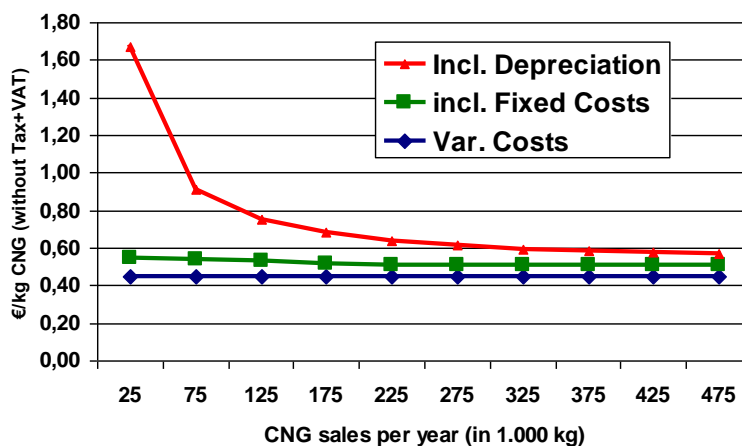
L-CNG may be an option for both LNG and CNG fuelling with “one NG retail infrastructure” only, but the overall costs to build such a network are today too high for the average station owner/operator (without given political support).

The gas infrastructure in the area may support one option better than the other (e.g. LNG-regasification terminals offering reasonably priced LNG (e.g. in Spain/France/Portugal and UK), versus high pressure gas grids (i.e. in Central Europe, Japan, the U.S., etc)). But the fuel station construction decision must be developed based upon the market needs and the types of vehicles that are available for fuelling.

LNG stations could be attractive, for example since one HDV equals more than 30-50 light duty passenger cars. Thus, in areas where LNG is available there might be the potential for faster development of sales volumes and gaining market share if the right mix of heavy duty vehicles also is available.

Developing the right sizing strategy for NGV fuelling stations to “build up new markets” (no over or under-sizing)

A special issue which, for instance, Europe faces is the build-up of new NGV markets without significant dedicated political support (including clear political targets to promote NGVs). New NG fuelling sites should be designed to enable future upgrading to match stronger growth of the vehicle population (i.e. some 3-7 years after start-up of each site). When building at a “minimum size for sales”, e.g. for a sales target between 50.000 up to 250.000 (1 million) kg CNG per site and year such stations are extremely inefficient when operated with sales volumes that are less than 30% of max. fuel sales capacity.



Scheme of production costs for a NG retail site (example for CNG, but valid also for LNG). Overall costs/kg CNG less than 0,70 €cent/kg when sales volume are greater than 30% of

design capacity (example: 300 m³/h compressor, sales target 500.000 – 800.000 kg CNG per year; European gas and power prices with oil at 110 US\$/bbl)

d.1 For “CNG retails sites” two typical growth strategies are

- Add 2nd compressor, or
- Change CNG compressor to larger size

Front-end planning for expansion seems to be the most economical approach, however, it adds to the complexity of planning and, in some cases, to the front-end cost.

d.2 For “LNG-/C-LNG retail sites”

Minimum sales figures have to be more then 2-3 million liters of LNG per year plus site costs in order to to keep costs reasonable.

“Types/Sizes” for qualitative benchmarks of NGV fuelling

To enable some quantitative benchmarks, “types/Sizes” need to be defined. Specific guidelines to adequately and economically size fuelling station capacity is based on the required max. consumption on an annual basis, taking into consideration the different size of NGVs and their fuelling capacities. We suggest the following categories:

Type/Size (CNG/LNG) max. fuelling volume (kg/year) and number of LD-NGV)

- Slow fill NGV fuelling < 50.000 (10-50)
- Small Size 250.000 (150-250)
- Medium Size 1.0 Mio (700-1.000)
- Large Size 5.0 Million (3.000-5.000 and/or HD vehicles)

Benchmarks for “CNG-Compressors” (including compressors for Mother-Daughter Stations) For CNG compressors the following categories were identified (with two different gas inlet pressures (“low/normal” and “high/best”) for small, medium and large size compressor stations).

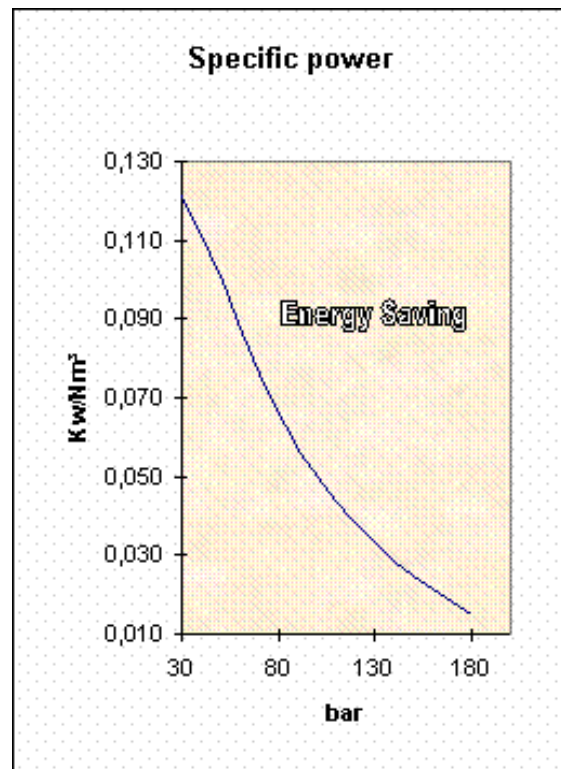
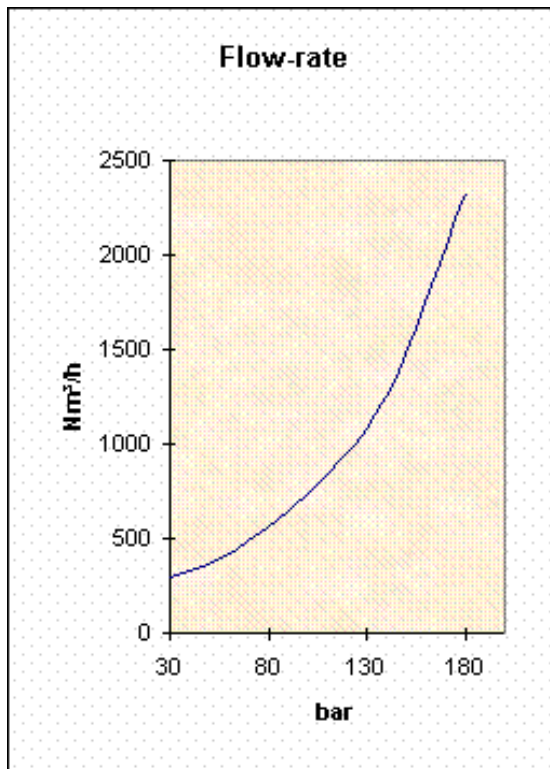
Structure for three sizes of CNG compressors and its Key Performance Indicators (KPI) depending on inlet gas pressure from gas grid. “Good practice” is defined as typically good values within the industry, both from producers and customers. “Good practice” sets the base line for “best practice”. How to achieve “best practice” starting from “good practice” is a target for survey. Benchmarks to be defined within step 2.

CNG Compressor – BENCHMARK TYPE		GOOD PRACTICE				
CNG Sales/year (m3)	Gas Inlet pressure	Compression kWh/Nm3 (to 260 bar/15 C)	Maintenance €cent/Nm3 (90% utilisation)	Operational availability (% over year)	Filling time for 20kg/100kg (in seconds)	Remarks on "Good practice"

250.000 (small)	2 bar			> 97%	< 120/<360	
	5 bar			> 98%	< 100/<300	
1 Mio (medium)	2bar			> 98%	tbd	
	30 bar			> 99%	tbd	
5 Mio (large)	2bar			> 98%	tbd	
	30 bar			> 99%	tbd	

Based on such categories a serious analysis can be done, e.g. here for CNG compressors. The influence of gas inlet pressure from the grid on energy demand is an important factor to consider in designing a fuelling station.

	two-stage booster							
Model	installed power: 37 kW							Delivery pressure: to vehicles (200 -220 bar)
Inlet pressure	Bar	50	60	65	70	75	79,3	
Flow-rate	Nm ³ /h	415	455	500	540	580	620	
Average power	kW	36,8	36,8	36,8	36,8	36,8	36,8	
Specific power	kW/Nm ³	0,09	0,078	0,072	0,066	0,061	0,058	



Note: the flows above can be obtained in absence of system restrictions. Please allow a ±5% tolerance

Influence of gas (grid) pressure on Flow-rate and Specific power for compression needed.
(Source: G. Gozzi, 2011)

Feedback from questionnaires on NGV fuelling

Two different groups of NGV fuelling station stakeholders were sent questionnaires during the autumn 2011.

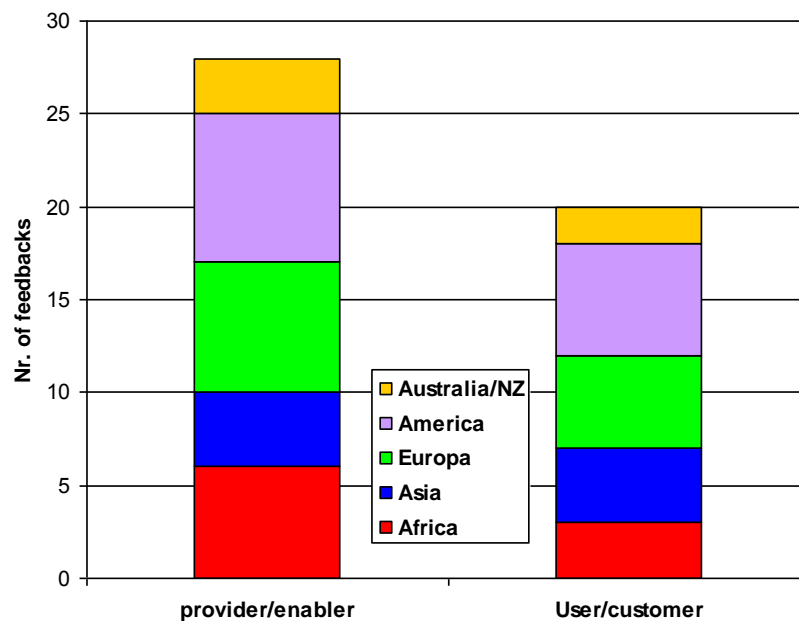
- Users/Customers of NGV fuelling equipment; and
- Equipment providers/suppliers (or in wider range: “enablers”) of NGV fuelling systems (including consultants, system suppliers, and system manufacturers,...)

The names and companies of the respondents are provided in the back of this report, as are the questionnaires for both groups.

Statistics on feedback

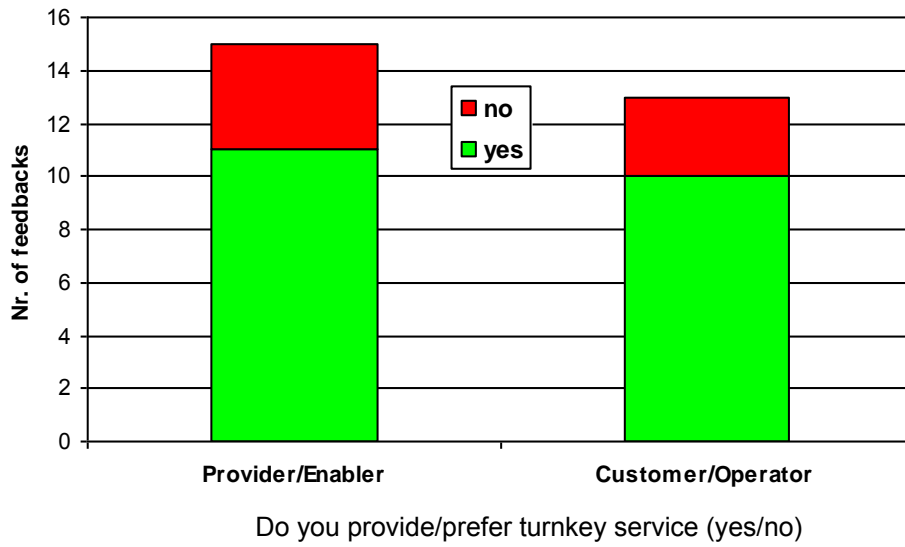
60 letters with questionnaires were sent worldwide to leading experts in the NGV business.

Twenty nine questionnaires were returned, representing a response rate of 48 %.

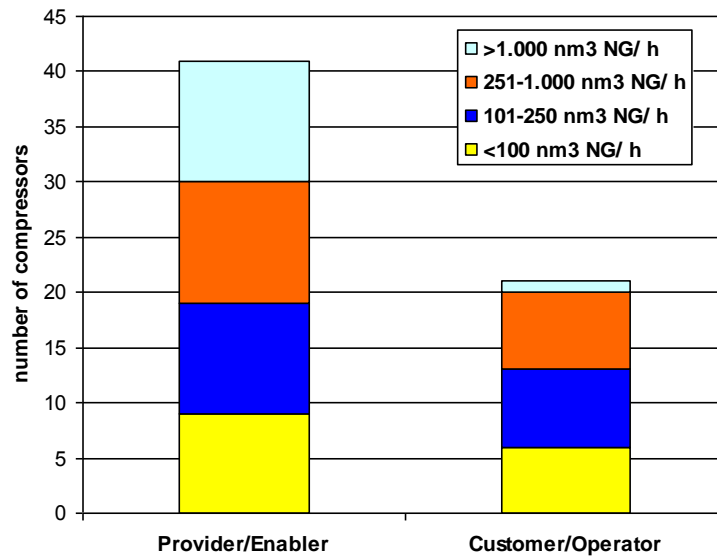


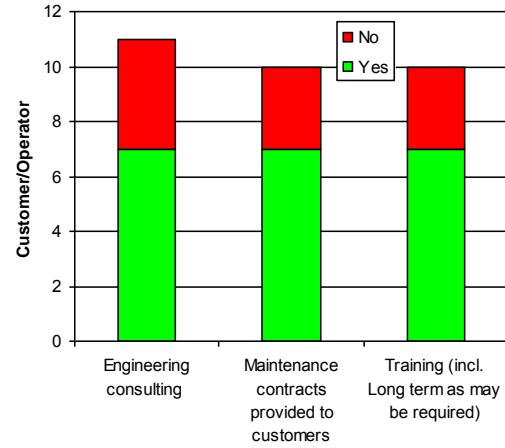
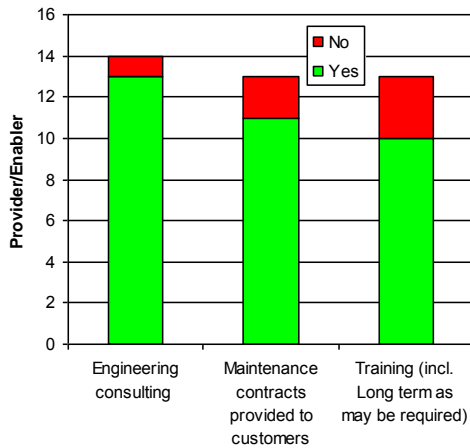
Responses by world region and type (Provider/enabler; customer/user)

Most of the respondents, system suppliers and customers indicated that complete ‘turnkey services’ has a very high value.



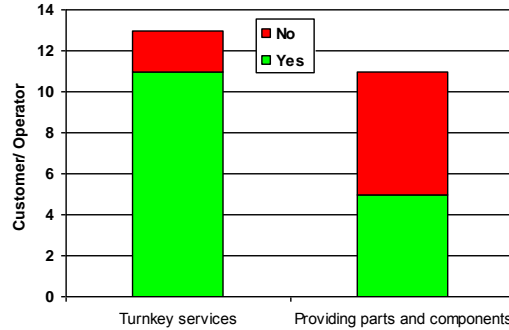
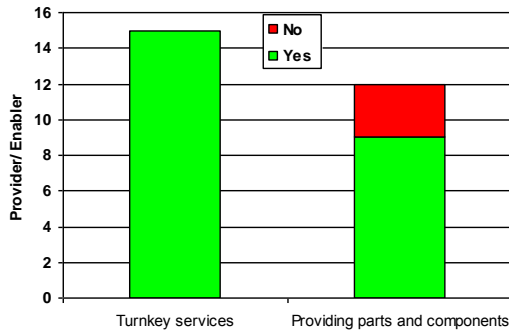
Most customer/operators taking part in this study operate smaller size NGV fuelling stations:





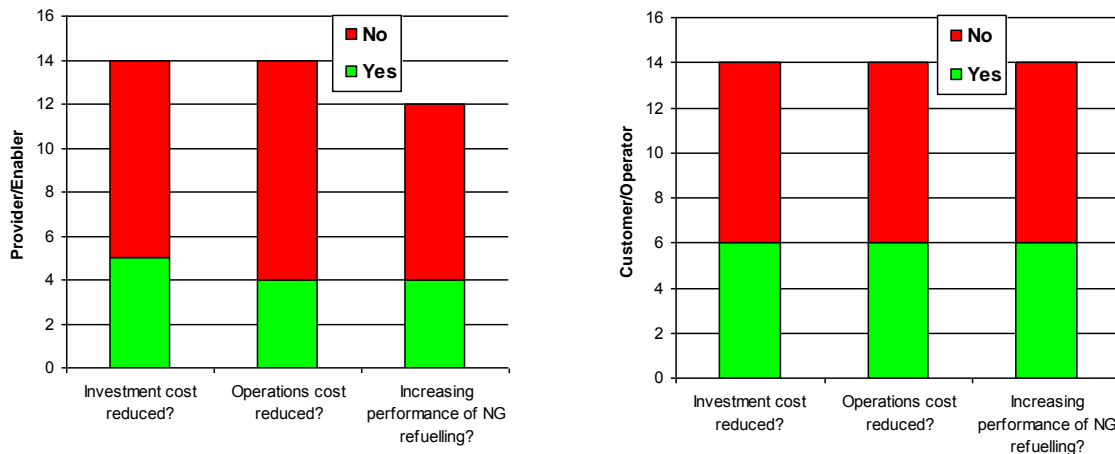
Other services that are provided/ used on NGV fuelling

All of the service providers offer full turnkey systems but not all are providing downstream parts and components. Most customers prefer turnkey services but less than half take advantage of after-market parts and components, preferring to source them locally and (likely) for a reduced costs (and sometimes at the risk of reduced performance or voiding warranties.)



Types of NGV fuelling station services preferred by customers

Of those suppliers responding, less tend to provide Mother-Daughter stations than traditional compressor stations. Customers who responded reflect marginally more willingness to consider M-D stations, but this is highly dependent upon the availability of pipeline natural gas. In both cases, cost reduction is not seen as a major motivation to adopt M-D as opposed to a standard fuelling station.



Mother-daughter stations for reducing costs for NG fuelling

Analysis of results from the feedback

Key for best practice in design/layout

Feedback from the customers/operators as “key for best practice in design/layout”

To summarize the three “top issues” from the customers/operators perspective:

- Location with “full integration into conventional fuelling site (gasoline/diesel)” (especially during “market build-up”), and
- Best performance (100% availability; fast fill; modern design; same performance as for liquid fuels...)
- Design capacity fit for market needs/size (including “upgrade”) (coverage of “peak loads at full performance”, sizing due to demand (no “over sizing”) and possibility of “upgrading” at reasonable costs (e.g. exchange or provide additional CNG compressor capacity)

With these three concerns addressed, then “overall costs” have to be optimized (Total costs of ownership for e.g. 10 years (TCO 10). For details on optimization of TCO see feedback by provider/enabler on this topic, below):

Special issues identified by customers/operators

Some customers/NGV fuelling operators highlight that in their view many owners of NGV fleets are not knowledgeable about the potential of natural gas as a vehicle fuel and do not fully understand NGV fuelling concepts (e.g. fast vs. slow fill; mother-daughter stations, etc.). As their statements highlight, in most cases the customers do not fully understand the need for demand-supply optimization.

Feedback from Provider/Supplier as “key for best practice in design/layout”

To summarize the three “top issues” from the providers/suppliers perspective:

- Highest possible gas grid pressure available;
- Shortest distance possible between the gas network and the fuelling station (minimizing the length and expense of new piping to connect to the grid);
- Reliable performance (of the fuelling equipment) .

With these three conditions ensured, then “overall costs” can be optimized (Total costs of ownership for e.g. 10 years (TCO 10)):

- Investment (design/layout, permitting and building);
- Operations (including costs for maintenance/service and operations, including electricity, oil consumption, etc.;
- Divestment (normally smaller part, but can get expensive too).

Key to optimizing the cost effectiveness and meeting performance requirements is ensuring that the station design is ‘fit for purpose’, including:

- Understanding the type(s) NGV to be refuelled (buses, taxis, passenger cars, etc.);
- Proper sizing of the required volume to meet the needs of the fleet size and the fuelling requirements on a daily basis;
- Sizing the system to meet demand during the peaks times when fuelling is required (applies to both public and private NGV sites).

For buses, if possible, slow fill is one way to reduce costs but this might not fit into the preferences of the operators, many of whom want to use their diesel fleets as the ‘benchmark’ for performance. (Many bus operators may not have the available space at their facilities for slow fill.)

Overall results/actions needed as “key for best practice in design/layout”

Most interestingly (but not surprising) “providers/suppliers” see the inlet gas grid pressure as the most important cost reduction -issue, whereas the customers/users see the possibility/need for upgrading the entire system as most important. (This feedback was mostly from European customers where most of the markets are in the “(early) build up” phase.)

a. Inlet gas grid pressure for CNG compressors

Make “customer/operators” aware, that this is a key topic for CNG compressors stations. Gas grid pressure higher than 30 – 50 bar is an appropriate target, even when that

- Reduces the possible sites dramatically;
- May add additional costs (e.g. for adding “gas-markers”.

b. Fit for upgrading of NGV-fuelling site

A special need appears in countries where the NGV market is in a growth phase. To secure a good network from the start and keep the investments at reasonable volumes, these

markets start with smaller public sites, e.g. in Western Europe with compressors from 150-250 Nm³, enabling sales up to more than 700.000 – 1.000.000 m³/year at a single site.

As the NGV business develops and demand for fuel increases upgrading is required. Concepts that have been mentioned most by the recipients include:

- Additional compressor/change of compressor;
- Use the mother/daughter (M-D) concept;
- Move the complete, existing NGV retail sites to new “built up” locations and install a bigger fuelling unit at the new site (to be considered as most expensive solution);
- Ensuring a reliable “base load” for new NGV fuelling sites from the start-up of operation (e.g. NGV fleet’s like bakeries, taxis, etc, who see benefits to improving their “green-image”; possibly CNG-buses (if they do not operate from their own private fuelling location), or package distributors i.e. UPS, DHL, etc.)

c. Design of NGV fuelling site

- Using standard-modules, (but only that are technically proven and not newly designed for single stations or special situations). Standard modules have positive influence on cost per unit and for parts replacement as well): Modular designs for fuelling systems and the use of standard-solutions are among the best cost-benefit (costs/savings-ratio).
- Safety standards and improving the level of best practices may be even more important than the concerns of local code officials. This can save operating costs (insurance, reduced distances between dispensers and compressors, etc.). It also can contribute to enhancing the overall image of natural gas as respected automotive fuel. (Note: Any incident where safety is an issue would damage the image of CNG fuelling and impact the growth in sales).

“Best practices” here may include:

- Radio Frequency Identification (RFID) to automatically control fuelling of cylinders, including those in NGVs (for encrypting vehicles, avoiding fraud, or controlling cylinder inspections and eliminating substandard fuel systems)
- Special test procedures before/during refilling (e.g. avoid filling an LPG-car in case of manipulated filling nozzle.) (An ‘LPG-test’ typically is done at Austrian CNG stations. The vehicle to refill is filled with 30 bar, this pressure is kept for ~ 30 seconds, and if there is no pressure drop within this time, the refuelling with CNG is started. So this ‘LPG test’ is also a safety measure to ensure tightness of the whole NGV system.)
- Documentation of safety procedures is needed on-site. These differ widely from country-to-country so code officials, installers and customers must be familiar with safety concerns and safety procedures in case of an emergency.

Action A1: Collect best practices from today’s operated NGV fuelling systems (including safety), and define solutions with best cost-value ratio. Support initiatives to develop internationally harmonized standards.

- Noise reduction and ventilation (optimized mix to be found, as the direction of ventilation highly influences level and direction of noise in the environment). (In some Western Europe countries the maximum noise emission allowed is around 55-60 dbA.)

- Using providers/suppliers with a “proven track record” (experience in design, building and operation of NGV-fuelling sites, including safety).

d. Special topics on “Building of NGV fuelling site”

- Protection of parts when welded (to ensure best quality of pipelines)
- Shorten the distance between the CNG-compressor and the fuel dispenser (reduce costs of pipelines at site, minimize pressure drop in high pressure grid at retail site from compressor to dispenser)

Practices typically “not done adequately” or “forgotten topics” for best practice in NGV fuelling station design and layout

Almost half of the system suppliers indicated a lack of awareness or understanding on the part of their customers about the total cost of operation (TCO) including maintenance and specific operational practices.

Items mentioned as part of TCO include, for example, electricity consumption (which can vary dramatically due to demand charges), consumables such as lube oil, oil filters, and desiccants for the dryer, costs related to the general overhaul of the compressors, and the need for periodic inspection of CNG storage systems.

Additional Concerns of Customers/Operators not already addressed

Considering the space needed for CNG stations (i.e. the ‘footprint’), and particularly when expanding the station capacity, consideration has to be given to things such as providing adequate space for turning or parking vehicles.

Safety issues are not always a first priority for operators and costs to ensure safety are a factor in station economics.

During the design phase it is important to consider local code officials concerns before construction begins so that there are no ‘surprises’ or added costs due to unforeseen requirements of local inspectors, code officials or fire marshals.

Additional Feedback. from Providers/Suppliers

a. Design/Layout

- Considerations of the costs in the design phase are needed to consider such things as new pavement, parking space, egress/ingress access to roadways, etc. This is particularly critical if a dedicated NGV station is being built rather than being integrated into an existing station that already has been designed to consider non-fuelling equipment costs.
- Leasing models for NGV fuelling stations and other business models should be considered for different customers (strong demand from customers).
- Ensure protection against direct exposure to sun/rain of dispenser

b. Organisation/Project Management

- Design/layout fit for all required building and fire safety permits, both national and locally enforced requirements.

- Delivery and construction times (for building and maintenance) can have significant influence on costs (construction/operations)

c. Operations of NGV fuelling sites

- Remote control of the NGV fuelling sites is often mentioned as important to operators. Off-site management can identify performance problems at the station and improve repair time once problems have been identified.
- Full service packages for service/maintenance can add to costs but save money in the long term.
- Spare part management (and costs).
- Increase intervals for maintenance (with providers/producer and legal standards).

Action A2: Collect and analyse best practice on technologies/systems to increase intervals for maintenance of NGV fuelling systems

- Payment options that typically are provided for gasoline/diesel have to be available for natural gas (i.e. credit cards, fuel cards, etc.)
- Information provided to the new NGV customers at site (i.e. using fuel connectors)
- Proper training of employees on-site who are unfamiliar with CNG equipment, for both operation and maintenance.

Preferences for types of NGV fuelling systems

Providers/suppliers argue that the majority of customers are unaware of different types of fuelling systems available and, therefore, do not know which are best for their specific needs. Most customers are not really interested in the technology of natural gas compression. They are looking for reliable and efficient solutions.

For the first time to introduce and consider options such as:

- LNG/C-LNG and
- M-D stations

The types of CNG compressors are mainly defined by the gas inlet pressure from the gas grid. There is an overall tendency to consider “oil free machines” due to issues associated with oil carry-over into the vehicle. Hydraulic (HC) and reciprocating (RC) compressors are seen best for:

- Wide range of operations (RC);
- Proven reliability and performance (making them first choice for mother stations M-D stations today (HC)); and
- Size of production worldwide (to lower costs/unit).

“High power, but small in size” is the key for compressors, but then cooling and noise reduction may become critical.

Hydraulic compressors (HC)

- HC are most energy efficient if inlet pressure from gas grid is high enough.
- Below a certain input pressure level HC have a tendency to “leak oil”, which may result in major problems with oil in CNG tanks.

Reciprocating compressors (RC)

- Reciprocating compressors can use near-atmospheric inlet pressure (a large part of the gas grid in many countries) to the required discharge pressure for NGV fuelling RC are available in oil-free models (advantage regarding possible problems with oil carry-over into CNG-tanks, both stationary storage and on-vehicle storage.)

L-CNG/LNG stations

- For LNG fuelling the existence of HD-NGV-fleets with sufficient scale is most important. Issues still remain with boil-off and venting of LNG systems, particularly where there are restrictions or concerns about methane leakage into the atmosphere. (Note: CH₄ is considered a more potent greenhouse gas than CO₂ by a factor of 23 when calculating for greenhouse gas emissions.) Overall safety and fast fill have to be ensured.
- Fuel volumes – storage and fuelling – are important concerns for LNG station design. LNG fuelling sites for base consumption at least larger than 1- 2 million litres of LNG/year
- The most important topic related to LNG/L-CNG stations (design, construction and operation) is the lack of internationally acceptable standards and regulations.

Action A3: Define LNG standards for L-CNG/LNG fuelling. There is on-going work within the International Standards Organization on various equipment standards for on-vehicle LNG fuel storage, connectors and fuelling stations. Standards related to vehicle components ultimately will be included in United Nations Regulation 110, most likely by 2013. Fuelling station standards will become norms (and not international regulations) that can provide guidance at the national levels for those countries interested in promoting LNG as a vehicle fuel. Standards and regulations also are being evaluated for the marine markets and bunkering of LNG at port locations and from ship-to-ship in some countries and by the United Nations.

Specific topics of concern for LNG stations

- Quality of LNG fit for purpose as automotive fuel (“High methane LNG”)
- LNG pumps with lower costs than compressors of the same performance (energy consumption of a high pressure pump less than 10% of the consumption of the compressor. At the LNG pump is the specific consumption for a unit of energy even lower).
- LNG pump filling speeds are up to 200 litres/minute (which is similar to diesel fuelling of trucks).
- Nevertheless the overall system costs for smaller/medium LNG size stations tend to be higher than for CNG compressors.

Specific topics for L-CNG stations

- L-CNG is an important option to combine advantages of LNG-fuelling with easy handling of CNG (CNG is the “easier NG fuel to manage” in operations). L-CNG offers CNG-fuelling advantages (to LNG) without restrictions of location due to grid connection requirements (including saving gas grid costs).

- Combination LNG fuelling with-L-CNG "adds costs and value". The option can be useful only if a CNG-market exists.
- L-CNG is seen as growing option for some sites with difficult pipeline connection or where there is a strong supply of LNG (as in the Iberian Peninsula)

a. Critical topics for LNG/L-CNG-stations

- LNG boil-off gas and venting management in order to avoid CH₄ emissions is vital, adding additional costs, but solutions are readily available. As market demand for these stations increases such issues will find a commercial solution.
- Establishing standards for dispensing fuel at a uniform temperature and pressure (or even establishing a range of temperatures/pressures) will be extremely challenging. Changes in LNG fuel characteristics and composition as it is transported or stored as well as different vehicle technologies requiring LNG at different temperatures will make harmonization very difficult.
Thus the cost and economics of installing LNG fuelling stations will continue to vary widely.
This tends to increase the time needed to install LNG stations. These challenges will tend to slow the rate of commercialization of the LNG fuelling station network.
- Higher energy density of LNG (than CNG) may lead to less frequent NGV fills/day or year but fill levels per vehicle and for whole fleets are dealt with in the design/layout phase of planning an LNG station.
- European standards for LNG vehicles and stations are in progress at the International Standards organizations. Lack of standards and regulations prevents challenges for expanding the marketplace. Where specific markets exist for marine applications (i.e. Norway) there are some standards/regulations that should lead the way to opening the marine market for LNG. When CNG networks are developing, the advent of LNG at the same time can add flexibility to: preferable NG fuel options but each customer will have to judge the options on their merits to ensure overall system costs are most beneficial for their specific application.

b. Most important topics for LNG/L-CNG fuelling system

- Establishing a wide scale LNG infrastructure is expensive but, like CNG, it is important to ensure demand from first day of operation of a fuelling station. Normally investments will not be made unless customer demand can be assured. Likely the network will develop on the basis of fleet vehicles and can be expanded to corridor concepts thereafter.

Mother-Daughter (M-D) stations

Even in countries with a well developed gas infrastructure there are towns and locations not reached by the grid. In locations where gas is not available, for whatever reason, the mother-daughter station concept plays a very important role in terms of ensuring access to CNG. Daughter stations are well-suited for light duty NGVs but may offer design and operational challenges concerning fuelling of heavy duty NGVs due to their increased demand for natural gas. Overall costs of a M-D station system are seen higher than those of a pipeline-connected station.

a. Critical topics for M-D-stations

- Space allocation for multiple fuel trailers must be considered at both mother and daughter stations. Daughter stations must be designed to allow for multiple trailers that are required to deliver uninterrupted fuel to the customers.
- Good planning of the distribution of fuel tankers to daughter stations is challenging due to differing demands for fuel (at the daughter station) and depending upon the number of trailers serving a network of M-D stations. Consistently good planning and a proper 'logistics service' for the fuel distribution to daughter stations is critical in order to avoid interruptions in service to customers needing fuel.
- Public awareness about road transport risks is increasing.

b. Most important topics for a mother-daughter fuelling system

- Location and pressure levels (both: in gas grid for mother and for daughter stations).
- Demand patterns at daughter stations (daily/yearly) as a basis for designing the Mother station as well.
- Distances between sites (including consideration of road conditions, traffic jams, etc.) and numbers of daughter stations.
- Withdrawal efficiency of the fuel. CNG tankers not using hydraulic or booster compression systems cannot serve fuel at high pressure once they tanks are approximately 40-50% of their total capacity. Systems and techniques that improve the withdrawal efficiency of the fuel would improve the overall operating costs and characteristics of M-D systems. Fuelling site development requirements and standards should be considered.
- Design on overall "Energy efficiency" (e.g. no pressure reduction system in Daughter station);
- As with any fuel station, location of the station and the anticipated demand for fuel (depending on anticipated customers) are important factors determining the need for the establishment of a mother daughter station.

Ionic compressors (IC)

- IC use a liquid instead of mechanical parts for compression of the gas. That can improve overall energy efficiency (better heat transport within compressor and use of this energy and lower energy demand.)
- ICs are a new development in compressor technology that today is being offered by a single manufacturer. The advantages in operation and costs are promising but have to be analysed for a longer period and by more customers before the technology is likely to achieve a substantial share of the market.

Appendix A

A summary of the survey responses to specific questions about the cost, operation, and preferences for different compressor systems are provided below. The top three preferences of both the provider/suppliers and the customer/operators are shown. (Refer to the questionnaire itself to see all the multiple choices provided to survey recipients.)

Most important opportunities to reduce the cost of filling stations

Table 2 -

Provider/ Supplier

1. Design for expansion of fuelling system
2. Improve International Norms on NGV fuelling
3. Development of international fuelling station standards

Customer/ Operator

1. Increase gas grid inlet pressure
2. Development of international fuelling station standards
3. Reduce the price to access the gas

Most needed issues to reduce NGV fuelling costs

Medium term maintenance and service contracts are provided and needed, with most preferred around three years.

Table 3 -

Provider/ Supplier

1. Consulting Engineering to determine station size/application (station layout & design)
2. Maintenance and service contract
3. Warranty (provided in Ø 2 years; preferred Ø 2,75 years)

Customer/ Operator

1. Maintenance and service contract
2. Warranty (provided in Ø 2 years; preferred Ø 2,75 years)
3. Training on maintenance and service (initial training; long term training)

Preferences for specific technical aspects of the NG compressor station

Table 4 -

Provider/ Supplier

1. Self service NGV fuelling
2. Ease of dispenser operation
3. Modular installation

Customer/ Operator

1. Ease of dispenser operation
2. Payment on fuelling site
3. Oil/lubrication free system

Most important issue to buy a NGV fuelling system

The key decision criteria is “Total cost of ownership (TCO)” for all. Customer then want to have a proper maintenance and service system provided, which typically is offered by many fuel station providers.

Table 5 -

Provider/ Supplier

1. System economics over its lifetime (investment + operations)
2. Maintenance & service
3. Warranty 1-3 yrs

Customer/ Operator

1. System economics over its lifetime (investment + operations)
2. Maintenance & service
3. Warranty 1-3 yrs

For the detailed questionnaire please contact the authors.

Appendix B

We thank all those individuals who provided their feedback to the questionnaires. From some of them we got additional information as well as additional inputs to this report (Names are in “**bold**”).

Thank you very much to all, who contributed.

Feedback received from customers/operators (in alphabetical order)

M. Boyadjiev / Overgas

R. Dumfart / OÖ Ferngas Netz GmbH

J. Figueiredo / APVGN

D. Graebe / Gazprom Germania GmbH

H. Heindinger / former Head of NGV OMV

S. Komlev / Gazprom

D. Kulyabin / Gazprom
A. Shin / Gazprom
A. Lederbauer / OMV Refining and Marketing
F. Marschler / OMV Refining and Marketing
D. Matic + S. Vulama / OMV Gas Adria
M. Petraccone / SAFE srl
S. Sulemanjee
G. Wyborny / EAA Erdgas Mobil GmbH

Feedback received from providers/suppliers (in alphabetical order)

J. Baldwin / CNG services
P. Boison / NGVA Europe
F. Braun / Atlas Copco
V. Chrz
R. Neura / Tvaja CNG
J. Figueiredo / APVGN
J. Flosman / Vítkovice Mechanika a.s.
G. Gozzi, Idromeccanica
T. Heumesser / Loebersdorfer Maschinenfabrik
V. Holovcak / Bonett Bohemia a.s.
O.Kühner / Bauer Kompressoren GmbH
M. Petraccone / SAFE srl
A. Pototskii / Metan-Technoservice Ltd.
N. Roosli / Viridis Technologies (Asia) Pte Ltd
H. Verbeek, Int. LNG/CNG Expert
S. Videnova / Avtometan LTD

7.3 LNG AS A BUNKERING FUEL

Valery Nemov, Gazprom Export

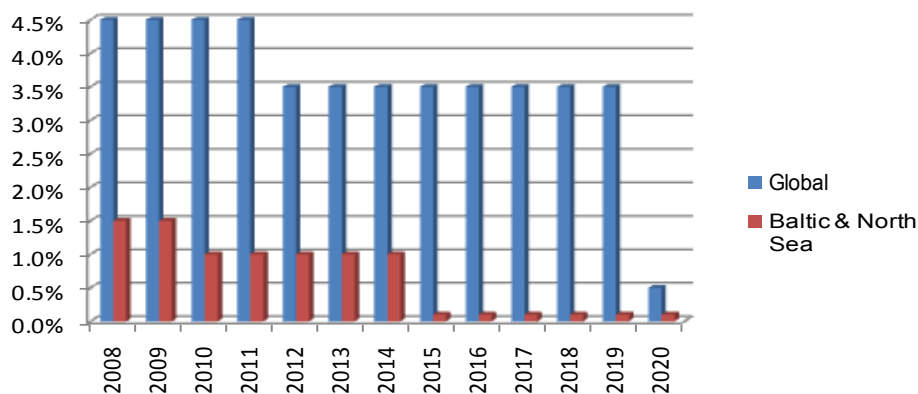
The significant change is going to occur in maritime traffic in the next several years as the new standards for ship fuels are being imposed.

The restrictions coming into force under Annex VI of the International Maritime Organization’s Marpol Convention include a cap of 0.1% sulfur on all bunker fuel burnt anywhere in four “emission control areas”, which are: the North and Baltic seas, North America and the US Caribbean. In most, the existing cap is 1% sulfur. Most ships in EU ports and inland waterways face a similar 0.1% cap.

Sulfur oxide emissions restrictions on fuels imposed on the maritime sector operating within the Sulphur Emission Control Area (SECA) by International Maritime Organization (IMO) are the major drivers for growth of LNG consumption as a bunkering fuel. The current SECA in Europe, which covers the Baltic Sea, the North Sea and the English Channel, leaves most of the European coastline less strictly regulated from 2015 and this may have negative implications with regard to competitiveness of the shipping sector for operations inside or outside of these boundaries.

Moreover, IMO imposed the limits for sulfur content in marine fuels at level of 3.5% as of this year, 2012 (4.5% formerly).

Limits on Sulphur Content in Marine Fuels



On this evidence, ship-owners will have three options: switch to distillates (gasoil with a sulfur content of 0.1%), switch to LNG, or introduce new technology, which could include scrubbers, which allow ships to keep burning bunker fuel oil.

A shift to LNG is therefore one increasingly interesting alternative in order to meet the new requirements.

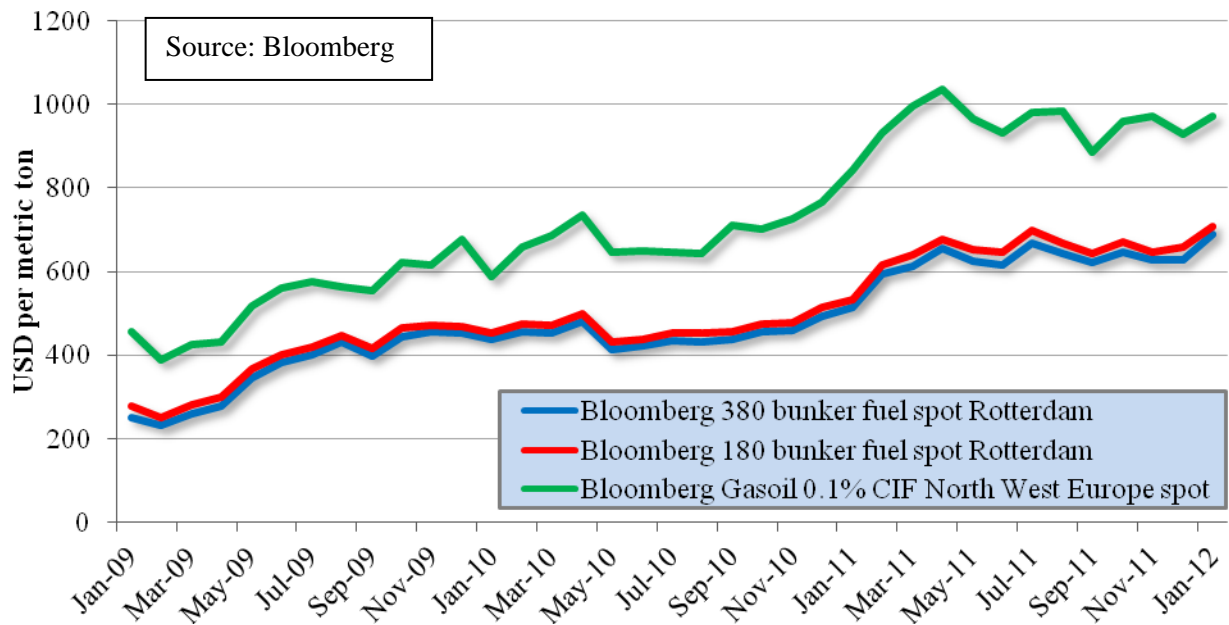
LNG fuel has the lowest ship emissions compared with traditional bunker fuels:

- NOx emissions are reduced by 85–90%
- SOx and particles are reduced by nearly 100%
- Net greenhouse gases emissions may be reduced by 15–20%.

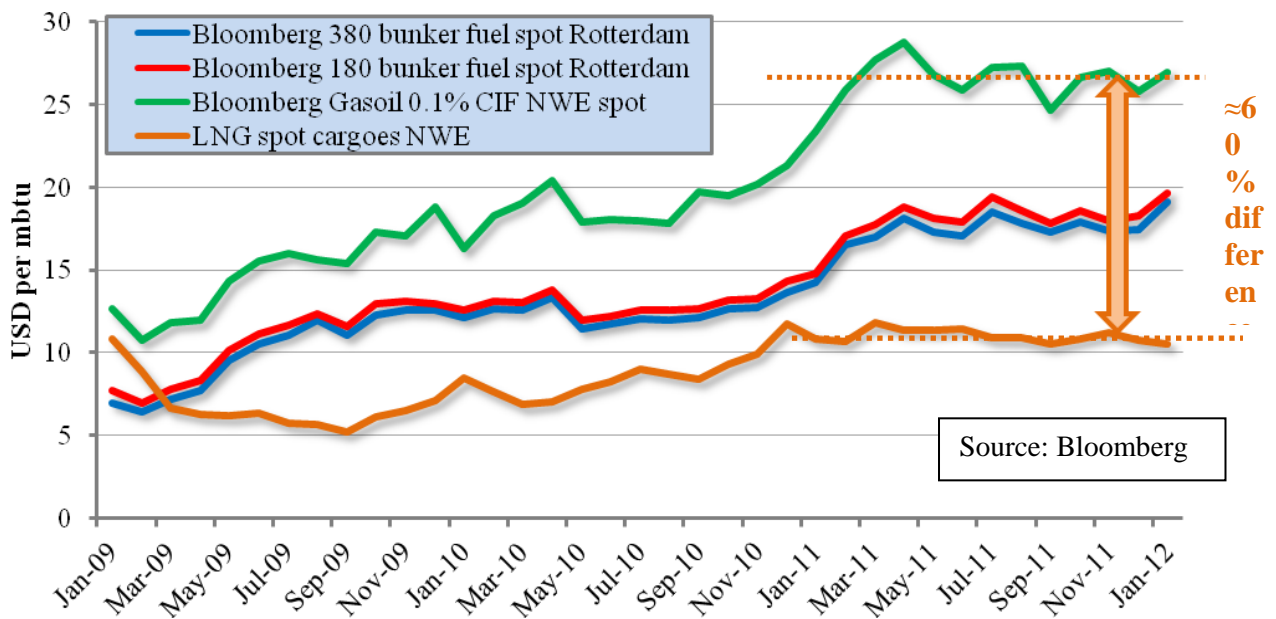
Traditionally used marine gasoil (MGO) and heavy fuel oil (HFO)

A 2010 study for the Danish government’s Environmental Protection Agency carried out by Norway’s DNV found out that LNG needs to be 45% cheaper than 0.1% gasoil to stimulate switching. We observe the positive dynamics for the bunker fuel prices in the last three years (see the graph below) that resulted as high as almost 1000 USD per metric ton for 0.1% gasoil in the North West Europe.

The prices for fuel oil with a maximum sulfur content of 3.5% and a maximum viscosity of 380 Centistokes (380 bunker fuel oil) were at level of 689 USD per ton in the end January 2012, for fuel oil with a maximum viscosity of 180 Centistokes (180 bunker fuel oil) – 708 USD per ton.



The comparison of price for spot LNG in North-West Europe and price for 0.1% gasoil converted to USD per mbtu demonstrates the difference around 60% during the last year (see the graph below). By the way, the difference between LNG and bunker fuel oil is around 45% that could be enough to stimulate switching to LNG. But we can’t still observe great success in switching, because the small-scale LNG supply system is not developed, and the cost of LNG transportation to the point is actually too high. The infrastructure development without governmental support seems currently impossible. But the restriction of burning undistilled fuels from 2015 boosts the chances of LNG considerably and perhaps without any governmental support.



The additional space for LNG fuel storage is required for retrofitting of existing ship propulsion systems. This makes retrofitting less attractive. From that point of view LPG could be more favorable, but the choice is based upon fuel availability and fuel cost.

Another option – low sulfur fuel oil – is the alternative for ship owners who are reluctant to make capital investments in the ships. Ships can be retrofitted with exhaust gas cleaning system (scrubbers or SCRs) to meet the SECA emissions requirements. Because the scrubber requires a smaller investment than converting to LNG (either as a retrofit or as a new-build), this is likely to be a favored solution firstly. But the higher prices for low sulfur fuel oil should be kept in mind.

The actual price at the end user (ship owner) will be a consequence of the international LNG price and the regional filling station infrastructure investments.

Infrastructure

LNG is supplied by a large-scale tanker to the import terminal from abroad or can be derived from pipeline gas right on the local market. LNG “feeder” ships are supplying satellite terminals which refuel LNG for the consuming vessels. Refueling at terminal is also possible via truck. At that time, development of new containment systems for storage on-board makes it possible to handle boil-off gas by pressure increase, reliquefaction or dual fuel gas consumption.



The current state of the market

The Global LNG Bunkering market represents only 0.5 bcm of demand in the North and Baltic Seas in 2011, but is expected to grow significantly by 2030 and expand globally.

Norway and Sweden are currently the only countries that have reached the real success in LNG bunkering infrastructure development. Ice-breakers cruise ships, ferries, and military, coast guard and platform supply vessels are all currently running on LNG in Norway. Three main suppliers have developed LNG bunker facilities along the entire coast: Gasnor in mid-Norway, Skangass in the south and Barents Naturgass in the far north.

Skangass, owned by Norwegian utility Lyse Energi, sources from its own 300,000 ton per year liquefaction unit near Stavanger.

Gasnor – owned by Statoil, E.On, Royal Dutch Shell and Total – has LNG production at Karmoy (20,000 tons/yr) and Bergen (120,000 tons/yr).

Barents Naturgass’ bunker terminal sources LNG from Statoil’s 4.2 million ton/yr Snohvit plant.

In Sweden, Linde subsidiary AGA Gas opened the country’s first import terminal at Nynashamn in March 2011, extending LNG bunkering into the Baltic. AGA can get LNG from Skangass or from its co-owned 15,000 ton/yr LNG unit at Tjeldbergodden in mid-Norway.

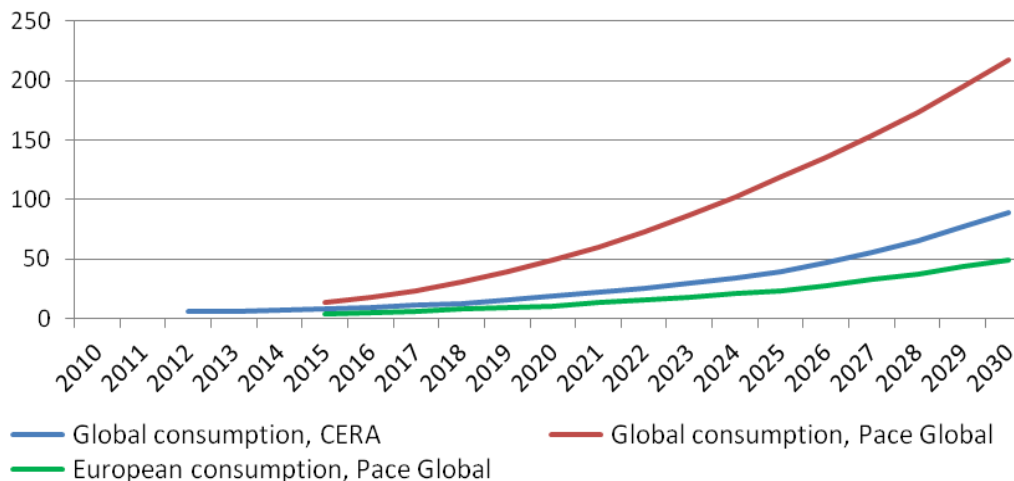
The potential development

Except of Norway and Sweden there is a lot of interest for LNG as a bunkering fuel in Europe. Port authorities in Rotterdam in the Netherlands and Antwerp in Belgium are studying the feasibility of break bulk terminals that could bunker small ships or Rhine barges using supplies from adjacent large import terminals. UK LNG terminals are also interested, provided the break bulk facilities are independently managed, and shipping traffic is kept

away from big LNG tankers. Rotterdam has commissioned Germany’s Linde to carry out a study this year on the best place to site a bunker terminal. The first LNG-fuelled inland barge entered service in November 2011 in the Netherlands, where it operates along the Maas and Rhine rivers. The problem now is the lack of small-scale LNG supplies, all the logistics still should be developed.

Outside Europe, there is some interest. In Canada, state-run Societe des Traversiers du Quebec (Quebec Ferries) in October 2011 placed orders for one large and two small new build LNG fuelled ferries for delivery in 2013-14 to operate on the St Lawrence River. In Argentina, delivery of an Australian-built rapid passenger catamaran running on LNG is awaited. It is expected to start up this year on the River Plate crossing to Uruguay.

Market consultants forecast the significant increase in LNG consumption for bunkering purposes. For example, Pace Global Energy Services believe that it’s going to exceed 200 bcm per year in 2030.



But, use of LNG as an alternative to fuel oil in parts of northern Europe and North America could boost only if ports, ship-owners and engine-makers are prepared to pony up sufficient investment in advance. It needs the governmental subsidies and incentives that have inspired LNG’s use as a marine fuel in Norway.

7.4 LNG IS THE SUSTAINABLE FUEL ALSO FOR AVIATION

Dr. Antonio Nicotra – Managing Director Air-LNG GmbH (Bonn), General Manager Gasfin Investment SA (Luxembourg) – Germany

1. BACKGROUND: *the transport sector needs to end its monopolistic dependency from crude oil*

Mobility and transportation interlink the global economy. Aviation is the preferred mode for connecting long distances, with future growth envisaged at over 4-5% per year, fastest particularly in Asia.

In the past XX^o century, the transport industry has built its backbone infrastructures, carriers and engines on just one main fuel resource: crude oil; and aviation has taken the best distillates grades: avgas and jet kerosene. The reason for this choice was clear: avgas-100LL and jet-A/B/P types kerosene were the “best picks” of the crude oil refining process, satisfying the 5 pre-requisites (availability, cleanness, economy, efficiency and safety) needed to power moving vehicles.

In the last two decades, it became evident that crude oil and its derivatives had lost 3 of the 5 pre-requisites, as they turn out to be short in supply, excessively polluting and expensive.

The stationary energy sector has already diversified its fuel needs away from oil, to improve competitiveness and reduce greenhouse gases (GHG) emissions.

The transport sector, and aviation in particular, only made significant steps in improving performances thus reducing fuel-oil consumptions and relevant emissions; but now, they need to sustain their development by ending the current dependency from the oil monopoly and finding alternative substitute fuels able to sustain their growth on a long term basis.

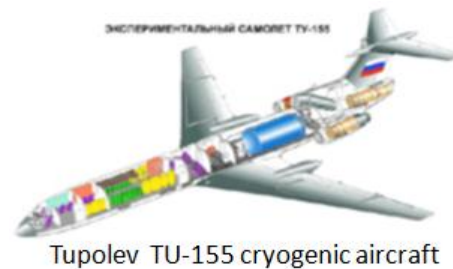
Long term availability and economic planning in a balanced environment are the fundamental requirements for the new substitute transport fuel candidates, together with efficiency & safety aspects.

Natural Gas (from fossil and renewable sources) is the sustainable alternative to oil (fossil or renewable) in this XXI^o century, for both stationary and mobile energy applications, as gas is more available, cleaner, cheaper, more efficient and safer than oil.

2. AVIATION

Aviation is the fastest growing means of long range transports and its contribution to air pollution is increasing even faster due to the impossibility of treating and decontaminating the exhaust gases. **NASA/Boeing** and **EADS/Airbus** have considered cryogenic hydrogen and methane as fuel for commercial aviation since the 1980s: in the early 2000s hydrogen was dismissed due to excessive complications and costs, and methane was summarily dismissed for its cryogenic similarity to hydrogen.

In mid-1980s, **Tupolev** built the TU-155 cryogenic aircraft on the basis of serial TU-154B.



In order to use liquid H₂ or LNG as fuel, airframe and some standard systems were modified, cryogenic fuel charging, storage and feeding systems were installed, ensuring fire/explosion safety, and data acquisition and recording system as well. Cryogenic fuel resource was kept in fuel tank of 17.5 m³ capacity installed in special compartment in rear portion of passenger cabin. 15 April 1988 the aircraft performed its maiden flight using liquid hydrogen. Upon flight testing and development, on 18 January 1989 TU-155 a/c performed its first flight on liquefied natural gas. Large flight testing program was fulfilled, with over 100 domestic commercial flights and several international flight demonstrations were made including those to Bratislava (Slovakia), Nice (France), Berlin and Hannover (Germany). Positive results encouraged the development of the new cryogenic model TU-156. However, in the 1990', following to the reorganization of the FSU and lack of financing, the program was terminated.

After 20 years, the world energy scenario has substantially changed and aviation requires cheaper, cleaner and more abundantly available alternative fuels. New alternative fuel solutions are searched, possibly compatible with kerosene in order to be mixable (drop-in) and sharing same infrastructures (for minimal aircrafts and airports modifications). Several **bio-fuels** options are currently being investigated for lowering GHG emissions. **AIR-LNG**, a private company based in Bonn and Luxembourg has revitalized the potential of using LNG (from fossil or renewable sources) as most sustainable fuel option for commercial aircrafts. Even though LNG can only be mixed with kerosene at the combustion nozzle, (therefore requiring separate storage and supply infrastructure inside the aircrafts and at the airport), AIR-LNG research work and solutions aim at proving that LNG is still the most sustainable and profitable option to complement and replace kerosene.

3. RESEARCH WORK FOR MID-TERM & LONG-TERM PROGRAM: *on LNG as sustainable fuel for Aviation*

AIR-LNG Research Work on LNG as sustainable fuel option for Aviation is currently in progress within the Burn-FAIR project of the LuFo IV-3 program (2010-2013), sponsored by the BMWi (the German Federal Ministry of Economics and Technology) and coordinated by EADS with partners including DLR, Airbus, Lufthansa, MTU, Hamburg Airport, TGE and Air-LNG. Aim of this program is to compare performances and sustainability of the HVO option (Hydrogenated Vegetable Oil – drop-in solution – coordinated by Lufthansa) with the LNG option (not-drop-in solution- coordinated by AIR-LNG).

AIR-LNG research work focuses on LNG as fuel for aviation on the following basis:

- I. Methane (CH₄) is a fuel chemically & physically more similar to kerosene (-CH₂-) than hydrogen (H₂). Methane and kerosene have similar “flame characteristics” and can be mixed in the combustion chamber. Methane flammability, safety risks and GHG emissions are lower than kerosene. Methane energy density is 1.6, compared to kerosene = 1, and hydrogen = 4, allowing to deliver the same thrust with 15% less fuel weight compared to kerosene (hydrogen: 1/3 weight).

- II. Methane cryogenic conditions (– 162°C) are much easier than hydrogen (– 252°C); cryogenic methane is stored and transported in insulated tanks & tankers (low pressure) that appear very similar to oil tanks& tankers, even though construction materials are different. Methane and oil are different fluids and not mixable before the combustion nozzle.
- III. The industrial technology & logistics network of LNG and methane for mobile applications is already commercially available and has increased enormously in the last 5 years, allowing to consider LNG as a suitable energy source candidate also for airports/aircrafts;
- IV. Renewable bio-gas (upgraded to bio-methane) is the most abundant bio-fuel available on earth; when recovered from waste biomass, bio-methane is not competing with the food industry and could become an inexhaustible source of energy for complete replacement of fossil crude oil; also the bio-methane technology is already commercially available.
- V. The bio-methane solution, as main substitute of kerosene, appears to be the only available option able to meet the IATA 2050 target of -50% GHG emissions and thereafter zero-emission.
- VI. The energy intensity and the economics of a new bio-LNG world mass production infrastructure chain appears to be more advantageous of the corresponding new infrastructure chain based on BTL or HVO bio-kerosene.
- VII. The possibility to install LNG systems as complement to kerosene appears economically and technically feasible even in existing aircrafts. New aircrafts based on LNG as main fuel will enhance the advantages.
- VIII. Prices of fossil LNG and bio-LNG are about 1/3 of fossil kerosene and bio-kerosene.
- IX. The setting up of LNG as main complement/alternative fuel to kerosene is feasible in a time frame of one or two decades, it will cease the oil monopolistic status in transports, will extend the time of oil availability in this XXI° century and possibly facilitate the transition to a future hydrogen age.

LNG solutions for airports and aircrafts have been worked out for existing aircrafts (short/mid term 5-20y) and new aircrafts (long term, >25y). Should the LNG technology be accepted by the aviation industry, potential LNG consumption may reach 10% in the 1st period and eventually >50% in new aircrafts, of total aviation fuel consumption of about 250 Mtpy (2010) expected to grow to 500 Mtpy (2035).

7.5 FUELLING TECHNOLOGIES NATURAL GAS BLENDS TECHNOLOGY GAS – HYDRO. NGVA EUROPE POSITION PAPER

Dr. Antonio Nicotra – Managing Director Air-LNG GmbH (Bonn), General Manager Gasfin Investment SA (Luxembourg) – Germany

Introduction

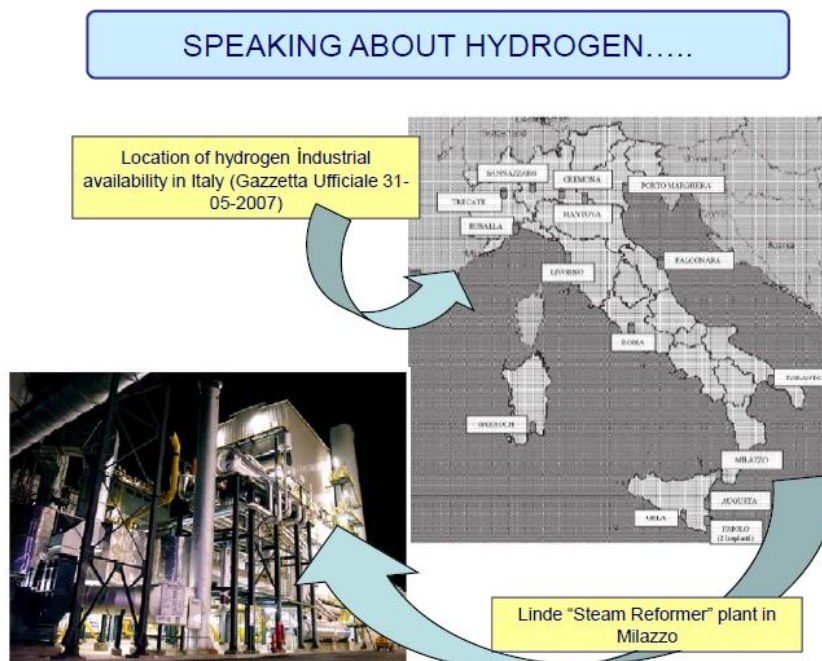
Today, natural gas and biomethane represent the most practical, realistic and easiest way to reduce pollution coming from road transportation. At the same time, Hydrogen as a vehicle fuel certainly is an interesting solution taking into account its environmental benefits.

However, and to be realistic, fully propelled hydrogen vehicles still remain an insecure long term option facing various obstacles, which must be solved first: open questions include e.g. production pathways with regard to coherent pollution, energy and cost dimensions; the organization and realization of a dedicated distribution network; the complexity and cost of hydrogen vehicles and their main components, etc.

As a natural consequence, the intention of this paper is to present the huge potential that methane/hydrogen blends can bring for the transport sector, as an ideal bridge to a more sustainable mobility, by using the existing NG/biomethane distribution infrastructure.

Production related aspects

A certain quantity of hydrogen is already available today, at least in some places. Just to give you an example we can report the situation in Italy where there are many locations where hydrogen is industrially produced, mainly by steam reformer on natural gas or higher hydrocarbons.



Another source of hydrogen, perhaps more important at least in Italy, is based on hydroelectric energy: it is well known that the production of hydrogen is a good storage

system when energy consumption is very low (i.e. during the nighttime); this approach is also under development in the area of Trentino Alto Adige, which is already equipped with several hydroelectric power plants. Moreover other technologies are under investigation for production of green hydrogen from renewable energies such as photovoltaic, wind and biomass.

Several application programs are in progress; one of the main interesting ones will be carried out along the interstate A22 Motorway with the main following objectives:

- To test the production of green hydrogen from renewable sources according to various technologies (hydroelectric, photovoltaic, wind, biomass).
- The availability of new generations of multi fuel filling stations every 100 km supplying Natural Gas, Hydrogen/NG blends and Hydrogen between Modena and Munich.
- The creation of a “hydrogen” corridor having a length of 600 km and a width of 300 km, through hydrogen connection with multi fuel filling station along side the motorway.
- So, even if for the moment, the production of hydrogen is clearly limited to industrial applications and not finalized to transportation fuel, some quantity of hydrogen may, or should be, however available.

It is now clear that, even if we confirm today once again the realistic actuality of natural gas, the future potential of hydrogen cannot be disregarded, and both “clean” fuels, natural gas and hydrogen must be considered.

Technology related aspects

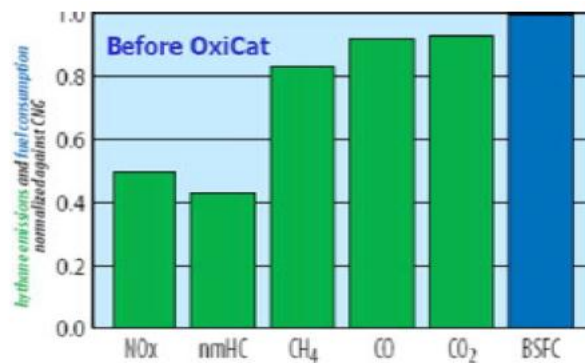
Taking into account these considerations any vehicle using a powertrain is basically able:

- to run with natural gas/biomethane (doesn't matter if it is one or the other because both of them have the same chemical composition)
- to include also hydrogen, if and where it is available, to be used as blended fuel
- to automatically adapt its engine control system to the characteristics of “in use” fuel
- to maintain a cost similar to present gas engines

All these requirements may be reasonably satisfied by a new fuel: the natural gas – hydrogen blends. We have to underline that perhaps the most important feature of this approach is that it does not require a revolution of the engine technology but only an evolution of the already existing natural gas engine. The advanced technology of hydrogen/natural gas blends can offer an important contribution vs. the emissions reduction and guarantee a strong positive synergy with gaseous fuels from renewable sources such as biomethane and green hydrogen. Moreover, the addition of hydrogen to natural gas improves the environmental properties of natural gas when burning in internal combustion engines. From another point of view we can say that mixtures of natural gas and hydrogen can in some way speed up the development of the hydrogen infrastructure considered necessary for future transport options.

The story of natural gas & hydrogen blends begins more or less twenty years ago with the invention of “hythane”, a blend of 20 % of hydrogen and 80% of natural gas in volume, patented to reduce the raw NOx emissions of passenger cars as a consequence of the lean limit potential extension, a concept well known to engine engineers.

Published emission reduction



® Hythane is a trademark of property of Eden Innovations Ltd (originally called Brehon Energy PLC), a wholly owned subsidiary of Eden Energy Ltd, but today is very often used to nominate every methane hydrogen blends

Probably it is not so much well known that the testing of hythane was also carried out in the field of heavy duty applications for many years and in different countries.

To quote only some of these experiences there have been tests carried out in USA in the last decade of the past century and later on, there were experiments in Sweden, China, France and India.

HYTHANE HISTORY IN HD APPLICATIONS

- **1992 – 1995** – Preliminary basic tests by G.M. Canada ,Toronto University, Colorado State University.....
- **1995** – **Canada** : Demonstration in Montreal by Novabus with Cummins/Westport engine.
- **2000/2001** – **California** : Bus demonstrator (Cummins/Westport engine) operated by SunLine Transit Agency
- **2002/2003** – **Sweden** :Hythane Malmö project : basic combustion studies by Lund Institute/Swedish Gas Company on 2 buses (Volvo engines)
- **2005** – **China** : Yuchai 7,9l engine adaptation
- **2006** - **France** : Althitude project : two cities (Dunkerque and Toulouse) with 2 Irisbus busses (FPT engines)
- **2006** – **India** : Ashok Leyland 6.0 l engine adaptation

In Italy the main focus was addressed to passenger cars and delivery vans, but urban transports were not forgotten.

.... AND IN ITALY?

MAIN FOCUS ON PASSENGER CARS/DELIVERY VANS :

- Performances analysis on FIAT Punto Natural Power (Second University of Naples)
- Bong-Hy project on IVECO Daily (ENEA)
- Regione Lombardia project on 20 Panda Natural Power “ad hoc” modified (Centro Ricerche Fiat, ENI, Sapio, NCT, FAST)

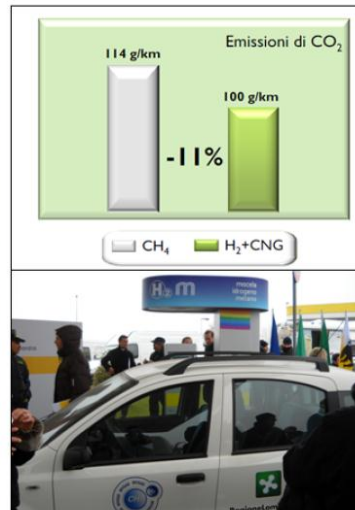
.....BUT SOME EXPERIENCE ALSO ON HEAVY DUTY VEHICLE

- Study for the use of hydrogen-natural gas on bus in urban context (ENEA with Regione Emilia Romagna)

In this context it is worth to point out that the more extensive testing plan is in progress in Lombardia, a region of Italy, where 20 modified FIAT Panda Natural Power cars (adapted for the use of a blend of Natural Gas with 30% of Hydrogen in volume) are in testing together with 2 blend refuelling stations.



Regione Lombardia Project
Experimental fleet based on 20 Panda vehicles
Realization of 2 filling station equipped with H2 / CNG blenders
(up to 30% v/v hydrogen)
Partners: ENI, SAPIO, FAST, CRF e NCT



Some tests for heavy duty application in city context are also in progress in the Emilia Romagna region, besides the more famous experimental programme carried out by the Althitude Project in Dunkerque (France) with two Irisbus buses modified to run with a NG/hydrogen blend using 20% hydrogen by volume.



Althytude

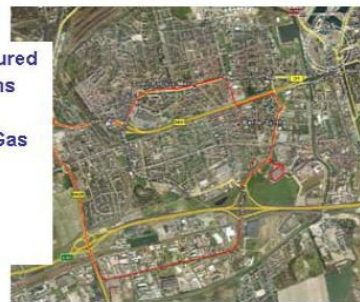
Gaz de France

6 cyl. - CURSOR 8 engine
 Blend with up to 20% v/v H₂
 2 demo bus IRISBUS
 Dunkerque site



Pollutant reduction measured under real life conditions

HCNG blend vs Natural Gas
 CO₂ : - 10%
 THC : - 30%
 NO_x : - 18%



As we have seen, “hythane” is a trade mark for a specific composition (20% of hydrogen and 80% of natural gas).

To take into account different and more general compositions, it should be better to use a different name, for example hydromethane which may be shortened with HCNG.

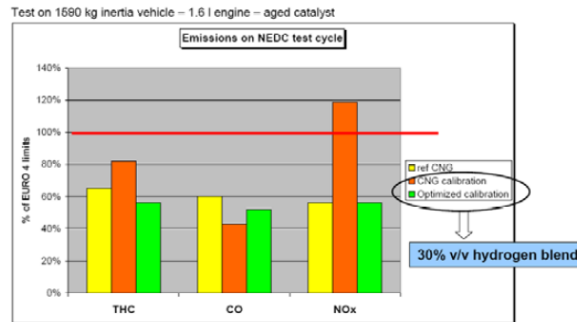
Moving to the control system, the hardware does not require any modifications, while some adaptations to the software of engine control and to the calibration dataset are necessary. In this way it will be possible to take into account the physical properties of the fuel and to have the possibility of adapting the parameters of the engine control to different blend compositions, sweeping from pure natural gas to the maximum hydrogen content that the specific application can safely use. In fact, running the engine with the calibration dataset normally used for natural gas can induce an increase of pollutant emissions, due to the wrong air/fuel metering and to a non adapted control of the lambda probe closed loop.

MINIMUM IMPACTS ON VEHICLE/POWERTRAIN TECHNOLOGY(2)

Engine control system & exhaust gas aftertreatment derived from CNG applications

But

- Slightly modification to the SW of electronic engine control
- Optimization of engine parameters calibrations

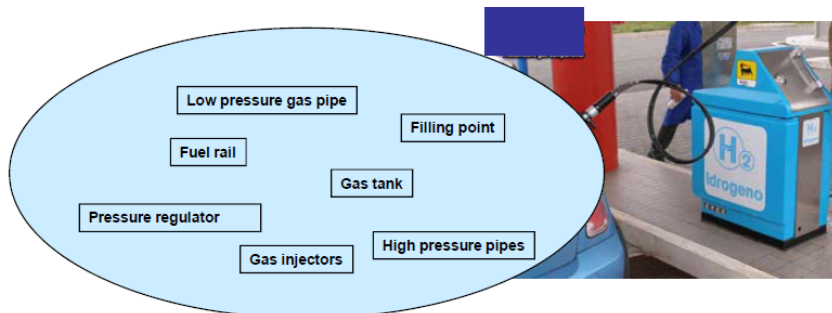


Of course this approach requires the availability of a gas engine equipped with an electronic gas injection system and an advanced engine control in order to exploit all the benefit from the hydrogen blend.

From the point of view of the compatibility of the materials, it is well known that the presence of hydrogen could cause some embrittlement phenomena with aging. For these reasons, even if a smoothing effect is expected thanks to the partial pressure of hydrogen in the blend, an exhaustive overview of the problem based on laboratory and durability test is needed.

IMPACTS ON VEHICLE/POWERTRAIN TECHNOLOGY(3)

Because of hydrogen, materials with good resistance to embrittlement phenomena “should” be used



More durability tests are still needed in order to evaluate engine & components aging in presence of Hydrogen blends

In the meantime it is recommended to use materials with good resistance to embrittlement phenomena, mainly the parts directly and permanently in contact with blend such as gas tank, pipes, fuel rail, and some details of pressure regulators and injectors.
But which are the reasons to use HCNG?

Benefits when using natural gas/hydrogen blends:

If we consider blends with hydrogen ranging from 10 to 30% it is possible to have, at the same time, significant environmental benefits together with minimum impact on vehicle and powertrain configuration.

In fact thanks to the hydrogen properties, in comparison with natural gas, the blend has higher H/C ratio, higher combustion velocity, and less ignition energy. This means that the combustion will result more complete, fast and stable.

HYDROGEN CHARACTERISTICS vs METHANE

With reference to methane hydrogen is characterized by :

- higher combustion velocity;
- Less ignition energy;

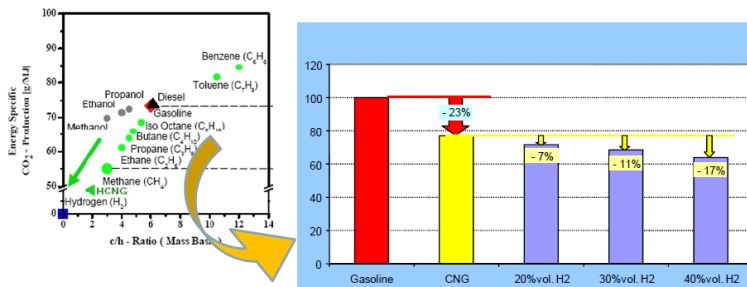
which implies

- more complete combustion reactions;
- less engine cyclic variation;
- increased speed of flame front in combustion chamber.

So, from the environmental point of view, the addition of hydrogen results in an increase of H/C ratio with a significant further reduction in CO₂ emissions in comparison with natural gas alone. For example a blend with 30% of hydrogen will cause an additional 11% reduction in CO₂ emissions in comparison to natural gas alone.

ENVIRONMENTAL BENEFITS

➤ Additional reduction in CO₂ emissions



- Reduction in THC and CO emissions (higher H/C ratio, reduction in flame quenching phenomena)
- Potential increasing in engine efficiency (higher combustion speed)

Less evident but always interesting is the reduction of total unburned hydrocarbons and carbon monoxide emission due to the resulting higher H/C ratio and also to the reduction of flame quenching phenomena leading to a more complete combustion.

Moreover, thanks to a specific regulation of the lambda control parameters, also a reduction of NOx emissions can be achieved at the exhaust where the standard CNG dedicated catalyst formulation can be maintained.

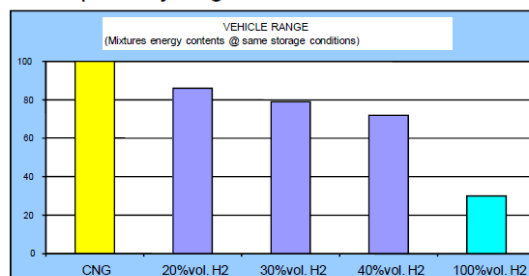
The increase of the flame propagation speed could also potentially result in slightly higher thermodynamic engine efficiency even if this aspect depends also on engine configuration and on its regulation.

But, apart from the environmental aspects, it is extremely important to notice that impacts of this fuel composition on vehicle and engine structure and technology are minimized.

Without changing the volume and the pressure conditions of the storage system it is possible to preserve a sufficient vehicle range: for instance, a 30% by volume hydrogen blend will reduce the energy content by approximately 20% compared to pure methane; this is an interesting result when we consider that, in the same conditions, pure hydrogen would reduce the vehicle range by more than 70%.

MINIMUM IMPACTS ON VEHICLE/POWERTRAIN TECHNOLOGY(1)

- Acceptable reduction of the vehicle range compared to CNG and pure Hydrogen



- Engine control system & exhaust gas aftertreatment derived from CNG applications
- Limited upgrade of the CNG component materials for compatibility to Hydrogen

Also as far as regards safety no major problems are expected. The only potential drawback is that, in case of leakage in the atmosphere, a demixing of the blend may occur. In this case, in closed room, we have to consider that the flammability range of hydrogen is much wider than that of natural gas.

SAFETY

Main properties of the base gases

	methane	hydrogen
Molecular weight	16,043	2,016
Fuel density (@ std cond)	0,717	0,089
Flammability limit in air - lower (% volume)	5	4
Flammability limit in air - upper (% volume)	15	74
Minimum autoignition temperature (°C)	580	570
Minimum ignition energy (mJ)	0,29	0,02
Laminar flame speed (m/s)	0,4	2,65
Diffusivity in air (dm ³ /s)	95	1636
Flame colour	blue	colourless

Which differences using HCNG mixtures compared to pure hydrogen ?

- 1) in case of leakage into atmosphere a demixing of the fuel occurs and the hydrogen fraction diffuses into air with its own properties: in closed room the flammability interval of pure hydrogen has to be considered;
- 2) a mixture leakage can be identified through the odour from the natural gas fraction (pure hydrogen is completely odourless);
- 3) the minimum value of the ignition energy is increased, thus allowing more safety to the mixture distribution operations; in case of leakage the same considerations as in item 1) have to be done;
- 4) the combustion flame is optically detected.

On the contrary some evident advantages, in comparison with pure hydrogen, are present: fuel leakage may be detected by natural gas odour, distribution operations may be more safety due to higher ignition energy, and combustion flame is optically detected while hydrogen combustion is not visible.

Conclusions

Finally we can draw the following general conclusions:

- mixing hydrogen in natural gas is profitable from the environmental point of view;
- in comparison with pure hydrogen, blends have no dramatic effects on vehicle range and engine performance;
- the best percentage of hydrogen depends on the engine configuration and mission, a 30% by volume hydrogen content may be considered a reasonable value;
- with hydrogen percentage less than 30% by volume no major problems are expected as far to regard to safety aspects and materials aging;
- HCNG may play an important role in the process of boosting future technology based on pure hydrogen.

At the end we may point out that, if today the use of mineral liquid fuels produces enormous pollution problems, tomorrow hydrogen will solve all environmental problems due to road transports: but “how we can go from today to tomorrow?” Natural gas – hydrogen blends may be a potential bridge for this transition.

7.6 PROMISING NGV RELATED TECHNOLOGIES TO ENHANCE EFFICIENCY AND SAFETY

Manuel Lage, Dr. Eng., NGVA Europe, General Manager

The bright future of NGV's

Other than the traditional technology of the existing NGVs, there is a number of new development lines, already in operation, that are paving the way for the medium and long term future. The main new concepts are:

- New engine combustion management technology
- Biomethane
- LNG for trucks and buses
- Dual Fuel Technology for heavy duties
- CNG Hybrid Vehicles
- Methane-Hydrogen mixtures

Biogas-biomethane. Another source of Natural Gas

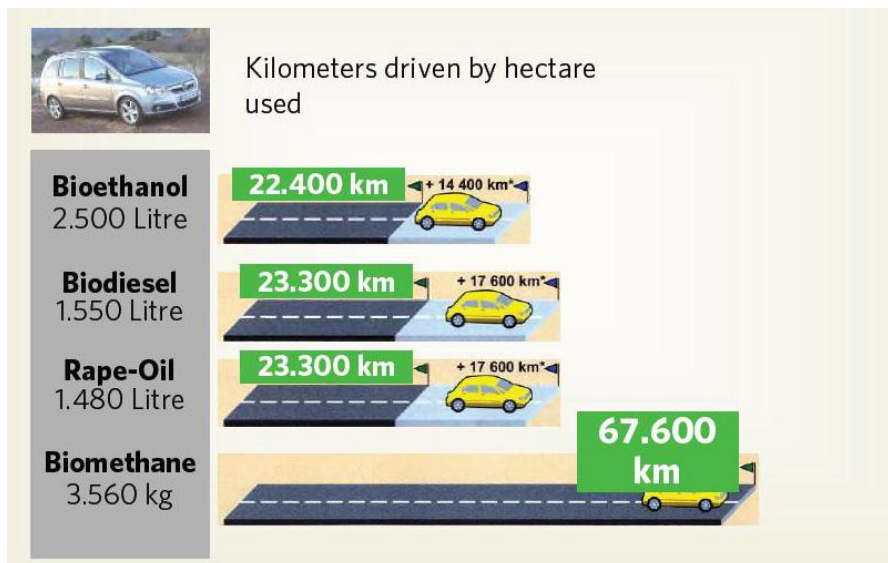
Biogas comes from fermentation processes of biomass (organic waste, landfills, vegetable and animal feedstock), which produces methane rich gases. Biogas brings together the advantages of natural gas with the environmental benefits of renewable energy sources. Due to the wide different types of sources: forestry, landfills, agricultural, there is a large and wide potential for biogas production in Europe, where it is expected to grow significantly in the coming years.

Biogas production potential

Among different options of biofuels, biomethane presents the highest efficiency per hectare of land. A global European estimation shows a potential of 2.750 TWh (9.9EJ=238Mtoe), made out of 1.500 TWh (5.4 EJ=130Mtoe) coming from crops, plus another 1.250TWh (4.5EJ=1.108Mtoe) coming from other sources: sewage, manure, landfills, etc.

If we choose bioethanol instead of biogas we would lose the potential of the waste, sewages, etc (1.250TWh, 4.5EJ=108Mtoe) and we would also reduce the efficiency of the land by 47%. In other words we would obtain 800TWh (2.9EJ=70Mtoe) instead of 2.750TWh (9.9EJ=238Mtoe).

(Data from NGVA Europe document “*Fact Sheet: Biomethane production potential in the EU-27+ EFTA countries, compared with other biofuels*”. September 2010)



Comparison of the land potential when dedicated to biomethane production compared with other biofuels. (Source Erdgasmobil)

The virtuous circle in big cities. Gas consumption vs biogas production

The high potential for production of biogas coming from the urban garbage landfills is really extraordinary. Based in existing cases in Europe, we can say that the yearly biogas production potential of a city with 4 to 5 million inhabitants could be of about 40 million m³ of raw biogas which, once purified, would become 22 million m³ of biomethane.

This volume is enough to fuel near 1.000 garbage trucks and/or urban buses during the full year, giving birth to the concept we have called in NGVA Europe, the “virtuous circle of the waste and gas in the city”.

This concept is directly linked with our proposal that natural gas should be considered as the “recommended urban fuel”, because of its significant advantages in pollutants and noise reduction, particularly appreciated in cities, plus the possibility of being part of the “biomethane virtuous circle”.

7.6.1 HYBRIDIZATION

Hybrid traction technology (thermal engine + electric motor), initiated with cars for taxi services, has shown a significant economy in fuel consumption and the consequent reduction also in exhaust emissions and CO₂.

This same hybridising concept, applied to heavy urban buses, initially equipped with diesel engine, confirmed the great advantage of this technology. Fuel economies of up to 25% compared with the traditional diesel buses are being recorded.

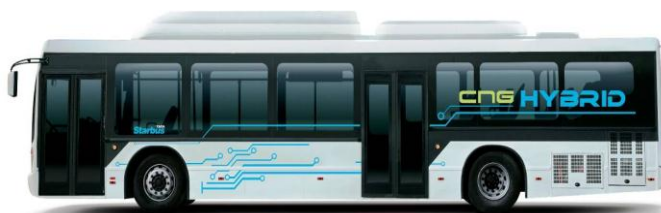
The following step in this development has been putting together the proven advantages of the hybridisation concept with the clear superiority of the CNG thermal engine, as the cleaner, affordable and more silent option for the prime mover of an urban bus.

By now there are already in Europe several producers offering the ultimate affordable technology for the urban buses: the CNG-electric hybrid units.

CNG Hybrid Urban buses are already available in Europe



Castrosua TEMPUS CNG Hybrid



Tata Starbus CNG Hybrid

The municipality of Madrid has already passed orders for 23 CNG-Hybrid buses: 13 from Castrovia and 10 from Tata Hispano, to be delivered in 2011-2012.

7.6.2 HIGHER LOADS



Some examples of LNG trucks around the world (from left to right): Europe, Europe, Australia, USA.

LNG is also the perfect solution for suburban buses and long distance coaches, that cannot use CNG because of the need for high autonomy

LNG Terminals are growing in number both in Europe and in the world.

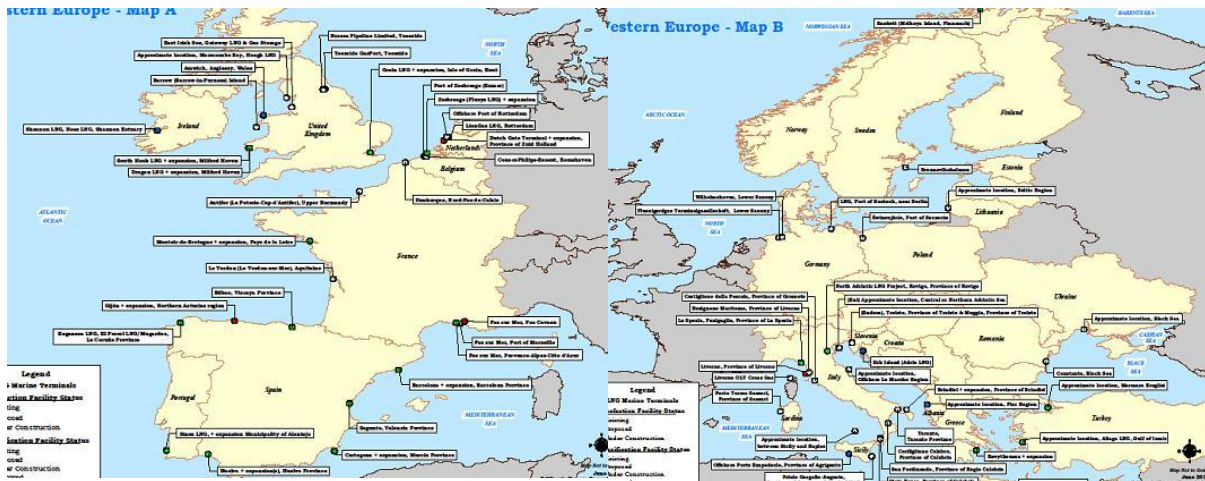
LNG terminals in Western Europe:

One for liquefaction in Norway, above the Arctic Circle

- 16 in operation for regasification (Portugal, Spain, France, Belgium, Italy, United Kingdom, Greece, Turkey)
- 52 additional projects (Albania, Croatia, Cyprus, Germany, Ireland, Netherlands, Poland, Romania, Ukraine)

LNG terminals in the world:

- Liquefaction: 21 in operation, 47 planned/being built
- Regasification: 62 in operation, 127 planned/being built



LNG supply to Europe. LNG Terminal in Huelva (Spain) & ships

European LNG terminals in operation or being built



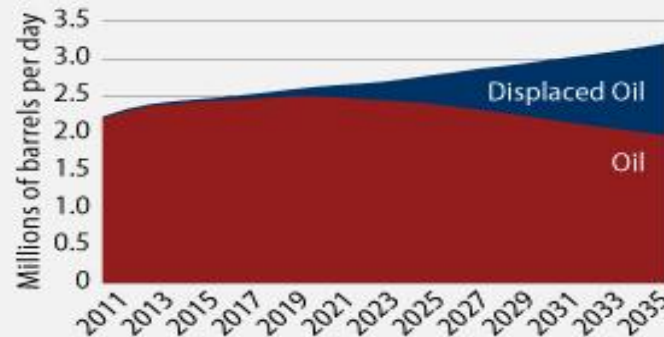
European LNG terminals in operation or being built

LNG terminal in Huelva (Spain)

First and second generation of LNG carriers. Spherical containers had been replaced by continuous, prismatic volume, making better use of the space in the ship.

USA forecast sees an important part of the diesel oil used in trucks and buses, being replaced by LNG in the next 25 years.

FIGURE 1
Potential oil displacement from natural gas trucks and buses



Sources: Energy Information Administration, Annual Energy Outlook 2010, Supplementary Tables 46 and 67, available at: http://www.eia.doe.gov/oiaf/aeo/supplement/sup_tran.xls#set3.1118a!C170 and http://www.eia.doe.gov/oiaf/aeo/supplement/sup_tran.xls#set3.1118a!C2275

38% of the fuel used in USA trucks and buses in 2035 will be natural gas!
Natural gas in either form, CNG and LNG, happens to be the only real, affordable alternative to any type of surface transportation.

Alternative to any type of surface transportation

Vehicle type	Present fuel	LPG	Liquid bio fuels	Full electric	Hybrids (energy recuperation)	Bio-natural gas (CNG & LNG)
Three wheelers	Petrol	Yes (converted)	Yes (%)	No	No	Yes (CNG)
Cars	Petrol & diesel	Yes (converted)	Yes (%)	Yes (city cars)	Yes	Yes (CNG)
Vans & delivery trucks	Diesel	Yes in vans (converted)	Yes (%)	Yes (city use only)	Yes	Yes (CNG)
Heavy urban trucks	Diesel	No	Yes (%)	No	Yes	Yes (CNG)
Saburban & urban buses	Diesel	No	Yes (%)	Yes, small Yes (wired)	Yes	Yes (CNG/LNG)
Coaches	Diesel	No	Yes (%)	No	No	Yes (LNG)
Heavy on road trucks	Diesel	No	Yes (%)	No	No	Yes (LNG)
Heavy off road trucks	Diesel	No	Yes (%)	No	No	Yes (CNG/LNG)
Railway locomotives	Diesel & electric	?	Yes (%)	Yes (wired)	No	Yes (LNG)
Ships	Diesel	?	Yes (%)	No	No	Yes (LNG)

(Source NGVA Europe)

7.6.3 DUAL FUEL TECHNOLOGY

Mr. Jeffrey Seisler (CFC, Belgium); Trevor Fletcher (Hardstaff Group, UK, Westport Innovations Inc)

Two engine technologies are available for heavy engines: Dedicated, using 100% natural gas and Dual fuel, using diesel injection for ignition and then natural gas as the main fuel.

So far, dedicated engines have been developed for car engines and also for urban buses and garbage collection trucks. In both cases the engine has around 300 CV, a power well adapted for either use.

The growing interest of running on natural gas also in heavy on road transport required more powerful engines and in the present European offer there are not dedicated engines with more than 330 CV.

The solution for engines in the range of 420 to 450 CV is now the dual fuel technology. This technology allows the use of the basic diesel engine, applying to it an additional gas injection in the inlet ports. The natural gas injection system is electronically controlled and can cater for multi-point, mono-point and sequential port injection.

A separate electronic control unit (ECU) is used for the natural gas fuel, providing a full closed loop feedback system that monitors existing variables alongside the diesel electronic control unit (ECU) and controls the gas injection based on the feedback from the various engine sensors. The ECU is fully programmable and can provide custom mapping for various vehicle applications, giving enhanced compatibility features.

A reduced diesel injection is kept, acting as the ignition for the combustion process, which develops mainly on gas mixture. The diesel injection can vary from 50% to go as low as 15%, only limited by the cooling of the injector.

The main advantages of the Dual Fuel technology are:

- CO2 important reduction. Diesel cycle practically maintained
- Easy development for heavy duty trucks and buses
- Retrofit market considered too for EURO 2 and 3 vehicles
- Possibility of full diesel operation when no CNG is available

Legislation covering homologation of dual fuel engines is still under development.

7.6.4 SUPERCHARGING/ TURBOCHARGING

Mr. Manuel Lage, General Manager, NGVA Europe (Natural & bio Gas Vehicle Association)

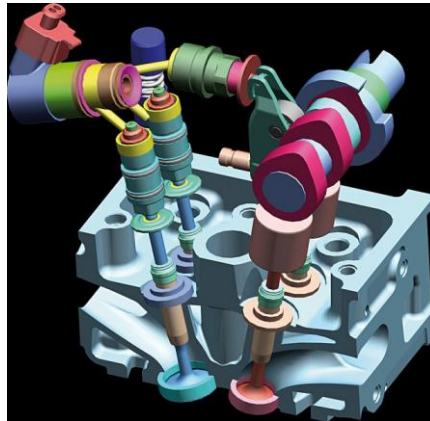
Lessons learnt with the experience of past years remind that the best technology for all internal combustion engines using CNG is the multipoint port fuel injection with positive ignition and stoichiometric combustion.

CNG offers the possibility to exploit all the innovations brought in the gasoline engines field. Advanced and innovative technologies mean to apply simultaneously downsizing concept via turbo charging combined with electronic valve control as Multiair® system (Fiat proprietary). The Multiair® technology is a full electro-hydraulic valve control system that allows a highly flexible management of intake valves in internal combustion engines. This technology is already in series production for gasoline engines allowing great benefits in terms of CO₂, fuel consumption, fun to drive and engine power output.

The application to NG engines will result in similar remarkable advantages, for example, moving from current HD NG engine for public transportation to the same engine equipped

with Multiair® system propelled by hydromethane (produced by 2nd generation renewable sources), the following benefits are expected:

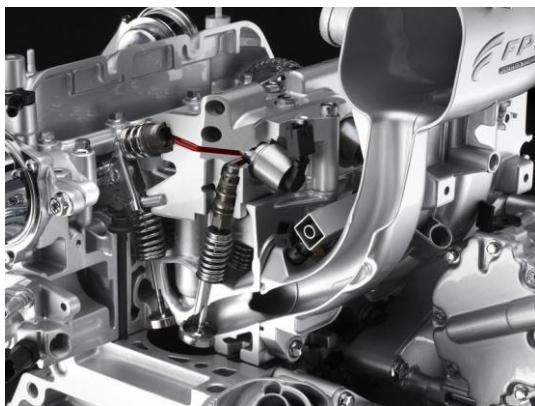
- 25% of CO₂ emission reduction
- 10% of NO_x emission reduction
- 10% of power output increase.
- 25% of GWI (Global Warming Index) reduction
- 10% of ozone promoters reduction



Multiair® valve actuators, from Fiat

A further innovation based on Multiair technology, is its combination with the downsizing concept, recently presented by Fiat and called Twinair®.

The new engine implements the revolutionary Multiair system combined with special fluid dynamics optimized for the best fuel efficiency. Furthermore, by taking the concept of downsizing to the extreme and masterly tuning the basic mechanics, the new engine family —delivering from 65 to 105 CV— emits 30% less CO₂ than an engine of equal performance. The Fiat 500 is equipped with turbo 85 HP version which has the lowest CO₂ emission levels for a petrol engine (up to 95 g/km) without compromising performance and driving pleasure. Furthermore, with respect to a four-cylinder of equal performance and medium displacement, the new engine is significantly shorter (-23%) and lighter (-10%), opening the way to interesting further developments. In particular, a methane version of the Twinair will be available soon providing a further CO₂ emission reduction.



Fiat Twinair® cylinder head and Fiat 500 car

Methane/Hydrogen mixtures

Methane/Hydrogen blend (Hythane, Hydrometano) is an easy combination of both gases, kept at the same 200 bar pressure of the natural gas, and with hydrogen percentages that can go from 10 to 30% in volume. This blend offers a number of significant advantages as a bridge solution for a future hydrogen fuelled transport:

- It can be used in the existing NGV engines and vehicles with minor engine resetting
- The inboard fuel storage uses the same type of tanks and fittings, with some specification changes in materials
- The H2 content considered (up to 30%) does not alter the autonomy of the vehicles
- There is an immediate impact as CO2 emission reduction (- 11%)
- The use of compressed H2 in a “large” basis will push ahead the development of the hydrogen production and its logistics

Conclusions

- Natural gas (methane) is an excellent energy vector, with the lowest Carbon to Hydrogen ratio of all the hydrocarbons. Additionally natural gas is an alternative fuel, having a different origin from the traditional oil derived diesel, petrol and LPG
- New engine combustion developments are offering much reduced CO2 emission than with the traditional petrol derived, gas combustion
- Natural gas is used in existing internal combustion engines, with minor additional investments, taking advantage of a well known and mature car & commercial vehicle technology.
- Dual Fuel technology offers the possibility of conversion for existing engines
- The increasing production of biomethane, both from urban waste and from agricultural stuff is giving natural gas the new and valuable consideration of a renewable fuel
- Natural gas has been used so far as CNG mainly for urban applications. The availability of LNG will spread its use for medium and long distances road transport
- Methane/Hydrogen mixtures, that could be used the existing NGVs will become the bridge to a potential hydrogen fuelled transport

NG vehicles are today the best and most economic affordable alternative to oil derived fuels, also improving gaseous and acoustic emissions.

7.7 SYNERGY OF BIOMETHANE AND NATURAL GAS

Mr. Olivier Bordelanne, GDF Suez, France

7.7.1 PRODUCTION OF BIOMETHANE (INCL. VARIOUS ORIGINS & VARIOUS PROCESSES)

By 2030, natural gas consumption in the European Union should increase by around 16%. With the supply of natural gas becoming ever more dependent on imports, it is worth evaluating the possible contribution that substitute products such as biomethane could make to satisfy the future demand for natural gas.

In the medium term, two different technologies for producing biomethane will be available:

- The production of biogas through anaerobic fermentation or biomethanisation is a mature technology being used more and more in European countries. Biogas must undergo a purification process to be converted into biomethane.
- The production of synthetic biogas through biomass gasification is currently at the demonstration stage, but it should be commercially available before 2020. Synthetic biogas must undergo a methanation and purification process to be converted into biomethane.

Biomethanisation and gasification for producing biomethane makes for an efficient use of resources in two ways:

- the great diversity of the resources necessary for these two technologies;
- the large quantities of available raw materials.

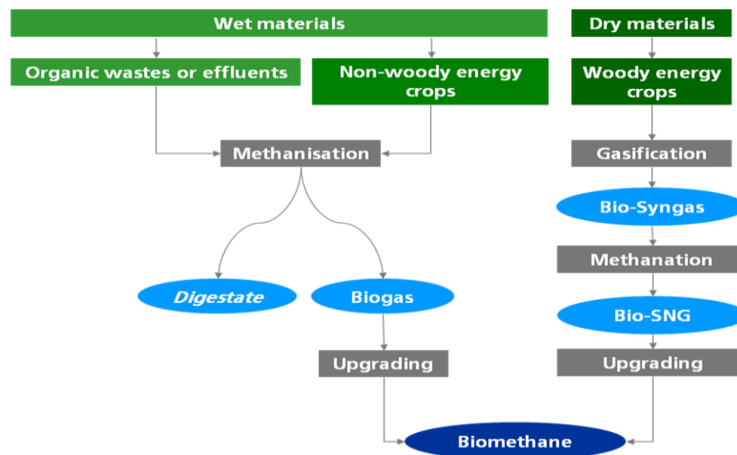
Two kinds of organic matter (or biomass) can be used to produce gaseous biofuels:

- solid wastes or effluents, from forests, from the residential sector or the industry, characterized by the fact that they are undesirable matters associated with desired productions by industrial, residential or agricultural process.
- energy crops.

For the remainder of this report, we call:

- **'Biogas'** the raw product of the biological process of anaerobic fermentation. Biogas is a mixture consisting basically of methane (CH₄) and carbon dioxide (CO₂).
- **'Bio-SNG'** (Bio-Synthetic Natural Gas) the product of the physico-chemical process of gasifying the biomass, then methanation of the synthetic gas.
- **'Biomethane'** the 'natural gas' quality gas obtained from purified biogas or bio-SNG. Biomethane is then biogas that has been purified to resemble natural gas (heating value, composition). It can be used as a gaseous biofuel, in which case it is called biomethane vehicle fuel. It is used exactly like natural gas, and to supply a vehicle must be compressed to 200 bar in a compression station.

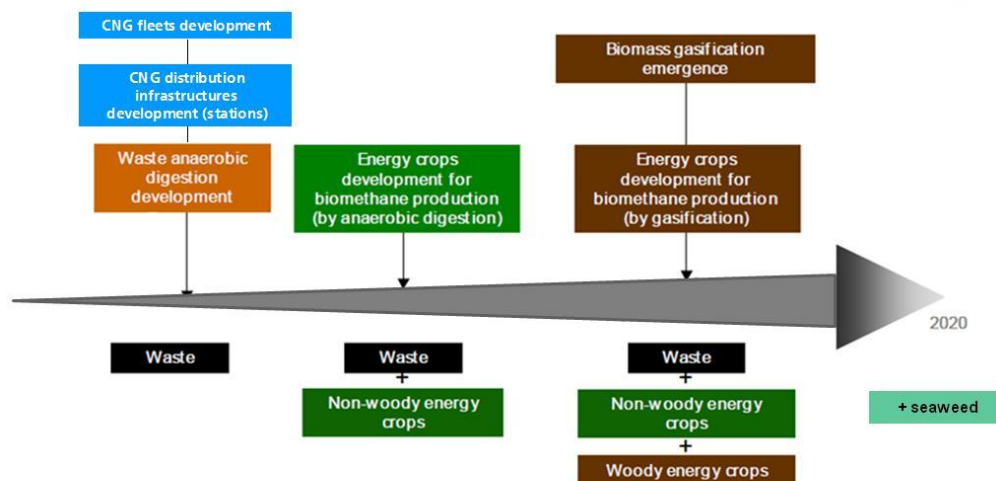
Several ways of producing biométhane:



Production of biomethane from methanisation and from gasification

(Source: GDF SUEZ/ CRIGEN)

- **In the short term**, use is made of **wastes or effluents of organic origin**. This approach is already well developed in many European countries. In France, the approach has undergone rapid development in the last few years.
- **In the medium term (2015)**, it may be possible to produce biomethane from **energy crops**.
- **In the longer term (2020)**, the **gasification** of biomass derived from lignocellulosic resources is also foreseeable.



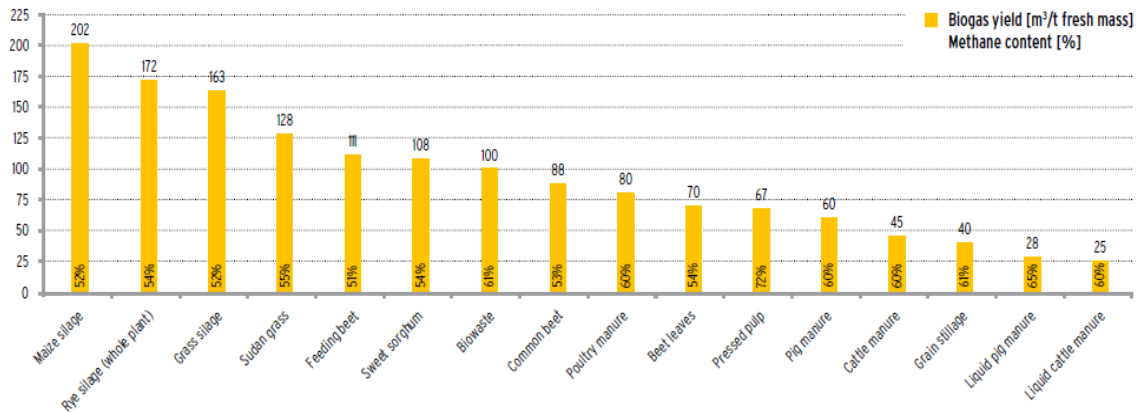
Progressive incorporation of various substrates for biomethane production. Biomethane as vehicle fuel will develop only if NGV infrastructures exist. (Source:GDF SUEZ/ CRIGEN)

Biological way (anaerobic digestion)

All organic material except wood can be used in digestion processes for biogas production, which can help solving various waste problems.

Many different feedstocks can be used for biogas production. A general distinction is made between biomass from agriculture like by-products (manure) or dedicated crops for biogas and various waste streams. High water content impacts the biogas yield per ton fresh mass as illustrated below. The figure shows that maize silage has the highest biogas yield of the described feedstock (waste like grease or molasses offer an even higher biogas output). Due to its high water content liquid manure has the lowest yield and therefore should be processed close to where it is produced in order to save transportation costs.

Biogas yields⁴



Different substrates can be used for biomethane production by methanisation.

Biomethane from organic wastes: a fast-growing, attractive renewable fuel.

On the industrial scale, two types of biogas production can be mentioned:

- storage installations for non-hazardous wastes
- anaerobic digesters

In storage installations for non-hazardous wastes biogas is produced by the spontaneous breakdown of the fermentable fraction of buried household and similar wastes. In the conventional management mode, the production of biogas can last approximately 20 – 30 years.

In landfills covered organic waste forms biogas (landfill gas) which builds up and is able to create an explosive mixture if mixed with oxygen. This gas can be collected and used for energetic purposes. However, it is often just flared right away. This can be seen as a waste of resources as the utilisation of this side product could offer a second income for the operator of the landfill site and prevent unnecessary CO₂ and CH₄ emissions.

In anaerobic digesters the basic process has been implemented on an industrial scale using digestion technology. After undesirable compounds have been removed, the organic matter is put into a reactor, or "digester", kept at temperatures of the order of 35°C or 50-55°C depending on the process; the residence time can be close to twenty days. In addition to biogas, this also produces a digestate that can be treated and composted to yield a useful organic product.

Different kinds of waste are used:

- Sewage sludge as by-product of wastewater treatment. After the use as a feedstock for anaerobic digestion the remaining bio solid can either be used as soil conditioner or be disposed of in a landfill, according to its toxicity (especially

concentration of heavy metals), or burned in a waste incinerator. Digestion also decreases the sewage sludge volume which reduces the disposing costs and problems.

- Manure: it is normally stored on farms for several months and then used as fertilizer. The manure already contains micro-organisms responsible for biodegradation and anaerobic digestion creating methane, ammonia and carbon dioxide which are released into the atmosphere during storage.
- The use of manure for biogas production offers several benefits:
 - it avoids CH₄ emissions during the storage of the manure
 - it reduces CO₂ emissions by replacing fossil fuels
 - it offers an additional energy carrier that does not compete with other uses
 - the substrate as final product after the biogas production is a valuable fertilizer

Compared to fossil transportation fuels like petrol and diesel, biogas from liquid manure is extremely efficient in reducing CO₂ emissions overall (minus 180 %, well-to-wheel), because of low fossil inputs and because it avoids natural emission during storage. Thus manure as renewable energy feedstock provides an efficient source of nutrients for crop cultivation and reduce green house gas emissions at the same time.

- Different by-products of the food industry – breweries, sugar plants, fruit processing, slaughter houses, etc. but also food waste, used kitchen oil, the organic fraction of municipal solid waste (MSW) can be used as biogas feedstock and thus increase the energy offered from biomass.

Biomethane derived from energy crops: a debated approach in Europe

Energy crops for biogas are dedicated crops planted on agricultural land to be used as feedstock for biogas production. Typical crops are maize or sweet sorghum. The mix of maize and manure is the most commonly used feed-stock for decentralized agricultural biogas plants. Energy crops maximize the yield (dry matter per hectare) and offer high conversion efficiencies.

Second crops, or **catch crops**, planted after the harvest of the main crop, can also be used as biogas feedstock. This system allows two harvests per year on one piece of land. Green cuttings, material from landscape maintenance can also be used as biogas feedstock. This type of feedstock should be available within a small radius of the biogas plant, as the transportation of feedstock with high water content is costly, both from an economic and ecologic point of view.

In addition to the biomethane potential associated with fermentable wastes, a large potential could be developed in the medium term by using farmland to grow dedicated crops that could be converted to methane, provided that this does not compete with the production of food, or with the production of other types of energy or materials from the same resource.

It must be emphasized that anaerobic digestion has a specific strength, the digestate, an organic by-product that can be used to fertilize farmland dedicated to energy crops, replacing chemical fertilizers.

The anaerobic digestion of energy crops is highly developed in Germany, thanks to tax breaks; however, the crop most used is corn, which, alongside its strong methane potential, has some drawbacks: irrigation needs, rising prices, etc. It is therefore essential to identify

plants that will make it possible to produce biomethane vehicle fuel more sustainably (alfalfa, sorghum, etc.).

Thermal way (gasification)

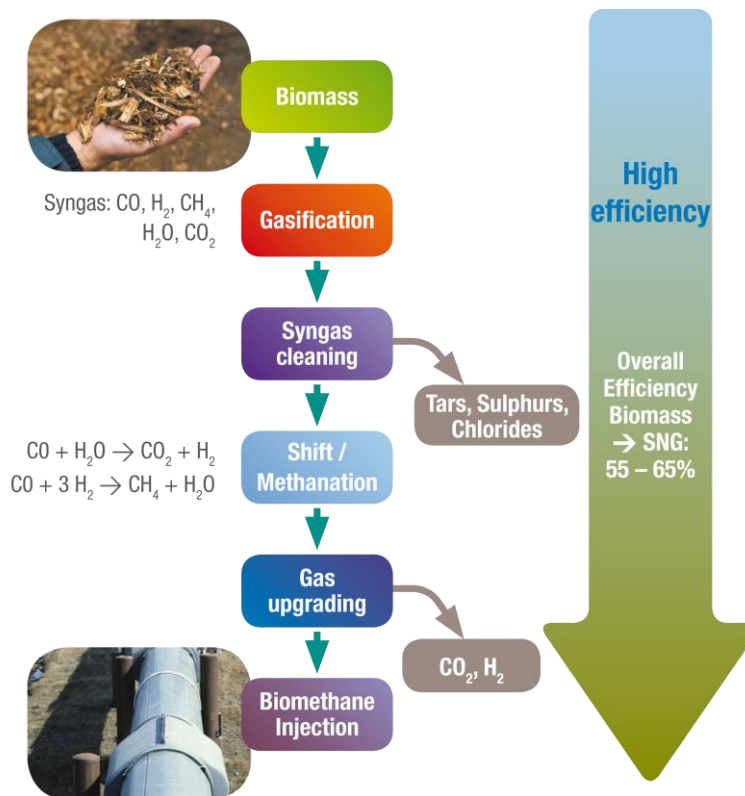
Gaseous biofuel can also be produced from ligno-cellulosic biomass by a first gasification step, followed by a methanation step.

The main difference between the thermal way and the biological way of producing biomethane is the substrates used: while methanisation is operated with wet biomass (water content above 50 %) based on fermentable compounds, gasification uses **dry biomass** (water content between 20 and 40 %) composed essentially of ligno-cellulosic material (some lower cost biomasses are expected to be used later in gasification processes). In addition, biological processes are operated at **room temperatures in anaerobic conditions** while gasification is a **thermo-chemical oxidation at elevated temperatures** (above 700 °C).

The thermal way has already been used in the 70s and 80s for coal gasification / methanation. Several processes have been developed in the 70s and 80s to produce SNG from coal or from liquid fuels, but most of the research programs dedicated to those technologies were stopped in the 80s after the decrease of the fuel prices. Today, linked to the necessary development of renewable, which increases the interest of the bio-methanation way, new research programs emerge on the feasibility of producing a green SNG from biomass gasification and catalytic methanation.

Even if many works have been done in the past years, the adaptation of the methanation process to biomass presents several technical and economical gaps to be removed before reaching commercial development. Technical issues are mostly linked to the presence of tars in the syngas. That is why the SNG production technology from biomass is still in the demonstration stage.

The diagram below shows the most “classical” thermal way of producing biomethane:



Biomethane can also be produced by a thermal process from dry biomass.

(Source : GDF SUEZ/ CRIGEN)

This thermal process contains four main steps:

Gasification:

Gasification is an **incomplete thermo-chemical oxidation**, which produces low calorific fuel-syngas thanks to a gasification agent, air or steam. This syngas is mainly composed of CO, H₂, CH₄, H₂O, CO₂ but also contains contaminants that need to be removed, like tars and inorganic compounds. The calorific value of the syngas may differ consequently from one to another process depending on the gasification agent use: in case of air, the LHV of the syngas is low (1-2 kWh/Nm³) and the syngas valorisation is difficult. Use of oxygen or steam avoid this decrease of LHV, and it can reach 4 – 5 kWh/Nm³.

Syngas can be valorised in 4 main ways:

- Combined Heat and Power production (**CHP**)
- **SNG** (Substitute Natural Gas): green methane production (for injection or bio-NGV uses)
- **Hydrogen**, after a water gas shift,
- Liquid bio-fuels (**BTL**) through a Fischer-Tropsch synthesis.

For SNG production, syngas need to be purified before the methanation step. It is then upgraded to produce biomethane.

Syngas purification:

That step is the most critical and the main issue of the whole bioSNG production chain. **The catalytic process of methanation is very sensitive to some pollutants**, which presence, by poisoning the catalysts and reducing drastically their lifetime, increase operational costs and decrease the plant availability. Sulphur, chlorine and tars are the most critical components and should be removed at a very low level (< ppm). Nevertheless, the purification processes have to be chosen not to crack or absorb the methane present in the syngas. Several processes, at low or high temperature can be used, but they still need optimisation.

Methanation:

Methanation is a catalytic process, which principally consists in transforming CO (and CO₂) and H₂ into methane. Methanation is a very exothermic reaction, but, for technical reasons (optimisation of the conversion ratio, preservation of the catalyst in the reactor...), the temperature has to be kept at a relatively low level. Two different technologies can be used:

- **fixed beds:** they can work under pressure, are easier to operate and have already been used on fossil fuels.
- **fluidized beds:** they have not yet been commercially developed but they allow a better valorization of the heat flows and are less sensible to pollutants.

None of those technologies has yet been tested at an industrial scale with a syngas produced from biomass.

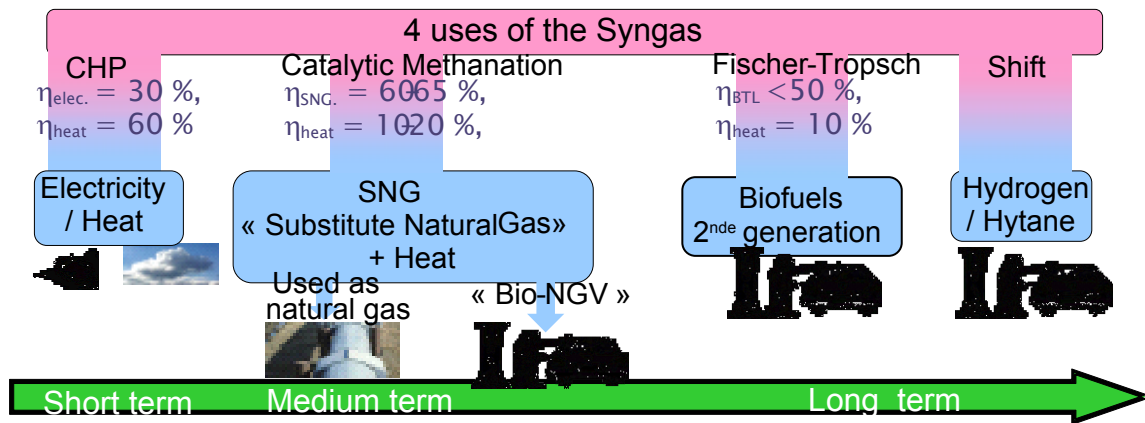
BioSNG upgrading:

The last step consists in conditioning the bioSNG produced, and especially, cleaning the bioSNG from water and CO₂. Depending on the biomethane quality expected, several additional treatments can be applied (NH₃ or H₂ removal for instance). Biomethane is then ready to be injected into the grid or used as vehicle fuel.

The diagram below summarises the thermal way for biomethane production :

Biomethane from gasification: a promising way

The global efficiency of the whole production chain is very high (**global efficiency from biomass to bioSNG is today evaluated around 55% and could reach in the future 65%**), especially compared to the efficiency of the BTL production (around 25-35%).



Efficiencies of the different valorisations of bio-syngas

That efficiency can be improved by the valorisation of the heat from the methanation step. Smaller plants are advantaged, as they can find more easily a local customer for the heat. Finally biomethane produced by gasification / methanation can be expected to occupy a favorable position among second-generation biofuels thanks to high-energy yields. The sizes of facilities producing biomethane vehicle fuel using this approach could be **adapted to local supply of biomass and easy local use of the co-produced heat.**

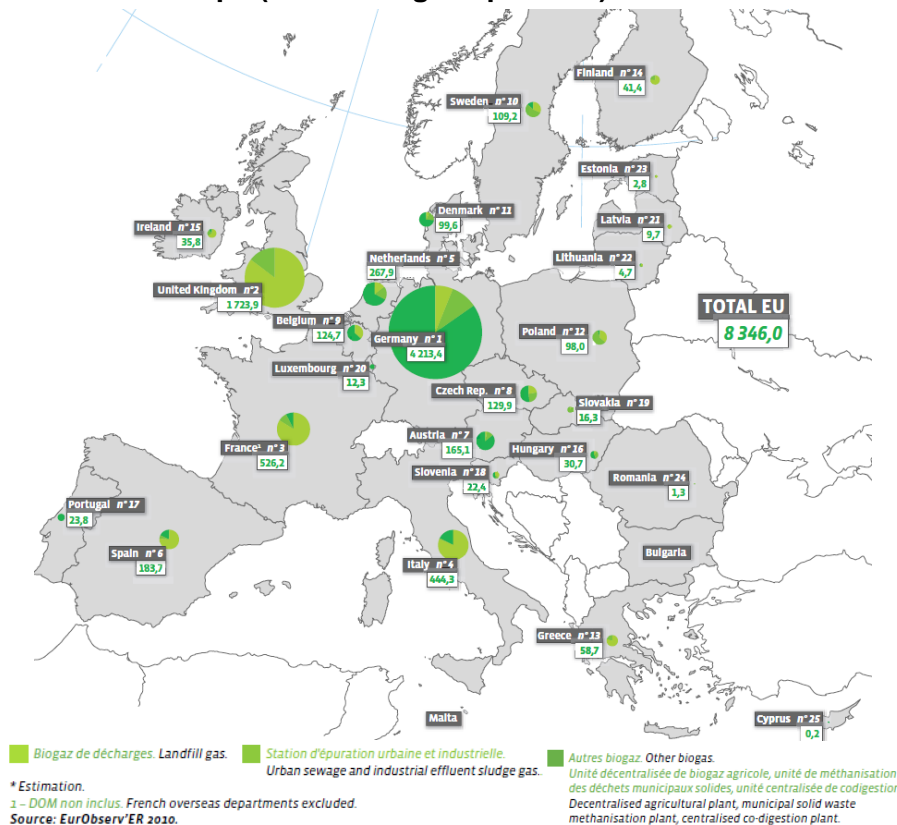
This thermal way uses a different biomass from that used for anaerobic digestion. In the long term, **the biomethane production potential would therefore be even larger.**

7.7.2 BIOGAS VALORISATIONS & THEIR ENVIRONMENTAL BENEFITS

Politics, technologies, regulations and economic aspects will be mentioned through all these different valorizations and for each of them.

Various biogas/biomethane usage

Biogas production in Europe (from biological process)



European biogas production in 2009 (Source : EurObserv'ER 2010)

Different valorisations of biogas (from biological process)

Because it is renewable, biogas contributes to reducing greenhouse gas emissions. It can be converted into heat, electricity, and/or, if correctly purified, a gaseous biofuel.

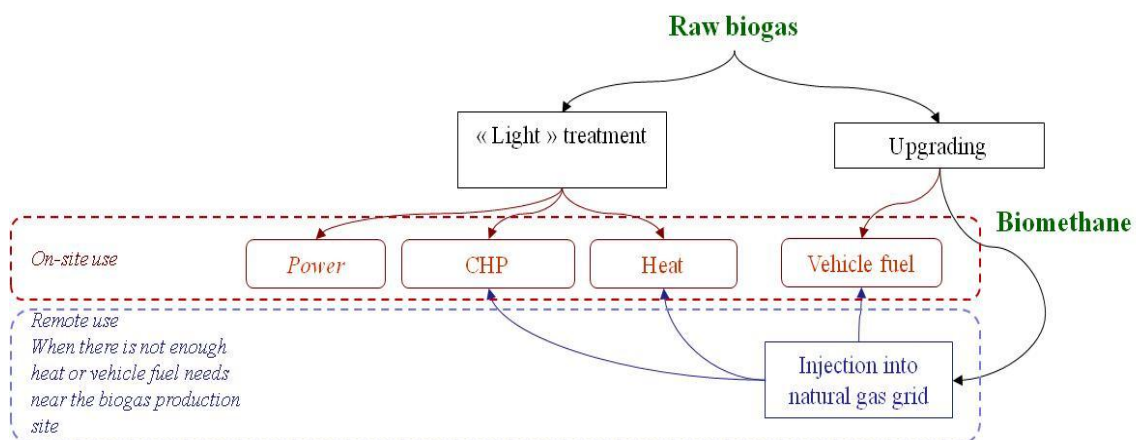
Currently, there are two options for using biogas in an economically reasonable way: Either it is converted to energy in an on-site engine power generator or in an on-site combined heat and power plant (CHP) (A combined heat and power plant (CHP) is a unit that produces electricity and heat at the same time. Basically, a CHP is a cogeneration plant. However, for biogas plants one uses the term cogeneration plant) or it is fed into the natural gas grid. In both cases, the crude biogas has to be cleaned before using it. If the biogas is incinerated in an on-site engine or CHP, a primary cleaning suffices. In this process, the gas is dehumidified and desulfurised. This is generally supposed to remove the corrosive matters that damage the engines. The waste heat of the engines can be used for maintaining the fermentation process and for the operator's own purposes. In principle, it is also possible to feed the heat into the local or district heating network. However, this is rarely done, as most of the facilities are located in isolated places. Consequently, the bigger part of the heat is lost, which considerably

decreases the plant efficiency. In recent years, though, (new) incentives and legislation has led to a significant improvement of the heat use.

The additional processing and feeding of the biogas into the natural gas grid allows a decentralized valorization of the energy: the biomethane can be drawn from and used anywhere in the natural gas grid. In this way, the biomethane can be incinerated in CHPs that are conveniently situated for heat use – like plants located in industrial parks or densely populated areas (that, hence, need a lot of heat). In doing so, the overall efficiency of the plant can be increased considerably.

Besides feeding the biogas in the gas grid, it can also be used as a fuel substitute.

In order to feed the biogas into the existing natural gas grid, several qualifications have to be fulfilled. The composition of the gas and the grid access are especially important. It is only possible to admix the gas as long as it does not change the basic combustibility of the natural gas.



Biogas or biomethane can be used either on-site or injected into the natural gas grid for a decentralised valorisation (Source : GDF SUEZ/CRIGEN)

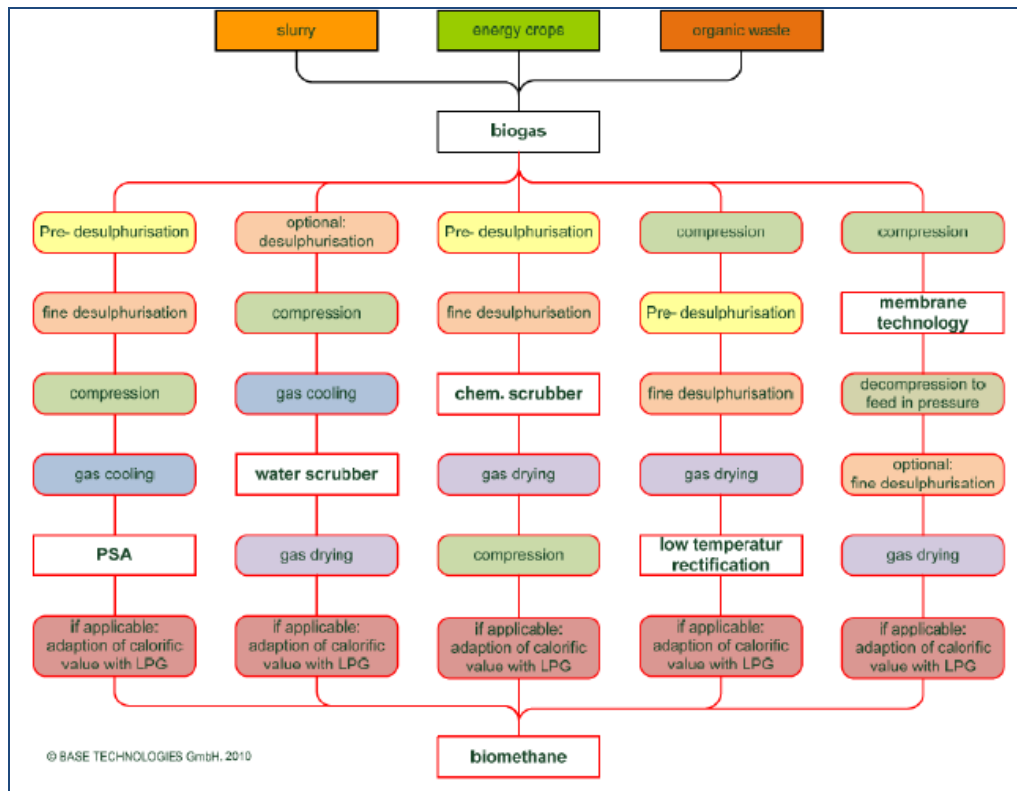
In lots of countries, incentive exists for biogas valorization. For instance, in some European countries, biogas conversion into heat and power benefits from green certificates or from feed-in tariffs.

Biomethane production (from biological process)

Biogas purification is used both to eliminate undesirable compounds and to increase the heating value of the biogas (in particular by eliminating CO₂, which is inert in energy terms). It generally comprises at least three steps:

- **decarbonation**: carbon dioxide is the second largest component of biogas, after methane. Its elimination reduces the risk of corrosion and increases the heating value of the biogas. This treatment can be performed by adsorption, by scrubbing (water or another solvent), or through membrane processes;
- **desulfurization**: H₂S is toxic and, in the presence of water, highly corrosive, even at a low concentration. It can be separated in particular by scrubbing and/or by adsorption on impregnated activated carbon;
- **dehydration**: water is the leading corrosion risk factor. To reach water contents as low as in NGV, it is possible to use the following processes: adsorption on activated alumina, silica gel or a molecular sieve, or scrubbing with a hydrophilic solvent (this last option tends to be reserved to very high gas flowrates).

If necessary, these treatments can be completed by the elimination of problematic trace elements, in particular heavy metals (generally by adsorption).



Summary of technologies for biogas refinement
(Source: Mattias Schmuiderer, BASE TECHNOLOGIES GmbH, 2010)

The biomethane vehicle fuel production chain is divided into four main steps:

- **production** of the raw biogas,
- **purification** of this biogas to turn it into biomethane,
- the **metering**, **odorization**, and **checking** of the biomethane quality,
- **storage** of the biomethane vehicle fuel, its distribution, and its compression to 200 bar.

Biomethane production in Europe (from biological process)

In Europe, biomethane vehicle fuel is highly developed in Sweden and Switzerland. In France, it is still an emerging approach. As an example, the Lille Métropole project treats 108,000 metric tons of biowastes with a view to producing enough biomethane to supply about a hundred buses. The process had already been tried and tested, over a 10-year period, by the demonstration operation of the Lille-Marquette purification station, where biogas derived from the anaerobic digestion of urban sludges served, after purification, to fuel 4 buses.

Environmental benefits

Sustainability of biomass...

From the sustainability of biomass point of view, two cases have to be considered:

- biogas and biomethane production from waste: as no natural resources are used, this supply is very sustainable. Furthermore, it permits to create energy and to treat waste at the same time, which makes it an even more interesting approach.
- biogas and biomethane production from cultivated wet and dry biomass: this is more delicate, and biomass should be cultivated in a sustainable way in order to assure that its environmental impact is profitable to the planet.

Generally speaking, some elements that should be taken under consideration to define biomass sustainability are:

- biomass harvesting locations (in order to prevent growth in nature protection areas, biodiverse grasslands and peatland). Even soils not suitable for food production can be used for the cultivation of energy crops and dry biomass. Indeed cultures that are net sequesters of carbon can be produced on agriculturally degraded lands and do neither displace food production nor cause loss of biodiversity.
- the frequency of biomass harvesting;
- water consumption,
- fertiliser consumption,
- soil depletion (Currently most energy crops (as well as most important food crops), are grown as intensive monocultures. Annual monocultures are often associated with high rates of soil erosion. Some crops, like maize, deplete soil nutrients more rapidly than others, and might require significant levels of agrochemicals (fertilizer, pesticides) unless the digestate is carefully recycled),
- supply chain...

It is important also to avoid competition with food production as much as possible (This more frequently concerns wet biomass (such as maize) than dry biomass). In this sense, the use of bridging or catch crop is under study. Advantageously, biogas can be produced from plants not being competitive with food production. Nowadays, the crop most used in Germany is maize, which, alongside its strong methane potential, has some drawbacks: irrigation needs, rising prices, etc.

It is therefore essential to identify plants that will make it possible to produce biomethane more sustainably (alfalfa, sorghum, etc.). Researches are necessary on the selection of the crops (and the combination of different crops) to both maximize the biogas production and minimize the impact on environment.

As a consequence energy crops should be carefully selected, depending on local climate conditions, availability of irrigation water, robustness against diseases and last but not least – based on biomass yield per hectare.

The European approach

The CEN Technical Committee (TC) 383 *Sustainability produced biomass for energy applications* was created in 2008 in order to work on European Standards dealing with sustainability principles, criteria and indicators including their verification and auditing schemes for biomass for energy applications. This includes green house gas emission and fossil fuel balances, biodiversity, environmental, economic and social aspects and indirect effects within each of the aspects. The Renewable Energy Directive (2009/28) sets the framework for the scope of the work of TC 383.

It has to be noted that the Renewable Energy Directive stands that in order to consider sustainable biofuels, the greenhouse gas emission saving from their use must be at least 35 % (From 2017: > 50 %; from 2018: > 60 % (for biofuels produced in installations in which

production started on or after 1 January 2017). Moreover, biofuels taken into account must not be made from raw material obtained from land with high biodiversity value (Such as: primary forest and other wooded land, areas designated for nature protection purposes or for the protection of rare, threatened or endangered ecosystems or species, highly biodiverse grassland.):

ISO works on the « Sustainability criteria for bioenergy »

Recently also the International Organization for Standards (ISO) started to work on the « Sustainability criteria for bioenergy ».

... and other social issues

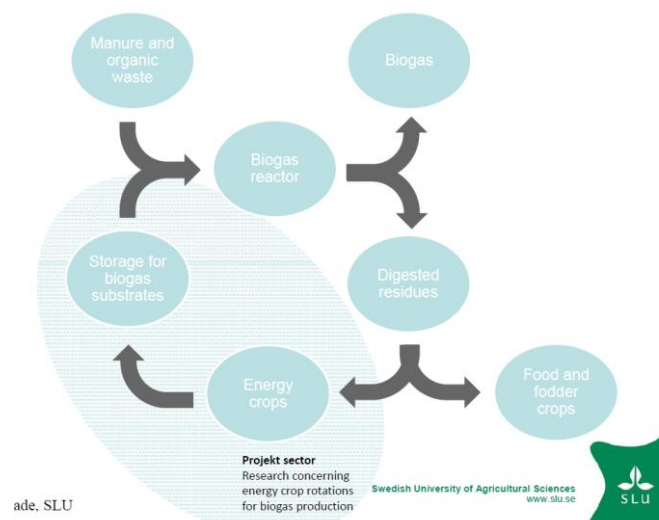
Biomethane production leads to the creation local (and difficult to shift abroad) employment. As an example, the French Energy Environment Technical Association (ATEE club biogaz) has assessed that more than 12.000 person-year and 5.000 permanent jobs have been created in France from 2005, of which more than 2/3 difficult to be relocated. Furthermore the cultivation of energy crops promotes rural investments and creates new jobs.

By products valorization

Digestate utilisation

It must be emphasized that anaerobic digestion has a specific asset, the digestate, an organic by-product that can be used under certain conditions to fertilize farmland dedicated to energy crops, replacing chemical fertilizers.

Its use has some environmental benefits, such as limiting inputs of chemical fertilizers, thanks in particular to the high mineralization of the nitrogen in the product and the preservation of the fertilizing value of the treated waste. However, in some local contexts, using the digestates may not be environmentally friendly: risk of volatilization of the nitrogen during spreading, low carbon content, etc.



Under certain conditions, the digestate produced by the anaerobic digestion of organic wastes or energy crops can be used as an organic fertilizer on cropland.

Heat utilisation

Biomass gasification produce an important amount of heat: it can be important, from an economical and an ecological point of view to valorise it.

Emissions & Life Cycle Analysis

Anaerobic digestion

The following height steps can be distinguished principally in digestion processes:

- Biomass production and harvesting (only for energy crops);
- Wet biomass collection and transport;
- If needed, pre-processing and storage of the substrate;
- Feed regulation (substrate preparation and dosage) and fermentation (digestion);
- Biogas treatment (and upgrading if biomethane production);
- Biogas/biométhane storage or biomethane injection;
- Biogas or biomethane valorisation;
- Treatment, storage and use of digestate.

Biogas, derived from wastes or (cultivated sustainably) energy crops is **renewable energy**: it can therefore contribute to reducing non-renewable energy consumption and reliance on fossil energy.

The results of the environmental assessment of biomethane production and utilisation can vary according to different factors such as

- a. Biomass supply: environment assessment can vary according to the type of biomass that is used.
 - Waste: it is the most profitable substrate from an environmental point of view because:
 - its production must not be taken under consideration in environmental assessment (point 1 above);
 - its use enable to avoid other waste treatments.
 - Energy crops: insofar as it is possible to convert the whole plant, the quantity of net energy produced per hectare is high. Here again, the performance of the approaches depends on what species are cultivated and how they are cultivated (cultivation and harvesting practices, type and amounts of agricultural inputs). Nevertheless, if sustainability criteria are met, the use of energy crops will reduce GHG emissions by replacing fossil fuels.
- b. Biomass water content: when waste or energy crops have high water content (such as liquid manure), they have lower yield and therefore should be processed close to where they are produced in order to save transportation costs (Form an economical point of view, it is generally said that liquid manure must not be transported for more than 10 km) and emissions.
- c. Biomass collecting distance: generally speaking, the emissions increase with the collecting distance.
- d. Optimisation of the chain: it is important to minimise the emissions all along the chain of production and utilisation of the biomethane;
- e. Biomethane valorisation;
- f. Energy replaced: the results will be different if biomethane replaces coal or natural gas;

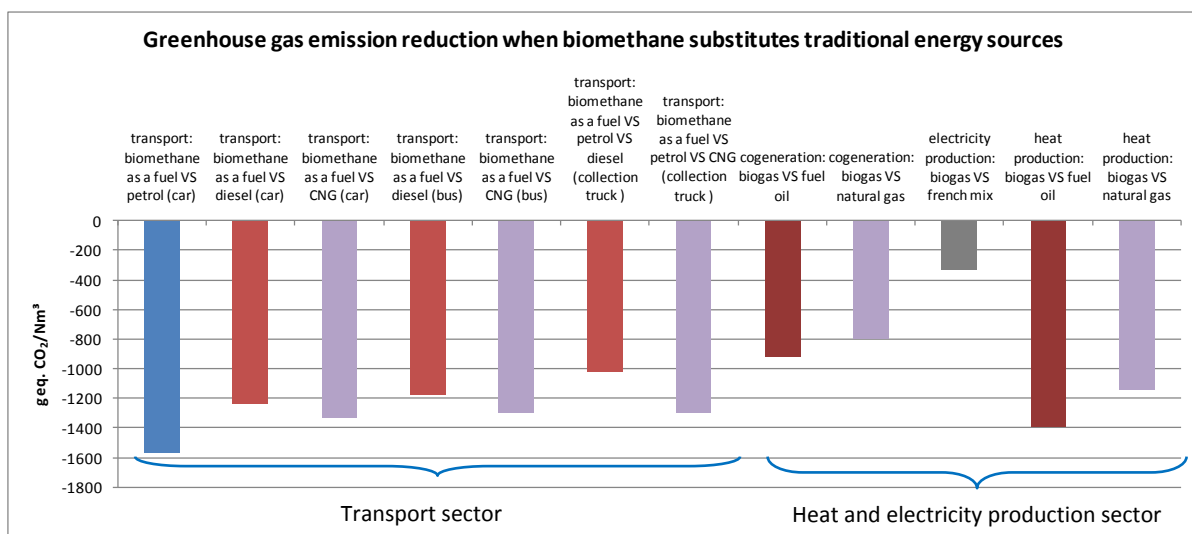
- g. **By-product valorisation:** the assessment results vary if digestate is used as a fertiliser or if it is considered a waste.
- h. **Greenhouse gas (GHG) emissions:** biomethane is very interesting from the point of view of GHG emissions reduction (especially when it is created from waste). All analysis of the replacement of fossil fuels by biomethane from wasteshighlight the reduction of greenhouse gas emissions achieved accordingly:
 - at the end-use step (combustion of fuel), as CO₂ emissions from biomass wastes (like those from all kinds of biomass) are considered as neutral with respect to the greenhouse effect,
 - at the production step, as the anaerobic digestion of organic wastes enables to eliminate CH₄ emissions occuring when wastes, animal breeding effluents, etc. are stored.
- i. **local emissions:** the environmental assessment is not always profitable to biogas production depending on very local condition and hypotheses (as an example, how digestate is treated and handled). For this reason, it is important to optimise the biogas and digestate production and valorisation chain.

Some results concerning the biological way (anaerobic digestion)

The French Environment and Energy Management Agency (ADEME) and GDF SUEZ has realised a Life Cycle Assessment (LCA) of biogas and biomethane production and utilisation concerning both:

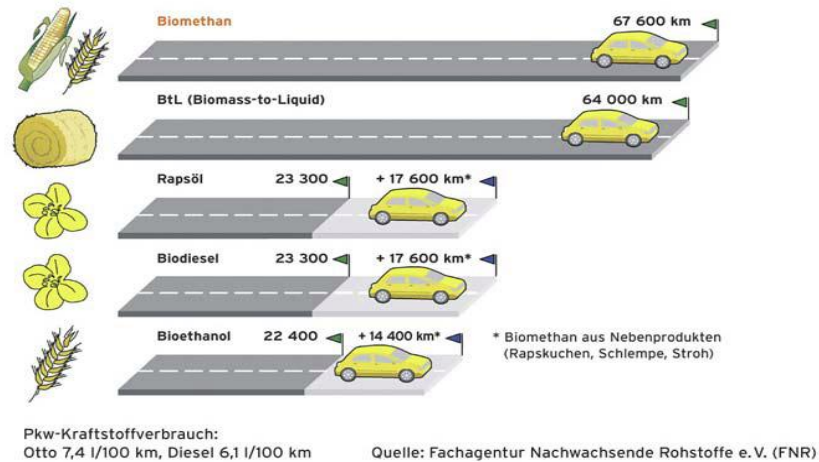
- the transport sector (car, bus and collection truck);
- the heat and electricity production sector (cogeneration, heat production and electricity production).

Biogas and biomethane emissions has been compared to the ones of more traditional energies sources, such as fossils fuels and de French energy production mix
 When biogas and biomethane replace traditional energies sources, the greenhouse gas emissions (on a *life-cycle* base) are considerably reduced.



Greenhouse gas emissions (on a life-cycle base) reduction of biogas and biomethane production and use versus traditional energies sources.

Other studies highlight the land use efficiency of biomethane production when compare to liquid production for vehicle fuel.



Comparison of biofuels production.

Thermal way

Similarly to the anaerobic digestion, in thermal way processes the following six steps can be principally distinguished:

- Biomass production and harvesting (with the exception of forest and industrial residues);
- Dry biomass collection and transport;
- Biomass pre-treatment and storage;
- Gasification, methanation and upgrading;
- Biomethane injection;
- Biomethane valorisation.

Biomethane production through biomass gasification is in R&D phases. For this reason, fewer publications on its environmental performances are available.

Two LCA (the one based on a UK case, and the second a Swiss case) are nevertheless been published.

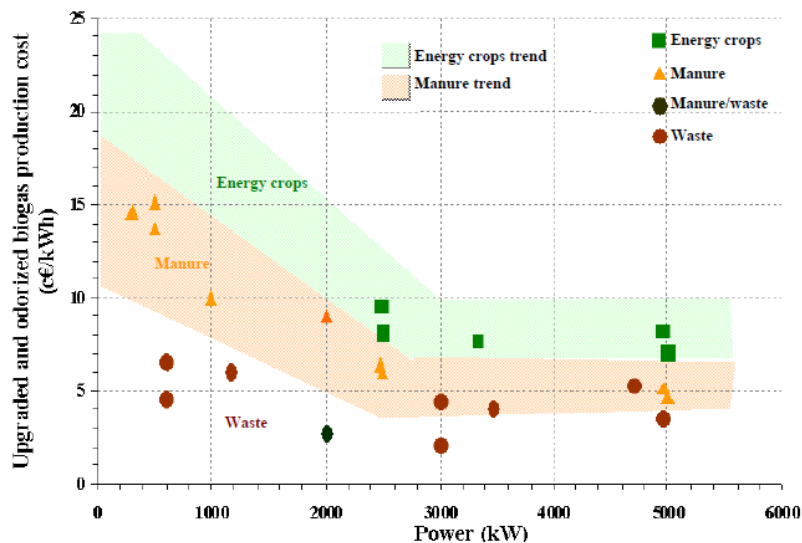
Basic results demonstrate that bioSNG production and use in commercial and domestic heating, industrial CHP and road transport achieves substantial net GHG emissions savings relative to fossil fuel alternatives consisting of natural gas and fuel oil-fired heating and CHP, and diesel and petrol for road transport.

Actual net GHG emissions savings depend on:

- the assumed default values in the workbooks (specifically a round trip distance of 20 km for delivery of biomass feedstock to the bioSNG plant),
- the GHG emissions calculation methodology applied
- and the specific choice of biomass feedstock.

Economic data (from biological process)

The production cost of purified, odorized, checked and metered biomethane, made from energy crops and from liquid manure, is between 8 and 21 €/kWh, and between 5 and 15 €/kWh, respectively, and decreases as the power increases. In the case of production from wastes, the cost of the purified biogas is less than 7 €/kWh; but it is difficult to estimate cost variations according to power.



The cost of producing biogas that is purified, odorized, checked, and metered varies with the substrates used and the capacity of the production facility. *The ranges plotted are only a visual representation of the major trends in the variation of the costs of purified biogas according to the substrate used. They are not the actual boundaries.*

In France, the price of NGV at the pump is approximately € 0.89 /L equivalent diesel, in other words approximately 8 €/kWh. **It is difficult to define a critical size** for biogas production facilities: the price at the pump includes any taxes on this fuel, which differ from country to country. It also includes the cost of infrastructure to convey the fuel from the production site to the customer's fuel tank.

However, producing biomethane vehicle fuel from wastes is expected to be more profitable than from energy crops. Without any fee for liquid manure, biomethane production projects relying on this resource should also include wastes to make these projects more profitable. Only a case-by-case study can determine the profitability of a biomethane vehicle fuel production project.

Focus on biomethane as a fuel and biomethane injection

Only data on biomethane produced from the biological process (bio-methanisation) will be presented in this paragraph : so far no production unit of biomethane from gasification is operational so that no data is available.

Biomethane injection

Regulatory framework and incentives:

Biomethane injection into the natural gas grid allows a **decentralized use of biogas**. It is particularly useful when heat produced from biogas cannot be used on site. To be injected into the natural gas grid, biomethane should not present any additional risk (compared to natural gas):

- From a sanitary point of view (health of the consumers, health of the operators...)
- From a technical point of view (integrity of the grids, corrosion problems).

When it does exist, the regulatory framework of the country usually states which kinds biogas can be injected, and what are the conditions of the injection. Then grid operators publish their technical specifications about biomethane quality.

In Europe, two directives should be mentioned concerning biomethane injection into the natural gas grid:

- **Directive 2009/28/CE of April 23rd, 2009:** in this directive, the aim of **20 % of renewable energy in the total consumption by 2020 is stated. In the transport sector, renewable energy should represent 10 % of the total consumption.** In particular, it is stated that wastes should contribute twice than the other biofuels to this aim of 10 % of renewable energy in the transport sector. In addition, it is stated that access to the grid for electricity and gas from renewable sources must be facilitated.
- **Directive gas 2009/73/CE of July 13th 2009:** this directive asks the member states **to take any necessary measure to support the use of biogas and provide non-discriminatory access to the gas network** to any non-conventional gas (when it is possible regarding security and technical rules).

In addition, European Commission gave a mandate to CEN (European Committee for Standardization) for the **development of standards for the use of biomethane**. This work is lead in TC234 / WG9 for the injection of biomethane into the grid.

Finally, European countries have **different incentive politics regarding biomethane injection:** feed-in tariffs for biomethane, green certificates, subsidies, tax reduction or avoidance...

Biomethane injection: state of the art:

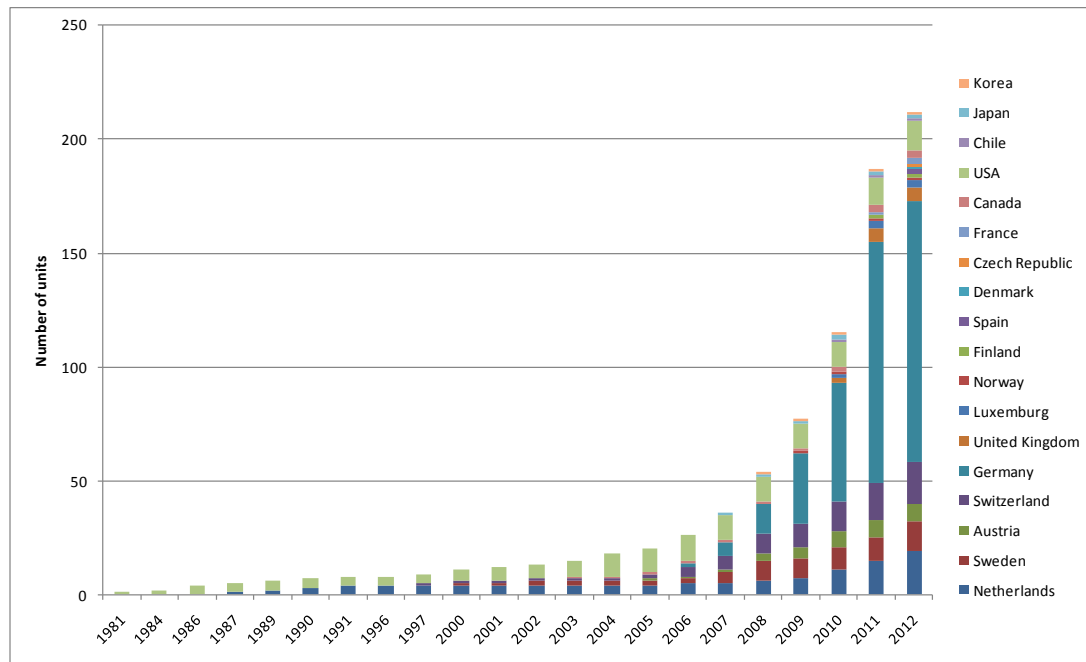
The Netherlands, Sweden and Switzerland are the European countries with the longest experience in the upgrade and feed-in of biogas: in the Netherlands like in the USA, biomethane has been injected into the natural gas grid since the 80s.

Since then, biomethane injection has appeared in other countries, and the number of units injecting biomethane into the grid has been steadily growing, especially in the last years.

Today, the following countries are injecting biomethane into the grids:

- In Europe: **Austria, Germany, Luxemburg, the Netherlands, Norway, Sweden, Switzerland, United Kingdom** (other countries like Spain, Finland, France... should be injecting soon);
- In other countries: **USA, Canada, Chile, Japan, Korea...**

Today, **Germany is leading in feed-in capacity** (with more than 30.000 Nm³/h) in comparison to all other European countries. This is partly related to the state of the infrastructure of the public gas networks in the different countries, but also to the fields of application best supported by the respective political structures. Thus, the German market has seen a significant growth in the last few years, with the first plants, however, having started operation only in 2006. Today about 50 installations are injecting biomethane into the grid in Germany, and this figure could double in 2011.



In the world, there are more than 110 installations which inject more than 40 000 Nm³/h of biomethane into the natural gas grid (above all in Europe). (Source GDF SUEZ/ CRIGEN; figures from www.biogaspartner.de and IEA Task 37)

Figures provided for 2011 and 2012 are prospective data on the basis of available data. **An important growth is expected for the next years, especially in Germany.**

Biomethane is usually injected into the distribution grid: pressures of the grids in which biomethane is injected are usually **below 16 bar** (even if in some cases the pressure can reach 40 or 70 bar). To our knowledge, there is no installation injecting into the national or international transmission grid (and therefore no injection of biomethane into natural gas storages).

Most of units injecting biomethane are **quite small installations: they usually inject flows under 1.000 Nm³/h**, or even 500 Nm³/h in most countries. Nevertheless, in Germany and in the Netherlands some bigger installations can be found.

In the future, when the thermal way of producing biomethane will be commercially available, **some bigger installations could inject biomethane into the grid.** In Sweden, Göteborg Energi is already planning to inject 100 MW of biomethane (produced from gasification) into the grid: a first unit of 20 MW should be operational in 2012. In addition, E.ON Sverige plans to produce 20 TWh of biomethane in 2020: 10 TWh by the biological way, and 10 TWh by the thermal way.

Biomethane as a fuel

Since the quality of biomethane is similar to that of natural gas, the incorporation of biomethane in NGV, in any proportions, is possible with no modification either of the vehicles running on natural gas or of the associated distribution infrastructure. **These two fuels are perfectly complementary, insofar as biomethane constitutes a renewable input to NGV, but it will be able to grow only if the NGV approach itself is well established.**

Investments in NGV (engine technology, larger number of stations) therefore contribute to the gradual development of biomethane vehicle fuel.

While the biogas sector grows impressively every year, it hasn't received the same attention as for example liquid biofuels for transportation. The majority of people are not aware that natural gas powered vehicles have been available for a long time and that biomethane could play an important role in the transportation sector. So far only Sweden has established a market for biomethane-driven cars. Due to its relatively low prices for electricity, Sweden has traditionally used biogas for heat production (today around 50 % of biogas) and focused less on electricity (8 %). About 25 % of the produced biogas is upgraded and used as vehicle fuel (the rest is flared or used for other applications). The upgraded biogas is injected into the existing natural gas grid in 7 sites with an injection capacity of 220 GWh (replacing 2 % of the natural gas in the system). The injection capacity is planned to increase to 1.6 TWh (10-15 % renewable in the natural gas system) within 5 years.

	Stand alone plant	Cooperation of 3 biogas plants 5 km gas grid network for each plant	Cooperation of 6 biogas plants 10 km gas grid network for each plant
Biogas plant	2,0	2,0	2,0
Gasgrid network	0,2	1,0	2,0
Upgrading plant	0,7	0,5	0,4
Biomethane (CNG) filling station	0,5	0,4	0,3
Total investment costs M€ for a 1 Mio Nm ³ /year unit	3,4	3,9	4,7

Example of investment costs for biogas plants and upgrading for use as vehicle fuel (M€ per 1 Million Nm³/year per unit – equal to a plant with 500 kWe capacity)

Biomethane as vehicle fuel	
Advantages	Challenges
<ul style="list-style-type: none"> • The existing natural gas filling stations can be used for biomethane • Energetic efficiency relatively high • Injection into the natural gas grid after upgrading possible • High fuel equivalent output per hectare. The use of catch crops can further increase the output and decrease the competition for arable land • More and more gas-vehicles enter the market. Improved cruising range and comfort. • Favourable combustion properties (e.g. the emission of nitrogen oxides and reactive hydrocarbon can be reduced up to 80% compared to petrol and diesel) 	<ul style="list-style-type: none"> • Costly cleaning and upgrading of biogas • Legislative framework (e.g. subsidies for natural gas in some countries) • Initial cooperation with natural gas needed (in order to increase the market share of vehicles running on gas) • Methane slip (the upgrading technology that removes unwanted CO₂ sets free methane as well; latest technologies reduce the slip to less than 0,1%) • High conversion costs of existing vehicles • Low number of gas vehicles in Europe • Gaseous fuel reduces the cruising range compared to liquid fuels • Gas storage

Since biométhane must reach the natural gas quality, natural gas infrastructure for vehicles can be used for biométhane.

7.7.3 RENEWABLE NATURAL GAS (RNG) / BIOMETHANE IN THE USA

Ms. Karen Hamberg, Westport Innovations Inc., Canada

RNG / Biomethane Sources

Renewable natural gas (RNG) is pipeline quality gas that is fully interchangeable with fossil natural gas and can be used as a 100% substitute for, or blended with conventional gas streams for use in vehicle engines. RNG is also referred to as biomethane or Renewable Gas.

RNG is produced from a variety of biomass and/or biogas sources including landfill gas, solid waste, municipal wastewater and agricultural manure via purpose-built anaerobic digesters (AD).² It can also be produced from ligno-cellulosic sources such as forestry and agricultural waste through the process of thermal gasification (TG). The use of RNG leverages the existing network to distribute or deliver a renewable fuel within the natural gas energy market and enhances the diversity of the transportation energy mix.

RNG / Biomethane Emissions Reduction

Compared to diesel, gasoline, fossil natural gas and liquid biofuels, RNG can offer significant greenhouse gas reductions. There is the potential for emission reductions upstream or tank-to-wheels (TTW) from the capture of methane emissions from landfills or dairies and well-to-tank (WTT) via the use of RNG as a petroleum substitute or in blended mixtures with fossil natural gas.³ The greenhouse gas benefits of RNG derived from landfill gas, dairy digester biogas and manure have been well-documented.⁴ For example, RNG from landfill gas liquefied into LNG for heavy duty transport applications has a WTW GHG savings of approximately 72-97% compared to diesel fuel pathways. In a 2009 report, the California Air Resources Board (CARB) determined that renewable natural gas is the lowest carbon transportation fuel currently available. The feedstock capacity available for the production of RNG and the percentage of RNG that can be directed to transportation will drive greenhouse gas emission reductions in the sector.

RNG / Biomethane Potential

The Gas Technology Institute's (GTI) 2011 report for the American Gas Foundation "*The Potential for Renewable Gas*" estimated the total potential impact of RNG in terms of production of energy, capital investment required, on-going operating costs and the reduction of greenhouse gases. The GTI study outlined a range of national economic, environmental and energy security benefits associated with the production and use of RNG and quantified state-by-state biomass resource availability suitable for the processes of anaerobic digestion or thermal gasification. The assessment was based on four components including annual resource availability, annual energy production from those resources, greenhouse gas reduction potential and economic impact. Three scenarios: Non-Aggressive, Aggressive and Maximum were selected for examination.

² Once biogas is purified to RNG, it can be injected to the natural gas grid and distributed via established infrastructure for use in transport applications if fuel quality specifications are met.

³ The GHG emissions reduction benefit is dependent on the feedstock and is not inherent in the fuel itself.

⁴ Argonne National Labs has published models derived from GREET for CNG and LNG from landfill gas for a range of cases including different electricity sources, on-site compression or liquefaction, and off-site compression or liquefaction. CARB has carbon intensities for CNG and LNG from landfill gas and dairy digester biogas with differing cases of liquefaction efficiency.

- **Non-Aggressive** – This scenario represents a low level of feedstock utilization that range from 15% – 25% for AD and 5% – 10% for TG. It assumes that approximately 5% – 25% of the biomass is processed into RNG. The total RNG production is 0.97 quadrillion BTU (quads) per year.
- **Aggressive** – This scenario has higher levels of feedstock utilization that range from 40% – 75% for AD and 15% – 25% for TG. It assumes that approximately 15% – 75% of the biomass is processed into RNG and represents a concerted national effort to employ this resource. The total RNG production is 2.48 quads per year.
- **Maximum** – This scenario assumes 100% biomass utilization and conventional conversion efficiency. The scenario is not realistically attainable but provides a theoretical upper limit for RNG production. The total RNG production is 9.5 quads per year.

Under the two practical long term scenarios that were considered for the GTI study, the market potential of RNG ranges from 1.0 to 2.5 quads per year. Depending on the end use, the production of RNG could result in the annual reduction of 146 million metric tons of carbon dioxide or the equivalent of taking 29 million cars off the road.

RNG / Biomethane End-uses

The GTI report does not recommend an end-use pathway for RNG resources but notes that it is a supply source for current industrial, residential, commercial and transportation users of natural gas.

The technology barriers for RNG in transportation are modest compared to other alternative or renewable fuels as it makes use of identical natural gas engines, pipeline infrastructure, liquefaction and compression technology, fueling stations and storage as conventional natural gas. Legislative and regulatory support for renewable fuels is critical in realizing scale production for these resources. Prudent and well-conceived policy changes can expand the use of RNG across the country.⁵

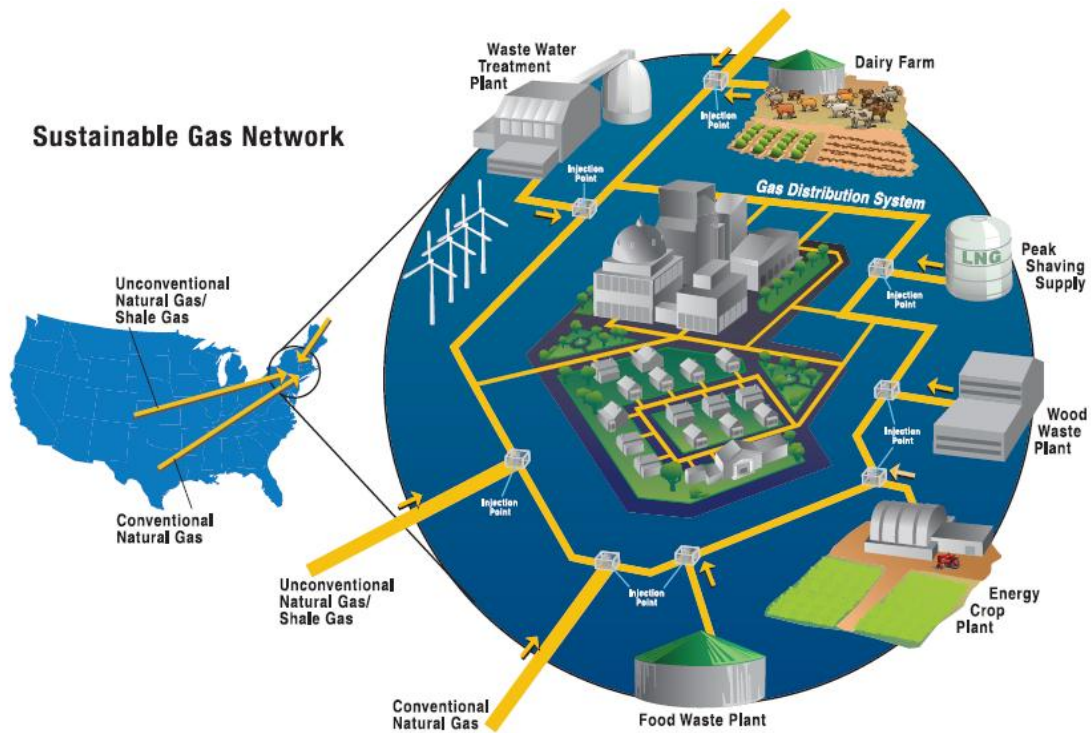
Vision for a Sustainable Gas Network

The ability to imagine the future and work back to the present to make policies that pave the road forward is a vital part of the process. The figure below depicts a vision for renewable gas that includes a natural gas network supplied by conventional sources as well as unconventional sources such as shale gas.

The recent discoveries of shale gas have significantly changed the U.S. energy outlook, and shale gas will play an increasing role in domestic supply as associated gas quality and delivery infrastructure issues are addressed.

The vision also includes utilizing liquefied natural gas (LNG) for peak shaving (Storage utilized during peak demand) or incremental supply as well as baseload integration of LNG imports. The future natural gas network will also carry renewable gas from dairy farms, waste water treatment plants, landfills, wood waste and food waste plants.

⁵ GTI recommends that these policy changes incorporate the principles of parity and accessibility/integration. Parity refers to RNG being valued and incentivized similarly to renewable electricity or liquid transportation fuel and accessibility/integration to pipelines enables the purchase and transfer of RNG through pipeline infrastructure.



National Grid's Vision for a Sustainable Gas Network
(Source: National Grid)

7.9 RFID SAFETY SYSTEM

Patent Pending

Ian Patterson, Viridis Technologies Inc., Canada

Introduction:

NGV or CNG vehicles are as safe as any other vehicles (gasoline, Diesel, LPG, etc) operating on the roads. However, safety incidents sometimes occur where a CNG system, primarily storage cylinders, have failed. The results have been personal injury or even death and property damage. These incidents have a negative impact on the NGV industry. Such incidents with the CNG cylinders are considerably less frequent than those with LPG storage systems and less harmful. Incidents happen even though there are established internationally recognized safety standards (For example ISO 19078).

According to the ANGVA, the following are examples of the cause of safety incidents

- Lack of routine and required inspections
- Poor Installation
- Poor Maintenance
- Non-CNG cylinders
- Defects in CNG cylinders and components
- Over Pressure
- Fire
- Human Error

The safety challenge to prevent such incidents is to ensure that only vehicles that meet codes and have been inspected and certified as being safe are able to fuel. Experience in several countries has shown that reliance on station personnel to determine the safety worthiness of a vehicle is not a reliable solution. There have been many cases of vehicles with improper and/or illegal cylinders being fuelled by operators who are unaware that the vehicle should be fuelled.

The solution is to have a means of automatically controlling the fueling of vehicles. This process would involve:

- Reliable and secure means of identifying vehicles.
- Control of the fueling dispenser to limit fueling to only those vehicles that have been certified for fueling.

It is critical that the approval of cylinders be verified before fueling begins. To ensure traceability of all vehicles, cylinders and other components a centralized database is required.

RFID System Introduction:

The purpose of the radio frequency identification (RFID) system is to provide a reliable means of assuring safe fueling of CNG vehicles. Despite the presence of established standards for components, installations & inspection procedures, unapproved equipment and/or modifications to equipment occurs in the field. Current means of control are limited to fueling personnel making the decision to fuel a vehicle. In most cases, these people will not decline to fuel a vehicle.

Traceability of CNG vehicles, components & inspections is primarily paper documentation that may or may not be accurate. Identification plates on vehicles do not necessarily provide adequate traceability. Stakeholders, regulatory agencies, CNG retailers and other concerned parties do not have an assured means of monitoring conversions and inspections.

All data programmed on the tags is encrypted to prevent unauthorized duplication or to bypass the control of fueling transactions. This patent pending, encrypted technology enables the RFID system to operate without the station to be connected to the on line database.

The only communication interface required by the RFID System is used for:

- Daily downloading a vehicle list of vehicle that are not to be fueled.
- Completion of tag programming on first fueling of a vehicle.
- Daily uploading of transaction data.
- Uploading error/failed transaction data.

This document outlines the RFID system and how it addresses the problem.

The functions of the system are as follows:

- To limit fueling to vehicles that have been approved and authorized for fueling by regulatory agencies having authority.
- To provide a traceable database of approved and authorized vehicles for use by gas companies, regulatory agencies and other stakeholders.
- To verify that no additional cylinders or illegal cylinders are installed on a vehicle.
- To provide traceable fueling transaction data.

The RFID system is comprised of six major components:

- RFID Tag installed adjacent to the fueling receptacle on the vehicle.
- Cylinder Identification tags installed on each vehicle.
- RFID Tag programming unit.
- RFID Antenna & dispenser control system.
- RFID web server.
- Intelligent Cylinder Identification System that verifies total cylinder capacity and identifies individual cylinders.

RFID Tags:

The RFID Tags are a passive, low frequency tag that are designed to retain significant amounts of data & have unlimited read cycles. Tags can be programmed only once. Once affixed to a vehicle, the tag cannot be removed without destroying the tag.



RFID Tag (with CNG Bus Nozzle) RFID Tag with CNG Buss Receptacle



The data that can be programmed to a tag is determined by the regulatory body issuing the tag. Typical data would include:

- ID such as VIN.
- Vehicle license.
- Vehicle owner.
- Conversion Company ID.
- Inspection Company ID.
- Date of conversion/inspection.
- Expiry date.
- Price level (discount/surcharge)
- Credit account data

All tags contain specific data fields relating to each specific tag. These fields provide traceability on individual tags. This assures that only RFID tags can be programmed. These fields cannot be altered.

RFID Tag Programmer:

This is a unique device that is specifically designed to program vehicle tags and cylinder tags. Each system has a unique identifier that is used to validate the programming device before a tag is programmed. This assures that only qualified companies are able to program the RFID tags. The programmer connects to a standard PC via a USB port.

An application program is included with the programmer that allows a user to complete the necessary documentation off line. Once the application form is completed, the programmer is connected to the secure RFID website and all data is uploaded to the secure server. The final tag programming is completed the first time the vehicle fuels at a station.

RFID Website:

This is a secure website that utilizes web security similar to that provided for credit card transactions. Access to the website is limited to authorized companies who are programming RFID tags. CNG station network operators are also able to access the data base of their

customers, installers & inspection agencies. This allows for a means of monitoring installers, inspectors, etc.

Individual databases are maintained for each CNG station network operators and are not accessible by others. The network operators can define who is able to access their unique database.

Dispenser RFID Control System:

This system is the heart of the RFID system. It is available as an integrated unit on CNG dispensers and as a retrofit to existing dispensers.

The system is comprised of the following major components:

- RFID Antenna.
- Unique RFID CNG delivery hose.
- Dispenser RFID Control System
- Graphic display.
- Optional keypad.

The RFID antenna is located in the fueling nozzle. It was designed specifically to ensure accurate, reliable reading of vehicle RFID tags. The antenna is encapsulated to prevent damage from dirt, water, impact, etc. The antenna is intrinsically safe and has third party approval to IEC 60079-11 The antenna module available for NZS probes, NGV1 Type I & II & (NGV2 is CNG cylinders standard) nozzles.



Bus Nozzle Antenna NZS Antenna NGV1 Antenna

The dispenser module interprets the unique encrypted code on each vehicle RFID tag without the need to access a database.



Sample SSM Data Output

TDR # *	Termination Code	Hose Id	Start Time	Stop Time	Base PPU	Tag ID	No Of Cylinders	License Plate No	Cylinder Size	Vehicle Type
34	1	1	2009:10:13-14:27	2009:10:13-14:31	1201	220--4431538	2	AXF 980	32	2
35	1	1	2009:10:13-15:05	2009:10:13-19:28	1201	220--4431539	2	AXF 981	32	2
36	1	1	2009:10:13-16:15	2009:10:13-17:33	1201	220--4431540	2	AXF 982	32	2
37	1	1	2009:10:13-18:10	2009:10:13-22:03	1201	114-24	8	GJ1VV8384	1600	1
38	1	1	2009:10:13-25:16	2009:10:13-27:45	1201	114-25	8	GJ1VV8385	1600	1
39	1	1	2009:10:13-33:55	2009:10:13-35:51	1201	114-26	8	GJ1VV8386	1600	1

Tag Program Date	Tag Expiration Date	sale Kg Amount	Total Sale Amount	Start Total Mass Flow Meter	Stop Total Mass Flow Meter	Start Price Totalizer	Stop Price Totalizer	PPU
2009:02:13	2018:01:07	5.20	624.52	8,452.24	8,457.44	666.709.86	667.334.38	120.1
2009:02:13	2018:01:07	3.60	432.36	8,457.44	8,461.04	667.334.38	667.766.74	120.1
2009:02:13	2018:01:07	2.50	300.25	8,461.04	8,463.54	667.766.74	668.066.99	120.1
2009:01:31	2016:06:01	3.25	390.33	8,463.54	8,466.79	668.066.99	668.457.32	120.1
2009:01:31	2016:06:01	5.20	624.52	8,466.79	8,471.99	668.457.32	669.081.84	120.1
2009:01:31	2016:06:01	6.33	760.23	8,471.99	8,478.32	669.081.84	669.842.07	120.1

Intelligent Cylinder Verification:

There are two critical matters that are detected / monitored by the RFID Intelligent Cylinder Verification System:

- Additional unauthorized cylinders installed on a vehicle.
- Unauthorized cylinders installed on a vehicle (although the total cylinder capacity is the same as when the RFID tag was issued).

To determine if an additional cylinder is installed the RFID system installed on the dispenser performs the following checks:

- Reads the total authorized cylinder capacity that is programmed on the RFID tag.
- Verifies that all cylinders are within their approval dates.
- If any cylinder is past its inspection date, the vehicle will not be fueled.
- The system verifies the total cylinder capacity at the beginning of the fill. If the capacity is detected to be greater than the approved capacity the transaction is immediately terminated.
- The system continuously checks the total cylinder capacity throughout the fill. If the capacity is detected to be greater than the total approved capacity at any time throughout the fill, the transaction is immediately terminated. This prevents someone from opening a valve to an unauthorized cylinder during the fill.

To determine if an unauthorized cylinder has been installed, the dispenser system performs the following verifications: (NOTE: The features of the total cylinder capacity system above are combined with the following features)

- Each cylinder is equipped with a patent pending Cylinder Identification Tag or “CIT”.
- The vehicle has an “Intelligent Tag” or “IT” that interfaces with each CID. NOTE: this IT is also patent pending.
- The dispenser reads the approved cylinder identification from the IT & compares this with the data from the CIT for each cylinder.

If any of the cylinder data does not match the approved data, the transaction is terminated immediately.

7.10 CASE STUDIES

7.10.1 LILLE AND THE FRENCH CASE

Olivier Bordelanne, GDF SUEZ, France

French situation

In France, the Grenelle II law sets the principle of a new feed-in tariff, more attractive, which should encourage investors and boost the biogas market. In fact, a series of incentives are currently under discussion to define the framework for biomethane injection opportunities: the implementation of a clearing fund, a system to guarantee the green origin of biomethane, technical specifications to inject it into the grid and specific feed-in tariff.

France’s biogas potential is hardly tapped. Most of the energy produced (526.2 ktoe in 2009) comes from biogas trapped directly in non-hazardous waste repositories (84% of the total) and for the most part, this deposit is still under-exploited. There are 300 landfills in France, 200 of which trap biogas but only 65 of them convert it. In 2009, there were also 74 urban wastewater plants and 90 effluent treatment stations that digested sludge primarily to produce heat and a little of electricity. Farm installations are also under-represented. So in 2009, biogas electricity output production was only 846.4 GWh, which is a fraction of German or UK output. The first biomethane injection into the grid is expected in France for the beginning of 2011, whereas biomethane injection is practised in the Netherlands since 20 years and is now even ready to feed the regional grid. Sweden is also particularly active in this field with more than 40 enrichments plants at the end of 2009 but only 7 of them are already feeding biomethane into the grid (19 Mm³/year).

Energy and environmental context

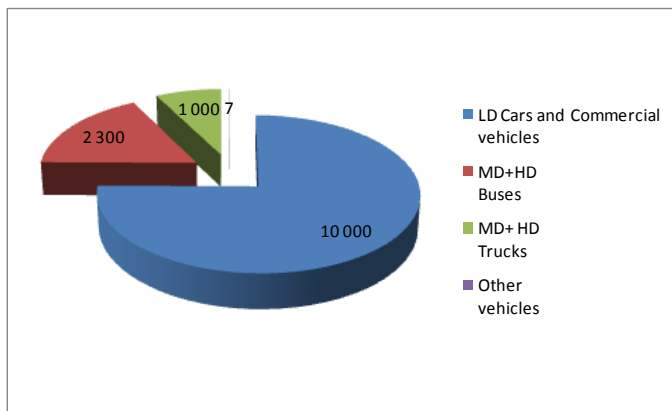
As its European neighbours, France is strongly dependent on fossil energies and started at the beginning of the eighties a program aiming at developing alternative energies. However, the development of a nuclear park and the monopolistic position of the historical energy operators slowed down the commercial rise of these alternative energies. The fiscal policy of fuels was and still remains an important barrier to the commercial development of substitutes to gasoline and diesel fuels, strictly limiting their uses to captive fleets.

In this context, the use of biogas as fuel was considered for a long time with no future. But since these very last years, with the strong increase in the oil prices and the rise of concerns relating to the climate warming, a new interest has appeared for it.

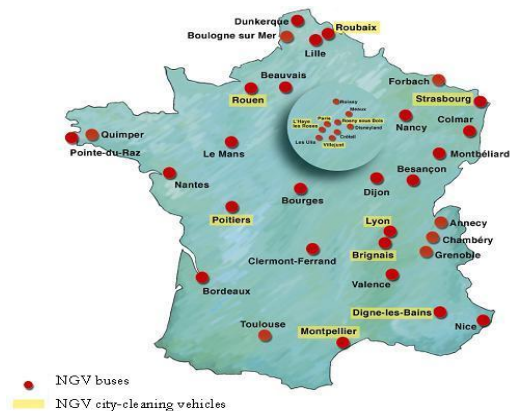
Development of NGV in France

The French position regarding NGV is far behind Italy, Sweden and Switzerland in terms of fleet and development of the infrastructures of distribution.

In 2010, there are 13.307 NGVs: 2.300 buses, and 1000 garbage trucks and approximately 10.000 light vehicles, for the majority belonging to local government agencies or companies



NGV vehicles in France



French cities with NGV buses or city-cleaning vehicles

About 125 refuelling stations can feed natural gas vehicles:

- 110 are private stations
- 15 are public stations
- 85% of these stations are located in urban areas where the natural gas grid exists. In this case, a simple joining ensures the supply of the station. Some highways and isolated stations need a specific joining.

In 2009, 18 stations were under construction.

French site: Lille

Lille situation

Lille Métropole Communauté Urbaine (LMCU) is a local authority with nearly 1.1 million inhabitants and the 4th largest conurbation in France. LMCU is primarily responsible for structuring the conurbation and harmonising the metropolitan territory through the organisation of networks and public services, as part of its global strategy of sustainable development. It has a strategy of integrating three key fields of responsibility: public transport, waste management and sewage treatment services.

The Marquette Pilot Plant producing biogas from sewage sludge was constructed in 1995. One part of the biogas was upgraded to fuel for the first 8 gas/biogas-powered buses in Europe, with the support of the THERMIE project (1993-1995). With an adopted policy since 1992 to implement an integrated scheme for urban waste collection & treatment, the gradual replacement of diesel buses with (bio)gas fuelled vehicles and the decision to massively expand its biogas production potential from sewage sludge, LMCU committed to being a key contributor to market expansion of biogas vehicle fuel.

Grid injection

The physicochemical characteristics of the biogas required for a grid injection are described by GDF SUEZ retailing prescriptions: "Prescriptions techniques du distributeur GrDF prises en application du décret n° 2004-555 du 15 juin 2004"

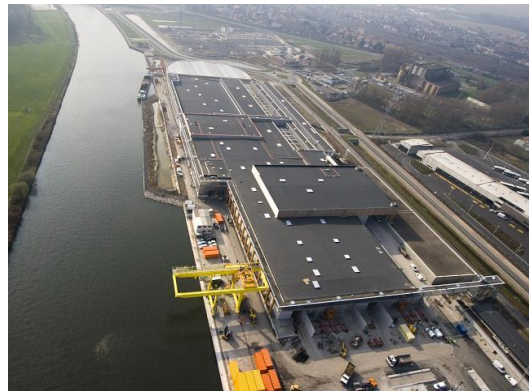
Physicochemical characteristics of the biogas required for a grid injection (source GrDF)

Characteristics	Specification
Upper calorific value (combustion conditions at 0°C and 1.01325 bar)	H-type gas (Gas with high calorific value): 10.7 to 12.8 kWh/Nm ³ B-type gas (Gas with low calorific value (as the biogas)) : 9.5 to 10.5 kWh/Nm ³
Wobbe Index (combustion conditions at 0°C and 1.01325 bar)	H-type gas: 13.64 to 15.70 kWh/Nm ³ (combustion at 25°C: 13.6 to 15.66) B-type gas: 12.01 to 13.06 kWh/Nm ³ (combustion at 25°C: 11.97 to 13.03)
Density	Between 0.555 and 0.70
Water dew point	Lower than -5°C at maximum pressure of the grid downstream from the connection (EN ISO 18453)
Hydrocarbons dew point	Lower than -2°C from 1 to 70 bar
Sulphur total content	Lower than 30 mgS/Nm ³
Mercaptan sulphur content	Lower than 6 mgS/Nm ³
Sulphur content from H ₂ S + COS	Lower than 5 mgS/Nm ³
CO ₂ content	Lower than 2.5 % (molar)
THT content	Between 15 and 40 mg/Nm ³
O ₂ level	Lower than 100 ppmv
Impurities	Gas that can be transported, stored or sold without being subjected to additional treatment
Hg	Lower than 1 µg/Nm ³
Cl	Lower than 1 mg/Nm ³
F	Lower than 10 mg/Nm ³
H ₂	Lower than 6 %
NH ₃	Lower than 3 mg/Nm ³
CO	Lower than 2 %

(Source: http://www.grdf.fr/fileadmin/user_upload/pdf/Navigation_Institutionnelle/Prescriptions_techniques_du_distributeur.pdf, access on July 29th, 2010).

Technical description of Lille site

The bus depot belongs to the LMCU and is exploited by Transpole. It is located in front of the Organic Recovery Centre on the other side of the road. It has been in service since December 19th, 2005 and was installed by GNVert. The bus depot reached its maximum capacity at the beginning of February 2008 with 152 buses.



NGV vehicles in France

A biogas dedicated pipeline built under the road between the Organic Recovery Center and the bus depot allows a direct delivery of the biomethane to the refuelling station. This pipeline is not currently in operation and the buses are still filled with natural gas from the grid.



The road between the Organic Recovery Center and the bus depot over the dedicated pipeline

At the Organic Recovery Centre, a grid injection post has been built but LMCU has not yet the possibility to inject the biomethane waiting for the authorisation of the French Administration that will rely on the result of the Working group on grid injection. Initiated end-2008 by both the Agriculture and Sustainable Development Ministries, this National Working Group on Grid injection identified the ways of supporting biomethane production and grid injection. Together with other partners involved in energy and waste issues (Amorce, Solagro, Atee-Club biogas), LMCU made proposals regarding recommendations on technical and economic aspects (feed-in tariffs systems....). Once the principle for purchase obligation was integrated into the Grenelle 2 law in May 2010, feed-in tariffs should be published early-2011, which will set up conditions for biomethane expansion in France.

Before that, a sanitary study has been led by the French Agency for Environmental and Occupational Health Safety (AFSSET), a public body reporting to the French Ministers for ecology, health and employment. The AFSSET study was published end of October 2008. The AFSSET Opinions and Recommendations concerning the biomethane injection into the French grid are the following : «Given the available data and the collective expertise conclusions, the AFSSET considers that injection into gas grid of some types of upgraded biogas doesn't seem to present any kind of additional sanitary risk for users before and after combustion, in comparison with the natural gas currently supplied. The concerned biogas are :

- upgraded biogas from domestic waste produced in storage plant of non hazardous waste.
- upgraded biogas from methanization of non hazardous waste in digesting installations:

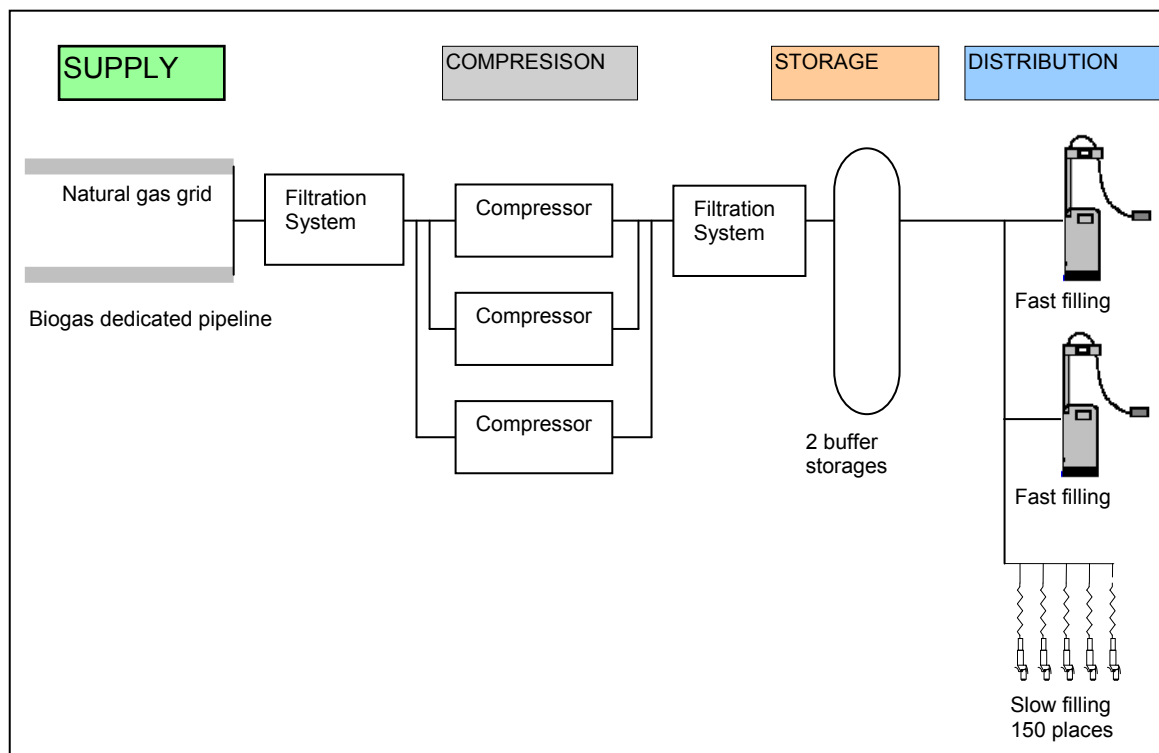
- inlet sorted biowaste or domestic waste;
- agricultural organic waste (breeding effluents and green waste), waste from the collective catering and fermentescible organic waste from the food-processing industry.

Nevertheless, the collective expertise doesn't allow to conclude on biogas from sludge of sewage treatment services and industrial waste different from the food-processing industry fermentescible organic waste.»



The Organic Recovery Center injection post

The following scheme represents the refuelling station of the bus depot.

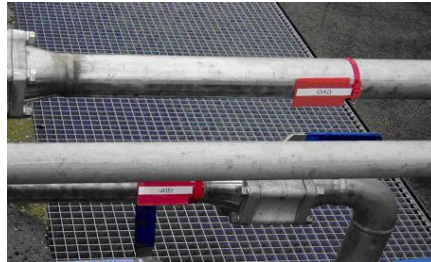


Scheme of the Lille bus depot refuelling station source (GDF SUEZ)

The Supply

The buses are filled with natural gas from the grid. The dedicated pipeline is not yet in operation.

In the picture below, the upper pipe marked “CVO” is the one from the biogas plant and the lower pipe marked “GDF” is the one from the natural gas grid. The third pipe is an input pipe with natural gas for the compressor to avoid gas hammering.



Station supply: gas grid and dedicated pipeline from the biogas plant (not yet in use)

The compression installation

There are 3 SAFE (Italy) compressors with a maximum flow of 1.500 m³/h. There are two distinct arrivals: one for natural gas and another one for the CVO biogas that passes by a dedicated drain. The natural gas is dried and vacuum-cleaned. Then the two gases are compressed up to 220 bar. The inlet pressure is 20 bar, the pressure of the gas grid. The compressors were designed to receive pressures ranging between 9 and 20 bar. Fire and gases detectors are also installed in the compressor unit. The installation has a power consumption of 75 MWh per month and has a contract of 200 MW per day with GDF SUEZ for the gas supply. The maintenance of the compressors is realised by Cofathec.



SAFE compressor of the Lille Bus depot

The storage installation

There is no biogas storage in the bus depot because the gas comes from pipeline (natural grid and dedicated pipeline in the future). But there are 2 buffer storages downstream from the compressor for the fast filling.

The distribution installation

The filling of the buses is conducted during the night and it takes a maximum of 5 hours. There are 150 filling stands for the buses and 2 fast dispensers (one for the light vehicles and one for the heavy vehicles).

The buses are driven to the filling stands by inspection agents and not by the bus drivers. The morning, the buses are not started by the drivers but by a dedicated team which starts the buses 10 minutes before the bus departure in order to preheat the buses and to prolong their lifespan.



NGV Bus in the Lille Bus depot

Economic data

The Organic Recovery Centre represents a total investment of 75 millions of euros. The investment for the bus depot is 8 millions of euros. The compressed gas represents 0.35 €/Nm³, including investment of compression unit.

Refuelling station investments in Lille

Parameters	Cost (€ Tax Free)
Engineering costs	33.560
Construction costs	156.000
Equipment costs	1.590.000
Installation costs (connection to gas grid and delivery device)	11.600
Global investment costs	1.791.160
Operation costs/year	
Employees	32.500
Energy consumables	
Planned maintenance costs/year	
Employees	90.000
Spare parts and consumables	

Details of the investments costs

Budget item	Investment costs (k€ tax free)	Observations
High Pressure compressor 250 bars	990	3 compressors (700 to 1.500 m ³ /h)
Refuelling station (distribution item + compressor)	600	2 fast dispensers + 150 filling places

Biomethane financial issues

The choice of biomethane production with the raw biogas generated by the new Organic Recovery Centre was based on the comparison: electricity generation vs. fuel production. In France in 2004, renewable electricity generation was not well supported by the French Authorities (compared to Germany for example). It changed in 2006 when the tariff of repurchase has been increased.

For the Organic Recovery Centre biomethane will be sold on the natural gas price basis (0.025 €/kWh). This income can reduce the treatment cost by 8 to 9 €/ton (treatment cost = 60 to 70 €/ton).

Environmental advantages of the project

The digestion process enables an energetic recovery (vs. composting) and therefore an income (8.5 € / ton) based on the same price as the natural gas (0.025 €/kWh currently). Biomethane does not contribute to green house effect.

With biomethane as fuel for the buses, 4 million liters of diesel are saved per year.

The bus depot is connected to the Organic Recovery Centre by a dedicated pipeline, which avoids road transport, and so reduces green house gas emission.

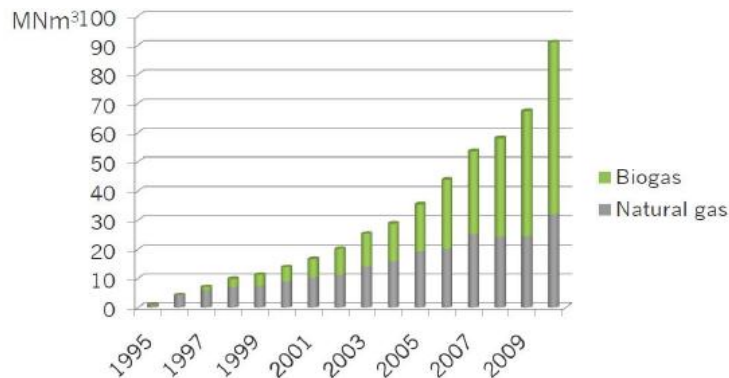
7.10.2 FIRST PUBLIC LCMG FILLING STATION IN SWEDEN.
NGVA EUROPE CASE STUDY

Background

The infrastructure of compressed methane gas in Sweden is well developed from an international perspective. The main supply comes from biogas supported by grid distributed natural gas through the western coast of the country. There are also a few LNG back-up systems for filling stations using biogas as the main fuel source.



The volumes of biogas and natural gas sold in the country have been growing at a fast rate since 1995, with a great contribution from the biogas. This increased market demand is due to the great possibilities to reduce both oil dependence and reduce CO2 emissions as well as local pollutants. The current situation in Sweden demonstrates the high potential.





The most important reasons for the development of LCMG infrastructure complementing the existing one are:

- Improvement of the economical distribution of biogas: liquefied gas will reduce the transportation costs and will permit the optimization of the location of filling stations for CMG;
- Creation of a new market for long haulage heavy transports: liquefied gas will permit longer vehicle ranges due to its higher energy density.



Liquefied to compressed methane gas is a new and effective way to use biogas or natural gas!

Technical specifications:

- Capacity of the stationary tank: 61 m³
- Required time for refueling the stationary tank: 1 hour
- Temperature inside the stationary tank: -150 °C
- Operational / Maximum pressure of the stationary tank: 6 / 10.5 bar
- Number of dispensers: 1 for LMG and 3 for CMG
- Dispensers capacity: 400 Nm³/h and 160 l/min for the liquefied gas
- System type: closed system with no release of methane to the atmosphere from the storage tank or during refueling
- Total cost of the station: 1.5 M € / 13 M SEK



Fuel supply

Sweden has today no domestic LNG nor LBG production plants. A LNG-terminal in Nynäshamn (eastern Sweden) is soon operating and will support the Stockholm area. However, Göteborg Energi, which is a part owner of FordonsGas Sverige AB, is now building a facility in Lidköping, 130 km away from the filling station. The Lidköping facility will supply the filling station with LBG as from 2011. The biogas will be produced mainly from food processing waste and the facility has been planned to deliver 60 GWh annually.



Location

Market base criteria for the location of the station has been:

- LMG refueling close to the truck operations local hubs
- Access to traditional truck-stop services
- Close to highway to support long haulage transit traffic
- Surfaces must be able to handle the the vehicles weight
- Close to existing CMG infrastructure for complementing both

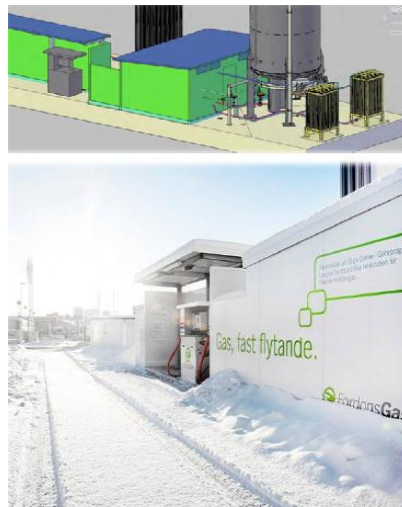
Based on the criteria of the different local and national authorities the location was finally done at “Stigs Center“, the largest fuel supplier in Sweden and a location close to all major forwarding companies. The location is just beside the E-6 motorway supporting transit routes between Malmö – Göteborg -Oslo/Stockholm.



Design and lay-out of the project

The design of the filling station has been done by the supplier of the equipment according to the criteria given by FordonsGas regarding capacity, etc. The layout of the filling station in terms of where the different components (storage tank, payment pillar, dispenser etc.) are placed has been done depending mainly on safety distances according to the existing regulations.

Experiences from the supplier together with the specific conditions at the facility and experiences from FordonsGas in the heavy duty CNG refueling business provided the final result as shown.



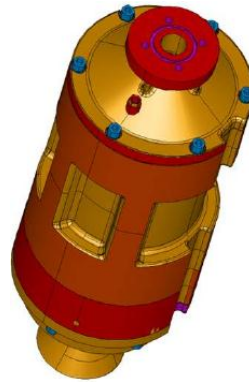
Selection of technology and supplier

To ensure the correct and exact functionality under all conditions the filling station is using a pump to deliver the LMG into the vehicle instead of using self storage pressure in order to avoid variances in filling times.

Price is naturally one of the most important criteria, but in order to also secure low life cycle costs other important criteria when choosing technology providers have been:

- Knowledge of both technical issues and market issues
- Reliability
- Environment
- Availability of spare parts
- Local representation and support.

Based on the total evaluation the technology provider chosen is Cryo AB in cooperation with Cryo Star.



General aspects. Working process

This project is not a standalone project, but a part of a totally new market for renewable fuel. To create an LNG/LBG facility both vehicle suppliers and customers must be involved. Therefore, FordonsGas Sverige AB took the initiative to invite Volvo Trucks and the other two main CMG-distributers for the development of a common project. The result was a project called BiMe Trucks and the purpose is to ensure that filling stations with liquefied gas are built to serve the launch of vehicles and to secure that vehicle technology and the refueling technology are compatible. Another important objective with the initiative is to work together to convince the market that LNG/LBG is a true market alternative to the diesel trucks.



Operating experiences

The station has, since opening 1st of October, delivered 242.000 kg methane to customers. Major part has been as CMG, since the number of LMG-vehicles is still low. The amount LMGtrucks is growing constantly and OEM serial production will start in Sweden mid 2011. Even if the amount of LNG-trucks is low, over 200 fillings have been made at the station until now.

The station will be supplied with LBG for the first time in June 2011.



Operating experiences

The station has a high reliability and there has been no unplanned operational standstills.

The station is constructed as a closed system, to avoid release of methane gas to the atmosphere. This system works as it should, and the station system has not released methane to the atmosphere, neither during the truck refueling process nor from the storage tank.



Operating experiences

Conclusions

The filling station was planned to be ready by the end of September 2010, and the opening ceremony was planned mid October 2010. Since the primary use of this station was to deliver LMG for heavy duty trucks, the time plan was adopted to follow the plan for launching test vehicles for LMG. The filling station and the vehicles had to be delivered at the same time. Since the technology is new and to a large extent unknown, a tight dialogue with all partners involved, suppliers, vehicle providers, branch organizations, authorities etc., has been the single most important key success factor.

The experience provided by this project clearly shows that it is an already known technology that has a high potential for further improvements. Standardization and development of user friendly and cost efficient solutions are obvious potential areas for improvement. The fact that this filling station is open for different vehicles and customers and should be operated by the drivers of the vehicles made it obvious that this project is a world first. Still, FordonsGas

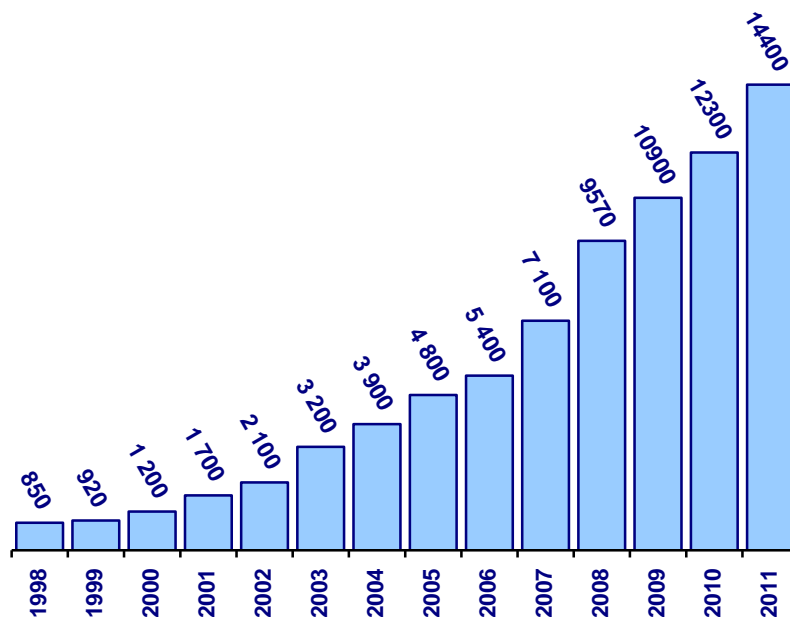
Sverige AB is convinced that public LNG/LBG stations for heavy duty trucks are the next big step forward. Therefore, we believe to have chosen the final solution for the filling station that will be a benchmark for further development of LMG infrastructure and a turning point when gas technology providers started to listen to end customer input.

8. NATURAL GAS VEHICLE MARKET IN 2010 – 2020: DEVELOPMENT TRENDS

Eugene Pronin, Davor Matic, Manuel Lage

While years of 2000 – 2010 were the morning of the global natural gas vehicle (NGV) market, the second decade of the XXI century is doomed to become the years of its maturity. 14 million vehicles powered by methane-based transportation fuels – natural gas and biomethane – are now on the roads in 80 + countries, both gas exporting and importing. Average annual growth of the world natural gas vehicles (NGV) population in 2001 – 2010 was a fantastic 25%. Naturally this can not last forever, and if one sticks to realistic numbers of 14% – 16% of annual growth, the world NGV fleet will expand by 2020 to 42 – 50 million units, which is actually the target proposed by the International Gas Union (IGU) Working Committee 5 Study Group 5.3 “Natural gas vehicles” (IGU WOC 5 S.G 5.3).

So far, the forecast, made by the international NGV experts team three years ago, comes true. Only during the past triennium (2009 - 2012) the number of NGVs worldwide grew impressive 21%.



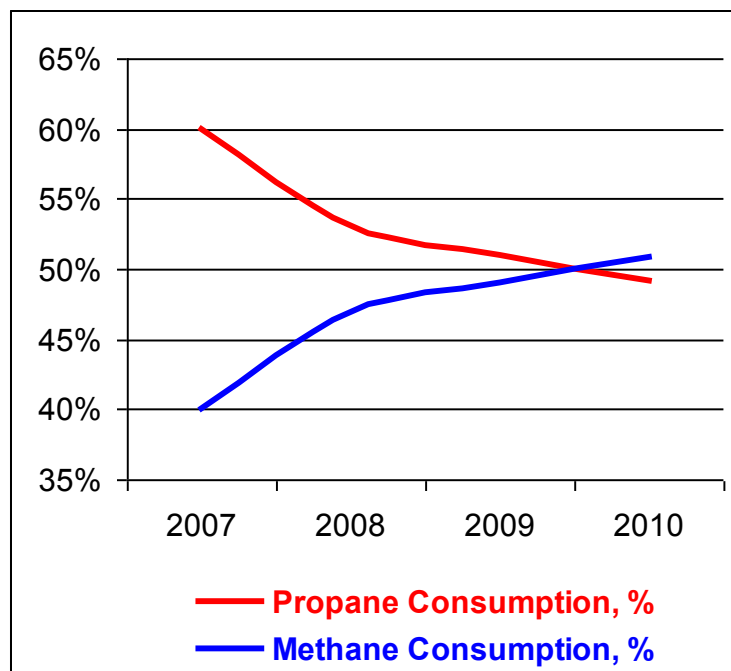
World NGV population growth, NGVs * 1000

Synergy of Natural Gas and Other Fuel Alternatives

- Traditionally LPG dominated in the sector of gaseous alternatives to diesel and gasoline. Analysis of data provided for in the Petroleum Economist, World LPG Association, IGU, GVR, NGVRUS and other sources shows that only four years ago LPG accounted for 60% of the oil fuel alternatives, whereas natural gas made up 40%. By the end of 2010 methane (regardless of its origin and/or state) became the equal alternative with 51% share

against 49% for LPG. In absolute numbers it means that consumption of LPG raised from 29.6 to 33.2 million oil equivalent tons, meanwhile demand for methane raised moved up from 19.9 to 34.3 million OET. The world fleet of LPG vehicles grew from 13.7 million vehicles in 2007 to 17 million in 2011, while during the same period population of NGVs raised from 7.1 to 14 million vehicles.

As for the world CNG/LNG filling infrastructure, the growth is also noticeable. In 2007 there were 12,2 thousand CNG filling stations. Since that time the number of methane stations rose to 20 thousand by the end of 2011. Statistics for LPG stations are controversial: although the world LPG fleet and consumption are growing, the World LPG Association counts only 40 thousand stations in 2010, which is 11,5 thousand less than in 2007.



CNG/LPG relationship in the gaseous fuel alternatives basket

- Methane will continue to serve as the pathway to alternative fuels in transport economy either as the feedstock for production of fuel (hydrogen) or by using natural gas system as the alternative energy carrier and storage (e-gas).
- In Japan, thirteen companies are planning the launch of fuel-cell vehicles (FCVs) in the Japanese market in 2015 and the development of the hydrogen supply infrastructure necessary for the successful adoption of the vehicles. Hydrogen fuel suppliers are aiming to construct approximately 100 hydrogen fuelling stations by 2015, based on the number of FCVs expected to initially enter the market. In the U.S hydrogen fuel cell/plug-in electric class 8 on-road truck (Tyrano Freightliner) was delivered in July 2011 and will be tested to evaluate their suitability for short distance cargo-hauling (“drayage”) and terminal operations. The truck, using a 536 HP engine draws its power from a battery kept recharged with H₂ fuel cell. India joined the International Partnership for the Hydrogen Economy (IPHE) as a founding member in 2003 and the project is underway for fuelling the buses with CNG and 15-20% hydrogen content. Production of hydrogen on-site through the reforming process of methane could be the feasible solution for such start-up project(s).
- Audi will begin series production of CNG models that will be powered by e-gas (synthetic methane created via the methanation of hydrogen produced by electrolysis with renewable electricity) starting in 2013.

- Methane will as well serve as fuel for production of electricity for fuelling the electric vehicles (EVs) through micro CHP (decentralized energy production). According to available data, in case the electrical vehicle is also charged by the micro-CHP (which serves primarily for satisfying 50-70 percent of electricity and all thermal needs (heat and hot water) of the accommodation) can be achieved significant primary energy savings (20 % from micro-CHP, 10 % from the electrical vehicle) and relieve of the electrical grid by supplying electricity to the electrical vehicle.

Strategic Trends – Non Technological

Regional overview of strategic trends; other than technology; which are expected to dominate the world NGV market in the coming decade is presented bellow.

- **In Northern America**, four factors promise to make natural gas a viable alternative to oil-based fuels (new supplies of shale gas, oil-supply vulnerability, environmental advantages and major advances in natural gas fuel technology) with a number of supportive policy measures introduced or announced in the U.S: NAT GAS Act; Memorandum requiring the Federal fleet to use alternative fuels; federal legislation of several states fostering development of natural gas fuelling stations on the main routes and replacement of diesel heavy-duty vehicles with natural gas oriented solutions; announced stricter CO₂ emission limitations for light and medium duty vehicles (which should add US\$950 to the cost of new vehicles in average). Major U.S fleet operators, natural gas producers and distributors and authorities (e.g. Department of Energy - DOE) are grouping together and forming alliances to advance the development and utilization of NGV and fuelling infrastructure in the North American market place. In Canada, the deployment roadmap report, sponsored by the government ministry, highlights the competitiveness and environmental benefits of introducing natural gas for trucking along key corridors and for urban fleets in Canada.
- **In Central and Southern America** governmental policies and support of major stakeholders (gas industry, service stations providers) is shaped through number of programs: financial support for conversions (Bolivia); required percentage (from OEMs and importers/distributors) of vehicles equipped with natural gas – petrol bi-fuel system (Venezuela); measures to promote natural gas Heavy-Duty public transportation vehicles (Argentina, Brazil).
- **Asia** will for sure continue to be the major NGV market driver. China plans to invest up to US\$1.5 trillion over five years in seven strategic sectors aiming at accelerating its transition from the world's supplier of cheap goods to a leading supplier of high-value technologies. Also, China is pledged to cut carbon emissions per unit of GDP by 2020 by 40-45 percent from 2005 levels. By 2020, car ownership in the country is expected to reach 140 million and around 200 million by 2030. In the car sector, the chosen technologies include also those using CNG, LNG, electric, hybrid, fuel cells, and LPG. Producers of NGV components from China are also expanding their market coverage overseas. In India, further development will be mainly linked with increase of the availability of natural gas within the country (gas network expansion). It is anticipated that by 2015-16, one fifth of cars in India will run on gas. Iran aims to become the world leader in terms of the highest number of CNG stations as well as in CNG consumption by 2015. Government is continuing its support to this segment and there is strong local production of NGV models and related components. The country is also moving towards being self-sufficient in production of CNG components not only to meet local demands, but also to be exported. In Pakistan the NGV share in total vehicle segment in mid-2010 was 80 percent of the total LDVs segment (cars, three-

wheelers, and other LDVs). It is about to see whether Pakistan will overcome the power (electricity), CNG supply and the decreasing petrol-CNG price gap issues. In early 2010, the government has re-activated the 8,000 CNG bus project in this country (with the support of the World Bank). Similar trend can be observed in Thailand where the Thai Ministry of Transport will push forward the 4,000 CNG buses leasing programme. Extensive NGV market development is present in Central Asia as well, governed by the state-owned gas corporation (Uzbekistan where officials estimate that 29 percent of total vehicle population in the country will be powered by natural gas by 2015) or with a wide range of stakeholders involved (NGV Road map for Kazakhstan with support of U.S DOE and involvement of a group of national and international stakeholders including EBRD and United Nations Development Program).

- **In Europe**, the EU has set out an ambitious strategy to reduce CO₂ emissions from road vehicles setting emission performance standards for new passenger cars requiring a fleet average emission of 130 g CO₂/km for new passenger cars to be fully achieved by 2015. This requirement could be achieved much sooner, however by increasing the proportion of natural gas vehicles which creates a significant opportunity for the methane (including bio-methane) use in transport sector. Methane is also part of the EU strategy for the future of transport outlined in the final draft of the report of the European Expert Group released on January 2011. Following the main recommendations from the Expert Group of Future Transport Fuels, the European Commission officially introduced the 5th FP7 call for 2011/2012 research, innovation and demonstration projects.
- One of the transport related calls is on the “Demonstration of heavy duty vehicles running with liquefied methane” to promote LNG Blue Corridors on medium and longer distances.

The overall objective is to perform large-scale demonstration in order to facilitate a broad market development for heavy duty trucks running with liquefied methane. The specific objectives for the project should be:

- To optimize the complete powertrain and storage system of LNG heavy duty vehicles with respect to energy efficiency and pollutant emission, by fully utilizing the technical potential of liquefied methane in an optimized fuel-engine system.
Implementation and management:
- The project should involve cooperation between heavy duty vehicles manufacturers, fuel suppliers, fuel distributors and fleet operators, including trucks and buses.
- The heavy duty vehicles demonstration should be carried out in at least three Member States, and should be complementary to existing demonstrations running at national level.
- The project should include a first definition of European LNG Blue Corridors, with strategic LNG refuelling points which would help to guarantee LNG availability for road transport in a simple and cost effective way.
- The demonstration part of the project should help to improve the knowledge and general awareness of LNG as alternative fuel for medium and long distance road transport.
- The project should also serve to remove the existing barriers for heavy duty vehicles running on LNG.

Expected impact:

- Oil substitution through the use of alternative fuels, namely liquefied methane (LNG).
- Reduction of GHG emission from transport using liquefied methane as fuel in heavy – duty vehicles.
- Market development for heavy duty vehicles running with liquefied methane.
- Increase of energy efficiency of heavy duty natural gas engines to the level of the current diesel heavy duty vehicle engines.
- Achievement of EURO VI standard for LNG heavy duty vehicles.

To be noted that the NGV development in Europe has been very uneven from country to country. Italy and Germany have a significant NGV running park, quite far are Sweden, Switzerland, Austria and Holland. Other countries like France, Spain and Greece are pushing the use of natural gas in their urban heavy vehicles fleets, reaching good volumes of gas used in transport without the heavy burden of a public nation-wide refilling network.

The new approach with LNG for medium and long distance heavy road transport, is going to be a pan European experience opening the way to the only real alternative to oil derived fuels in the road transport.

LNG development and availability is taking momentum in all the world. Western Europe has by now some 16 regasification terminals, but 52 other are under construction or planned. In the whole world the number of regasification terminals is 62, but more than 120 are being built or planned. Unconventional shale gas is converting the US from being importer to become exporter, necessarily through LNG.

- **Eastern Europe** will keep growing in terms of NGV market. The number of NGVs is growing and almost reached a noticeable level of 360 thousand units – a little less than one third of the European NGV fleet. Ukraine, Russia and Bulgaria lead the CNG market in the area. However new NGV countries will shortly emerge. NGV industry – OEM gas powered vehicles (trucks and buses), conversion kits, CNG cylinders, LNG equipment, CNG/LNG carriers - is well established in Eastern European countries and will develop further. CNG filling station packagers typically use compressors imported from Western Europe and Latin America. No strong government support to NGV market is offered in Eastern Europe so far.

- **Africa** is paving its way on the global NGV map. So far, seven African countries with gas fields in their territories have conducted demonstration projects and adopted NGVs and CNG stations. Further development is supported by Governmental policies and support such as replacement of older vehicles with new environmentally friendly units (Egypt); national program of promotion and development of NGV with the participation of national companies (Algeria) and fuel switch in transport sector in order to utilize domestic natural gas and reduce oil (products) import (Mozambique, Tanzania, Nigeria).

The availability of not expensive conversion technologies from petrol to bi-fuel petrol/NG and also from diesel to dedicated NG, of course in emission levels less stringent than Euro 3, will allow low resource users to go in a much cleaner and alternative transport fuel, also reducing its oil dependence.

Strategic Trends - Technology

Heavy duty Vehicles

Major changes in the heavy duty sector will be most visible in the segment of urban transport. Communal vehicles (garbage trucks, street sweepers, vacuum vehicles), public transport (buses and taxis), utilities/services fleets (postal, gas, power, water, construction), and other will demonstrate environmental and economic advantages of methane-based fuels.

Municipal Buses

The volumes of diesel used on urban public transport and communal vehicles may be shrinking. One of the reasons for that is the ban on the use of diesel in municipalities. This has already happened in a number of countries (Bolivia, India, Spain, Japan). Similar intention has been expressed by Moscow authorities (Russia).

Chinese made buses with far lower price than European or American units are being very well received in some South American countries where exhaust emission limits are still Euro 3.

- In contrast to the above trend in a number of countries dual fuel technologies for heavy duty vehicles are becoming popular (Australia, Brazil, India, Sweden). Volvo has developed a new computer controlled engine that burns 30% of bio-mix diesel and 70% of methane.
- To gain more kilometre per filling heavy duty and super heavy duty buses and trucks are equipped with cryogenic liquefied natural gas and biomethane on-board storage systems. Cleaner emissions – even compared to CNG - are the bonus.
- The era of aftermarket conversion of municipal buses in Western and Central Europe is almost over now. It may still be witnessed in some municipalities in the Eastern and Southern Europe. But the numbers of converted or retrofitted buses is significantly smaller than five years ago.
- Methane (natural gas and biomethane) will remain premium commercial fuel alternative for municipal buses. Experimentation with compressed or liquefied hydrogen and its blends with methane will continue to be appealing and may achieve initial phase of commercialization. However, at this point of time only natural gas has unique combination of environmental and economic advantages.
- The share of alternative methane will slowly grow. Major alternatives to natural gas are biomethane, e-gas, coal-bed methane and shale gas. However, these fuels are definitely more expensive at the time and for that reason in foreseeable future natural gas will dominate the market of non-conventional transportation fuels.
- Hybrid, hydrogen fuel cell, and micro-turbine power trains are being investigated and over time may mature into economically viable solutions.
- According to Pace Global, USA purchase price differentials between natural gas vehicles and conventional gasoline or diesel fuelled vehicles will decrease due to both the increasingly mainstream presence of natural gas vehicles (volume production and competition amongst producers of such vehicles) as well as the need for progressively more complex and costly technological advances to petroleum-fuelled vehicles to make them compliant with more and more stringent emissions standards. NGVRUS believes that by the

end of this decade additional cost of gas bus will decrease from the current 15 – 30 thousand to estimated 5 – 10 thousand Euros per vehicle.

- Liquefied natural gas (liquefied bio-methane) will get further development in the heavy duty sector in general and bus segment in particular. Suburban and intercity LNG buses are coming to the front stage.

School Buses

- Natural gas is becoming a fuel of choice for school buses. In the United States only, according to the U.S. Department of Energy, currently, there are more than 2,500 CNG buses in school districts across the country. The shift from oil to natural gas is motivated by the urgent need to meet budget constraints (given the high prices for diesel and gasoline) and stricter emissions regulations for heavy vehicles. A natural gas-powered school bus can displace 5,300 litres of diesel fuel per year.

Trucks



Volvo Dual Fuel (Natural Gas - Diesel) Heavy Duty Truck, Sweden

- Today major producers and stakeholders are engaged in the development of natural gas Heavy-Duty engine technology (400+ horse power) either solely or through alliances (e.g. in the U.S: CAP & Navistar, International Trucks & Emission Solutions, Gas Technology Institute & Cummins Westport, American Power Group etc.) with natural gas Heavy-Duty models on offer or announced (e.g. in the U.S: Volvo Trucks, Freightliner Trucks, Foton, Mack Trucks, Peterbilt, Gilig Corporation, Kenworth Truck; in Asia, Hino, Isuzu, Tata, Shaanxi Auto; in Europe Volvo & CAP, Hardstaff & Optare).
- New solutions are underway also for utilization of CNG with HPDI engines for long distances (Australia, Japan).
- To be taken into account that a long distance truck in the European road uses as much as 30 to 50 tonnes of fuel per year, same with Diesel or LNG engine.

Light Duty Vehicles

- Major OEMs are present with CNG models in this segment and the increasing share of OEM models is expected in the mid-term future.
- In the U.S the QVM – Qualified Vehicle Modifiers will continue to cover a range of the models of cars and vans of all major producers (whose engines usually comes with hardened exhaust valves and valve seats for improved wear resistance and durability for gaseous fuel systems).
- New trends with OEM CNG models are expected to continue in the direction of downsizing and hybridization. To name a few examples. Volkswagen has launched its new Up! small car range, which will include a natural gas engine version and should be available on the market in 2012. This new car, available under VW, Seat and Skoda brands, will not offer any diesel engine version. To some extent it is following the way opened by Fiat with its small “500”, also offering a very efficient 2 cylinder, NG version. The basic bi-fuel engine (petrol/natural gas) has a combined fuel consumption of 3.2 kg/100 km (natural gas), equivalent to a CO₂ value of 86 g/km. As a BlueMotion Technology version the natural gas-powered version attains a low CO₂ value of 79 g/km. In Russia the Yo LPG or CNG/electric hybrid car may hit the road in mid-2012. The average fuel consumption is announced to be 3.5 liter/100 km.

The main lesson from these new small city cars is the non-written message: the best fuel in city is methane.

Off-Road Vehicles

- **Mine haul trucks.**

Super heavy duty mine hauling trucks (both dual fuel and dedicated CNG or LNG) were successfully demonstrated during past two decades in the United States of America, Ukraine and Russia. Synergy between gas powered tracks and locomotives at the same location, particularly in the open coal mines, look very attractive for efficient project investment. However, significant marketing phase will probably not be reached very soon.

- **Airport vehicles.**

Airports of big cities host big concentrations of surface vehicles in continuous operation. An exhaust emission study made in the Barajas airport in Madrid a few years ago, show that there are more than 2.000 surface vehicles in service in the inner area of the airfield, never leaving it. Most of them are diesel, with a heavy emission of PM and NO_x. The most polluting units being gensets for electric supply to the planes, because of its continuous operation and also because the different (more permissive) emission level required to this type of equipment.

Luggage tractors, ground power units, push back tractors, etc. are vehicles easily redesigned to run on CNG, and not depending on public fuelling network. The AVIA project carried out in Madrid, defining and prototype building of all types of vehicles with CNG was a success. These types of airport vehicles could be considered an urban fleet, to be refuelled in a single, specific point.

Unique blend of inherent environmental, economic, and technological advantages makes airports increasingly attractive business target for NGV technologies. These sites have very high concentration of heavy and light duty vehicles serving both inside (ground support

vehicles) and outside needs (bringing passengers and cargo/luggage in and out). A concentrated, emission and budget concerned, 24/7 guaranteed methane customer of CNG/LNG will tempt investment into both fleets and infrastructure. The combination of air and ground use of gaseous fuels will make the project even more efficient.

- **Inland waterways.**

The rivers Amstel (the Netherlands), Chao Phraya (Thailand), Dubai Creek (United Arab Emirates), Mississippi (USA), Moscow and Neva (Russia), Seine (France), Yangzi (China) have seen successful demonstration and commercial operation of different size and purpose river boats that use CNG or LNG (dedicated and dual-fuel) instead of diesel. Many of those pilot tests matured into sound commercial projects to be executed in the nearest future. The coming decade will witness a good rise of the natural gas boat fleet in many countries in the world. For European environment, for instance, it is time to develop a continental project European Blue Ring: to arrange for the movement of passengers and cargo boats/ships from the Baltic to the Black (and Caspian) Sea across Russia, then westwards (cross the Black Sea) to the Danube River, and then up North to the Baltic Sea again to link the circle. European rivers and channels may link many nations with methane inland waterways.



European Blue Ring for Methane boats and ships

- **Maritime.** Emission Control Areas (ECAs) that soon will be introduced in the Baltic and Northern seas (ECA Zone 1), North America (ECA Zone 2), the Mediterranean (ECA Zone 3) and Singapore (ECA Zone 4) will require ship owners to use cleaner marine fuels with low sulphur dioxide and particle content. The most attractive option is to use LNG. It might be expected that as many as 10% short-sea ships calling at ECAs will be running on LNG by 2015. Ice-breakers, cruise ships, ferries, military and coast guard ships, platform supply vessels and other watercraft will start consuming considerable amounts of LNG in the coming years. Denmark, Estonia, Finland, France, Germany, Great Britain, Latvia, Lithuania, Netherlands, Norway, Poland, Russia, and Sweden are already facing the challenge of rapid and investments consuming transition to LNG power: building new ships and developing bunkering infrastructure.

- **Rail Road.** In addition to current utilization of natural gas to power locomotives (U.S, Brazil) the new projects aim to demonstrate the technical, economic and environmental viability of LNG (Russia, Canada) and CNG (India) engine technology for locomotives (offering greenhouse gas reductions of up to 500 tonnes per year for each natural gas locomotive relative to diesel locomotives). The Russian-developed gas turbine-electric locomotive has set a new world record for a single prime mover by hauling 16,000 tonnes in 170 rail cars with record low emissions.



LNG Gas Turbine Locomotive, Russia

- **Snow Blowers.** Dual-fuel Snow-Blower initially for demonstration purposes is scheduled for delivery to Stockholm airport, Sweden. Natural gas snow cleaner is already in application in ski resorts and protected and sensitive natural areas in Austria.
- **Lawn mowers.** Now available the Dixie Chopper CNG/LNG Lawn Mower is aimed at reducing the US EPA estimate of 5% of total U.S emissions from home lawn-mowing.

Immediate Market Trends

World Energy Outlook 2011 by IEA labels coming years as the **Golden Age of Gas**. The global natural gas resource base is quoted to sustain current consumption for over 250 years. This will naturally apply to automotive use of methane along with industrial and domestic sectors.

- Composition of the global NGV fleet will slide from light duty vehicles (LDV) in the direction of more polluting and fuel- hungry heavy duty vehicles (HDV) with longer mileage: trucks, buses as well as different off-road applications.
- Environmental and budget efficiency will make national and municipal governments to buy more and more HDVs – municipal buses, garbage collection trucks, street sweepers and other vehicles – thus stimulating their production.
- The worldwide fleet of heavy duty (HD) natural gas vehicles will dramatically grow to become the biggest consumer of compressed/liquefied natural gas (CNG/LNG). By 2020 HD sector may reach annual methane consumption of 200 billion cubic meters (BCM).
- This will motivate vehicle manufacturers to market more and newer types of heavy duty vehicles.

- The growth of HD sector will inevitably trigger the rise of the small scale liquefied natural gas (LNG) market. Commercial use of LNG will aggressively spread into HD automotive, railroad and marine transportation. LNG for airplanes may technologically be available sometime around 2015 - 2017, although commercial phase will hardly begin till the end of this decade.

- Development of small scale LNG technologies and growing needs if filling capacities will activate further shift from pipeline-dependent filling stations towards off-grid sites. More traditional oil fuels stations will host natural gas filling capabilities.

- Small/mid scale LNG market will attract investment into the network of LNG hubs first in the Baltic, Mediterranean, Sea of Japan and later other national and international waters. These LNG hubs will supply both watercraft and on-road vehicles with clean and economic fuel.

- Growing demand for CNG/LNG for vehicles will be supported by unconventional gas reserves: shale gas, biomethane, coal bed methane, hydrogen and its bends and other. This will be one of the ways to reduce dependency on imported oil in the transport sector and secure new jobs.

- Intercity traffic will make international Blue Corridors, Green Highways, Gas Highways – whatever is the name – a reality. And not only for on-road vehicles: Blue Corridors will connect sea- and airports, railway terminals.

Immediate Imperatives

Without detracting the importance of other alternatives to oil-based transportation fuels, one may conclude that the only commercial – not political – option is methane. It is the viable fuel which at a time offers exclusive combination of environmental and economic benefits.

To achieve the modest goal of 50 million NGVs on the roads by 2020 it is necessary to:

- improve and harmonize national legislative/regulatory environment;
- expand incentives for investors;
- build up public awareness;
- secure leadership of gas industry in developing filling infrastructure;
- further develop NGV diversity;
- invite oil-fuel retailers to expand the range of products to sell CNG/LNG.

APPENDIX I:

GASHIGHWAY PROJECT

(The sole responsibility for the content of this material lies with the authors. It does not necessarily reflect the opinion of the European Communities. The European Commission is not responsible for any use that may be made of the information contained therein.)



NGVA Europe, together with another 12 partners, has been participating in the GasHighWay Project since May 2009. This project is co-financed by the European Commission under the Intelligent Energy – Europe, a part of the EU's Competitiveness and Innovation Framework Programme (CIP). The aim of the project is promoting the uptake of gaseous vehicle fuels, namely biomethane and CNG, and especially the realization of a comprehensive network of filling stations for these fuels spanning Europe from the north, Finland and Sweden, to the south, Italy – in other words: the GasHighWay.

The main objectives of the project are: increase of the general awareness of target groups in the use of natural gas vehicles (NGVs), increase the supply of NG/biomethane by boosting the investments in distribution systems for these alternative fuels and in biogas production and biogas upgrading to enhance NGVs demand.

In order to achieve these objectives, several activities have been done since the launch of the project:

- Dissemination activities to increase awareness among the target groups on the benefits and advantages of using biomethane and CNG as fuel for vehicles.

- The project website www.gashighway.net has been continually updated with all the material and information produced in the project, including the best practice case brochures, the first GasHighWay magazine, web-diaries etc. Additionally, the project's website and the project itself have been presented at several national and international exhibitions and conferences as well as several newspaper and magazine articles have been written.

- The map of filling stations and upgrading units has been prepared and is available online. The maps have been developed to become user-friendly, and it's possible to download them to GPS devices. These maps will be available at the NGVA Europe website at the end of the project.
- Different main actors interested in the infrastructure development at national and international level have been identified.

Some common barriers that represent obstacles to natural gas/biomethane refuelling infrastructures development were identified.

Barriers for NG development						
Country	Lack of actors (investors, companies, municipalities, technology producers)	General unawareness on methane and biomethane	Lack of legislation, incentives or bonus	Poor variety of NGVs models, high costs, limited space	High investment costs	Inadequate localization of refuelling infrastructure
<i>Italy</i>		X	X		X	X
<i>Estonia</i>	X	X	X			
<i>Poland</i>	X	X	X		X	
<i>Austria</i>	X	X	X	X		
<i>Germany</i>		X				X
<i>Finland</i>	X	X	X			
<i>Czech-Republic</i>		X		X	X	

In particular one of the main obstacles is represented by a general unawareness of customers towards methane and biomethane, regarding both the refuelling infrastructures and the payback of investments and the NG vehicles (fuel distance, inner space, safety). Among these barriers, the lack of investors, both municipalities and technology providers together with a lack of a long-term strategy of incentives and bonus represent the main problems for a complete development of NG refuelling infrastructure in Europe.

According to EU target for 2020 it is possible to identify the need of NG refueling infrastructures and to localize the optimal location for new openings.

The table below summarizes the hypothesis of increasing number of gas filling station in each country involved in the project and their possible localization.

Increasing number of gas filling station (target 2020)	
Italy	According to the expansion trend, in Italy it is estimated more than 100 new NG filling stations in the North, 50-100 in the Centre and less than 50 in the South of Italy. The new openings will be focus on motorways and city centres and will include bioCNG as a fuel
Estonia	The optimal number of CNG filling station in Estonia is estimated around 13 in 2020
Poland	For 2020, 20 new optimal locations have been identified: 9 of them should be constructed in the cities, suitably for companies (investors) and urban traffic; 11 of them on the highways and motorways.
Austria	By 2020 the numbers of filling stations were supposed to be 600 and the numbers of NGV to be more than 650.000.
Germany	The focus for new gas filling stations is mainly near the motorways, where about 150 new stations are planned. It is also planned to fill the “white spots” of the gas filling station map in the near future.
Finland	Based on the visions and operational environment it is estimated that in 2020 there could be about 200 gas filling station in Finland
Czech-Republic	There is a plan of private investor for creating more than 30 of filling stations within next 10 years.

AUSTRIA

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The European Union has set the target of at least 20 % of fuel consumption not being oil based by 2020. Half of these alternatives, i.e. 10 % of all fuel, are to be CNG. These EU targets provide the basis for the intensive filling station expansion plans of the Austrian gas industry. CNG is currently available at around 168 public and approximately 40 private filling stations in Austria.



In order to drive this development onward, the Austrian gas industry is consistently working on expanding the filling station network – the target is to have 200 public natural gas filling stations in operation by 2010. Nevertheless the whole area of Austria is already well covered in regard of CNG-filling stations. The future focus of the CNG-filling station operators – mainly regional gas suppliers – is put in the efficiency increase of the individual natural gas filling stations.

Statistics (number of methane/biomethane filling stations, distribution towards the national road network and localization, distance from the natural gas grid).

All 168 CNG filling stations are well distributed over Austria (Vienna: 19, Upper Austria: 33, Lower Austria: 29, Styria: 22, Tyrol: 20, Salzburg: 17, Vorarlberg: 12, Carinthia: 9 and Burgenland: 7) and are situated along the natural gas grid, as the natural gas grid is well developed in Austria. The stations are placed in large cities (> 50.00 inhabitants), along commuting or strategic national roads or traffic junctions. Just few of them (approximately 3 to 5) are on or nearby highways. The public CNG filling stations are mostly integrated into existing conventional filling station, where also petrol and diesel will be sold.

Generally virtually biomethane can be fuelled at each CNG-filling station, but biomethane will not offer at the moment – but the trend goes towards biomethane. Currently only one pure biomethane filling station (Margarethen am Moos) exists in Austria. The target of the Austrian gas industry is to offer a product with a rate of 20% biomethane and 80% natural gas.

Type of plant (number of methane pumps, technical characteristics, use of CNG or LNG, private or public use etc.). All CNG-filling stations consist of a compressor and tank unit, gas dryer systems, filling priority and sequential refuelling controls as well as filling systems. The dispenser are equipped with 1 or 2 hoses – using a standard "NGV1" connector – and with 1 or 2 mass flow meters for a non-simultaneous or also simultaneous vehicle refuelling on both sides of the dispenser. NGV1 is the standardized connector.

(Comment: Vehicles in Austria, Germany and Switzerland are fitted as standard with connectors of this type). All public filling stations are "fast-fill" fuel station with a filling time of 2 to 3 minutes per car. According to the VBV (container regulations), self filling of natural gas vehicles is fundamentally permitted in Austria.

In Austria only H-Gas quality are offered. H stands for high quality gas. The calorific value makes the difference; it is higher in H-Gas than in L (low)-Gas. For comparison: H-Gas has a calorific value of approx. 11.1 kWh/m³, L-Gas of approx. 9.5 kWh/m³. The price for CNG differs between 0.75 to 0.94 Euro/kg. Until today, LNG (Liquefied Natural Gas) as fuel is not a theme – there are some few pilot projects or field trials ongoing which are done by Salzburg AG in connection with a project called "Clean Heavy Duty".

Current status on legal conditions

National and regional laws, technical regulations

The design, production, installation and operation of NGV filling station is described in the regulation ÖVGW G97, Feb 2008 – published by the Austrian Association for Gas and Water – ÖVGW. This regulation will be currently reworked and the new edition will be issued by end of 2010. The natural gas quality as well as the quality for upgraded biogas (biomethane) is regulated in the quality standards ÖVGW G31 and G33.

Welfare benefits, incentives, support scheme for methane and biomethane filling stations development: The Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management launched a program called “klima:aktiv”. klima:aktiv is embedded in the Austrian federal climate strategy, consisting of a bundle of measures of regulation, taxes, and subsidies. In the four thematic clusters Building, Energy Efficiency, Mobility, and Renewable Energy, specific programmes are carried out by various programme managers of different institutions. These programmes follow a comprehensive and systematic approach in supporting the market introduction of climate-friendly technologies, services and activities.

One target of this program (“klima:aktiv – mobility”) is to reduce CO₂ emissions in the transport sector. One part of this program is focused on NGVs – where the purchase of NGVs will be supported – the financial support is up to 30 % of investment costs (additional costs to implement the CO₂ reduction measurement).

This program also includes a subventions for building CNG-filling stations (per pump Euro 10.000). The Austrian government and the individual provinces also wish to promote natural gas as fuel. Therefore since July 2008 the "NOVA-new" (NOVA means Normverbrauchsabgabe – duty payable on standard consumption) is supporting vehicles with minor CO₂ emission.

Furthermore mainly all gas suppliers are offering different incentives for the purchase of NGVs (free fuel or bonus).

Investment costs and barriers

Refuelling station investments and rate of profit

The investment cost for a public CNG-filling stations are between 220.000 to 380.000 Euros, depending on size, design and location of the plant. The CNG-filling station infrastructure was mainly built by gas suppliers whereas major gas suppliers had established co-operations for a common development of the market. The building up of the station will be supported by means of third party financing. To run a filling station profitable a turnover of 200.000 to 300.000 Nm³/year is needed – this means approximately 200 to 300 NGVs per station.

Main barriers (technical, economical, legislative) The more favourable NOVA for NGVs, defined in the “Ökologisierungsgesetz” supports NGVs with a bonus of up to 500 Euro and acts as a positive factor. The exemption from the mineral oil tax (Mineralölsteuer Möst) is itself positive, but has also got a negative aspect since there is no tax security, regarding the use of natural gas or biomethane as fuel, given in Austria until now.

A clear development of the general taxation for gas as a vehicle fuel is missing. Furthermore there are unclear legal framework conditions.

Following major roadblocks or weaknesses have been identified to boost the NGV/CNG market:

- Variety of NGV models
- Driving range of vehicles
- Effectiveness of engines
- Lack of know how (car dealer, end user)
- Awareness of customers (low advertisement of car sellers)
- European fuelling station network

Potential in methane/ biomethane filling station

Trends in technologies

The actual situation is that there are more than 340 biogas plants in operation in Austria. Manly of them are agricultural plants which are focused on production of electrical power (estimated performance: 90.1 MWel). Approximately 45 to 50 plants are in operation in Styria.

First plants for the production of biomethane and the feed-in to the natural gas grid are already established in Austria:

- Pucking / Upper Austria: 6 Nm³/h (Pilot project)
- Bruck a.d. Leitha / Lower Austria: 150 – 200 Nm³/h
- Eugendorf / Salzburg: 100 – 150 Nm³/h
- Leoben / Styria: 130-160 Nm³/h

The upgrading of biogas to biomethane shows an alternative way of using the energy content of the gas instead of the conventional way of generating electric power and heat. Upgraded biogas can be used as a fully-fledged natural gas substitute in all the natural gas applications like fuel for households and industry as well as propellant for the automotive sector (CNG-vehicles, compressed natural gas). Doing this, the already well established natural gas

infrastructure like pipelines and fuelling stations can be utilised to transport the produced gas to the consumers.

In upgrading plant the raw biogas will be upgraded to the required natural gas quality according to the quality standards ÖVGW G31/G33. Subsequently, this gas is injected to the natural gas grid at elevated pressure. Natural gas and biomethane have the same quality. Through CO₂ neutral biomethane natural gas as a fuel can be substituted.

The estimated amount of produced biogas lies between 265 to 414 mil. cubic meters per year in Austria. Taking the estimated amount of 414 mil. Nm³ per year with an average consumption of 1.200 Nm³ per vehicle and year approximately 345.000 vehicles can be served in Austria (one vehicle: 1.200 Nm³ = 15.000 km per year). This means that 2.350 vehicles with an average consumption of 1.200 Nm³ per year will actually use 2.820.000 Nm³. A number of 200.000 vehicles, which is the goal for 2020, would consume approximately 240 mil. Nm³.

Trends in legal and financial conditions (incentives, benefits, laws) As there will not make a differentiation between natural gas and biomethane filling stations the strategy for the expansion (filling saturation network, NGV) is the same. The only difference is, that for biomethane the reduction of CO₂ will be more highlighted. Therefore the subventions for purchase a natural gas vehicle and using biomethane as fuel are higher (e.g. klima:active program: Natural gas vehicle get a financial support of 500.- Euro and additional 500.- Euro by using a mixture of at least 40% biomethane and 60% natural gas).

Attitudes towards methane/biomethane filling station (stakeholders, customers, biogas producers, lawmakers etc.). Natural gas (biomethane) filling stations are well accepted. The association of customers is that the use of natural gas and as well as biomethane as fuel is environmental friendly and helps to reduce emissions.

Interviews with customers show following picture concerning the use of NGVs:
Positive aspects:

- Better environmental performance
- More quiet in operation
- Positive cost effects

Negative aspects:

- Weak fuelling station network
- Lower safety
- Higher investment costs
- Lower range/mileage
- Narrow range of car models
- Higher space volume needed for fuel tank

It was clearly visible that the lower operation costs – the cost for CNG – is mostly important for customers to decide for an NGV. The second important point was environmental aspects, whereas the future use of biomethane was a major aspect. Customers appreciate the introduction of biomethane at already existing CNG-filling stations although biomethane as product is not launched until today.

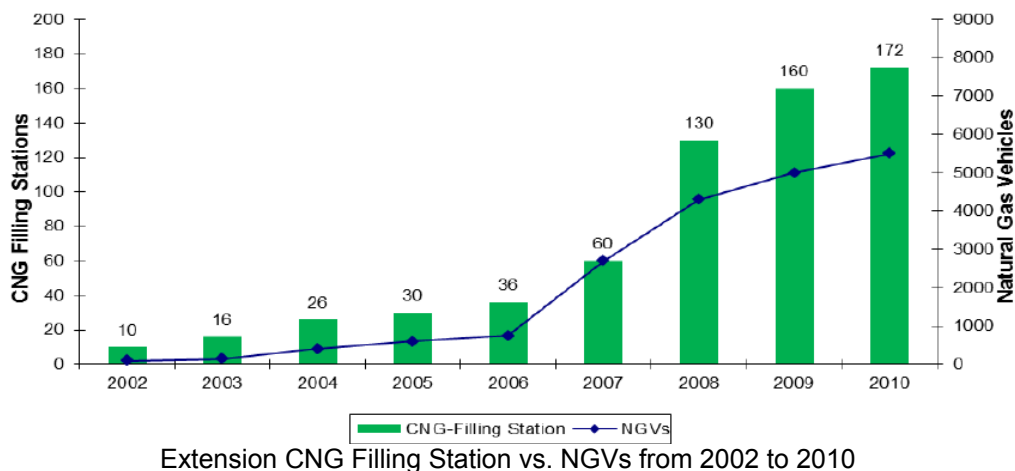
Still missing are feed-in tariff (green electrical fees or subsidies) and feed-in regulation for biomethane into the natural gas net. Nevertheless the motive for biogas plant operators to

built upgrading plants and produces biomethane as well as feed it in the natural gas net, is the increased efficiency of the entire plant (electrical power, district heating and gas delivery – connection to the natural gas grid).

Optimal location for new gas filling stations in Austria

Actual location of gas filling stations in the country

In Austria the network of gas filling stations is well established and the stations are distributed all over Austria. At the end of 2010 172 public CNG filling stations and approximately 40 to 50 private filling stations were in operation.



Since 1997, were the first station was opened, the CNG filling station network was continuously extended. Most of the public CNG filling stations are integrated into conventional petrol stations. Private stations are mainly built in co-operation with the industry and are used for fill fork lifts. The illustration shows that from 2006 on till now the filling station infrastructure was expanded rapidly.

The following table shows the amount of CNG filling stations as well as the vehicle situation in Austria per region.

The amount of CNG filling stations as well as the vehicle situation in Austria per region

Region	Vienna	Lower Austria	Burgenland	Upper Austria	Salzburg	Tirol	Vorarlberg	Styria	Carinthia
CNG filling station	19	32	7	33	18	24	11	23	9
Fleet passenger car	669.279	969.902	172.902	816.173	275.430	350.821	185.857	676.453	423.210
NG passenger car	943	965	174	886	383	372	212	704	300
NGV per CNG station	50	30	25	27	21	16	19	31	33
Percentage NGV (%)	0.14	0.10	0.10	0.11	0.14	0.11	0.11	0.10	0.09

CNG filling station – Source: www.erdgasautos.at

Fleet of passenger car – Source: Statistik Austria – Bestand an Kraftfahrzeugen 2010.

NGV passenger cars – Source: OMV Refining & Marketing 2010.

Beside of the approximately 5.000 NG passenger cars also 580 trucks and 67 busses are registered in Austria by end of 2010. That equates to only 0.11 % of the total number of passenger cars.

As there is a lack of natural gas vehicles, gas filling station operators – which are mainly natural gas suppliers – are more interested to increase the gas sales than to further expand the gas filling network because none of the existing CNG filling stations are running profitable. The main barriers are that the Austrian government is restrictive regarding natural gas as fuel and that car dealers are not interested to sell NGVs – instead they find it easier to sell diesel or petrol cars. To increase the knowledge concerning natural gas a fuel the Austrian gas industry invested a lot in marketing- and sales activities (exhibitions, info days, workshops, incentives for car dealers, subventions for cars, etc.). Nevertheless the number of vehicles could still be higher.

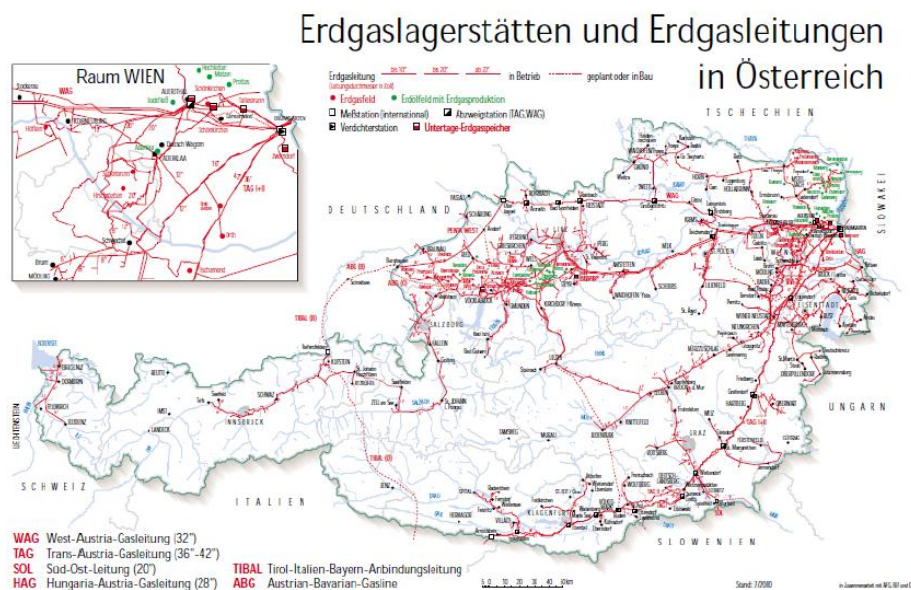
Development of the natural gas grid in the country

The Austrian gas grid is a system that has evolved over time and because of its geographical location it has an important function as a hub that transports natural gas imports onwards to destinations in Western Europe. Grid development activities are mainly aimed at underpinning and increasing security of supply for Austrian gas consumers.

The Austrian gas grid consists of transmission and distribution pipelines as well as the connections to them and other auxiliary equipment such as control and metering equipment.

Transmission systems are high-pressure gas transportation pipelines or high-pressure networks which are also used for cross-border transportation or transportation to other transmission or distribution systems.

The total length of the Austrian transmission grid is approx. 2.900 km, and that of the distribution networks approx. 39.500 km.



Natural gas fields and natural gas network in Austria

The following table shows the length of the gas network per region:

The length of the gas network per region

Region	Vienna	Lower Austria	Burgenland	Upper Austria	Salzburg	Tirol	Vorarlberg	Styria	Carinthia
Length of gas grid (km)	1.100	13.400	2.500	6.600	1.200	2.500	1.500	4.280	700

LNG, as an alternative fuel is not at topic in Austria because of the availability of LNG and the high investment costs for LNG filling stations. For regions that are not directly linked to the natural gas grid, LNG could be an alternative product in the future.

Location of existing biogas plants provided with upgrading system

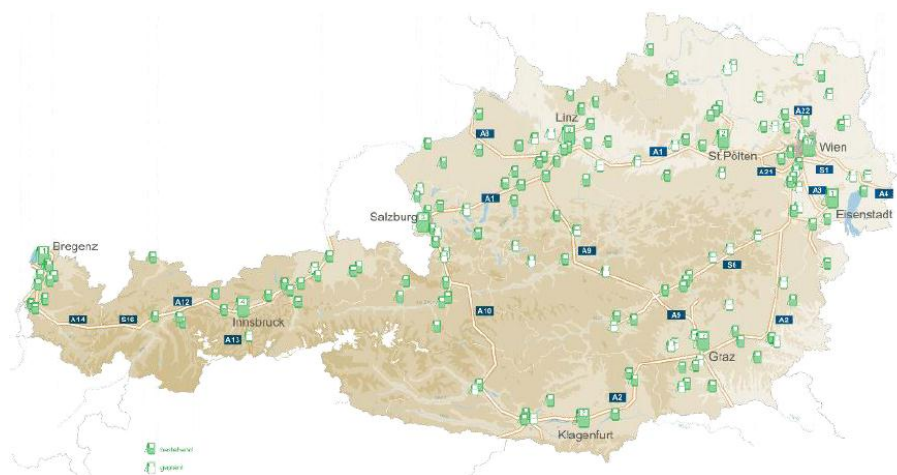
At the moment there are five biogas plants with upgrading units (Pucking / Upper Austria, Asten / Upper Austria, Eugendorf / Salzburg, Bruck a.d. Leithner / Lower Austria and Leoben / Styria) in operation. All of them are connected to the natural gas grid and insert biomethane into the gas grid.

Three of them are equipped with a CNG/Bio-Methane filling station (Pucking; Eugendorf and Bruck a.d. Leithner).

In St. Margarethen am Moos the first Bio-methane filling station which is not connected to the natural gas grid is situated. Sustainable renewable energy crops are used to produce the biogas. A membrane technology for upgrading the biogas into bio-methane is used.

Analysis of the already existing gas filling stations in the country

There are only one or two public filling stations which are not in the area of existing petrol stations. In the ramp up phase of CNG as fuel it was a customer requirement that CNG filling stations are next to petrol stations.



Existing CNG filling stations in Austria

As you can see in the map above all CNG filling stations are next to the natural gas grid and also along all major highways (A1, A2, A9, and A12) and motorways. Furthermore all large

cities (Vienna, Linz, Graz, Salzburg, Klagenfurt, St. Pölten and Innsbruck) are equipped with more than one station.

The investment costs for a CNG filling station are between 200.000 Euro and 350.000 Euro, depending on the type of compressor, gas storage, pressure (0.22 mbar up to 6 bar), location and requested infrastructure.

Most of the CNG filling stations are owned and operated by Salzburg AG, OMV Gas GmbH, OÖ Gas-Wärme GmbH and EAA Erdgas Mobil GmbH. In Styria for example Salzburg AG is operating the filling stations but has a co-operation agreement with the regional gas suppliers (Steirische Gas-Wärme GmbH and Energie Graz).

Leading fleet companies in the country

The willingness to invest in CNG filling stations depends on the customer and their needs. Business and industrial customers (mainly with CNG fork lifts or internal NGV car park) are open to invest in CNG filling station or ask for contracting (third party financing).

Fleet companies like taxi companies, social services, carriers etc. are more interested in public CNG filling stations, but there is no willingness to invest in the establishment of further public gas filling stations.

Natural gas busses are only running in three major cities (Linz, St. Pölten and Salzburg), whereas all of them are having a gas filling station near their bus depot. In Linz and Salzburg bio methane is used as an alternative fuel for busses.

Development of gas filling infrastructure on highways and motorways

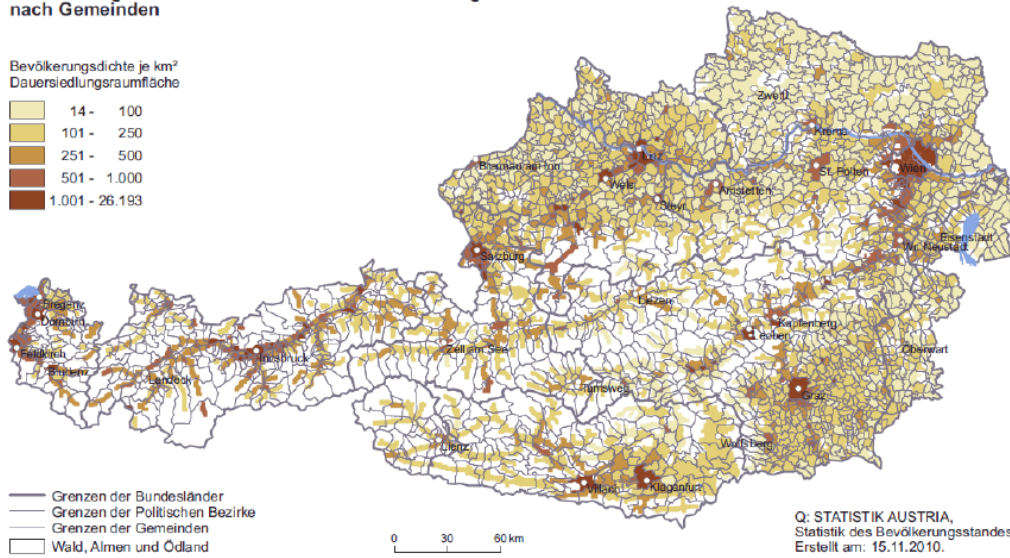
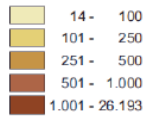
As you can see in the above map, there are already CNG filling stations next to highways and motorways. There is still a need for further stations, but as the existing stations are not fully utilized further expansion plans were moved beyond 2013/2014.

Development of the gas filling stations network related to the population density

Mainly all existing CNG filling stations are built either in large cities, places with high traffic level, next to large fleets, or junctions.

Bevölkerungsdichte berechnet auf die Dauersiedlungsraumfläche am 1.1.2010 nach Gemeinden

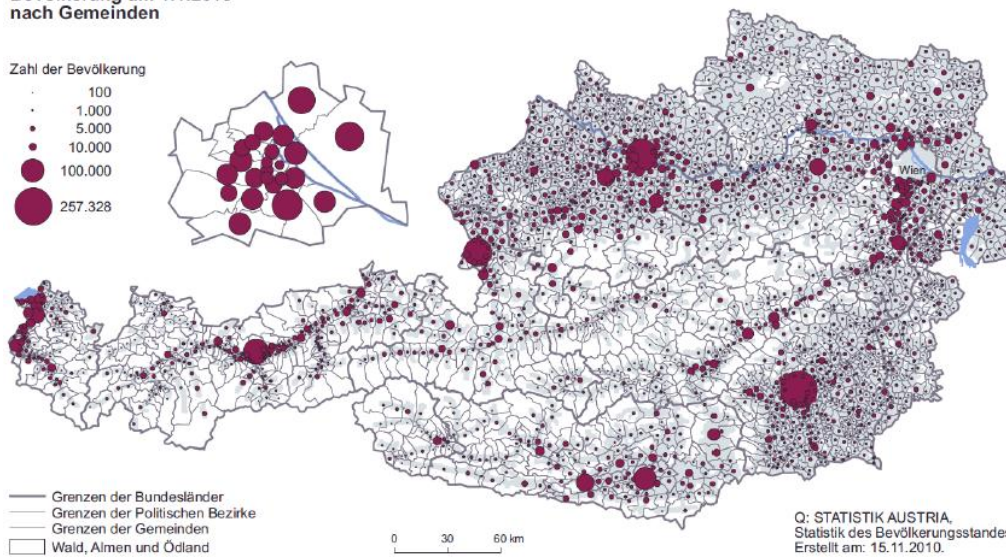
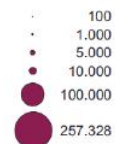
Bevölkerungsdichte je km²
Dauersiedlungsraumfläche



Population density Austria

Bevölkerung am 1.1.2010 nach Gemeinden

Zahl der Bevölkerung



Population density Austria

Comparing the pictures of existing CNG filling stations, natural gas grid and the population density also in comparison to communities and cities it is clearly visible that all correspond very well.

Areas without CNG filling stations are areas where there is not a natural gas grid or the requirements to build a CNG filling station cannot be met.

Potential investors in the development of gas infrastructure in the country

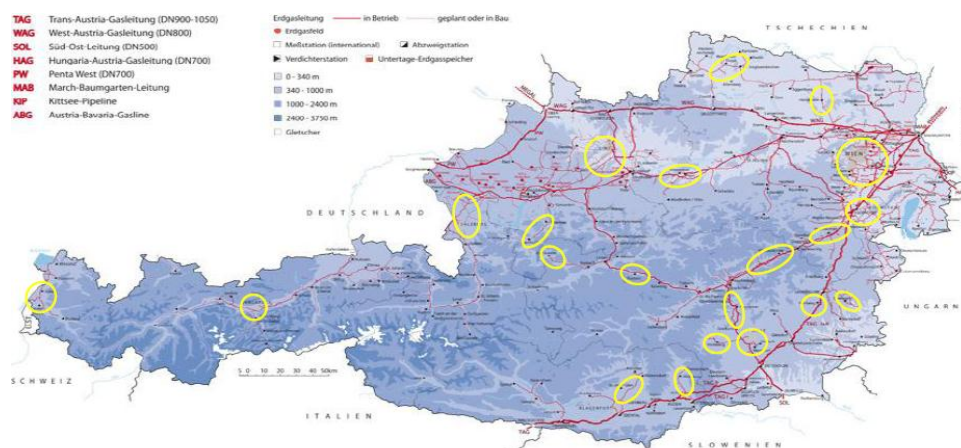
The main investors in the natural gas station infrastructure are Austrians gas supplier like Salzburg AG, OÖ. Gas-Wärme GmbH, OMV Gas GmbH and EAA Erdgas Mobil GmbH.

At the moment none of them is interested to invest in the expansion of the CNG filling station infrastructure as long as the existing stations have the potential to become more efficient. Please note that we have already 170 public filling stations but only 5.500 NGVs. To run all 170 stations profitable approximately 40.000 to 50.000 NGVs would be needed!

According to the answers to the previous questions, identify the **number** and the **possible optimal location** for **new gas filling stations** that should be opened by 2020, and point them in the relative map of your country.

In 2003 the Austrian gas industry did an expectation on needed CNG filling stations and CNG sales in Austria by 2020. This expectation was based on the directive 2003/30/EC of the European Parliament and of the Council of 8 May 2003 on the promotion of the use of biofuels or other renewable fuels for transport.

According to this paper by 2010 approximately 225 CNG filling stations (private and public) should be established and approximately 87.000 NGV should be on the road. By 2020 the numbers of filling stations were supposed with 600 and the numbers of NGV with more than 650.000.



Identified locations for new CNG filling stations

Based on our investigations and interviews with CNG filling station operators and investors, some areas in Austria were identified for new CNG filling stations. But as already mentioned all interview partners highlight that investment for new stations are depending on the pervasiveness of natural gas vehicles. As long as the existing filling stations will not be fully utilized and the maximum natural gas volume can be sold at each filling station, no new filling stations will be established in Austria in the next years.

CZECH REPUBLIC

Prepared by: Pavel Novák, NGV Manager, Czech Gas Association

The concept of CNG development in the Czech Republic was drawn up by the Czech Gas Association in 2004 as the Government's policy paper on "The Programme of Support for Alternative Fuels in Transport – Natural Gas". The Government of the Czech Republic approved this programme in its resolution of 2005 and it was then formulated in more detail in an Agreement between the Government of the Czech Republic and Gas Companies. The Agreement was signed in 2006 and among other things guaranteed zero excise duty on CNG between 2007 and 2011. CNG sales in the Czech Republic continuously increase every year. It can be expected that the gradually rising excise duty imposed on CNG starting in 2012 will not affect this development and that CNG will continue to be the least expensive and most advantageous motor fuel in the Czech Republic. For the development of the excise duty see Chart 5.

CNG filling stations came into being in the CR as initiative of gasworks companies, the beginning of building of network of filling stations in a larger extent dates back to the turn of years 2005/2006. In this period, a voluntary agreement of gasworks companies was concluded of CNG filling stations constructions for big consumers, in places with strategic meaning for building the functional network of filling stations (e.g. at main international transport routes). The Czech Republic's government passed a resolution in 2005 for the promotion of natural gas as an alternative fuel. The resolution aims to build natural gas up to 10 percent or all transportation fuel consumed by 2020, in-line with European White Paper on transport policy in effect at that time. That target would see 400.000 CNG vehicles and up to 400 CNG stations in operation by 2020. Currently the Czech Republic is covered with the OEM CNG manufacturers and CNG models, both in the Light and Heavy Duty segment with the SOR and Irisbus Iveco CNG buses also manufactured locally. The third local producer, company Tedom, finished its CNG buses production in 2011.

Companies operating in the CNG business:

Gas companies:

RWE, E.ON Energie, a.s., Pražská plynárenská, a.s., Vemex, s.r.o.

Non-gas companies:

Bonett Gas Investment, a.s., Gascontrol spol. s r.o., Tvaja CNG, s.r.o., Aquacentrum, s.r.o., Motor Jikov, a.s., NEAT, a.s., CNG Company, s.r.o.

CNG vehicle manufacturers:

Buses: Iveco Czech Republic, a.s., Tedom, a.s. (production finished in 2011), SOR Libchavy spol. s r.o.

Forklifts: Linde Material Handling CR, s.r.o.

Importers of CNG vehicles into the CR:

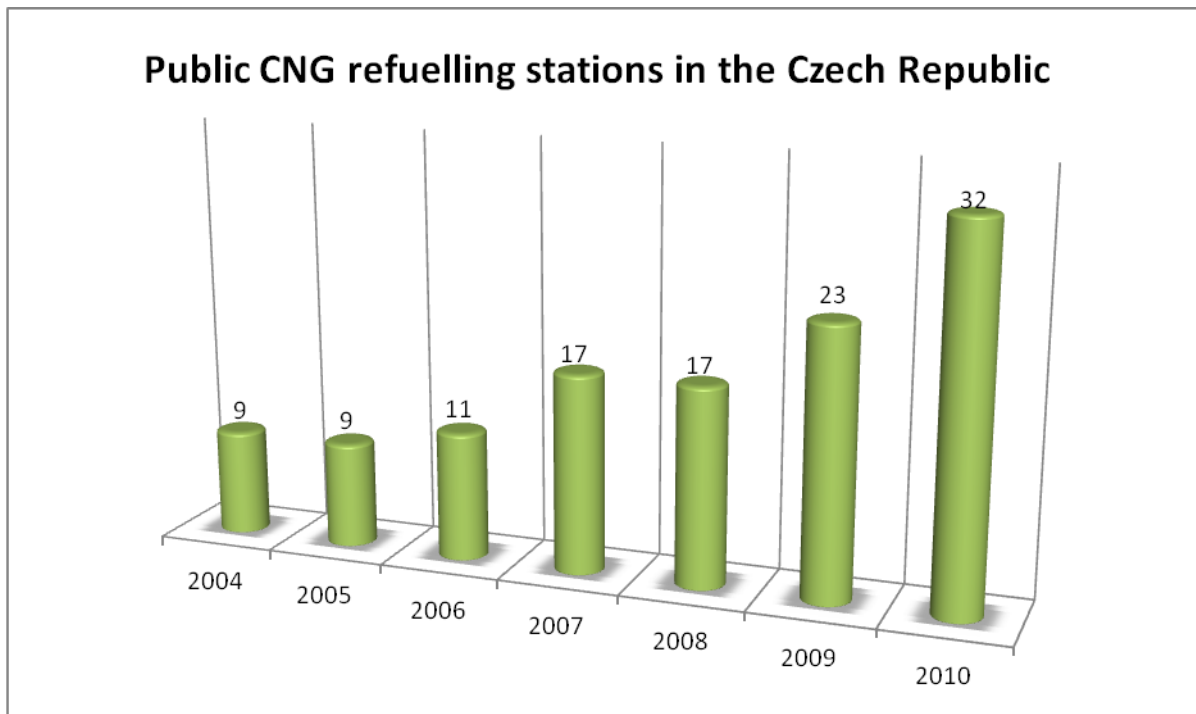
VW, Mercedes Benz, Fiat, Opel, Iveco

Ice resurfacers: Zamboni

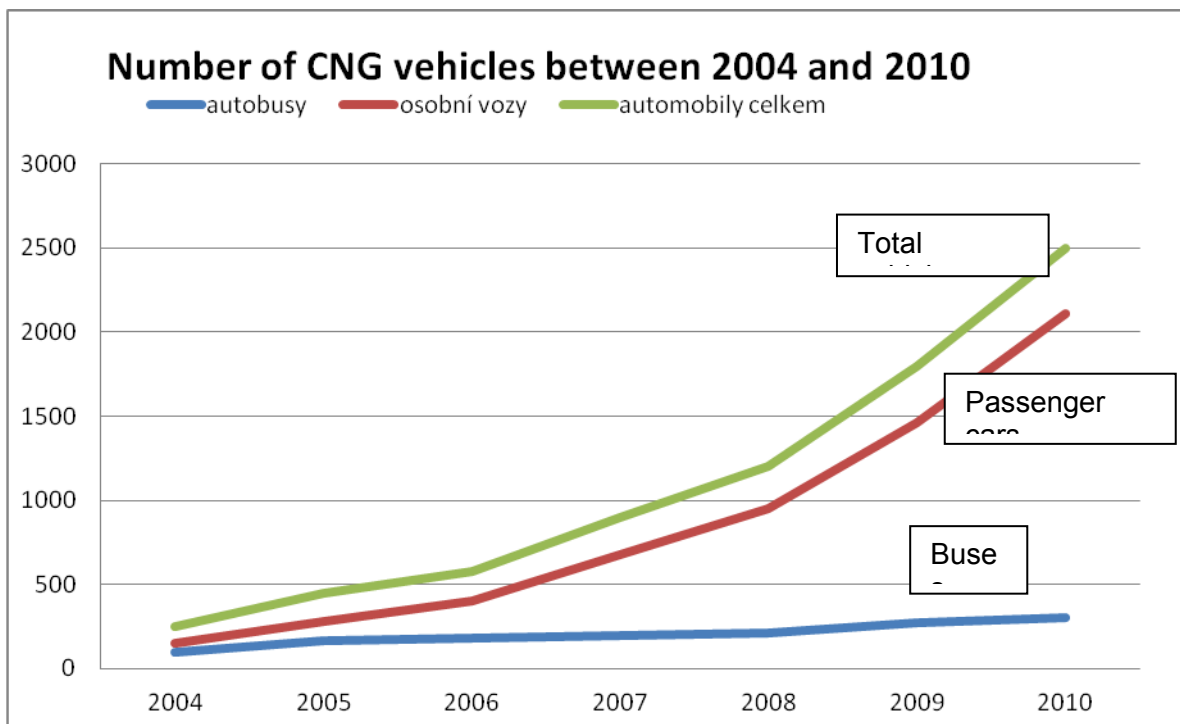
The table and chart show CNG development in the Czech Republic between 2004 and 2010. For example, CNG sales increase by more than 20% annually, NGV sales increase by 45% and the number of public CNG refuelling stations rises by 23%.

NGV development between 2004 and 2010

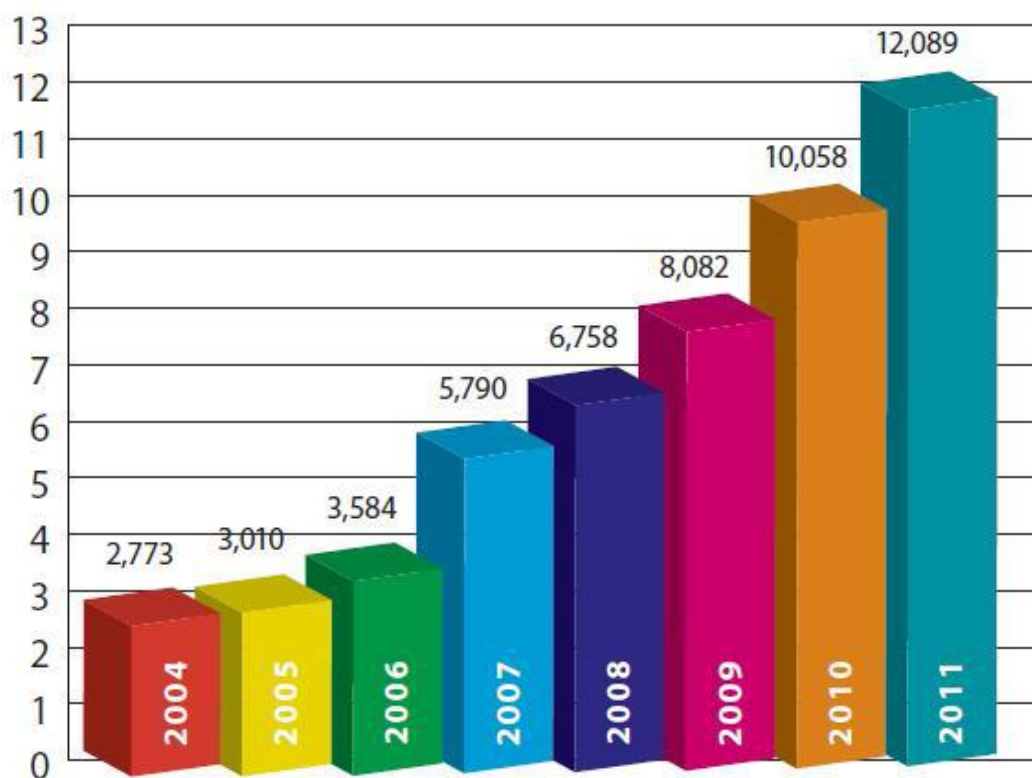
	Public CNG refuelling stations	Total vehicles	Passenger cars	Buses	CNG sales, in million m ³	Increase in CNG sales, in %
2004	9	250	150	100	2.773	
2005	9	450	280	16	3.010	8.5
2006	11	580	400	180	3.584	19.1
2007	17	900	680	195	5.790	61.6
2008	17	1 200	950	215	6.758	16.7
2009	23	1 800	1 465	270	8.082	19.6
2010	32	2 500	2 112	300	10.058	24.4
2011	34	3 250	2 807	336	12.089	20.2



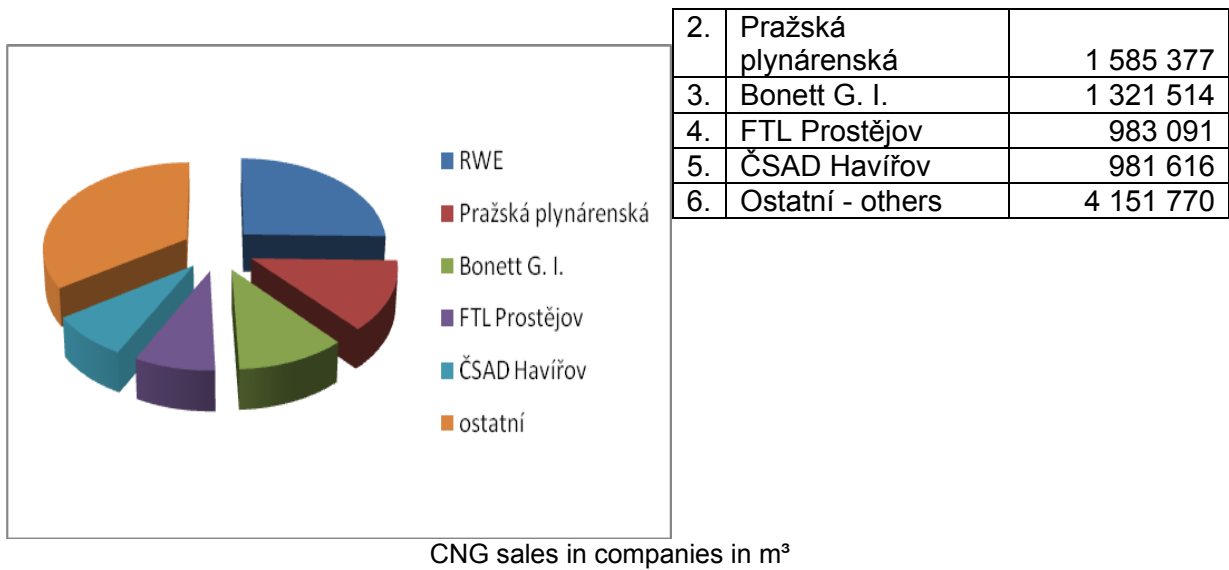
Public CNG refuelling stations between 2004 and 2010



CNG vehicles between 2004 and 2010

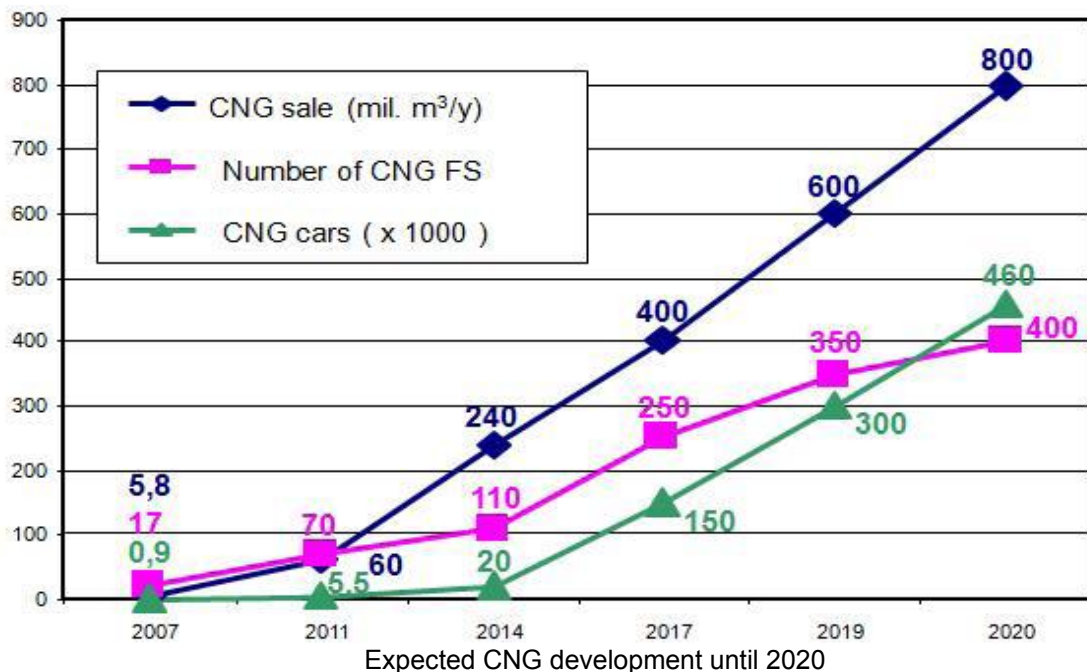


CNG sales in the CR between 2004 and 2011 (in thousand m³)



CNG sales in companies in m³

Developments over the past five years clearly indicate that in the Czech Republic, a favourable business environment has been created for the infrastructure, i.e., the rollout of a network of CNG refuelling stations, and for the related industries, as well as a good market environment for the sales of all categories of CNG vehicles (passenger cars, delivery vans, buses and municipal vehicles). Part of this successful development in CNG is the existence of technical legislation, technical standards and other legislative documents related to CNG.



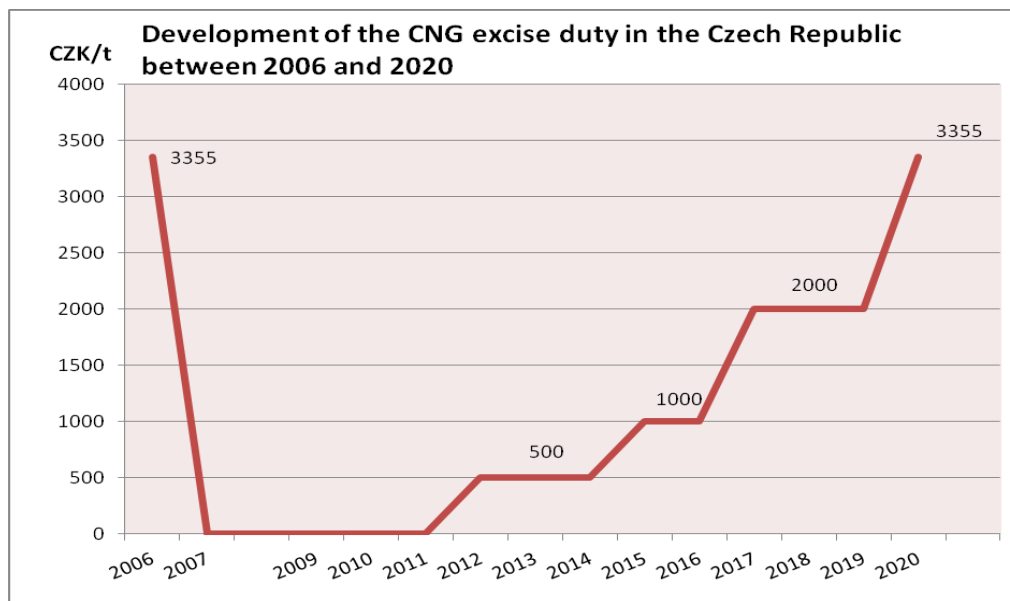
Taxes and subsidies

CNG excise duty

The subsidy scheme of the Czech Ministry of Transport for the replacement of vehicles in public bus transport in 2011 has been cancelled, which also means the cancellation of subsidies from the Czech Ministry of Transport for CNG buses.

Although governmental support has been withdrawn, gas companies continue to contribute CZK 200,000 to the purchase of every new CNG bus. This involves marketing support, for example, the buses carry advertising posters of the respective gas company (RWE, Pražská plynárenská, a.s., E-ON) provided that the bus operator also takes CNG from the gas company.

There is also an opportunity to transfer funds for CNG bus procurement from the budgets of regional operational programmes. However, it is up to each city to decide on the way in which it will allocate the funds and on how it justifies this transfer; for example, the municipality can declare low-emission zones allowing access to “clean” vehicles. In the Czech Republic, it is now possible to buy CNG buses cheaper than diesel buses. However, it is up to each operator to decide which fuel it will use.



CNG Excise Duty Structure until 2020 (CZK/t)
Rate on 1 September 2011: EUR 1 = CZK 24.095

Road Tax

Under Section 3 of Act No 16/1993 on the Road Tax, since 1 January 2009, under 12-tonne vehicles with an electrical, hybrid or gas drive have been exempt from the road tax in the Czech Republic.

CNG refuelling stations

The Czech CNG refuelling network is improving. The concept of building refuelling stations inside companies’ compounds, often with complicated access to the dispensers, is being abandoned and preference is given to publicly accessible places in the compounds of shopping centres or in the networks of existing fuel filling stations (for example, LUKOIL and

Benzina, a.s.), which have in place suitable facilities and services for drivers. Unfortunately, Czech technical and safety standards in general complicate and hinder the rollout of CNG refuelling stations and their integration within the structure of the existing filling stations in this country. It is therefore necessary to revise the regulation called TPG 304 02 CNG Refuelling Stations for Motor Vehicles, which will make it possible to install multi-product dispensers (petrol, diesel, CNG) and also to install CNG dispensers very close to other fuel dispensers. In the Czech Republic, CNG refuelling works completely on a self-service basis. Thanks to the development of an autonomous CNG Card Centrum network supporting the use of customer cards, CNG can be refuelled at 31 CNG dispensing points; credit cards can be used at 16 CNG dispensing points and cash at 27 CNG dispensing points. Customer cards for the CNG Card Centrum system are issued by six contracting partners (RWE, E.ON Energie, a.s., Pražská plynárenská, a.s., Bonett Gas Investment, a.s., Vemex and Vítkovice Doprava, a.s.).

The number of CNG refuelling stations as at September 2011 is shown in a map of the Czech Republic (Fig. 1). Cooperating with Gibgas, the Czech Gas Association updates the refuelling network on the *CNG Road Planner* website on a regular basis, see http://www.gibgas.de/Tankstellen/Umkreissuche%20-%20Routenplaner?locale=en_GB Price of VRA with the total capacity up to 20m³/h (filling last up to 8 hours and depending up the compressors' output - for max 10 vehicles) vary from about 4 800 – 40 000 Euros. Measuring of CNG is here also requested because of taxation of CNG.

Investment into public CNG filling stations vary up from 320 000 Euros and depends very much on the project conditions and local needs.

Regional differences in CNG filling stations' network in the country

There are some regional differences in density of filling stations in the Czech Republic. It is possible to say that the most of filling stations are located around Prague, Central Bohemia and North East of the Czech Republic (see attached map). Main barriers were identified in willingness of CNG station's investors who take into account quantity of CNG cars among drivers. On the other hand some areas (especially cities in highly polluted industry areas) are more active in conversion to CNG with focus on ecological asset of CNG buses in public transportation. Once municipalities are intended to undergo purchase of CNG vehicles it usually boosts up an investor's interest.

In the past the most of CNG stations were designed as separately constructed stations. Majority of public CNG filling stations is located according to demands of specific users (transportation companies) with possibility to serve for public, as well. This does not correspond with position needs of public station for conventional fuels, however, the recent trends are to build CNG dispensers as a part of petrol station (also as a multiproduct dispenser – gasoline, diesel, CNG) in its chains which a newly revised legislature allows (Lukoil, for example).

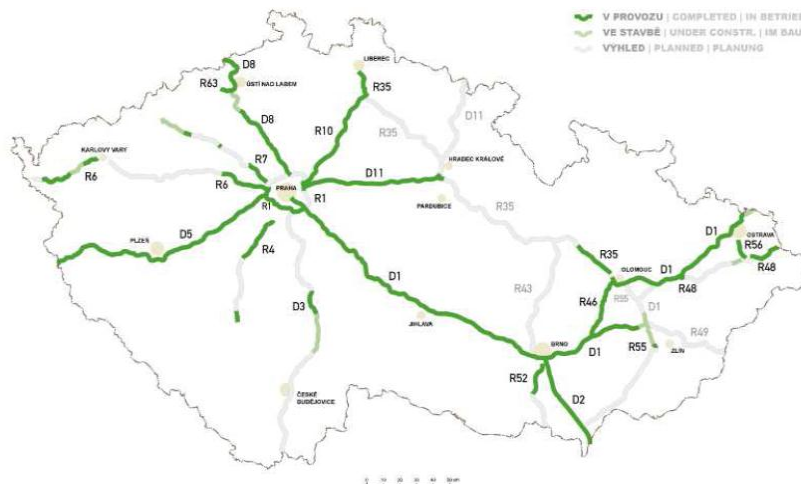
The big fleet companies have unique position for the start up of the NGV industry – consumption of CNG can potentially replace a substantial volume of their traditional fuels. Additional value they have is an ownership of land that enables them to place CNG filling station without problems with other owners. Also there are subjects, mainly gas companies, willing to invest into CNG infrastructure and sell CNG. This solution is for those users "risky free" because of no need to maintain CNG technology they can be focused on transportation only – their key business activity.

Most of CNG filling stations' investors in the Czech Republic comes from private sector. Of the total number of 50 CNG stations in the Czech Republic to the end of 2011, 37 stations are designed as public whereas most of them with the access 24h daily/7 days in the week.

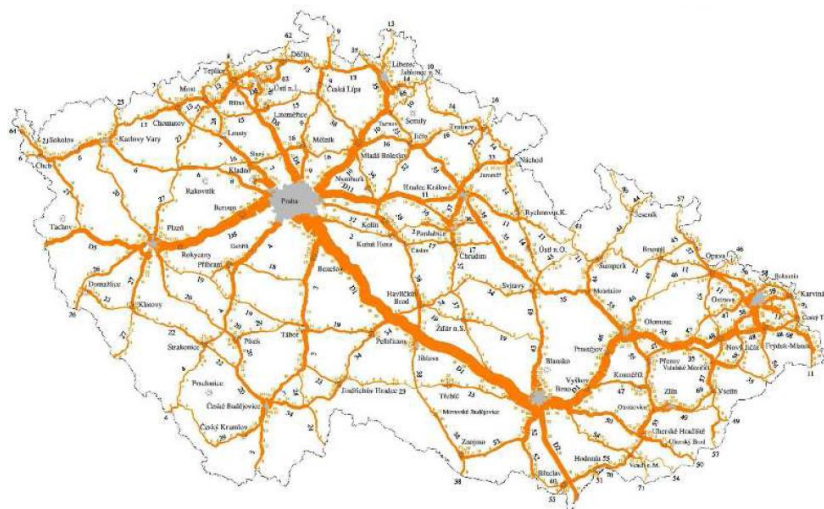
Since 2007 is applied the CNG CardCentrum payment system where used a special customers' CNG Card issued by 6 companies (RWE, Prazska plynarenska, E.ON, Bonett Gas Investment, Vitkovice Doprava and Vemex). System allows invoice a CNG taking once a month. CNG Cards are accepted at 31 points. Credit cards VISA and EC/MC are accepted at 16 public CNG stations and 27 stations accept payment cash. Since 2007 is also applied a self-service filling of CNG in the Czech Republic. NGV1, NGV2 nozzles and self-service safety measures are required.

Development of gas filling infrastructure on highways and motorways in the country

There are some strategic plans (mainly by private investors) for further development of gas refueling infrastructure. Paradoxically the most of stations are located out of highways and motorways. It is also matter of insufficient highways infrastructure in the Czech Republic and higher costs of investment along existing highways and motorways (see map).



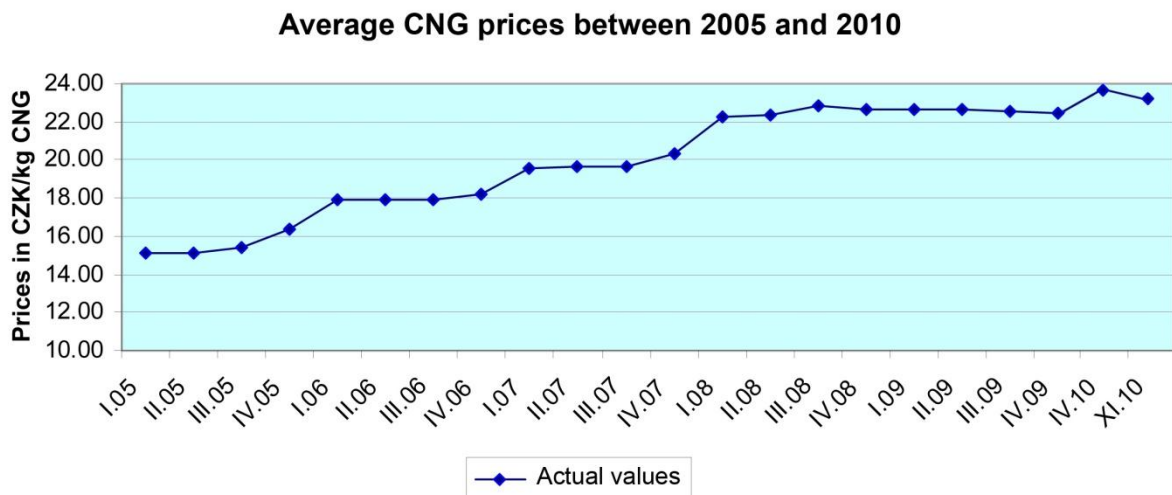
Infrastructure of highways in the Czech Republic



Traffic intensity in the Czech Republic (vehicle annual average per 24 hours)

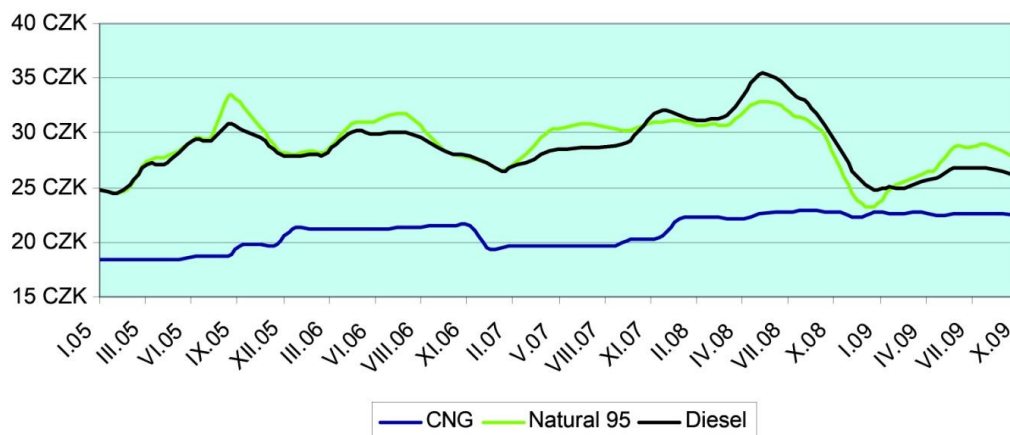
Average CNG prices between 2005 and 2010

Compared with oil-based fuels, the end price of which can change on a daily basis, CNG prices change very little. The various companies change their prices only rarely, in most cases at intervals of several months or years.



Average CNG prices in CZK between 2005 and 2010
Rate on 1 September 2011: EUR 1 = CZK 24.095

Development of fuel prices



Development of fuel prices for consumers between 2005 and 2009
Source: Ministry of Industry and Trade of the Czech Republic



■ CNG public refuelling stations, gas companies
■ CNG public refuelling stations, non-gas companies
 CNG public refuelling stations in the Czech Republic, September 2011



A CNG public refuelling station, Česká Lípa municipal transport company, in operation since 2011

CNG vehicle garaging

Unlike other countries in which CNG vehicles can be freely parked in underground car parks, in the Czech Republic CNG vehicle parking under the ground meets with certain difficulties because of the persisting unwillingness on the part of the fire services. After many years of relentless effort, the provisions of Regulation No 23/2008 on the technical conditions for the fire protection of buildings and the relevant provisions of the ČSN fire protection standards have been amended so that subject to certain conditions, CNG vehicles can now enter into and park in underground car parking facilities intended for multiple vehicles.

Technical regulations on CNG prepared by the Czech Gas Association:

TPG 304 02 – CNG Refuelling Stations for Motor Cars – revised and valid since February 2012

TPG 982 01 – Garages and service and repair shops and other facilities for NGVs – *under revision*

TDG 982 02 – Requirements for the Operation, Repair, Maintenance and Inspection of NGVs

TDG 982 03 – NGV Refuelling Appliances.

ESTONIA

Ahto Oja, MM – Mõnus Minek SEES

Current status on refuelling infrastructure

National situation and regional differences

National situation on refuelling infrastructure of gaseous vehicle fuels is at emerging market phase. More exactly, refuelling infrastructure of methane (natural gas) and biomethane doesn't exist in Estonia, only the first refuelling station of natural gas was opened in Tallinn in August 2009.

Statistics

The first natural gas refuelling station locates close to the natural gas grid. The company called AS Eesti Gaas plans to open 2 more refuelling station close to the natural gas grid, namely in cities Tartu and Pärnu.

Type of plant

The owner of the natural gas refuelling station is private company, which majority shareholders are E.ON and Gazprom, minor shareholder is the Republic of Estonia. Two methane pumps are used for CNG. Payment is possible only with AS Eesti Gaas client card, opening hours are 8.30- 17.00, natural gas is supplied by Gazprom. Schwelm Anlagentechnik GmbH compressors and filling station equipment are used. The cost of methane is 10.6 Estonian crowns per kg (0.68 €cents/kg., the liter of gasoline costs 1.15 €cents).

Current status on legal conditions

National and regional laws, technical regulations

National laws and technical regulation almost doesn't cover the issue of using natural gas and biomethane in vehicles. No standards has been set down.

Welfare benefits, incentives, support scheme for methane and biomethane filling stations development

Directly no benefits, incentives and support schemes exist for methane and biomethane filling stations development.

Investment costs and barriers

Refuelling station investments and rate of profit

AS Eesti Gaas has monopoly over natural gas grid and thus also over the distribution and pricing. Thus the calculations for open market investments costs and rate of profit are not predictable.

Main barriers (technical, economical, legislative)

The main barrier for using natural gas and biomethane is in attitudes. It seems to be the fact, that Estonian citizens and companies are not used to do so. Biomethane for vehicle fuel is not produced in Estonia. Natural gas was used for some years by one company, which is now bankrupt.

The second barrier is in poor legislation. The governmental regulation (no...) states the incentives for liquid biofuels, but doesn't mention gaseous biofuels, e.g. biomethane. The economic barrier is in fact, that AS Eesti Gaas can put the price for natural gas in its refuelling station freely, not depending from market actors, thus risks to invest to biomethane refuelling station is quite high.

The smallest barriers are in technology, there are no local refuelling equipment providers, but via export all needed technology is available.

Potential in methane/ biomethane filling station

Trends in technologies

Trends in methane/biomethane refuelling station technologies are not predictable.

Trends in legal and financial conditions (incentives, benefits, laws)

Attempts have been made to include biomethane and methane as gaseous vehicle fuels into new Renewable Energy Strategy of Estonia. Also some indications are recognizable on making progress of working out quality standards for biomethane to allow the injection of biomethane into national gas grid.

Attitudes towards methane/biomethane filling station (stakeholders, customers, biogas producers, lawmakers etc.)

Attitudes towards methane/biomethane filling station's development is contradictory. Estonia is in the "egg-chicken" development stage. Market for using methane/biomethane as vehicle

fuel doesn't almost not exist yet. However, some biogas producers and also some fleet managers has expressed their interest to find out profitability of using methane/biomethane as vehicle fuel. E.g

Tallinn Bus Company (owned by municipality) implemented 1 month test with M.A.N methane bus and got very promising results: the cost for fuel was almost half of comparing with diesel.

The lawmakers are still quite reluctant and support development of biofuels first of all because EU (directives) demand it, not because they think and feel themselves that this is right and good thing to do.

Optimal location for new methane gas filling stations in Estonia

Introduction

Natural gas is imported into Estonia from Russia and from the Inchukalns underground gas storage in Latvia. AS Eesti Gaas has two gas metering stations on the border of Estonia, where the volumes of imported gas are measured. Gas is distributed to customers through gas pipelines, distribution stations and gas pressure reducing stations. In August 2009, the first CNG car filling station was launched by Eesti Gaas and the car vendors are a natural partner of Eesti Gaas as the fuel provider. The success story of using methane gas as a clean car fuel depends on three factors: the social demand for environmentally-friendly transport and the quality of products and services offered by the fuel and car vendors.

Starting from September 1, 2010, prices of natural gas apply to residential customers

Consumption of natural gas	Price without VAT EEK/m ³	Price including VAT EEK/m ³
Up to 200 m ³ per year	8.639 Eur/m ³ 0.55213	10.3668 0.66256
201 – 750 m ³ per year	6.108 Eur/m ³ 0.39037	7.3296 0.46844
750 m ³ and more per year	5.130 Eur/m ³ 0.32786	6.1560 0.39343

The price of CNG as vehicle fuel in first filling station in Tallinn is 10.6 kr/kg, (0,6 €/kg) The sales income of AS Eesti Gaas totalled EEK 2, 646.4 million in the 2009 fiscal year. The natural gas sales amounted to 634.8 million m³ in 2009, which is by 15.4% less than in 2008. Of the total natural gas sales in the fiscal year, 57.8 million m³ was sold to residential customers and 577.0 million m³ to eligible customers.

Biomethane has not been produced and used as vehicle fuel in Estonia. Some initiatives have shown interest to the topic, but no investment decision has been made.

For identification of the optimal location for new Compressed Methane (Natural Gas and Biomethane) Gas (CMG) filling stations following criteria were used:

- Regional Differences
- Proximity to gas grid compared with the possibility of using LNG
- Proximity to biogas plant and upgrading platform
- Existing traditional refuelling stations that could be implemented
- Fleet companies interest

- Long distance pattern demand: highways and motorways
- Short distance pattern demand: urban areas
- Investment plans

Regional differences in the distribution of gas filling stations

The current only CNG station stands in Tallinn, the capital of Estonia, on the main natural gas pipeline. The two new planned locations, namely Tartu and Narva are second and third biggest cities. Tartu locates 186 km from Tallinn towards South-East and Narva locates from Tallinn 200 km towards East. Natural gas pipeline passes both Narva and Tartu.

The biggest need to establish CMG filling station is in Pärnu, which locates 126 km from Tallinn towards south and it is on the main International transport corridor, called Via Baltica uniting Tallinn with Latian capital Riga (300 km from Tallinn towards South). There is private natural gas pipeline, which is not operated by AS EG Võrguteenus.

The second priority can be Haapsalu city and western regional centre, 80 km from Tallinn towards West and island Saaremaa. The barrier for establishing CMG filling stations to these areas is in fact, that natural gas pipeline doesn't exist there.

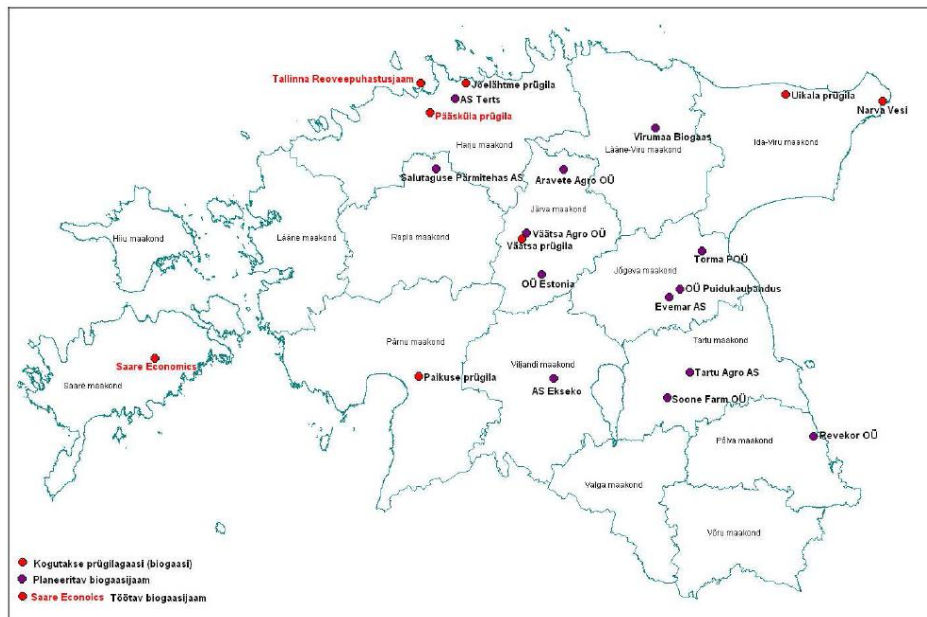
There is no LNG storage facilities in Estonia, but 2 different private initiatives compete to build one, with argument of being able to provide cheaper natural gas than current natural gas from Russia. The potential LNG storage facility will increase the energy safety of the Estonia, while currently 100% of natural gas is imported from Russia and Europe has experienced few times, what it means. This argument, namely independence from Russian natural gas, is the reason why LNG terminal is important from national economy point of view.

The development of the natural gas grid is hard to predict as this can be sensitive information from competition point of view. The possibility of establishing LNG terminal has been discussed, currently there is no LNG terminals in Estonia.



Estonian natural gas grid in 2010.

There are few biogas plants in Estonia, 1 on manure, 3 on sludge and 3 on landfill gas. Biomethane is not produced in Estonia.



Estonian biogas plants at 2010 (red – existing; purple – planned plants).

Current situation with CNG filling stations in Estonia

Currently one CNG filling station is under operation in Tallinn, Estonia, owned by AS EG Võrguteenus. The same company plans to open second CNG filling station in Tartu in March 2011 and third in Narva. The decision of establishing Narva CNG station is under consideration, the final decisions are not made yet.

Leading fleet companies have not yet decided to convert their fleet to use gas. Private fleets consider economic and investment risks too high, while contracts for passenger transport are usually made for 5 years. Municipal bus companies lack political decision making to convert bus fleets to use gas. Exception is Tartu City Administration, which also wrote the support letter to GasHighWay Project. They manage the Interreg Baltic Biogas Project and as part of this included the condition to start to use 5 compressed methane gas buses to the public procurement tender and the bus fleet company, which won the contract is now obligated to use 5 CMG buses in their fleet in March 2011. This is the main reason for establishing second CNG filling station to Tartu.

No plan or map doesn't exist for CMG stations. GHW Project has made the proposal for new potential CMG filling stations after consulting with members of Advisory Committee and other leading experts in the field.

It is likely, that 4 main traffic corridors will be developed in Estonia, these are not so much related to the population density, while Estonian population is decreasing. The main traffic corridors are related first of all to cargo transport and transit, while Estonia bigger harbours locate around Tallinn, and Sillamäe, also Pärnu has big harbour. Traffic corridors will thus be from Tallinn towards East (Narva and further to Sankt Peterburg). South – East (further to Russia, Pihkva, and down to Moscow) and to South to Pärnu (and further to Riga- Vilnius- Warzawa-Berlin, shortly Via Baltica). The fourth route probable comes from Sankt Petersburg to Narva and then to Pärnu and further. Minor corridors will be between Narva and Tartu and Tartu and Pärnu.

The first 2-3 CNG filling stations will be owned and operated by AS EG Võrguteenused. Few private companies have started to make strategies to enter to CMG market in Estonia.

According to the Estonians situation, the **number** and the **possible optimal location** for **new gas filling stations** that should be opened by 2020 was identified. Our very rough estimation is, that optimal number of CMG stations in Estonia by 2020 is 13.



Optimal location of CNG filling stations (black – close to natural gas grid, blue – off the natural gas grid, either biomethane or natural gas from LNG terminal will be used).

FINLAND

Jyväskylä Innovation Oy, Jyväskylä Innovation Ltd

Current status on refuelling infrastructure

National situation and regional differences

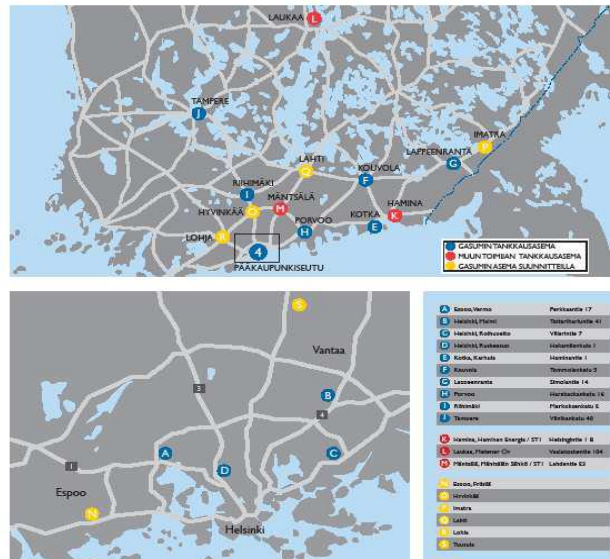
In Finland methane refuelling infrastructure started to develop in 2003 when changes in political regulations made it possible to use methane as traffic fuel. Even before that in 2002 the first biogas upgrading plant and refuelling station was started its operation in Kalmari biogas farm in Central Finland. Today the refuelling stations are mostly in southern and eastern part of the country where the natural gas grid is located. The filling stations are covering the area, where high share of inhabitants are living in Finland. There are still big cities like Turku (in the south-west) and Oulu (in the north), where gas filling stations do not exist yet. Geographically the gas filling stations are covering only a part of the country. Practically people living South and south-east from Tampere and Jyväskylä are able to use methane as vehicle fuel when living or working nearby a gas filling station.

The whole country can be reached with a bi-fuel car when using gasoline outside the gas filling station area.

Statistics

In the beginning of 2010 there were totally 16 methane filling stations in Finland. The basic network of filling stations in the area of natural gas grid has been built up, and the challenge in the future is to extend the network to areas outside the gas grid and to fulfil the basic network with new filling stations. The filling stations are mostly located in vicinity of a city, and usually the locations are also good from road network point of view. The only filling station outside the natural gas grid is located 10-15 km from Jyväskylä city in Laukaa. The distance

to the closest point of natural gas grid is about 170 km. The newest filling station was opened in Lohja in the beginning of March 2010.



The map of methane filling stations in Finland. **Blue** = Existing CNG filling stations owned by Gasum Ltd. **Yellow** = Gasum's filling stations under construction or planning. **Red** = Other company owned gas filling stations. The only bio-methane filling station is the northernmost one in Laukaa marked with red symbol. Two of the filling stations marked with yellow have already been opened after the map has been published (Source: Gasum Ltd.).

Type of refuelling stations

The gas filling stations are using fast fill technology. The nozzle type is NGV1, and in two stations there is also (NGV2 is CNG cylinder standard) nozzle for buses and other heavy duty. The gas company Gasum Ltd. is building widely the network of filling stations, and is operating most (13) of the existing gas filling stations. In Gasum stations there is only possible to pay with a GasCard, that is Gasum's own credit card. Energy companies also own two natural gas filling stations, and they have the normal bank and credit cards as payment possibilities. The price of CNG and bio-methane in Finland is nowadays around 1 €/kg.



Gasum's CNG filling station in Lahti.

The only filling station outside the natural gas grid is owned by Metener Ltd. and is located in Kalmarin farm. The station also uses fast fill technology. Biogas is produced in farm's biogas

plant, and is upgraded to vehicle fuel quality with a farm-scale biogas upgrading unit developed by Metener Ltd.



Bio-methane filling station in Kalmari farm.

Current status on legal conditions

National and regional laws, technical regulations

Before the year 2003 there was an extremely high tax for gas vehicles, which made it impossible to generate markets for methane as a traffic fuel. Since then the gas vehicle taxation has been alike the taxation of fossil fuelled vehicles, and there has been no fuel tax for gaseous fuels. However the fuel tax system is changing in 2011, and the new model of bio-methane and CNG taxation is not known yet.

The technical regulations related to building a methane filling station are quite clear. The Finnish Natural Gas Association has together with Safety Technology Authority made a guidebook of mtechnical regulations of a gas filling station.

Support scheme for methane and bio-methane filling stations development

In Finland there is government's proposal of feed-in tariff for biogas in process. In the future the feed-in tariff for biogas would support production of electricity and heat in Finland. If bio-methane production will not be included to the support scheme the produced biogas might be utilised more often in CHP-production than in transport fuel use.

Investment costs and barriers

Refuelling stations investments

The investment costs of a gas filling station in Finland are about the same as in other European countries. Metener Ltd. offers a unique technology of biogas upgrading and refuelling system in small scale (capacity 30-100 Nm³/h of raw biogas). The technology enables cost-effective filling station solution for biogas producers. It also enables to invest first in a small scale upgrading unit and to expand the capacity when the number of gas

vehicles increases. A study about cost-effective solution for methane road transportation is going on in GasHighW

ay-project in Finland. Cost-effective methane transportation from biogas plant to filling station is key factor when creating CNG and biomethane markets to areas outside the natural gas grid.

Main barriers

The main barrier for methane infrastructure to develop is challenge to start the first refuelling stations in areas where there is no gas driven vehicles yet. The problem usually is lack of actor, municipality or company, that would have interest to invest to a refuelling station and find the first customers to the filling station. General unawareness of possibilities in bio-methane production and use as traffic fuel is often the key point among politicians, municipal decision-makers as well as normal consumers. However the situation is getting better all the time when the basic network of filling station in natural gas grid area has developed and gas driven vehicles have become more common. In addition the production of biogas is increasing and utilisation of methane in traffic fuel is becoming more interesting.

There are also legislative barriers. Even though the taxation of bio-methane and CNG nowadays is favourable and high gas vehicle tax has been removed, it is not known how methane will be taxed in new transport fuel taxation system in 2011. Many investments are waiting for definition of policy.

Potential in methane/bio-methane filling station

Trends in technologies

In Finland natural gas is an essential energy source, and there is good potential to increase the use of CNG in traffic sector. Transportation of CNG and bio-methane by using pressurised containers or LNG containers is becoming more common in Europe, and in Finland methane transportation creates promising markets for natural gas vehicles in areas outside the natural gas grid. Gasum has got an LNG production unit in Porvoo in south Finland, so the first investments to gas transportation have already been done in Finland.

Biogas production units are covering almost the whole country and new biogas plants are under construction. The increase in biogas production creates good potential to upgrade biogas to vehicle fuel and build new bio-methane filling stations. The gas companies Gasum and Biovakka are planning to start bio-methane injection to natural gas grid in 2011 to distribute bio-methane to refuelling stations. There is also a local energy company in Hamina that owns the local natural gas grid and is planning to produce bio-methane to the grid.

Trends in legal and financial conditions

Main incentives like methane fuel tax is nowadays favoring gas vehicles to become common and thereby new filling stations to be opened. Long term strategy of incentives related to methane use as traffic fuel is still missing in Finland. The unawareness of the new fuel taxation system is a barrier for many companies to invest to new filling stations and for customers to buy a gas vehicle.

Attitudes towards methane/bio-methane filling station

The attitudes towards methane as traffic fuel are basically quite good. Usually the attitudes will get better when getting more information about gas vehicles and use of methane as fuel. Lack of information and general unawareness are the main points to work with, when trying to boost the NGV markets ahead. In Finland there are many projects going on related to bio-methane filling stations, and through the projects people are getting informed also in areas outside the filling station network.

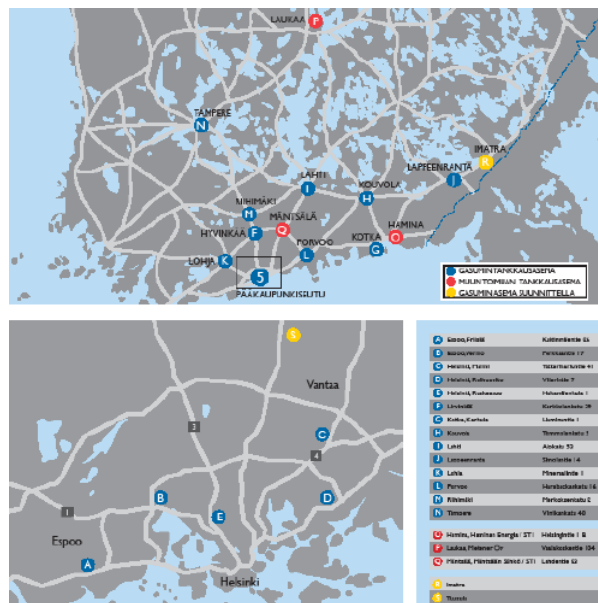
Optimal locations for new gas filling stations by 2020 in Finland

Regional Differences

In Finland there is good potential in expanding the distribution infrastructure of gaseous vehicle fuels, biogas and natural gas, by 2020. The gas vehicle market started to grow in 2004, and in six years the number of gas vehicles has increased to 800 NGVs in Southern Finland, providing a good base for growing markets. There is convincing entrepreneurship in gas distribution sector in Finland, and the companies are actively developing the markets ahead.

The natural gas grid, and hence the existing natural gas filling stations are covering southern part of the country. A big share of the most populated areas in Finland is in proximity of natural gas grid. There are still highly populated areas outside the gas filling station network in South-Western and Western Finland.

Finland is a sparsely populated country with long distances between the cities. In order to develop a functional gas filling station network the whole country should be covered with a basic network of filling stations. A challenge is to find economical solution in covering the most sparsely populated areas in Northern and Eastern Finland. However, biogas and liquefied natural gas (LNG) are bringing new possibilities for areas outside the natural gas grid.



Existing gas filling stations in Finland in October 2010 (Source: Gasum Ltd.)

Proximity to gas grid compared with the possibility of using LNG

The existing natural gas grid is an important gas distributing infrastructure in Southern Finland. The number of gas filling stations in natural gas grid area can significantly be increased by 2020. The existing gas pipeline can feed gas filling stations only in South Finland. The northernmost point of the gas grid is Tampere (and Kyröskoski) providing gas supply for the third biggest city in Finland. The natural gas grid may expand in next decade, but new gas lines will be constructed only if some key actor will invest in gas consuming technology. A potential large-scale investment in natural gas grid by 2020 is a new pipeline to Turku and Naantali in South-Western Finland. It can be assumed that by 2020 the natural gas grid is used as distribution infrastructure of natural gas and biomethane in the area of existing gas filling stations, and apparently in some new areas near the present natural gas grid.

In areas outside the natural gas grid, but close to natural gas area (max. 50-100 km) methane can be transported to filling stations by using compressed gas containers. LNG would be an effective way to distribute gas in countries like Finland and Sweden, where the natural gas grid is limited and long-distance distribution is needed. Gasum Ltd. has invested in LNG production unit in Porvoo, and there are no technological barriers related to LNG distribution. The challenge is to find big gas vehicle fleet operators and/or industrial companies with high gas consumption to generate economical base for LNG distribution.

An interesting opportunity in the future is long-haul ship transportation of LNG and importing to Finland. Large-scale LNG-ships are becoming common worldwide, and because the business is based on high gas volumes, lower price of LNG can be achieved. It depends on market built up if an LNG-terminal will be established in Finland by 2020. There is interest in LNG also in shipping companies like Viking Line that is surveying possibilities to invest in more environmentally friendly LNG-ships.



Natural gas grid in Finland, totally 2990 km (Source: Gasum Ltd.)

Proximity to biogas plant and upgrading platform

The existing biogas production units are covering the whole Finland excluding the northern part of the country. Biogas is produced in waste water treatment plants, landfills and biogas reactors. In addition many new biogas plants will be established by 2020. There is a good potential to utilise produced biogas as traffic fuel and expand the gas filling station network to central and northern Finland. There is the existing biogas upgrading plant and refuelling station near Jyväskylä showcasing and proving that the concept works. In addition investments have been done to start injecting upgraded biomethane into natural gas grid in 2011. In eastern Finland there is also survey going on to produce liquefied biogas (LBG) from landfill gas for traffic fuel use. It can be estimated that a high share of gas filling stations could be based on biogas production in Finland by 2020.



Biogas production units (totally 62 units) and localities where natural gas is used in Finland (Source: Finnish Gas Association)

Existing traditional refuelling stations that could be implemented

The petrol and diesel refuelling station network is dense in Finland. There is nowadays about 2200 traditional refuelling stations. However, the trend is that the number of traditional fuel filling stations is decreasing, and some fuel distribution companies have gone out of business in Finland. The existing gas distributing companies have co-operated with the traditional fuel distributing companies and there are already gas filling stations on the same refuelling sites with diesel and petrol pumps. The co-operation will be more widespread in the future, and some traditional fuel distributing companies might also start distributing biogas and natural gas.

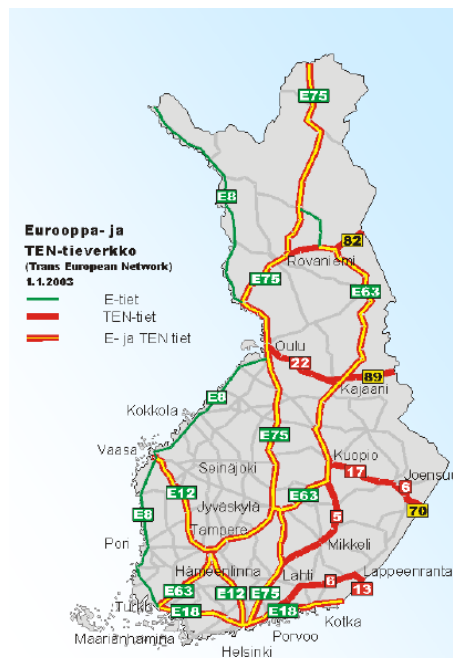
Fleet companies interest

The fleet companies are aware of environmental issues and potential crisis related to traditional fuel price. The awareness of gaseous fuels and gas vehicles is increasing, and it is

improving fleet companies interest in using gas vehicles. The gas refuelling infrastructure is boosting NGV markets ahead, and the increasing number of NGVs is boosting the establishment of new gas refuelling stations. The facts are positive related to biogas and natural gas as vehicle fuel, and these positive aspects will get even stronger emphasis by 2020.

Long distance pattern demand: highways and motorways

The most crowded highways in Finland should be covered with gas filling station network. Even though the population in Finland is moving more and more to southern Finland and big cities, the highways through the country are important traffic lanes in serving for example transportation companies as well as private persons driving to summer cottages and ski centres. The best locations for gas filling stations are along highways near a city so that filling station can serve both the local population and customers passing by through highway. The optimal situation would be to have a gas filling station every 50 km along the highways.



The most crowded highways in Finland (Source: Liikennevirasto)

Short distance pattern demand: urban areas

The population density in Finland is much higher in South- and West-Finland compared with northern and eastern part of the country. The traffic volumes are focused to South-Finland and to city areas. The urban areas with dense population are the most favourable locations for new filling stations. The 15 biggest cities are shown below, and by 2020 there should be several gas filling stations in each of these cities. In city centres of Helsinki, Espoo and Vantaa the aim is that the distance between the gas filling stations is max. 5 kilometres. In other urban areas the distance between the gas filling stations could be max. 15 kilometres. Additionally, in other cities with strategic location should be at least one gas filling station by 2020.

Biggest cities in Finland (Source: Väestökisterikeskus 10/2010)

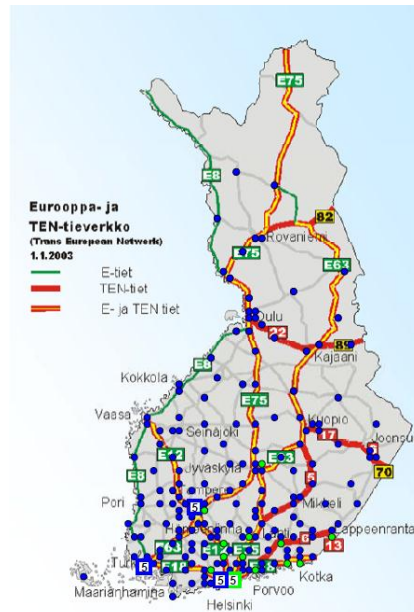
Town	Population
1 Helsinki	588.195
2 Espoo	247.333
3 Tampere	213.143
4 Vantaa	199.897
5 Turku	177.504
6 Oulu	141.284
7 Jyväskylä	130.857
8 Lahti	101.542
9 Kuopio	93.333
10 Kouvola	88.110
11 Pori	83.045
12 Joensuu	73.147
13 Lappeenranta	72.035
14 Hämeenlinna	66.790
15. Rovaniemi	60.038

Investment plans

There are nowadays five companies distributing methane as traffic fuel in Finland. The NGV market is increasing and new filling stations are needed to improve the infrastructure of gas distribution. The role of biogas is becoming stronger and new biogas plants are established in Finland. It is estimated that there are several new actors in gas distribution business in 2020 compared to the situation today. In the near future the operators of the local biogas production plants could be also operators and owners of the filling stations distributing biomethane. It is foreseen that the number of local biomethane distributors will increase rapidly.

Optimal locations of gas filling stations in 2020

Based on the visions and operational environment described above it is estimated that in 2020 there could be about 200 gas filling stations in Finland. To meet this target it requires new gas distributing companies in addition to the existing ones. Political regulations should also be favourable rather than hindering the development of NGV market. The optimal locations of new filling stations are shown on the map.



Optimal locations of gas filling stations in Finland by 2020
(Map layout: Liikennevirasto).

GERMANY

Fuelling Stations

The German Fuelling Station (FS) landscape has changed tremendously since the late nineties when stricter environmental laws were introduced. In 1969 there were in the „OLD“ part of Germany 46684 conventional FS. Since then the number of conventional FS has decreased to 14.100 in 2010.

The first Compressed Natural Gas Vehicle Fuelling Stations (NGVFS) came in operation in 1995 and since then have increased to 860 stations. Most of the NGVFS have been integrated into a conventional station.

The faces and images of the FS have changed quite a lot and every station has a supermarket with more than 500 articles for sale. From foodstuff, traveling needs, via cigarettes and alcohol. Most of the stations are operated 24 hours. The turn-over and profit from the supermarket is normally higher than the sales from the fuel.

The retail industry is not satisfied with this "substantially unequal treatment" of the different businesses. The FS's are very popular with the youth in the rural areas where they are used as meeting points for their later individual actions. Majority of the FS are operated and owned by the 7 international mineral oil companies like Shell, Aral, Esso, Total, OMV, Avia and Agip. Over 3500 FS's are independent stations from the big companies.

Natural Gas

The very old and poisonous „Town Gas Grid“ systems were changed to the Natural Gas Gridsystem all over West Germany until 1980. After the German unifications the rest of Germany has changed to the Natural Gas Grid in the late Nineties.

Now the length of the Natural Gas Grid in whole of Germany is over 440 000km. The Natural Gas supply contributes 22,5% of the Total Energy consumption in Germany. The supply is approximately 100 Mil m³ per year.

The local Natural Gas production is contributing approximately 20% of the Natural Gas Supply. The biggest local producer is BEB Erdgas und Erdöl GmbH (Hannover). Most of the Natural Gas is imported via pipelines from Russia (32%) Norway (26%) and the Netherlands (19%). There are new Gaspipeline Projects in the design stage. There are 2 Gas Groups in Germany. The H-Gas has a calorific value of 13.2 KWh/kg and the L-Gas of 11.2KWh/Kg Under the private gas utility companies is E.ON Ruhrgas (Essen), RWE Energy (Dortmund) the leaders with VNG – (Leipzig), Shell (Hamburg) and Exxon Mobil quiet close by.

Distribution companies are E.ON Gas transport, Gasunie (Germany) and Wingas (Kassel). There are over 700 local gas utility companies (mainly local Municipality owned companies) supplying the Natural Gas to the end user incl. the NGV Refueling Stations.

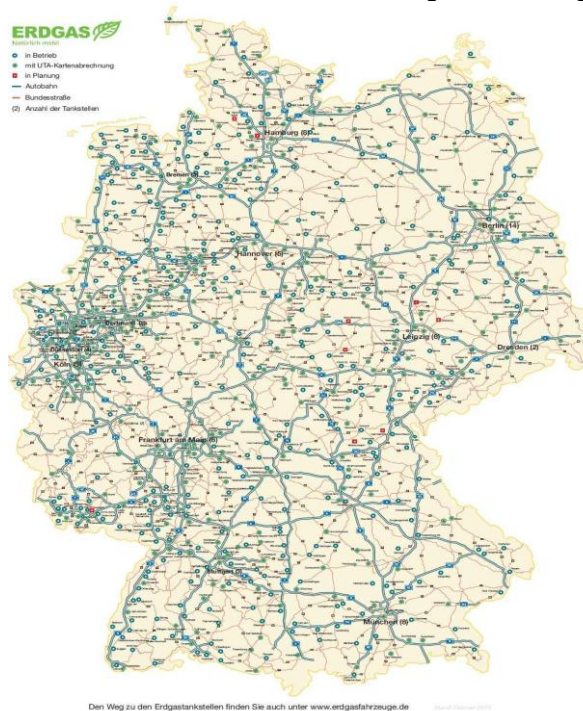
To overcome supply shortages and „Peak Demands“ 18.6 Milliard m³ of Natural Gas are stored in several Underground storages all over the Republic. The Gas Price is still connected to the Oil Price. Up to now there are no Liquefied Natural Gas (LNG) Terminals in Germany.

Vehicle Situation in Germany

The Total Number of registered Vehicles was 51.948.862 at the 01.01.2009 The Total Number of Natural Gas Vehicles (NGV) was at 90.397. That means that the NGV were only 0.17% of the Total Numbers of vehicles.

National situation and regional differences

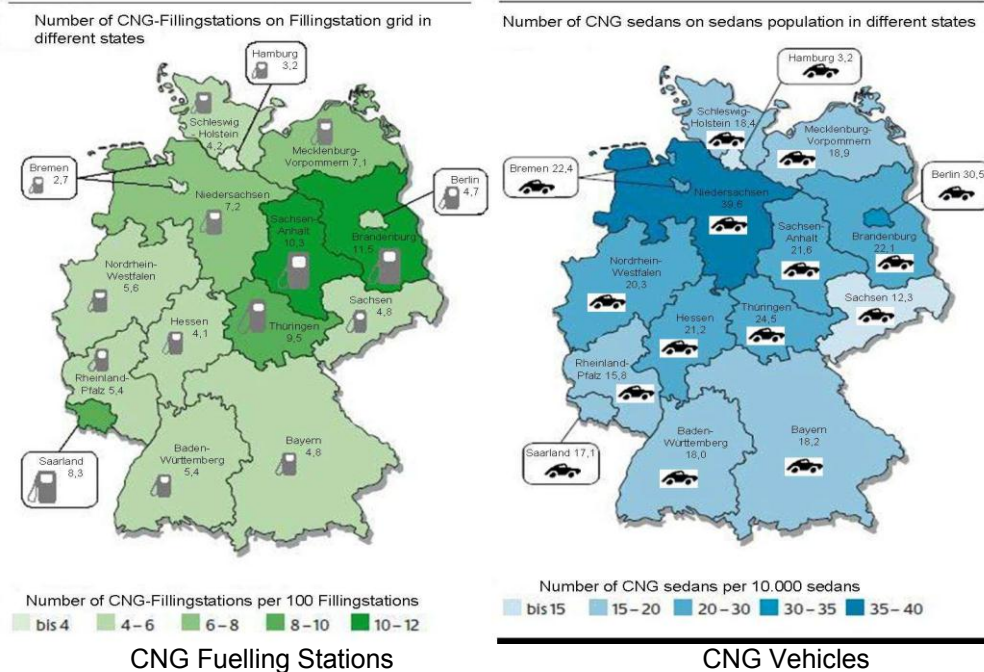
End of 2009 there were 860 Natural Gas Vehicle Fuelling Station registered.



Green circles are existing NGV/CNGFS.
The blue dual lines are the German „Autobahn“ Highway

Statistics

The following maps show the different Federal States with their corresponding NGV/CNG :



From the maps we can see that the Federal State Brandenburg with the highest number on NGV/CNG Vehicles has not the highest number on NGV/CNG Fuelling Stations.

The reason for this could be the marketing or incentive scheme of the local gas suppliers or the very local rural conditions. At the German Autobahn system there are 385 conventional Fuelling Stations with only 2 NGV/CNG Fuelling Stations. These Fuelling Stations have all restaurants and sanitary conveniences integrated.

Just 1 km from the Autobahn there are 125 NGV/CNG Fuelling Stations located. There also close to the Autobahn 210 „Truck Stops“ located with 24 NGV/CNG Fuelling Stations. The Autobahn A20 in the North/Eastern Part of Germany near to the Baltic Sea has over a distance of 340 km NO NGV/CNG FS facility.

Biomethane

Up to now there are only 2 Biomethane Refueling Stations in Germany.

Jameln and Dannenberg

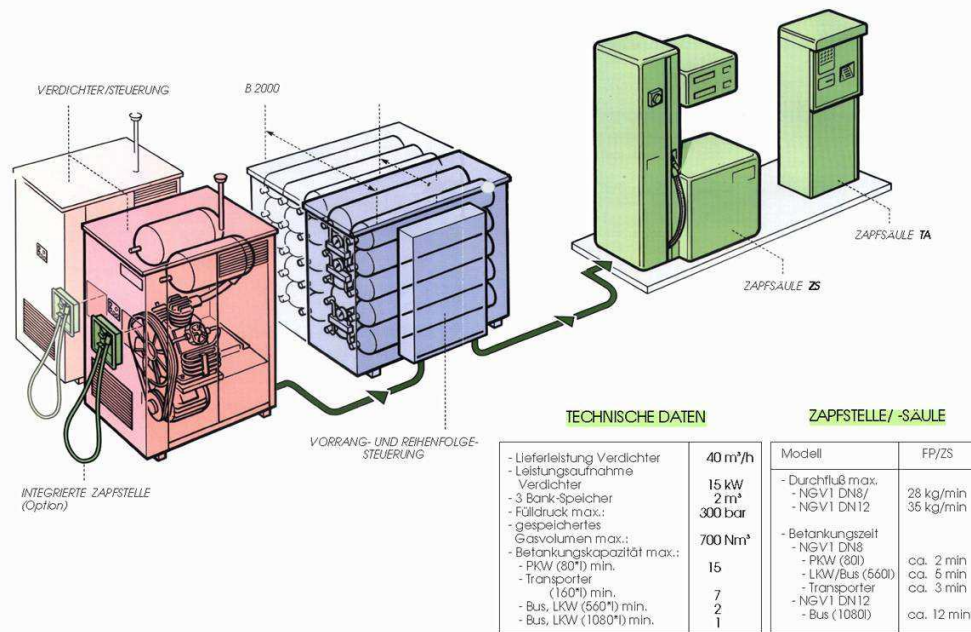
The first one is in Jameln in Niedersachsen (Lower saxonia) where the Farmers association (Raiffeisen Genossenschaft Jameln) is operating since June 2006 a NGV/CNG FS. After 3.5 years in operation the NGV FS reached its maximum capacity. Over the years the vehicle population has increased to over 200 NGV/CNG. The driving distance in these rural community is in average over 20.000 km/a. In Germany Vehicle average driving mileage is 12.300 km/a. The Jameln NGV/CNG FS gets its Biomethane from a close by Biogas Upgrading Plant.

So the vehicle owners drive their vehicle nearly without CO₂ emission because their fuel comes from energy crops. An interested farmer has already built another Biomethane Fuelling Station System with a dispenser at an existing conventional Fuelling Station (Raiffeisen Genossenschaft Dannenberg). The Biogas Upgrading Equipment is installed but they have to wait to get the permission from the local gas supplier to allow for the injection of the Biomethane to the National Gas Grid.

Type of Refueling Plant

In Germany with a number of 90.397 NGV/CNG vehicles and 860 NGV/CNG Fuelling Station we have in average 105 vehicles per Fuelling Station. In reality the average will be less because the Public companies with their Fleets (busses, refuse vehicles etc.) have their own filling stations.

The average sales per NGV/CNG Fuelling Station is 8.000 kg/month. The Flow Diagram of an average NGV/CNG Fuelling Station is below.



Function of a NGV/CNG Fuelling Station (NGV/CNG FS)

General description

The NGV/CNG FS is connected direct to the National Gas Grid. The air cooled compressor(s) and storage tanks (banks) are installed in a prefabricated concrete building.

Gas alarm device, dryers, gas safety devices and controls are installed in the same building. The compressor package(s) are controlled by individual programmable logic controller's (PLC's) located on-board, as well as a master PLC located in the control room. These PLC's control the starting and stopping of the compressors as the demand for gas changes, monitor for faults and alarms, and control the functions of the compressor packages. The motor starters for compressor package are located in the power room.

The majority of stations is run on self-service and „fast fill“ with filling times of 2 -4 minutes. There are 2 different gas qualities available on the market. It will depend on the areas in Germany where the supply of gas is coming from.

The H-Gas has a calorific value of 13.2 KWh/kg and the L-Gas of 11.2KWh/Kg. The price differs between 0.69 to 1.02 Euro/kg. because of the different value. There are few hundred „slow fill“ installation done all over Germany. No Mother and Daughter (Virtual Pipe) and Liquefied Natural Gas (LNG) Installations have been done in Germany.

We can find the following station installations:



Dispensers integrated with the other fuels Jameln with Compressor Building in the back



NGV/CNG Fuelling Station with Concrete Compressor Building on a conventional Fuelling Station with external Dispensers



NGV/CNG Refueling Station alone without any conventional Fuelling Station



Owners of NGV/CNG Refueling Stations

In most cases there will be cooperation between the Local Municipality and the operator of the conventional Fueling Station. The operator of the Fueling Station might be the Mineral oil company or the operator is owing or leasing the Fueling station.

In the majority of cases is the Mineral oil company the operator. The Local Municipality is in-charge of running the NGV/CNG Refueling Station. They are taking care of maintenance and their own CNG price. A rent will be paid for the occupying space of the NGV/CNG FS and service charge for collecting the CNG gas price.

Current status on legal conditions

National and regional laws, technical regulations

For the technical erection and running of a CNG Refueling Station only National laws and National standards will apply. The Building permit for the construction of a Fuelling Stations will be issued by the local authorities and their procedures have to be follow. The joint Technical Standard for CNG Fuelling Station G 651 A vdTÜV was introduced by the DVGW and TÜV. DVGW stands for (German Technical and Scientific Association for Gas and Water) and the world renown TÜV (Technical Inspection Authority) For NGV's construction is the UN-ECE 110 responsible.

For all CNG Fuelling Stations an individual explosion proof safety document has to be produced. All necessary standards and by laws identifications can be find in the G 651 A vdTÜV. Maintenance and operation of an CNG Fuelling Station will be done according to DVGW Standard G 651.

Welfare benefits, incentives, support scheme for methane and biomethane refueling stations development Incentives and Promotions

Most of the incentives are related to the NGV/CNG Vehicles and only indirectly to the Refueling Stations More than 120 of the local gas utility companies have incentive schemes which are all related to new, used – and/or converted CNG vehicles. The incentives are in the form of:

- Grant of EURO 200 per year for 3 years. The cars must carry the approved stickers to indicate that you are driving a sponsored NGV from the respective gas utility company. Payment yearly after one year and audio inspection of the NGV.



CNG Credit of 400 kg – 750Kg on the local gas utility companies Refueling Station. The same thing applies here also for the stickers. In average the credits are in the region of EURO 500 – EURO 750

- Taxi and Fleet vehicles can get in some municipalities a special rate for CNG.

The Bank for Reconstruction **kfw** gives special incentives for commercial NGV's and Biomethane driven vehicles when they have the following criteria:

- Exhaust Emission Standard EURO 5
- Vehicles according (EG) 715/2007 from 20.06.2007 (Class N1+ N2 up to 12 tons)
- Fuelling Stations for the vehicles mention before
- Heavy Duty Vehicles more than 12 tons with minimum Exhaust Emission Standard EEV

Bremer Offensive

It is a joint venture between the local gas supplier from Bremen (swb) and the Volkswagen Light Duty Division North.

For the whole year of 2010 the VW dealers and „Bremer Offensive“ will supply for a working week a VW Caddy Eco Fuel for all interested companies. The NGV is available for all its normal working tasks.

The driver can learn in this week all the advantages these vehicles can offer:

- Cheaper fuel Costs
- Driving in the otherwise forbidden „Umweltzone“ (restricted driving areas)

Only the fuel cost has to be paid.

Vehicle Taxes

From the 01.07.2009 all new limousines are under the new vehicle tax laws will be charged as follows and will consider CO₂ emission. (only consider petrol- and diesel fuel)

- Taxation for petrol vehicles for every started 100cm³ engine displacement Euro 2.00. Diesel vehicles will be charged Euro 9.50 for every started 100 cm³ engine displacement.
- CO₂ exemptions will be: a basic from 120g/km CO₂ will stay tax free but Euro 2.00 will be charged for every g/km above.

Investment Costs and Barriers

Refueling station investment and rate of profit

The Investment cost for a CNG refueling station is between Euro 190.000 and Euro 350.000. (No building included) The cost will depend on what type of installation, location and infrastructure will be there.

Normally there are 2 dispensers installed. Most of the installations are done by the local gas supplier and municipality. There are no private owners. The average monthly gas consumption at a refueling station is below 8.500kg with an average of 100 vehicles. Price per Kg in average 0.97Euro/Kg. This is not an economical and profitable turnover. The figures of vehicles have to be increased at least to 400 per FS and the vehicles frequenting the stations have to be on a wider range not only limousines and some Light duty vehicles (LDV). At the moment there are only few Heavy Duty Vehicles (HDV) using the public CNG stations.



Main barriers (technical, economical, legislative)

The general public is not aware of the Natural Gas as an vehicle fuel. If there is any knowledge in alternative fuels many people mixing it up with LPG. The advantages in the vehicle tax law for vehicle with lower CO2 emission have to be made more public. The benefits when using Biomethane as a fuel is not mention. Pricing at the refueling station is not very clear. It does not show the price advantages to the other fuels. All fuels should be related to its calorific value.

The following points are part of the frequent mention disadvantages:

- Not enough Refuelling Station
- Variety of NGV models (particular Taxi operators)
- Driving distance of NGV
- Engine sizes
- Car dealers sales staff knowledge

Potential in methane/ biomethane refueling stations

EU TASK and Request

The European union has set the target of increasing the share of biofuels and alternative fuels, including natural gas, in traffic to 10 and 20%, respectively, by 2020.

Biomethane

One of the most auspicious applications of biomass is the generation of biogas. In mid-2008 roughly 4.000 plants existed in Germany alone, in which biogas was created through fermentation.

Innovative technologies are available on the market, allowing biogas to be upgraded to natural gas quality – also called “biomethane” or “bio-natural gas” – and to be fed into the natural gas grid. This process makes possible the replacement of conventional natural gas in many areas, thus representing an important contribution to climate protection. Currently, around 39 plants feed biomethane into the natural gas grid in Germany. Several other projects are currently being planned or constructed, with a very clear growth trend □□Here are 13 good Resons as given by the Biogas Partners (dena German government parastatal organization):

- Biomethane protects our climate
- Biomethane reduces import dependency
- Biomethane stimulates regional development
- Biomethane is eco-friendly
- Biomethane secures material flow at the local level
- Biomethane comes from natural processes
- Biomethane stabilizes the energy system
- Biomethane uses existing infrastructure
- Biomethane exhibits a versatility of application
- Biomethane supports efficient combined heat and power systems
- Biomethane is a highly efficient biofuel
- Biomethane creates partnerships
- Biomethane is the intelligent option for the future

In reaching the aim the German Gas Suppliers associations has given a **voluntary statement** in where they promise to inject a minimum of 20% Biomethane to the National Gas Grid which will be used as vehicle fuel in the year 2020.

The aim of the government fuel strategy also is to have 1,4 Million NGV's on the road in the year 2020. That would mean that there has to be a 29% increase of NGV's every year. By 2020 the target of the Government is to inject 6 Mrd. m³ per year to the National Gas Grid. To reach this aim few hundred medium size Biogas Upgrading Plants have to be built.

In Germany most of the injected Biomethane will be used in the more profitable Cogeneration of electric power and heat. The prices for the cogeneration are contractually guaranteed for the next 20 years by the EEG Law. (EEG=Renewable Energy Sources in the Electricity Sector) Biomethane is exempted from the Energy Tax up to 2015 but does not receive any other favourable incentives. The Government is checking the exemption from the Energy Tax for the mixture of 20/80 (Biomethane/Natural Gas).

Biomethane Refueling Stations

There are only 2 100% Biomethane Refueling Stations in Germany. A third one is ready to be opened. The oldest and public station is in Jameln and opened in 2006. The Biomethane is produced from Energy Crops. The Biomethane production is now over 15.000kg per month.(The German average is 8500kg/month) So the CO₂ emission from these over 200 CNG vehicles is nearly neutral and the prices are the same as any other CNG station 0,96 Euro/kg.

The design limit of the Biogas Upgrading equipment and the CNG compressor station is achieved. A farmer from the community has only 15 km from Jameln built close to his biogas plant and Biogas Upgrading equipment the Third Biomethane Refueling Station in Germany. He is awaiting for his legal connection to the grid.

Both installations have CHP and Biogas Upgrading installations and they are doing the upgrading of the Biogas with Amin wash and Physical Absorption Scrubber. The second Biomethane Refuelling station was built in Bottrop on a Sewage treatment Plant. The Biomethane is produced from the sewage sludge and supplies internal the 20 Light Duty vehicles of the plant and of the Municipality.

Bioerdgas Refuelling Stations

Bioerdgas is the term used by the German Gas Supply companies when a mixture of a minimum of 10% Biomethane is at the dispenser at the Refueling Station. End of 2009 12% of all 850 CNG refueling stations had 10% Biomethane at the dispenser. The aim is 20% Biomethane at all dispensers by 2020. Berlins 15 CNG Refueling stations receive their 20% Biomethane from 1 Biogas Upgrading Plant (Rathenow) where half of its daily Biomethane production is injected to the National Gas grid and been used as fuel. The price of the Bioerdgas 20% is not increased by the Natural Gas supplier GASAG.

Optimal location of new gas filling stations in Germany

Regional Differences

There are over 14.500 conventional filling stations compared to 860 CNG filling stations at the end of 2009. The following maps show the different Federal States with their corresponding CNG vehicles and CNG filling station:

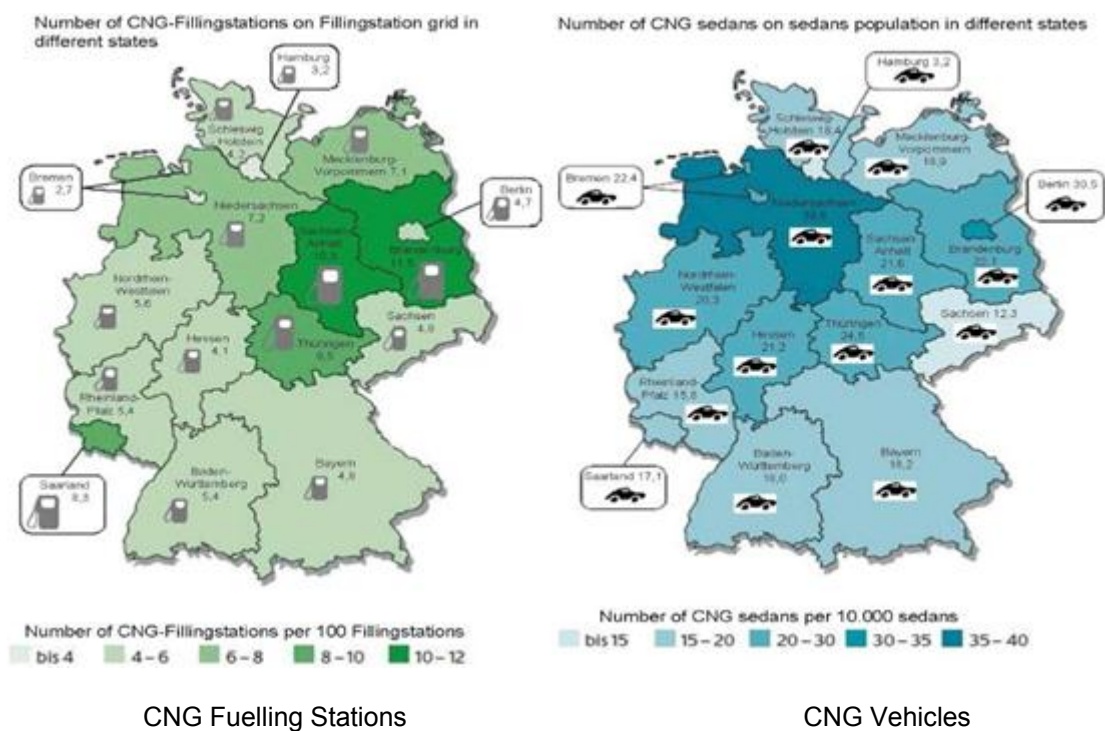


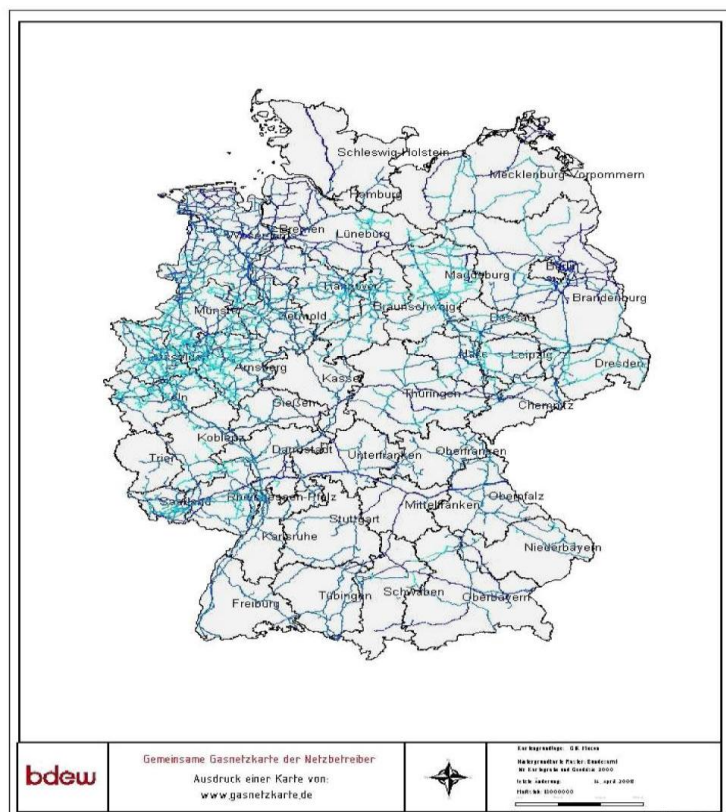
Fig. 139 shows that the Federal State Lower Saxony with the highest number on CNG vehicles (39.6 CNG vehicles per 10.000 vehicles) has not the highest ratio on CNG filling stations (7.2 CNG filling stations per 100 conventional refueling stations). One of the highest numbers of CNG filling stations is in the Ruhr Region in North Rhine-Westphalia. Another region with lots of CNG filling stations is from Saarbrücken to the Rhine-Neckar Metropolitan Region to the Stuttgart Metropolitan Region – especially along the motorways in these regions.

Proximity to gas grid compared with the possibility of using LNG

The natural gas grid in Germany is over 440.000 km long. In Germany there are 2 different gas groups with different calorific values. Calorific value of the H-Gas is in the region of 12.9 – 15.7 KWh/m³ and the L-Gas of 10.5 – 13.0KWh/m³.

The natural gas supply contributes 22.5% of the total energy consumption in Germany. Gas supply is approximately 94 billion m³ per year (2009). Local German natural gas production is contributing approximately 20% of the Natural Gas Supply. BEB Erdgas and Erdöl GmbH (Hannover) is the biggest local producer. Most of the natural gas is imported via pipelines from Russia (32%), Norway (26%) and the Netherlands (19%). There are new gaspipeline projects in the design stage. The biggest gas utility companies in Germany are E.ON Ruhrgas (Essen), RWE Energy (Dortmund), VNG (Leipzig), Shell (Hamburg) and Exxon Mobil (Hannover). The leading gas distribution companies are E.ON Gastransport (Essen), Gasunie (Germany) and Wingas (Kassel). More than 700 companies – mainly local public utility companies – distribute natural gas to end users. Existing CNG filling stations are all connected to the natural gas grid.

As there often is no gaspipeline next to the motorway, therefore the use of LNG could be an alternative. Up to now there are no liquefied natural gas (LNG) terminals in Germany. The LNG has to be imported from the Netherlands, Italy or Spain. For more than 25 years there are considerations to built a LNG-terminal to reduce the dependency from gas transports via pipelines. There are few companies are considering to use LNG for special application e.g. ferries on the Lake Constance and for ships on the different river transport. The problem here is another, which are the non-existence of regulations for dual fuel engines.



Natural gas grid without local distribution systems (www.gasnetzkarte.de)

Proximity to biogas plant and upgrading platform

In mid-2010 roughly 4.800 biogas plants existed in Germany. Innovative technologies are available on the market, allowing biogas to be upgraded to natural gas quality – also called “biomethane” or “BioErdgas” – and to be fed into the natural gas grid. This process makes possible the replacement of conventional natural gas in many areas, thus representing an important contribution to climate protection. Currently around 40 plants feed biomethane into the natural gas grid in Germany. Several other projects are currently being planned or constructed, with a very clear growth trend. By 2020 the target of the government is to inject 6 billion m³ per year to the national gas grid. To reach this aim few hundred medium size biogas upgrading plants have to be built.

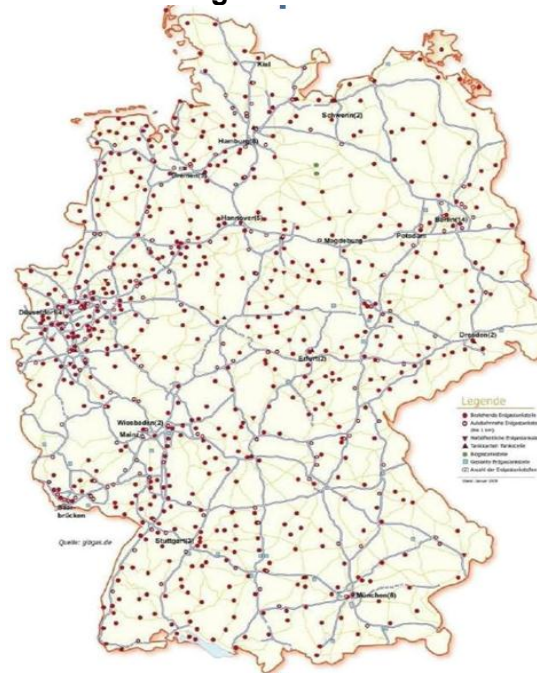
In Germany most of the injected biomethane is used in the more profitable cogeneration of electric power and heat. The prices for the electricity are contractually guaranteed for the next 20 years by the EEG (Erneuerbare-Energien-Gesetz, Renewable Energy Act). There is a bonus for biogas upgrading and feed-in to the grid, but only in case that the biomethane is used for electricity production in CHP units. There is no financial support for using biomethane as a vehicle fuel.

In reaching the aim the German gas suppliers association has given a voluntary statement to inject a minimum of 20% biomethane to the national gas grid which will be used as vehicle fuel in the year 2020. The aim of the government fuel strategy also is to have 1,4 million NGV's on the road in the year 2020. That would mean that there has to be a 29% increase of NGV's every year. Biomethane is exempted from the Energy Tax up to 2015 but does not receive any other favourable incentives. The Government is checking the exemption from the energy tax for the mixture of 20/80 (Biomethane/Natural Gas).



Biogas plants with upgrading and feed-in to the natural gas grid (GERBIO)

Existing traditional refuelling stations that could be implemented



Gas filling stations (www.gibgas.de)

There are only 2 biomethane (100%) refueling stations in Germany. A third one is ready to be opened in January 2011. The oldest station is in Jameln and opened in 2006. The biomethane is produced from energy crops. The biomethane production is now over 18.000kg per month (German average: 8.500kg/month). So the CO₂ emissions from these over 245 CNG vehicles are nearly neutral and the prices are the same as any other CNG station 0.96 Euro/kg. The design limit of the biogas upgrading equipment and the CNG compressor station is achieved. A farmer from the community has built only 15 km from Jameln close to his biogas plant and biogas upgrading equipment the third biomethane refueling station in Germany. He has received after a long struggle his permission for his legal connection to the grid. Both installations have CHP and biogas upgrading installations and they are doing the upgrading of the Biogas with amine gas treatment and water scrubber. The second biomethane refuelling station was built in Bottrop on a sewage treatment plant, it is non-public. The biomethane is produced from the sewage sludge and supplies internal the 20 light duty vehicles of the plant and the municipality. "Bioerdgas" is the term used by the German gas supply companies when a mixture of a minimum of 10% biomethane is at the dispenser at the refueling station. End of 2009 12% of all 850 CNG refueling stations had 10% biomethane at the dispenser. The aim is 20% Biomethane at all dispensers by 2020. Berlins 14 CNG refueling stations receive their 20% biomethane from 1 biogas upgrading plant (Rathenow) where half of its daily biomethane production is injected to the national gas grid and used as fuel. The price of the Bioerdgas 20% has not been increased by the gas supplier GASAG. Basically the implementation of CNG pumps at existing petrol stations is the "normal" way in Germany. But there are also some filling stations that only consists of a CNG pump and no common petrol station.

Fleet companies interest

All local public utility companies and gas supplier operating NGV refueling stations have CNG vehicles. Until now only 3 % of the fleets include gas vehicles – and these are not only

NGVs but also LPG-vehicles. For example the “Deutsche Post” and some parcel services and the “Telekom” have NGVs. Some rental car companies offer NGVs as well, but there are still enough people who are afraid that there are not enough filling stations or that the refuelling is too complicated or even dangerous. Some cab companies also use NGVs, but this is depending on the number of refuelling stations that are located near their main catchment area. According to a survey in 2009, 17 % of the fleet managers consider to purchase gas vehicles (CNG or LPG) within the next three years. Especially smaller companies that act regional are interested in case there are one or two gas fuelling stations in the proximity.

Long distance pattern demand: highways and motorways



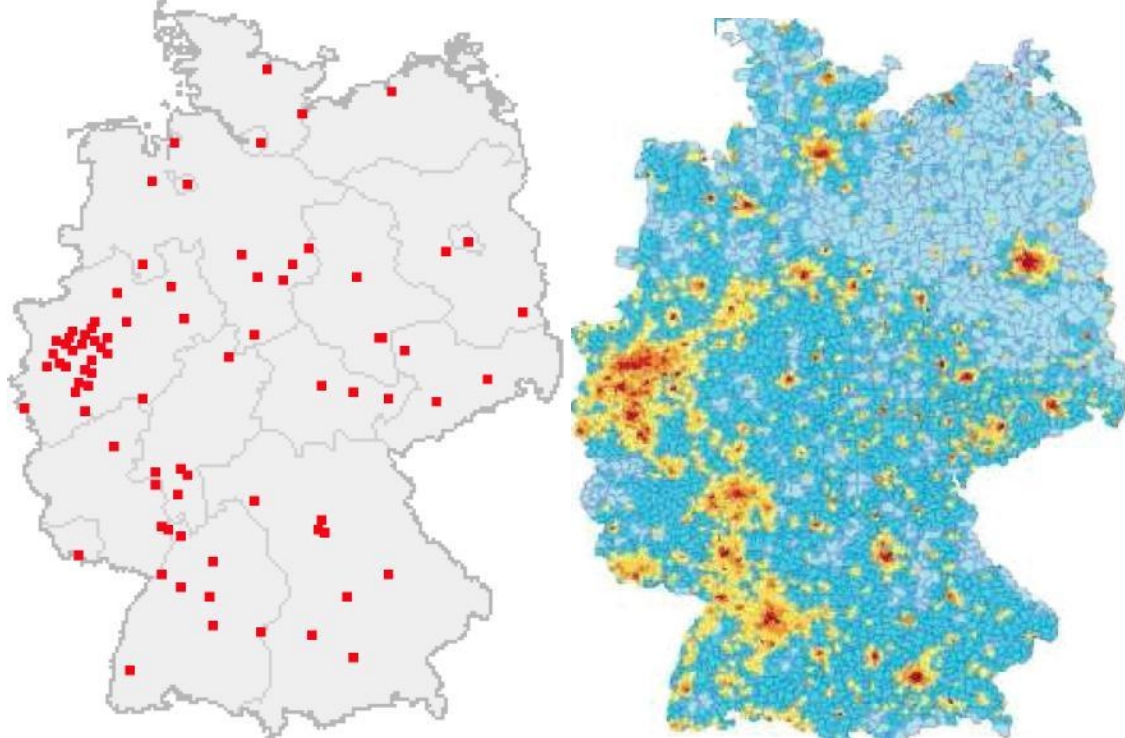
Motorways (source unknown)

At the German motorway system there are so-called “Raststätten” or “Rasthöfe”, motorway service areas where you don’t have to leave the motorway and so-called “Autohöfe”, motorway service areas where you have to leave the motorway. There are 385 Raststätten with conventional filling stations but only 2 with CNG filling stations. The reason for this is, that there often is no gas pipeline next to the motorway so it would be too expensive to build a gas pipeline only for one filling station. Close to the motorways there are located 210 Autohöfe, 24 with CNG filling stations. Just 1 km from the motorway there are 125 CNG filling stations located. The motorway A20 in the North/Eastern Part of Germany near to the Baltic Sea has over a distance of 340 km no CNG filling station.

As the NGVs are particularly interesting for long-distance drivers, it is important to expand the gas refuelling system near the motorways and highways. For most people it will be acceptable to leave the motorway to refuel at a Autohof, but almost nobody will accept to drive away more than 2 km from the motorway only for refuelling.

Short distance pattern demand: urban areas

Most cities with more than 100.000 inhabitants have at least one gas filling station. From Fig. 4 you can see, that there are some rural areas with low density of gas filling stations. There are some areas in east Germany or for example the mountain ranges Eifel and Hunsrück where are only less filling stations, these are areas with low population densities. One can say that areas with high population density as well as areas with high traffic density have also the highest density of gas filling stations.



Cities with more than 100.000 inhabitants (left), traffic density (right, www.pvt.de)

Investment plans

In 2009 the Federal Network Agency decided on 200 applications from energy suppliers for investment budgets. From 4.3 billion Euro that were permitted, about 4 billion were for the expansion of the electricity grid and only 80 millions for the expansion of the natural gas grid. The transmission grid is owned by a few large gas suppliers in Germany or neighbouring countries. The local distribution grid is owned by gas suppliers or local public utility companies. The gas filling station is often located at a “normal” filling station. Responsible for the gas filling station is the gas supplier, not the owner of the petrol station.

In “Erdgas Mobil” some leading companies of the gas economy incorporated to establish natural gas and biomethane as a vehicle fuel. According to Timm Kehler, the CEO of Erdgas Mobil GmbH, the focus for new gas filling stations is mainly near the motorways, where about 150 new stations are planned. And it is also planned to fill the “white spots” of the gas filling station map in the near future.

ITALY

Barbara La Licata, Fabio Sagnelli, Paola Zitella ENVIRONMENT PARK S.p.A.; Francesco Bazzoffi, Maurizio Cocchi, ETA FLORENCE.

Italy is strongly dependent on natural gas imports which in 2007 supplied around 40% of its gas requirements. Italy has emerged as a Euro-Mediterranean trading hub for natural gas coming from North Africa, the Middle East, Russia and elsewhere, with considerable investments in recent years on infrastructure. Pipelines exist between Italy and Algeria, Russia, Norway, Holland, and Libya.

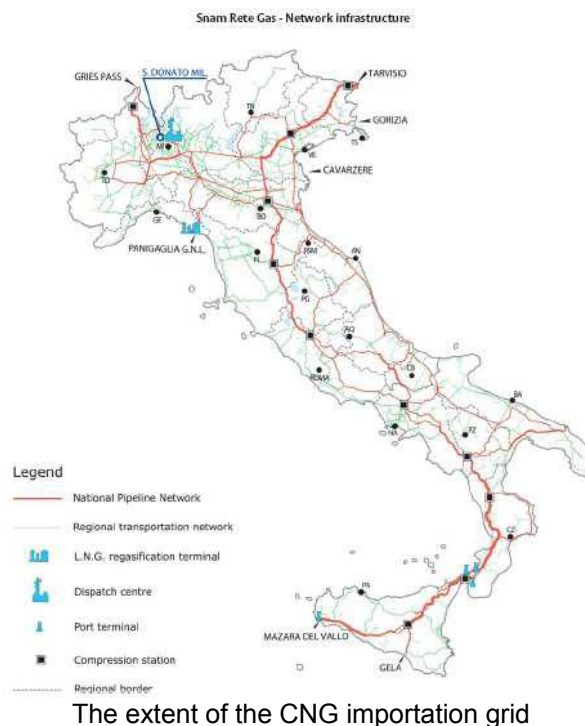
Italy also imports a relatively small amount of gas as liquefied natural gas (LNG), but is increasing its ability to import LNG by constructing additional receiving terminals at some of its port facilities with a new terminal recently approved in the south of the country and around five further projects currently under discussion.

Snam Rete Gas manages the natural gas transportation service in Italy, through its nationwide gas pipeline network system. Snam Rete Gas is the market leader in the Italian natural gas transportation and dispatching sector, it transports and dispatches natural gas and regasifies LNG using an integrated system of infrastructures:

- gas pipeline network (approximately 31.500 kilometers in Italy);
- 11 compression stations;
- the Panigaglia LNG terminal;
- 8 regional operating centres;
- 55 maintenance centres

The network is directly connected to the production fields, import lines and storage centres which feed the Italian gas system. Commercial and domestic end users are supplied via a group of local distribution companies.

The following map demonstrates the extent of the CNG importation grid which is currently existing:



In total, the national situation says that in 2007 over 420.000 cars run on Natural Gas, with around 100.000 new NG cars in 2007, refilling at more than 650 stations. In addition, about 50 Italian towns run 2.100 Natural Gas urban buses and around 800 NG vehicles for municipal services and urban goods distribution.

Statistics

Italy currently has the largest number of CNG vehicles in Europe and is the 4th country in the world for number of CNG-powered vehicles in circulation. Refuelling stations have grown from 370 at the end of 2001 to more than 700 in 2009. Italian filling stations distribution and localization are summarized in the figure below:



Number of filling station in Italy

In 2008 Eni, the Italian main integrated energy company, strengthened its leadership (sixth place in the world) in terms of automotive methane sales. In Italy in particular, which has the greatest number of methane powered vehicles in Europe, with over 500,000 vehicles on the road, Eni increased its sales from 440 million m³ in 2007 to 452 million m³ in 2008. Of the 702 automotive methane service stations, 492, equivalent to around 70% of the total, are supplied by Eni.

The distribution network for methane is growing continuously. Recent estimates indicate around 430.000 vehicles running on methane. The Italian regions with the highest number of vehicles running on methane are: Emilia Romagna, Marche and Veneto.

Type of plant

Italian industry is a leader in production and development of natural gas technologies in transport.

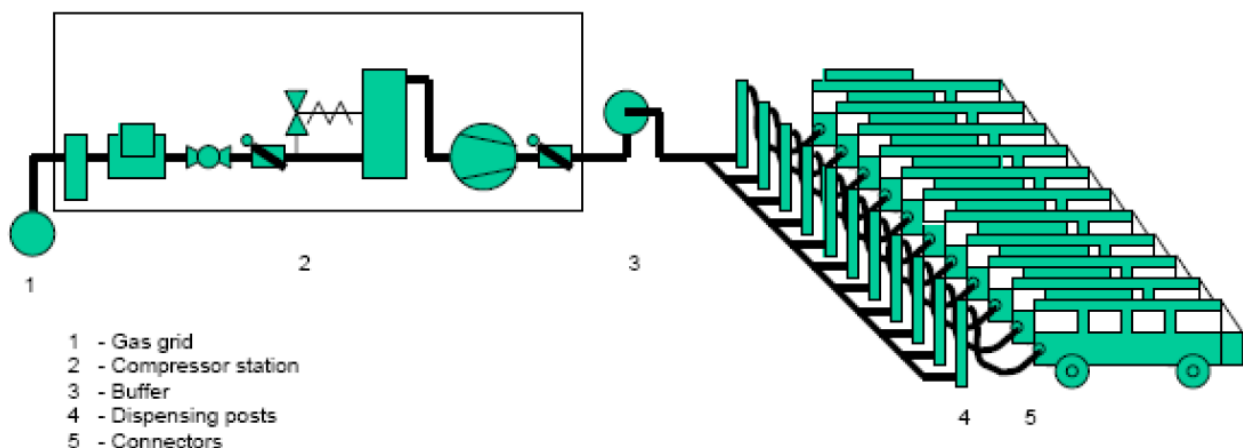
The Italian Companies can offer filling stations from min to max size, from design to “turn-key” supply as well as engines, fuel systems for OEM and aftermarket, fuel control modules.

Type of CNG filling stations can differ mainly in terms of size of the plant and in terms of type of fleet that is going to use the filling stations but, in general, a filling station full-service maintenance covers all the following components:

- compression units
- electric motor drive
- main cooling system
- extra cooling system for gas at distribution
- lubrication system
- gas storage
- power control/panel
- control/managing instrumentation
- operation and regulation devices, both manually and automatically operated
- mechanical and electronic safety devices
- gas measuring system
- air compression system
- particulate filtering, liquid separation and moisture drying systems
- auxiliary storage
- high pressure tubing
- CNG multilevel dispensers
- CNG high capacity dispensers
- sequential refilling systems.

However, summarizing, the main components of a CNG filling stations are the gas inlet, the dryer, the compressor, the storage and the dispenser.

The mentioned components can be used in different ways according to the following general scheme:



Main components of a CNG filling stations

The use of CNG for vehicle propulsion in Italy is quite widespread, both in the public as well as in the private sector. Main reasons are not only the environmental benefits from using methane for transport but also, besides polluting less, that CNG is cheaper than oil and diesel and that the refueling infrastructure for methane is growing continuously.

Fiat pioneered methane fuelled vehicles over 10 years ago and is now Italy and Europe's leading manufacturer of original methane fuelled vehicles (OEM) offering a wide range of dual fuel models. Fiat's ecological "Natural Power" versions are available in a choice of models, from the compact (Panda) to the multi-space models like the Doblo and the Qubo.

Current status on legal conditions

National and regional laws, technical regulations

The natural gas sector has been subjected to stringent regulation at national and Community levels. Specifically the regulation process was set in motion at the European level by the Gas Directive which defined common rules for the transportation, distribution, supply and storage of natural gas. This Gas Directive was adopted in May 2000 in Italy through the Legislative Decree of 23 May 2000 (the so-called "Letta Decree").

The Letta Decree introduced regulations in the gas market in Italy to encourage a greater deregulation of the market. The Decree specifically identifies and defines segments of the gas market (import, production, export, transportation, dispatching, storage, regasification of LNG, distribution and sale) and establishes the main regulating principles in terms of liberalisation, corporate separation, network access and transparency.

On the basis of current regulations, the important role and responsibility for regulation of the sector is delegated to the Ministry for Economic Development and to the Italian Authority for Electricity and Gas.

Italian current regulations for CNG filling station realization can be summarized by the following:

- D.M. 24 maggio 2002 – fire prevention regulation for CNG road filling stations
- D.M. 24 novembre 1984 – fire prevention regulation for CNG tubing
- D.Lgs. n. 93 del 25 febbraio 2000 – Attuazione
- Direttiva 97/23/CE – for CNG vessels
- Norma CEI 64-8 (IV ed.) – for electrical system
- Direttiva 94/9/CE del 23 marzo 1994 (Atex) – for electrical system
- Norma CEI EN 60079-10 – for electrical system in case of CNG installations
- Norma CEI 31-35 (classif. 31-35) – for electrical system in case of CNG installations.

Moreover, the recent modification of the legislation that allows the construction of multi-fuel stations with CNG or small CNG station next to petrol ones, as well as the possibility to install selfservice refueling systems at the CNG filling stations, will bring a further increase of the Italian CNG distribution net.

Welfare benefits, incentives, support scheme for methane and biomethane filling stations development

The country’s successful development in the use of CNG for transport can be attributed to the government’s attitude toward this kind of fuel, with a technological developments in the country.

The Italian government has shown strong commitment over the years to address the issues of air quality and energy dependency. As part of this initiative, the Italian government has provided a number of incentives for car manufacturers and consumers to switch to CNG and LPG vehicles. The Italian government decided to promote the purchase of methane fuelled vehicles in 2009 by offering a high incentive (3.500 Euros) in addition to that already available for scrapping an old car:

2 nd package of anti-crisis measures (decree-law 10/02/09, n.5)	
Incentives for buying cars	A bonus of € 1.500 for the purchase of a Euro 4-5 car (below 130 gCO ₂ /Km if Diesel, below 140 gCO ₂ /Km if gas) with contemporary scrapping of an old vehicle (more than 10 years). A bonus of €1.500 for the purchase of an ecologic car (methane/electric/hydrogen) without scrapping. In case of scrapping incentives are cumulated (€3.000). Ecologic cars with particularly low CO ₂ emissions can reach a bonus of € 3.500.
Incentives for buying commercial vehicles	A bonus of € 2.500 for the purchase of new vehicles with the contemporary scrapping of Euro 0-1-2 vehicles. Incentives up to € 4.000 for the purchase (without scrapping) of innovative new vehicles (methane/electric/hydrogen). Incentives can be cumulated with scrapping.
Incentives for the conversion to LPG/Methane	The State contribution for transforming gas engine cars towards lower-environmental impact cars increases from 350 to 500 € (for LPG) and from 500 to 600 € for methane.

In addition to incentives for vehicles, some Italian regions have enacted special incentives for the developing of the CNG filling stations infrastructure:

- Liguria Region, year 2010: Public bid (total budget 1.050.000€) for private or public entities interested in opening new CNG filling stations. Eligible costs can be reimbursed up to 70% of the total with a limit of 90.000€ per CNG filling station
- Lombardia Region, year 2010: Public bid (total budget 2.000.000€) for private or public entities interested in opening new CNG filling stations. Eligible costs can be reimbursed up to 50% of the total with a limit of 200.000€ per CNG filling station.
- Piemonte Region, year 2009: Public bid (total budget 339.000€) for SME interested to install natural gas fueling dispenser in traditional fueling stations. Eligible costs can be reimbursed up to 70% of the total with a limit of 90.000€ per CNG filling dispenser.
- Trentino Region (Bolzano city area): Until 31.12.2011 (three years). Financial contribution (total budget 3.200.000€) to cover part of the investment costs borne by

service stations which install a gas outlet. The contribution will depend on the number of outlets already existing in the various comprensori. It will be 70% of the eligible costs for the first two outlets of a comprensorio, and 40% for the next outlets, up to the fifth outlet. A contribution of 70% will be granted to existing gas outlets for investments concerning the upgrade of existing equipment enabling a reduction in refueling time. Overall eligible expenses cannot exceed 500.000€.

Investment costs and barriers

Refuelling station investments and rate of profit

In Italy, depending on the region, a CNG filling station can be realized as a solely installation or, in order to differentiate the fuel offer, in an already existing station.

Before deciding to invest in natural gas filling station, it is necessary to consider some elements:

- Area location;
- Eligibility in full obedience of the overall development plan;
- Safety regulations;
- Feasibility project;
- Preliminary project of the installation;
- Estate costs, demolition and renovating costs;
- Filling station costs (fuel dispensers, pumps, compressors, point of services etc.);
- Possibility of connection to the gas grid;
- Possibility of power supply and connection to water;
- Electrical equipment;
- Public works (shelter, large square, link road);
- Environmental impact analysis (use of renewable energies for energy consumption reduction).

To build a gas filling station it is necessary to have many permits; in Italy, 12 month is the time required to build a gas filling station. The authorizations inquiry required are:

- Declaration of the suitability of the area for the specific installation from the cognizant Municipality;
- Fire department preventive advice;
- Licence for fuel selling (station asset and mode of se – private or open to the public);
- Planning permission (from the cognizant Municipality), s well as the environmental impact;
- Analysis and the sanitary authorization;
- Permit for road access.

As regards the investment costs, in the table below there is a summary of costs for a public or a private gas filling station.

Investment costs for gas filling station

	PUBLIC GAS FILLING STATION		PRIVATE GAS FILLING STATION		
	Mono-fuel	Multi-fuel	Minimum	Medium	Large
Annual supply (m ³)	>1.000.000	>500.000	150.000-200.000	1.000.000-1.200.000	2.000.000
Number of vehicles	500-600	250-300	50 cars+ 2 bus	100 cars + 20-30 bus	>100 cars +50 bus
Technologies costs € (Fuel supplying, compressors etc.)	350.000-450.000	250.000-350.000	80.000-120.000	350.000-450.000	500.000-800.000
Connection to electrical grid €	50.000-70.000		15.000	25.000-40.000	
Connection to gas grid €/m	200				

The pressure of methane from gas grid affects compression costs:

- low pressure (3-5 bar): 0.02-0.03 €/m³
- medium pressure (20 bar): 0.02 €/m³
- high pressure (40 bar): ≤0.015 €/m³

The maintenance costs could vary from 3.000 €/year to 8.000 €/year according to the dimensions of gas filling station.

Main barriers (technical, economical, legislative)

In Italy at the moment, there are approximately 580.000 CNG running vehicles; in fact, due to the high cost of gasoline and diesel, many car manufactures have introduced natural gas vehicles in the market. Despite of this leadership, the refuelling infrastructure is not optimized and is still insufficient compared to other countries: about 700, with 23 gas filling station on the motorway, one methane service station every 3.6 LPG service stations.

In order to enhance the potential value of methane, it is necessary to enlarge the number of gas filling stations and to promote the developing of alternative filling system like home filling system.

In particular one of the main problems connected to CNG filling stations is the location: most of methane service stations are out of the cities, far away from the centre, and a very low number of stations are localized on Italian motorways compared to the number of gas vehicles. So it is necessary to develop the network of CNG filling stations both near the centre of the cities and on the main roads.

As regards the agreement between the customers of gas filling station and the Grid operator, one of the main problem is represented by the penalties if they exceed the daily allowed consumption rate.

One of the most frequent technical problem that customers face daily is the waiting period for supplying methane in service stations. The engine of the compressors often doesn't support

the load for the supplying from gas grid, so the time for supply a car could increase till 10-15 min, causing a dissatisfaction on final customers.

These types of problems could be solved by improving the methane services technologies with most suitable engine compressors related to the number of vehicles served. For examples in this of view, Regione Emilia Romagna has been fixed the lower limit for CNG supply at 450 m³/h in order to optimize the vehicle filling time (DCR 355/2002, Emilia Romagna). Furthermore, photovoltaic panels for the production of electric energy (at least 8 KW) are integrated in the structure of recent service station in order to support internal costs.

Potential in methane/ biomethane filling station

Trends in technology

Actually, technology improvements could be carry out both on natural gas vehicles and on gas filling stations. The technology in vehicles' engines has undergone steady refinement during its ten years on the market, in particular many steps further are taken in these ambits:

- Gas cylinder valves with enhanced safety features;
- Monitoring of on-board CNG installations;
- Connections and couplings optimized for very fast filling;
- High-strength steel or fibre reinforced gas cylinders that lighten vehicles and increase energy efficiencies;
- Gas cylinders integrated in the vehicle structure;
- No on-board space limitations;
- Low fuel consumption and very low emission engines;

The cost of a methane-fuelled engine makes the price of a new car slightly higher, but driving on methane generally means significantly lower operating costs – and the higher purchase price is quickly recovered through lower fuel costs. Depending on the market, the cost of driving on methane is 20 – 60 percent lower than for petrol and between 20 and 40 percent lower than when running on diesel.

As regards innovation in gas filling station technologies, the trends are:

- Trend to develop modular filling stations;
- Low energy consumption;
- Low noise in the supplying;
- Urban environment care;
- Use of hydrogen and biogas blends;
- Trend to develop self service and multidispenser CNG filling stations;
- Use of renewable energy by using photovoltaic panels integrated in the structure of service station in order to support internal costs;
- About the logistics of gas filling station network, the main steps that could be take are:
- Plan of filling station distribution for service optimisation on a “regional” basis
- Use of innovative systems for CNG fleet management
- Use of innovative systems for filling station management (both on public and private stations)

Besides the use of compressed natural gas on vehicles, a new trend is represented by Liquefied Natural Gas (LNG) that is natural gas that has been converted temporarily to liquid form for ease of storage or transport.

The liquefaction process involves removal of certain components, such as dust, acid gases, helium, water, and heavy hydrocarbons, which could cause difficulty downstream. The natural gas is then condensed into a liquid at close to atmospheric pressure (maximum transport pressure set at around 25 kPa/3.6 psi) by cooling it to approximately $-162\text{ }^{\circ}\text{C}$. The reduction in volume makes it much more cost efficient to transport over long distances where pipelines do not exist. Where moving natural gas by pipelines is not possible or economical, it can be transported by specially designed cryogenic sea vessels (LNG carriers) or cryogenic road tankers.

Global demand for natural gas may double by 2030, with LNG growing perhaps fivefold – driven by continued cost reduction. Despite the capital intensity of LNG projects and the complexity of the value chain, LNG supply capacity is increasing rapidly. Existing schemes are being expanded and many greenfield projects are moving ahead. The operational costs (electric power and maintenance) for CNG delivered from an L-CNG station will be at least 2/3 lower than the costs at a conventional CNG station; in fact, for a conventional CNG stations the electric power demand depends on pressure in the grid, the higher the inlet pressure, the lower the compression energy demands). Moreover the transportation costs for LNG are lower than for CNG, as report in tab.22.

Transportation costs – CNG vs LNG

One way distance	CNG 1.6 ton swapbody (S/GGE)	LNG 21 ton trailer (S/GGE)
62.5 miles	0,78	0.11
125 miles	1.46	0.22
250 miles	2.91	0.34

Although the spot market for LNG is growing, new projects continue to be underpinned by longterm sales contracts.

On the other hand, the upgrading of biogas into biomethane for its use as transport fuel has been recently gaining a lot of interest among biogas producers, fleet owners, public institutions and other stakeholders. The December 2008 Green Paper on the Management of Biowaste in the European Union recognized biogas as an opportunity to reduce GHG emissions most significantly if used as a biofuel for transport or directly injected into the gas distribution grid.

Bus fleets using purified biogas are already running in the major European cities, Sweden being the pioneer in testing this technology at large scale. Italy is the third European biogas producer (80% from landfill) with 220 million of cubic meters of biogas produced against a potential of 54 million of cubic meters. Despite of this great potential, biogas is used in Italy in CHPs for the production of electric and thermal energy supported by the issue of green certificates. A feasibility study, led by Piedmont Region in collaboration with CRPA, showed the economic convenience of biomethane production for its use as a fuel when the size of the production plant is large enough to produce at least 150-200 Nm³/h.

The lack of specific references to biogas/biomethane in the national legislation for the regulation of transport and distribution of natural gas represents the main barrier to the exploitation of this renewable source of energy as a fuel for transport. It is the most markets free of fuel tax and, in a wide-range vision, the increase of natural gas grid use will lead to a strong development and use of biomethane. Moreover, cryogenic upgrading of biogas, liquified biomethane, dual fuel technology for HD trucks used in long distance, will reduce diesel use by 80% without any loss of energy efficiency, and will thus yield 20% reduction of tailpipe CO₂ emissions (some 80% reduction if NG is replaced by biomethane).

Trends in legal and financial condition

Till now the policy on NGVs could be applied just to the purchase of alternative fuelled vehicles, and not to the use of alternative fuels. These benefits have been used to purchase vehicles, returning a cost benefit to the owner, but the owners sometimes have continued to fuel its vehicles with gasoline or diesel and not with alternative fuels.

The most effective policies should:

- provide a direct financial benefit to the end users;
- ensure use of alternative fuels;
- develop and expand an adequate infrastructure that support long-term use of NGVs;

In these terms mandates could be applied to vehicles owners by using a particular percentage of a fleet on natural gas, or mandates could be applied to energy suppliers to provide alternative gas filling stations in the territory. In the same way, the government could exercise control through taxes and fuel excises, both as a benefit to the energy suppliers or retailers and as a reduction in prices for final users. Therefore by providing grants or rebates to purchasers of natural gas vehicles or conversion systems, governments can offset the additional costs incurred by the vehicle owners, moreover this approach could encourage use of natural gas on vehicles. In that countries in which equipments for natural gas vehicle are imported, government could reduce or eliminate import tariffs and, on the other side, could promote investments in technologies in order to reduce the offset costs of bringing technologies.

As regards Italian laws, the Government has issued in the past years many decrees in order to incentive the purchase of alternative fuelled vehicles and the conversion of existing vehicles. For example, in 2009, for the purchase of an alternative fuelled vehicles, the Italian government grant a bonus of 1.000-1.500€ for GPL vehicles and a bonus of 3.500-4.500€ for methane vehicles (depending on the size of the cars) These can also be combined with the scrapping incentives.

Moreover, other bonus were established for boosting the use of CNG/GPL vehicles: 500€ for engine into GPL engine and 650€ for conversion of petrol engine into methane engine On the other hand, Italian Government has not supported expansion of gas filling station in terms of bonus or incentives but many works has been made in order to modernize and improve gas filling station network. In particular in October 2008, Italian Ministry of Interior has issued two new decrees on the safety norms for CNG refuelling stations with important amendments that allow for the adoption of multi-dispenser and self service stations in public CNG refuelling stations.

These decree draw up Italy to other European Countries such as Austria, Germany, Czech Republic, Sweden and Switzerland where these aspects have been in application for a long period.

In addition there are also the activities related to the technical regulation within the ISO and ECEONU standard, in particular:

- ECE-ONU R110 “uniform provisions concerning the approval of I. specific components of motor vehicles using CNG in their propulsion system, II. Vehicles with regard to the installation of specific components of an approved type for the use of CNG in their propulsion system”;
- prEN 13.638 “ NGV Refuelling Stations”;

- ISO 15.501-1:2000 “Road vehicles – Compressed natural gas fuel systems, part I: safety requirements and part II test methods”;

Therefore some Italian Regions, Piemonte, Lombardia and Liguria, have allocated funds in order to improve the supply of gas filling stations in these regions and to expand the network. For example, Liguria Region has approved an announcement of competition of one million of euro for public or private enterprises that will decide to place side by side a methane pumps in our traditional fuel filling station.

Besides institutional incentives, in Italy many associations work to improve the network of gas filling station and of methane fleets. For examples NGV System Italia, the association of the Italian Industry for natural gas, brings together the most significant companies whose products allow and ease the use of natural gas in transport and builds up the channel for common initiatives in the field of regulations, communication, and commercial operations, in a dialog with all national and international institutions.

Federmetano is an association of gas filling stations owners and components producers and sellers (engine systems, compressors, gas cylinders etc.). The aims of this association are:

- To safeguard sectorial’s interests;
- To study technical problems involved in methane sale and transport;
- To promote initiatives for sector development;

AssoGasMetano, established in 2008, is an association of the principle enterprises in Italy in the field of methane and carry out an intensive political role in safety and promotion of the entire sector.

Progetto Metano Auto is an association of stakeholders (construction, management and distribution of gas filling station network) that support customers on the entire life-cycle of a gas filling station from feasibility studies till management.

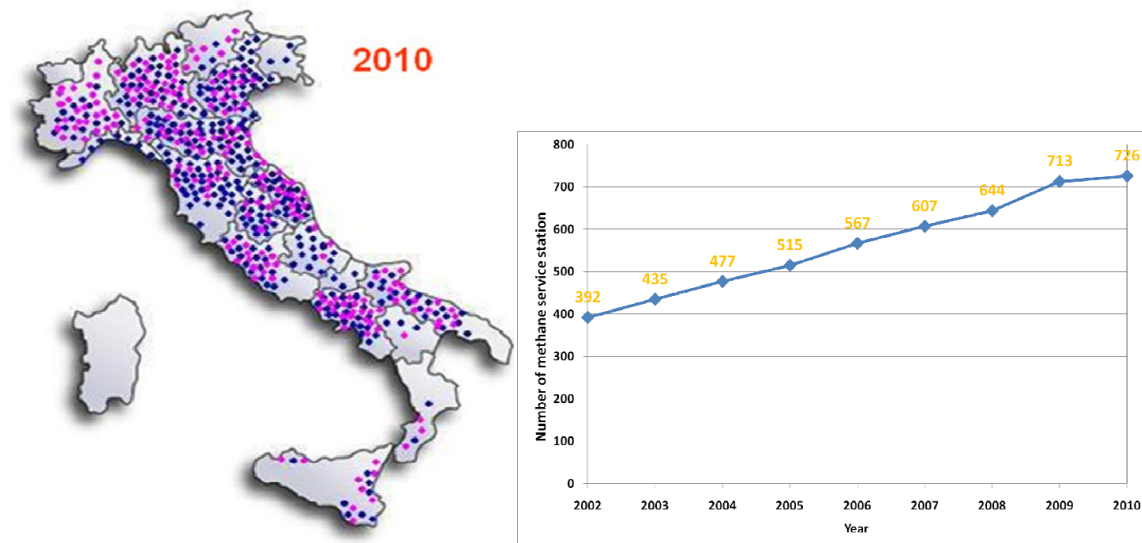
On a local region, Torino Metano, a leading company in the field of low emission and alternative fuels, supplies integrated solutions applicable to the natural gas and hydrogen automotive sectors, works for public transport utilities, alternative fuels fleets companies and natural gas components manufacturers for the automotive sector.

Attitudes

Natural gas represents one of the most potential fuel for transport if compared to the alternative fuels, due to the its environmental and economic convenience. Worldwide there are about 6.7 million NGVs supported by a network of 11,500 fuelling stations; in Europe there are 820.400 NGVs (548.850 in the EU-27), 82.7 % are passenger cars; 6.8 % are buses; and 10.5 % are trucks; just over 580.000 of the European NGVs are in Italy.

Today there are some 65 manufacturers worldwide that produce nearly 300 vehicle models and engines that run on natural gas. In Europe, Citroen, DaimlerChrysler, Fiat, Opel, Peugeot, Renault, and Volkswagen produce a total of 13 different category M1 factory built passenger cars running on NG/biomethane. A similar number of LD/MD commercial vehicles are offered by the same manufacturers, and by Iveco. HD engines and vehicles (buses and/or trucks) are offered by Daimler Chrysler, Ekobus, Iveco, MAN, Scania, Tedom, and Volvo.

Over the last years in Italy, the number of service stations selling methane has increased by 64%, in Piemonte, over the same period, the number of gas filling station increased four times (as shown in fig. and)



Natural gas is one of the cleanest low polluting fuels available today. Used in cars, natural gas reduces CO₂ by 20-25% over similar gasoline vehicles, moreover natural gas is economical: as a vehicle fuel it is about 30-50% cheaper than petrol or diesel, due to a combination of the cost of natural gas on an energy equivalent basis relative to petroleum fuels and fuel taxes.

Besides these remarks, renewable biogas upgraded to biomethane represents an outstanding opportunity to reduce as much as 100% CO₂ on a well-to-wheel basis. The analyses supporting the CO₂ and emissions reduction policy has not considered the multiple benefits of using biomethane as a vehicle fuel. The cost/benefit strategy of building an urban waste management infrastructure for biogas/biomethane has not been given adequate attention compared to efforts supporting liquid biofuels.

Optimal location of new gas filling stations in Italy

Regional differences in the distribution of gas filling stations in the country

In Italy refueling stations have grown from 370 at the end of 2001 to 766 at 2010, 26 on the motorways with a 107% rise during 9 years. Gas filling station distribution and localization vary along Italy with the highest number of stations mainly located in the northern part of the country, despite the development of gas grid all over Italy. In particular, central and southern regions of Italy present a lower number of gas filling stations if compared with northern regions (Lombardia, Emilia Romagna, Piemonte, Veneto and Trentino Alto Adige). This is mainly due to the lack of a strategic plan for the development of gas refueling infrastructure at national level for the coordination of different regional plans.

An effort has been done to overcome this barrier in recent years by some gas companies as for example GasNatural which is directly involved in the opening of more than 11 new gas filling stations in the south of Italy (Campania, Lazio and Sicilia).

Other possibilities for regional development of new gas filling infrastructures are related to the GALSI project which will bring natural gas in Sardegna where actually there are no gas stations. Italian filling stations distribution and localization are summarized in the figure below (last update October 2010)



Distribution of gas filling stations in the different regions of Italy

Development of the natural gas grid in the country

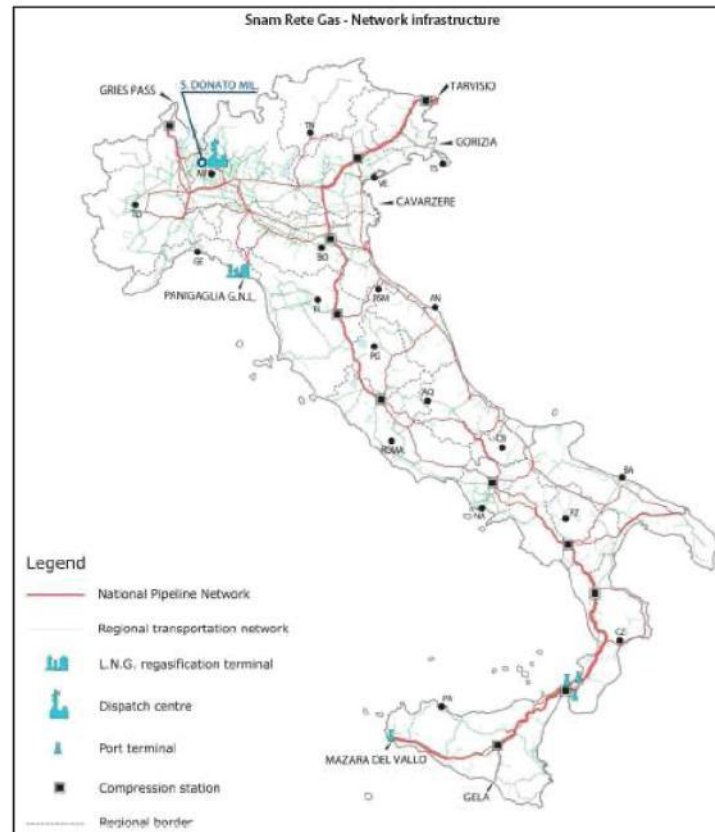
Italy has a 31.500 kilometers gas pipeline network. One of the main element taken into account for the installation of new gas filling stations is represented by the distance from the natural gas grid. Connection costs depend on the distance from the grid (approximately 300-600 €/m), while operating cost for gas compression are related to the methane pressure in the grid (low pressure (3-5 bar): 0.02-0.03 €/m³; medium pressure (20 bar): 0.02 €/m³; high pressure (40 bar): ≤0.015 €/m³).

The widely spread gas grid would allow a better development of gas refuelling infrastructure, especially in the central and southern regions where a better exploitation of the existing network would be possible.

Since its higher energy density, LNG could represent an interesting and environmental sustainable solution for HD transports both in existing multi-fuel stations not easily connectable to the gas grid and in new monofuel LNG stations for public and private fleet, i.e. buses, waste harvesting trucks, road haulage, etc... LNG can represent also a solution for the refueling of vehicles along motorways where the connection to the gas grid is more difficult for technical and regulatory reasons.

LNG could represent a suitable alternative only if regulatory national barriers for its usage can be overcome and the environmental convenience in terms of GHG emissions (WellToWheel Analysis) is proved. In this sense, in Italy there is actually only one LNG

station in Piemonte and some companies, such as Polargas, are hardly working for the development and establishment of this technology.



Map of gas grid Italy

Location of existing biogas plants provided with upgrading system

In Italy there are actually 542 plants producing biogas of which 235 from livestock effluent in co-digestion with energy crops or agro-industrial waste (121 plants from municipal and industrial sewage sludge, 14 plants from organic fraction of municipal solid wastes; 31 plants from agro-industrial wastewater and 141 plants from the recovery of biogas from MSW landfills). Regarding biomethane, only one up-grading system unit is actually present (Rome, Malagrotta) and two pilot projects are under development (San Giovanni a Persiceto and Legnano).

The possibility for the use of biomethane as a fuel for vehicles complementary to natural gas during the next 10 years is strictly connected to:

- The updating of national legislation for the definition of physical-chemical characteristics of biomethane for its injection into the gas grid
- The assessment of a feed-in tariff for selling biomethane
- The realization of centralized large-sized upgrading platforms to connect different biogas production plants

Already existing gas filling stations in the country

The implementation of existing petrol stations with CNG/biomethane service represents an economical optimal solution for the development of gas filling stations if compared with mono-fuel stations due to lower investment costs. The optimal strategy would be to harness what's already in place, rather than building a parallel infrastructure.

In Italy a recent modification of the legislation allowing the construction of multi-fuel stations with CNG or small CNG station next to petrol ones, as well as the possibility to install self-service refueling systems at the CNG filling stations, will bring a further increase of the Italian CNG distribution net (Decree 11 Settembre 2008, Ministry of Interior).



Map of existing CNG filling stations

Leading fleet companies in the country

In Italy many fleet companies have invested or are going to invest in purchasing new CNG vehicles; for example DHL Italy, Ericsson, AMA Rome, Würth srl Italy, Vepal, Coop Aura, Poste Italiane, GTT and also municipalities. In case of CNG buses, for example in the city of Turin, the gas filling station for refueling urban buses is located in the same area of bus depot.

The development of CNG fleets is also correlated to the possibility for this means of transport to circulate during limited traffic hours in the city centre.

The development of gas infrastructure for the refueling of public fleets could represent a preliminary step for the opening of gas stations to the public in order in all the regions where a CNG/biomethane market hasn't been assessed yet. Valle d'Aosta region is an example in this sense in Italy.

Technical and economic feasibility studies should be performed in order to evaluate the investment costs, the operating costs and the environmental benefits in terms of GHG emissions of CNG fleets compared to traditionally refueled transports. One main barrier to overcome is related to the believing that maintenance costs for CNG public fleet are higher than diesel/petrol fleet.

Development of gas filling infrastructure on highways and motorways in the country

The network of motorways in Italy is represented in the figure below; on 6.400 Km of motorways there are only 26 CNG filling stations. With 580.000 vehicle running, the actual structure of methane service system is still incomplete. In Italy the EU directive on air quality was received in every region by drawing-up the regional strategic plan on air quality. Inside these documents every region have planned measures for the recovery of air quality and also for the CNG filling station development. As already mentioned in point n. 2, LNG can represents a feasible alternative for increasing the presence index for gas refueling stations along motorways for the overcoming of technical and regulatory barriers to the connection to the gas grid.



Map of national motorways

Development of the gas filling station network related to the population density

Areas with high density population are well pre-disposed for methanization; this is probably due to the possibility of being allowed to use CNG/biomethane vehicles even during traffic limitation periods. In the case of areas with high traffic level, the identification of optimal locations for new gas filling stations should take into account short, repeated and regular vehicle patterns.

As concerning operating costs for new gas filling stations near to city, if the plant is located close to a town it's likely to have very low network pressure, requiring a need for more power. But filling stations closer to urban areas represent a better appeal on drivers. Conversely, outside the cities the so-called primary network would flow CH₄ at a close-to-desired pressure. This implies a lower use of energy but plants relatively out of reach for the majority of end users.

In many regions in Italy, a strategic plan for the expansion of actual gas infrastructure in the city centre is under development; for example in Turin a study has been led by Torino Metano, with the identification of 19 locations for new gas filling stations for the province of

Turin by taking into account the typology of patterns, the number of inhabitants, the traffic level and the actual existing gas refueling network.

Potential investors in the development of gas infrastructure in the country

Some regions have planned to expand CNG refueling infrastructures as a measure for the improvement of air quality. One of the largest plan in this sense is represented by the investment assessed by Regione Lombardia and by the agreement signed by Regione Lombardia and ENI for the opening of 30 new gas filling stations by 2012.

In Trentino Alto Adige Region there is a plan for the implementation of methane refueling pumps in 18 of the actual 22 petrol stations along the motorway A22 (Autobrennero) connecting Italy to Germany.

A recent regional determination in Piemonte (13/10/2010) has allocated funds for the implementation of actual existing petrol stations with natural gas refueling service.

On the other hand, GasNatural is directly involved in the opening of 11 new gas filling stations in the south of Italy (Campania, Lazio and Sicilia).

POLAND

Agencja Rozwoju Regionalnego S.A. w Bielsku-Białej Regional Development Agency in Bielsko-Biała; Instytut Paliw i Energii Odnawialnej Institute for Fuels and Renewable Energy.

The refueling infrastructure for CNG in Poland is, as for the country of approximately 40 million people, rather poorly developed. There are in total 32 refueling stations open for public use. What is most important, the CNG market is not developed with the focus on private users; the decisive majority of stations was built with the focus on corporate users and after the strategic partnership between Polish Gas and Oil Company (currently the main investor in a CNG refueling infrastructure and gas provider) and some big company (municipal public transportation or private shipping companies) have been concluded.

The small number of CNG refueling stations are now hardly sufficient, but it is also true that the amount of NGVs is very small, too. Statistically there are 19 refueling stations per 1000 NGVs. This is comparably (for example with Italy, Europe's CNG market leader) not a bad result, but only due to the fact that there are very little NGVs. The other indicators, reflecting the situation more realistically, are not that good for Poland. This is especially true if we look to number of refueling stations per 100.000 inhabitants. This indicator is less than 0.08 for Poland while in other countries with established CNG market and well developed infrastructure the indicator reaches 1 or is even higher.

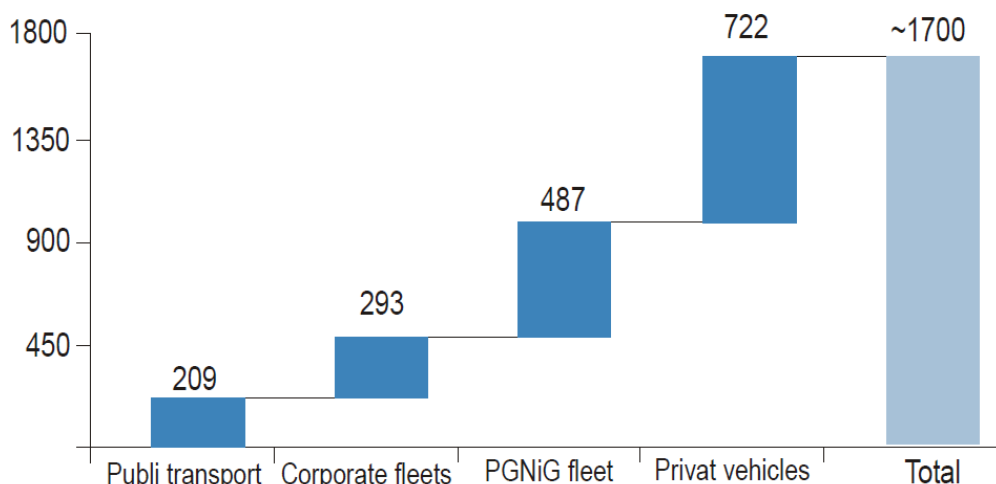
Comparable data about the CNG refueling infrastructure development level

Country	Number of NGVs [thousands]	Number of NGVs per 100 000 inhabitants	Number of stations per 100 000 inhabitants	Number of stations per 1000 NGVs
Italy	523,1	899,6	1,20	1,3
Germany	76,8	93,2	1,10	11,8
Bulgaria	60,3	829,7	0,96	1,2
Sweden	16,9	186,8	1,30	7,0
France	12,5	19,4	0,16	8,2
Austria	4,0	48,8	1,58	32,4
Spain	1,9	4,6	0,10	21,7
POLAND	1,7	4,4	0,08	19,0
Czech Rep.	1,2	12,0	0,32	26,6
Netherlands	1,1	6,7	0,13	19,5
Greece	0,4	3,9	0,02	5,1
Portugal	0,4	3,6	0,05	14,1

Source: PGNiG elaboration

It may be concluded, that looking only at number of CNG refueling stations in relation to number of NGVs the situation in Poland seems very good. This indicator however, is important but not crucial. It can be low, but only if the number of stations in relation to total population and market potential is relatively high, which is not the case in Poland. That means firstly that the number of stations is very low comparing with the country population and that the infrastructure is not ready for the growth of NGVs use.

The next figure shows the main groups of consumers for refueling stations in Poland, what also has an influence on the level of infrastructure development. Firstly to state, the private users of natural gas vehicles constitute only 42 % of total sum. The rest is composed of public transportation companies (12 %) and corporate fleets (46 %).



The 4 main groups of consumers for refueling stations in Poland
Source: PGNiG elaboration

Polish Gas and Oil Company (Polskie Gornictwo Naftowe I Gazownictwo, PGNiG) is the biggest NGV fleet operator (the PGNiG's fleet itself constitutes almost 30 % of the total number of NGVs in Poland) and, as already mentioned before, the company is besides the major player on the market when it comes to investments in the CNG refueling infrastructure and therefore it's important to mention few words about it. Firstly to say, the company is divided into several, very autonomous regional branches, that have independency when it comes to development strategies and policies, also towards development and investment in CNG which leads to regional disparities in CNG infrastructure development. Secondly, the PGNiG has a very broad scope of business and commercial activity, CNG constitutes very small percent of company's activity and as well, comparably, does not bring significant income. That's why CNG development lies not within the priorities of PGNiG. And here the paradox: regardless the small (or even marginal) interest in it, PGNiG remains the main investor in CNG infrastructure in Poland so far, simply because there is no one else.

This situation of course implies a big pressure put on PGNiG to invest further and develop the CNG infrastructure. This pressure is especially coming from private users. For the company, however, it is not profitable unless a big corporate purchaser is interested in partnership (in this case the private users may use the built infrastructure, but the services are focused mostly on convenience of corporate partner). This situation comes also as the result of Polish CNG/NGV market structure: the corporate users (including PGNiG itself with the 30 % market share) are the most important and biggest group. PGNiG has recently prepared the special strategic document dedicated to development of CNG infrastructure.

Regional differences

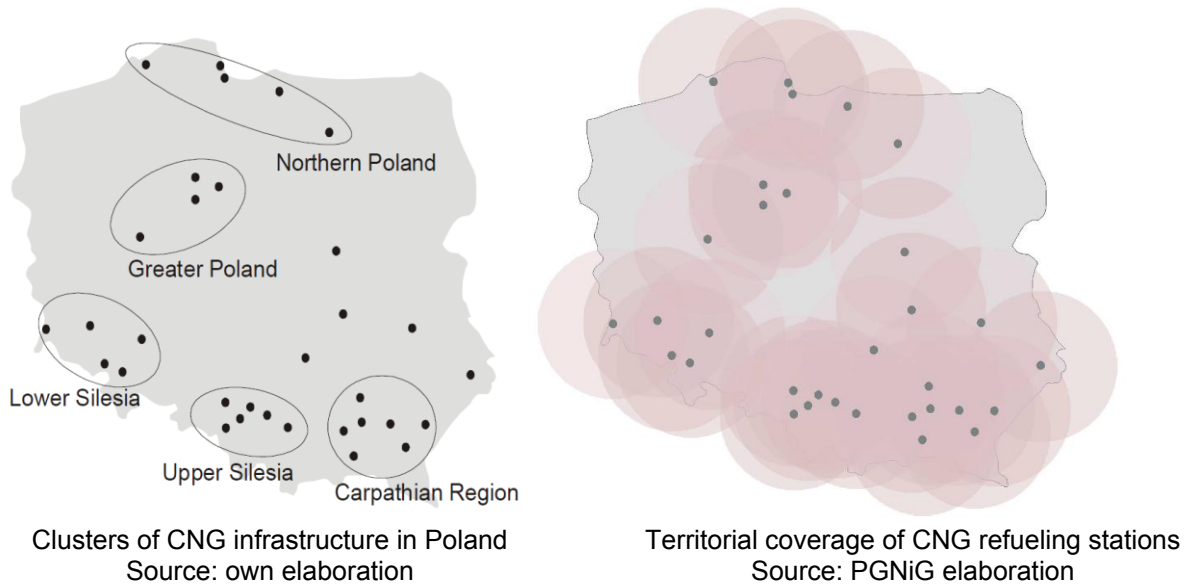
The figures below are showing that the regional differences in the development of CNG refueling infrastructure are quite big in Poland. The first one shows 5 main clusters, regions where concentration of CNG refueling stations is high comparing to the area they serve.

Generally the infrastructure is better developed in southern Poland, especially in Carpathian Region (results of popularity of CNG for a public transportation purposes and positive activity of PGNiG regional branch). Quite big concentration of CNG refueling station is also in Upper Silesia and Lower Silesia, also the northern part of Poland along the Baltic Sea.

The figure shows the potential territorial coverage of one refueling station as a pink circle (the distance that one vehicle can make without the need of refueling). Again, it's clear that in some regions the territorial coverage of stations are overlapping with each other, making NGVs usage more flexible – the more pink the region is, the better the CNG refueling infrastructure is developed. On the other hand there are regions completely without the infrastructure of refueling stations, light pink or even totally blue, especially at the western and eastern border and in central Poland, literally meaning that it is not possible to drive NGVs there and the users would need the backup of second fuel.

This is definitely a very negative positive phenomenon. Such a big regional disparities preclude a significant part of people potentially interested from using CNG as an vehicle fuel, make driving NGVs rather comfortable only in few regions and affect possibilities for long-distance travels.

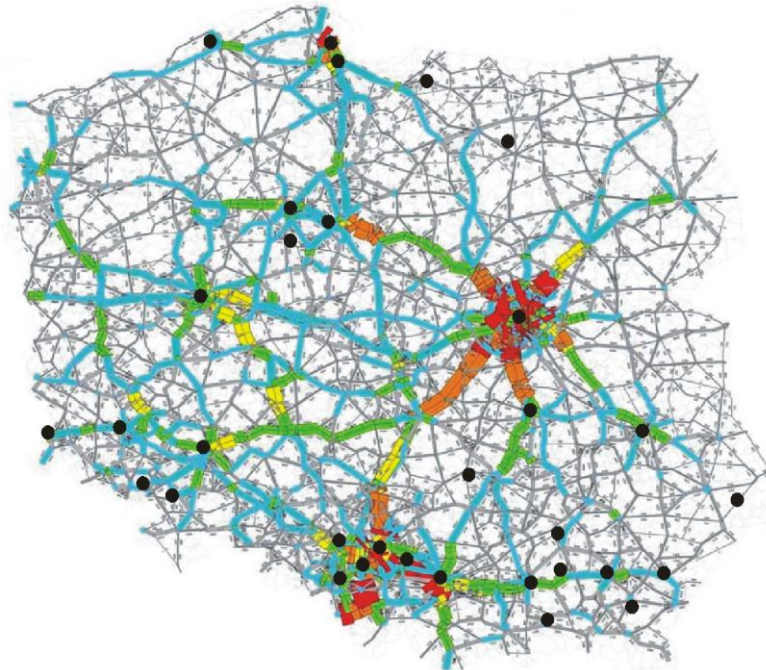
That's why existing infrastructure is rather good for locally-operating car fleets than for longdistance traveling, when in lot of situations it becomes absolutely necessary to use a backup fuel other than CNG.



Statistical data

All 32 stations are using natural gas, and none of them biogas. The first company that declared the will to include bio-methane into their offer is the 'Biogaz Inwestor', a joint stock company with majority of municipality shares in the city of Toruń. This is however still a distant future before the offered gas will become at least partially bio (company exploits the waste biogas power plant).

The only gas provider for all of the refueling stations so far is the Polish Gas and Oil Company already mentioned before. All of the stations are directly connected to the gas grid. There are only 9 stations opened non-stop, a lot of stations operates in standard working hours of gasworks where they are located, so between 7 am and 5 pm, or even 7 am and 2 pm.



CNG refueling stations in relation to the traffic streams

Source: own elaboration based on the map of General Directorate of National Roads and Highways

Approximately 40 % of the stations are owned and located at the area of Polish Gas and Oil Company (the gated area of local gasworks). 50 % of the stations were built on basis of other various partnerships of public and private companies with PGNiG (majority of them being public, such as municipal authorities, municipal public transportation companies) and in this case are located at gated areas of companies (bus de in any case, no matter the partnership conditions, the technical equipment (pumps, distributors, compressors) is legally owned by PGNiG or one of its daughter-companies.

As mentioned before, the stations are not distributed equally across the country, it's a bit better situation if the road network and traffic streams are take under consideration. In some cases station is located where the biggest daily traffic streams appear – this is basically next to big cities especially in Upper Silesia and in major cities such as Warszawa, Poznań, Wrocław, Gdańsk, Gdynia or Radom. There is however lack of stations located next to the mostly used traffic routes especially within the axis north-south, from Gdańsk and Toruń to Warszawa and from Warszawa to Upper Silesia.

Main disadvantages of polish CNG refueling infrastructure

The main disadvantages of most of the Polish CNG refueling stations can be describes as follow:

Lack of focus on private users

As already mentioned before several times, the existing filling stations were built to satisfy mainly the corporate needs of big fleet operators (city bus companies, long-distance transportation) since only very high and stable demand for natural gas can guarantee the profitability of investment in natural gas refueling infrastructure. The sector of private natural gas cars drivers is still very low in Poland and also still instable, so in majority of cases it is not a sufficient base for investors to go for.

Location

Also the location is problematic, especially for the users from outside the city or area where the station operates. Most of them are located at the outskirts of the cities, but far from the communication routes and nodes, in an industrial areas. The location is chosen according to the need of the key corporate partner (eg in case when the bus company is the strategic partner the station is located next to the bus depot, the other possibilities are gasworks or private area of transportation companies). To reach the station very detailed directions are needed, and even then there are situations when drivers get lost. It's necessary to get off the motorway or simply the main road, since the stations are not located along the communication lines. When the address is finally found, there's a need to find the entrance to the gated area, get through the security check and finally find the station inside the gated area, what is often a big challenge.

This gets especially difficult for outsiders and foreigners.

Poor or inconvenient service

Due to the fact that majority of refueling stations are adapted for the use of big fleet operators, the service for the private users can be rather inconvenient: □

- □Lack of possibilities to pay by credit cards (applies to almost 90 % of the gas refueling stations) or sometimes even lack of possibility to pay by cash (only by bank transfers for those who have signed the special contract with the station operator), which of course eliminates from using the station those from outside of the city or area around the station, all the travelers.

What's more interesting, the majority of stations (as already mentioned 85 % of all stations) are owned by the subsidiary entities (kind of regional branches) of parent company – The Polish Gas and Oil Company, state controlled. The biggest problem is that regardless the fact that in reality it is one holding company, the contract for bank transfers signed with one of the subsidiary entity does not extend for the others. As the result, even if the given person signs the contract, the payment for the gas is limited to only one station, or few stations in one region, while in fact it could be extended for the entire network of stations owned by Polish Gas and Oil Company covering the whole country. Such a solution would at least enable Polish citizens from different cities and regions to refuel their cars more easily.

□Inconvenient opening hours. Only 37 % of the natural gas refueling stations in Poland are opened 24 hours daily! There next 3 are open 24 hours but with very long breaks (those breaks are reserved for corporate refueling). 25 % of the refueling gas stations in Poland are open only during weekdays until 3 PM (the working hours of grid gas distribution centers where the stations are located).

The rest of the stations are generally opened on weekdays since morning till later evening (8 or 10 pm) and on Saturdays since morning till noon or early afternoon, closed on Sundays. This all limits the possibility of driving the natural gas driven car in Poland when you are the traveler, cause you would need to know one needs to know exactly where and when he'd have to refuel the car, which is very difficult to plan, eliminates the possibility of traveling in weekends and at night. It is in fact only possible for those living in the area where the station is located to use this stations, since they are able to plan when to refuel the vehicles.

□Time required to refuel the car. Very often the time required to refuel the car is very long. First, if one gets to the station in time of refueling the vehicles of the strategic partner of the

station (busses, trucks) she/he has to wait in line (refueling those types of vehicle lasts quite long, especially that in lot of cases the compressors are of low capacity) and there are no additional distributors reserved only for private users.

Additionally, even if there is no queue for the distributor, a lot of the stations do not have the separate worker dedicated only to servicing the CNG refueling and the distributing devices are well hidden in the private area. One have to first wait for somebody to let him in the gated area of the gas distribution center or bus depot, then wait for the specific worker to come, and finally go through the complicated payment procedure. Sometimes even the pre-call is necessary.

Frequent breakdowns. The breakdowns are frequent and normally it takes a considerable time period to fix them. In case when the station with the breakdown is the only natural gas refueling station in the area, it makes it impossible for the owners of natural gas driven cars to refuel their vehicles. Which in turn discourage users to buy only natural gas driven cars, as very often they would need gasoline backup and makes the natural gas availability very unreliable.

Language skills of the staff. In majority of case the staff does not speak English. This is not a problem with normal, commercial refueling station, located next to the communication routes and well signed.

However, in the situation when the driver must call, get through the security check, find the right person and explain what she/he wants and then pay according to sometimes not clear rules the language skills are very important.

Barriers and possibilities for investments

When it comes to natural gas, there are no direct, legal barriers for investment in CNG infrastructure. In Poland the biggest barrier to invest in CNG is lack of interest to do so, especially by major petrochemical holdings and companies operating in the country. The lack of interest is in turn a result of small market, that such an investments are for now economically not rentable and that such companies or other private investors simply do not see the profits in this fuel segment. The costs of building one, modern and effective refueling station for CNG are huge, the equipment is very expensive. From the other hand, the awareness of the society about gaseous fuels is very low and there is no overall societal pressure on developing CNG market. Also the incentives and stimulation from government's side are lacking.

When it comes to biogas use for vehicle fuel, all the actions undertaken by government are now targeted to foster biogas production as such, but little is talked about biogas for cars (the standard utilization of biogas in Poland is for cogeneration). From the strictly legal barrier it's maybe worth to mention that Polish law requires that biogas produced is always being introduced to the grid, what may prevent some biogas plants operators from utilizing the gas for a car fuel (they would prefer to utilize it directly, without the need of introducing the gas to the grid). Except for that, the awareness of bio-gas as a car fuel is even smaller than this of CNG in general. As mentioned before, there is only one company that declared the will to include biomethane into their offer is the 'Biogaz Inwestor', a joint stock company with majority of municipality shares in the city of Toruń. If the plan will be realized, the case of 'Biogaz Inwestor' should serve as the best example for others.

Few years ago, the plan for investments in CNG refueling infrastructure presumed that the network should consist of at least 60 refueling stations, located not further than 60 km from each other (in other case it with the harm for individual NGVs market). The plan was only discussed, but no real actions followed.

The closed circle: □lack of refueling infrastructure □lack of users □lack of infrastructure lack of users... and so on and on is the major problem in Poland. Lack of interest of private companies to invest in CNG causes two other major problems:

1. Big expectations towards PGNiG, often not rational (it cannot be expected from PGNiG that it will be the remedy for all the problems and that as single company will develop CNG infrastructure in Poland). PGNiG cannot remain the only investor on the market, first, because it simply economically impossible for the company, and second, the monopolists, even when it comes to investments, is never good for future and quality development.

2. Very poor accessibility for individual traffic (location of the refueling infrastructure far from the communication routes, where regular gasoline stations are located, poor payment possibilities, very bad working hours, subordinated to corporate needs and very often eliminating possibilities individual traffic based on CNG and definitely eliminating refueling infrastructure from the use of long-distance transportation. One thing is clear in this situation: the refueling infrastructure will not develop itself on its own.

The parallel actions from several directions are needed:

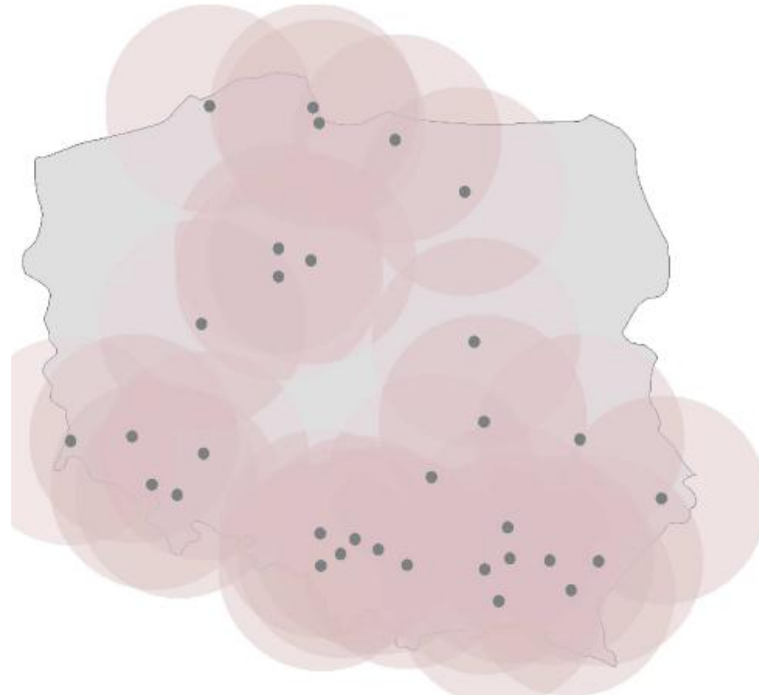
- A need to promote of CNG as a fuel in general,
- A need for incentive governmental policy towards CNG and NGVs
- A need to convince fleet operators to switch to CNG, where the successful cases of public transportation in some cities could serve as an examples for others
- A need to convince private investors (not only PGNiG) to invest in the refueling infrastructure.

Above mentioned actions apply to both, natural gas and bio-gas. The promotion and incentives for users are here same: it's only gas-driven vehicles that should be promoted (doesn't matter if it's a natural gas or bio-gas). However, the promotion for investors could be different, or better say, different groups should be targeted. The overall trends are positive. Environmental protection is getting more and more important, also the government is legally bound by international treaties to reduce the pollution. Therefore, sooner or later the governmental attention will have to be drawn to methane and biomethane as a vehicle fuel. Incentives towards expanding refueling infrastructure and not yet existing, but looking at the other sectors (for example other green solutions) where those incentives are already introduced can suggest that there will also be a change when it comes to CNG and bio – CNG. But, it must be highlighted, governmental actions and more attention put towards development of CNG from public authorities' side market are crucial for the success, just as the extended cross-sectorial cooperation between public and private bodies.

Optimal location of new gas filling stations in Poland

Regional differences

There are very big regional disparities, shown by the maps. Firstly, there are 5 main clusters, regions where concentration of CNG refueling stations is high comparing to the area they serve (Northern Poland, Greater Poland, Lower Silesia, Upper Silesia, Carpathian). Generally the infrastructure is better developed in southern Poland, especially



Coverage of CNG refueling infrastructure in Poland

in Carpathian Region (results of popularity of CNG for a public transportation purposes and positive activity of PGNiG regional branch). Quite big concentration of CNG refueling station is also in Upper Silesia and Lower Silesia, also the northern part of Poland along the Baltic Sea. It's clear that in some regions the territorial coverage of stations are overlapping with each other, making NGVs usage more flexible – the more pink the region is, the better the CNG refueling infrastructure is developed. On the other hand there are regions completely without the infrastructure of refueling stations, light pink or even totally blue, especially at the western and eastern border and in central Poland, literally meaning that it is not possible to drive NGVs there and the users would need the backup of second fuel.

This is definitely a very negative phenomenon. Such a big regional disparities preclude a significant part of people potentially interested from using CNG as an vehicle fuel, make driving NGVs rather comfortable only in few regions and affect possibilities for long-distance travels. That's why existing infrastructure is rather good for locally-operating car fleets than for long-distance traveling, when in lot of situations it becomes absolutely necessary to use a backup fuel other than CNG.

Gas grid

There is no problem with natural gas grid in Poland. Definite majority of places are in very proximity of the gas grid. Therefore, in Poland the gas grid is not a barrier nor a driver towards refuelling infrastructure development.

Biogas plants with upgrading system

There are no biogas plants in Poland equipped with upgrading units. There are currently 6 biogas plants big enough to potentially supply the refuelling stations, but they are located in remote rural areas, close to big farms in northern Poland.

Already existing refueling infrastructure

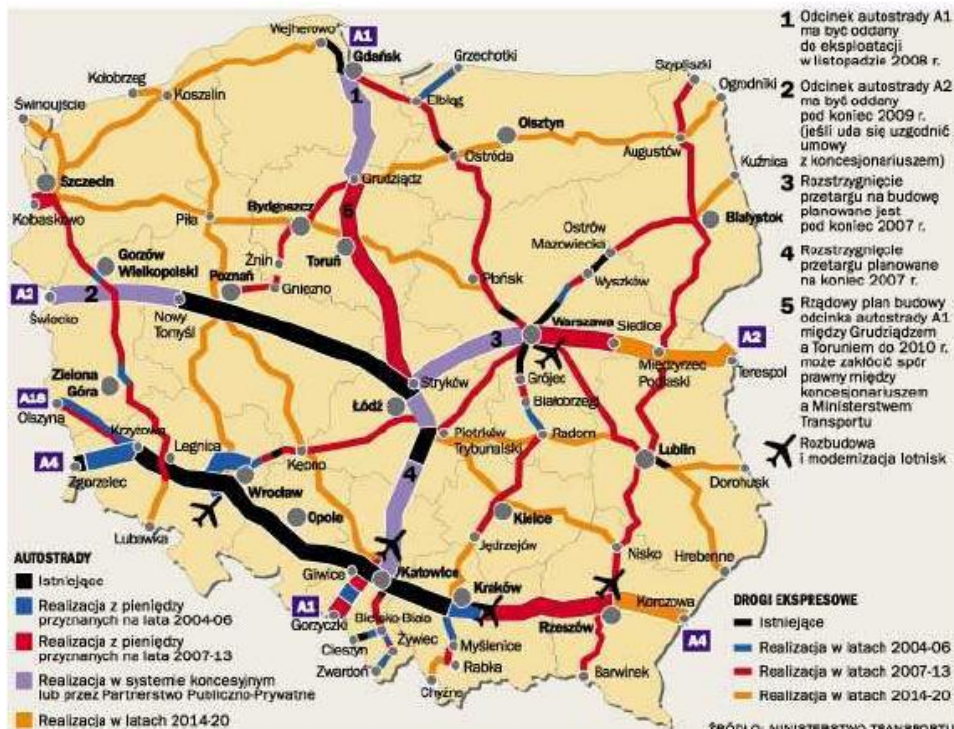
The already existing filling stations in Poland and the petrochemical concerns are not interested in investing in CNG refueling infrastructure. Therefore the possibility of implementing CNG into existing petrol stations is very low.

Fleets' development

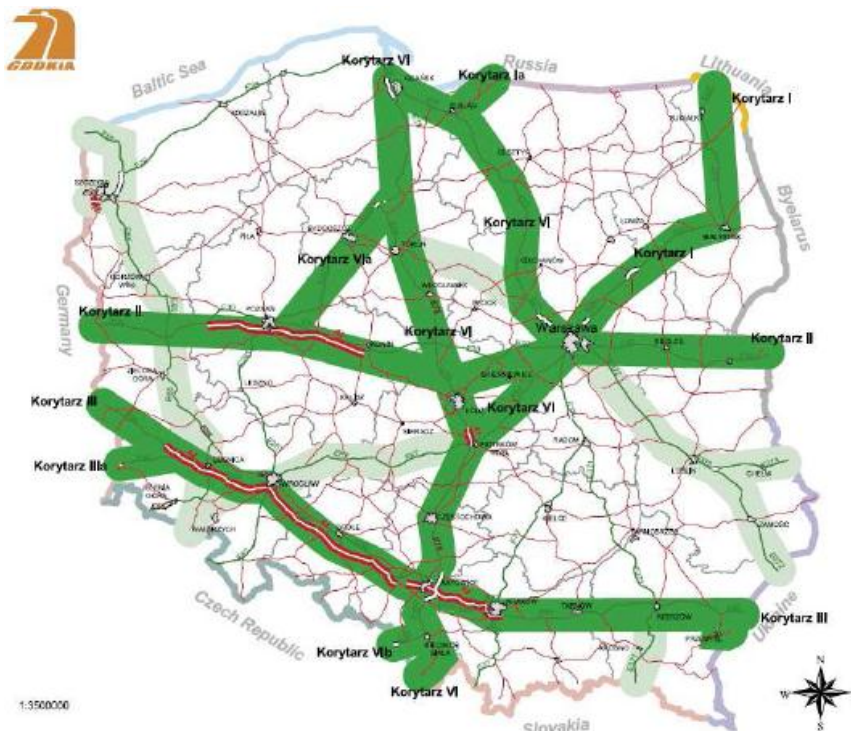
Development of the vehicle fleets that run on CNG is the most important driver to boost Polish NGV market in general. Currently only fleet development guarantees erection of new refuelling stations, therefore the prospective and potential fleets' identification is crucial when designing the optimal location for new refuelling stations. Potentially there are big fleets in majority of bigger cities in Poland, due to the fact of bigger municipal and regional passenger transport and also due to existence of big companies.

Location of stations at the highways and motorways

Currently there are only two refuelling stations located at the highways, motorways and at roads which will be converted into motorways, and this is very low number. Majority of stations are located in the city centres or at the outskirts, but not close to any important roads, and they are hardly accessible. Therefore it is highly recommendable to include locations close to the motorways and future highways in the plans.



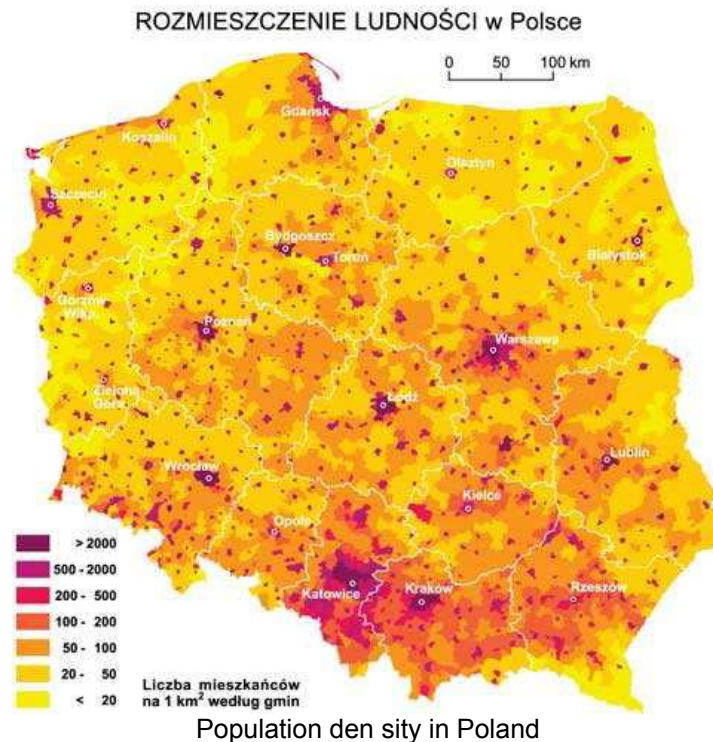
Network of planned motorways and highways in Poland



European Transportation Corridors

Population density

According to population density patterns, definitely more stations shall be located in Mazowieckie Region especially around Warszawa, in Silesian Region, especially around Katowic, in central Poland, especially around Łódź.



Potential investors

In Poland the only investors that exists are, first of all the branches of Polish Gas and Oil Company (possible investment only when big gas consumption is guaranteed) and private companies that wish to convert their fleets into CNG (investments according to company needs, mostly at the headquarters).

After the analysis of the above mentioned factors, 20 new optimal locations have been identified. However 20 new stations by 2020 is not enough to form a sufficient network of refuelling infrastructure, it is rather realistic number if the development of CNG market in Poland will follow current patterns. 9 of them should be constructed in the cities, suitably for companies (investors) and urban traffic, 11 of them at the highways and motorways to serve the transit transportation.

The main goal of the chosen locations is to:

- Decrease regional disparities in location of CNG infrastructure,
- Provide the CNG infrastructure to the most densely populated areas
- Provide the CNG infrastructure in most important transportation nodes along existing and planned highways and motorways.

Locations in the cities, mostly for urban purposes, but also with benefits for transit:

- **Łódź:** the 3rd biggest Polish city and with vast metropolitan area (population density), lots of industry and transport companies (potential investors), big fleet of municipal busses (potential investor), in the middle of Poland with big deficiency of CNG infrastructure (decreasing regional disparities), located at the transportation corridor VI
- **Szczecin:** 7rd biggest Polish city (population density), big fleet of municipal busses (potential investors), in north-western Poland with big deficiency of CNG infrastructure (decreasing regional disparities)
- **Bielsko-Biała:** 23rd biggest Polish city with developing metropolitan area (population density), big municipal fleet and existing CNG corporate station with possibility for being open to public (potential investors, potential for public-private partnership, low investment costs due to initial infrastructure existing), close to border with Czech Republic and Slovakia and to the express road S1 (European corridor VI)
- **Białystok:** 11th biggest Polish city with developing metropolitan area (population density), big municipal fleet (potential investors), in north-eastern Poland with big deficiency of CNG infrastructure (decreasing regional disparities), located at the important travel route and I European transport corridor.
- **Częstochowa:** 13th biggest Polish city with developing metropolitan area (population density), big municipal fleet (potential investors), in central Poland with big deficiency of CNG infrastructure (decreasing regional disparities), located at the important VI European transport corridor
- **Opole:** 30th biggest Polish city in densely populated area, with municipal fleet (potential investors), located at the important III European transport corridor
- **Zielona Góra:** 33rd biggest Polish city in densely populated area, with municipal fleet (potential investors), located at the important south-north corridor in Poland, in Eastern Poland with deficiency of CNG infrastructure (decreasing regional disparities)
- **Gorzów Wielkopolski:** 31st biggest Polish city, in densely populated area, with municipal fleet (potential investors), located at the important south-north corridor in Poland, in Eastern Poland with deficiency of CNG infrastructure (decreasing regional disparities)
- **Katowice:** 10th biggest Polish city, capital of biggest conglomeration in Poland (very densely populated area), with very big municipal fleet and numerous companies, industry and logistics (potential investors), located at the crossing of two very important European transport corridors (III and VI).

Locations in at the highways and motorways or in their proximity (mostly transit):

- **Stryków:** at the crossing of A1 and A2 highways, central Poland, very important transportation hub and big traffic volumes
- **Warszawa:** at the eastern ring and eastern beginning of A2 highway, big traffic volumes
- **Warszawa:** at the western ring and western beginning of A2 highway, big traffic volumes
- **Kobierzyce:** close to Wrocław, at A4 highway, very important transportation hub and big traffic volumes
- **Sośnica:** centre of Katowice agglomeration, at the crossing of A4 and A1 highways, very important transportation hub and very big traffic volumes
- **Olszyna:** very important A4 highway, at the border with Germany, very big traffic volumes
- **Świecko:** very important A2 highway, at the border with Germany, very big traffic volumes

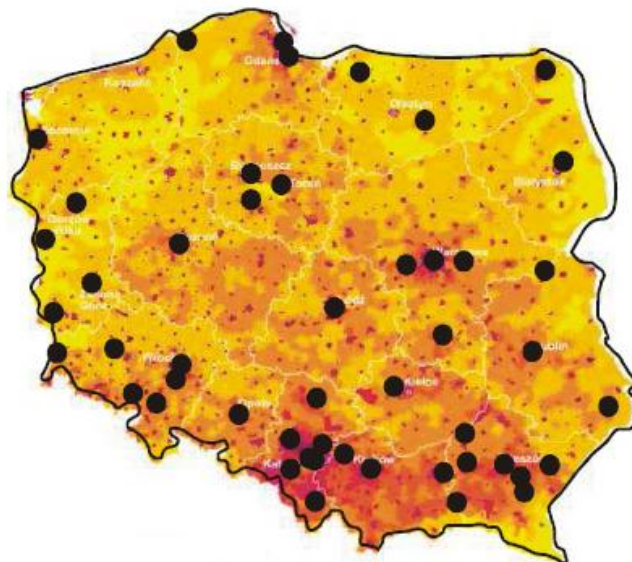
- **Międzyrzecz Podlaski**: at the crossing of A2 highway and express road S19, close to border with Belarus
- **Kraków**: at the A2 highway in the proximity of the airport
- **Suwałki**: at the express road S8 and close to the border with Lithuania
- **Rzeszów**: at the crossing of A1 highway and express road S19, important transport hub

Such a locations for new filling stations will ensure:

- The existence of CNG refueling stations in majority of biggest cities in Poland
- Significant decrease in regional differences

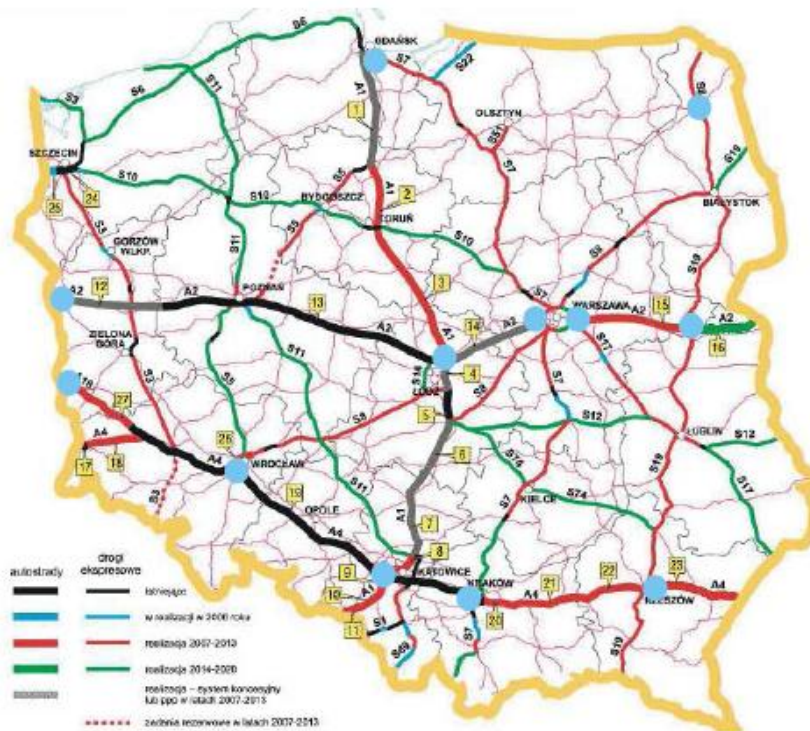


Network of CNG stations in 2020 is covering the whole country

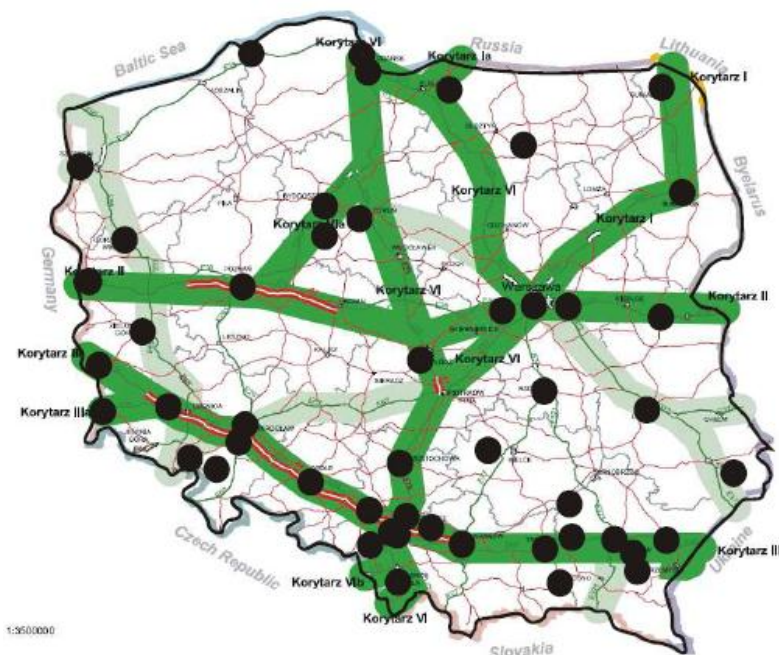


Network of CNG stations in 2020 is more respecting the population density

- Possibility for transit transportation of NGVs along Polish motorways and highways with no need for getting off the main roads.



CNG stations in 2020 located at the highways and motorways



CNG stations in 2020 in relation to European transport corridors

However the situation may improve if new filling stations will be located in the depicted locations, the network of Polish CNG refueling stations will not be still totally efficient. Further investments will be needed, especially along express roads and in Northern and Central Poland.

APPENDIX II: BLUE CORRIDORS ON OUR PLANET

EUROPE

A.Andreevsky, Gazprom, Russia.

During the last decades the European NGVs market has traditionally held the third place in the world after the most dynamically developing Asian and Latino American markets. As of the end of 2011 1.56 M NGVs were running across Europe (2.0 M in UN ECE region, i.e. including USA and Canada and others), which were filled with 4.033 (5400 in UN ECE region) NG filling stations.

The spread of CNG as a motor fuel is due to different factors.

One of them is the aspiration of European countries and their governments to new alternative economically sound, sustainable and environmentally friendly kind of fuels.

In 2000 in the concert with that trend the international Blue Corridor Project was launched, and as early as in 2002 an official study on the project was issued by the United Nations Economic Commission for Europe being the result of work of experts from 18 European countries. The study grounded the feasibility, as well as economic, environmental and social benefits of organizing international NGVs traffic through three pilot transport corridors: Rome – Berlin; Berlin – Moscow and Moscow – Helsinki.

Nowadays the idea of Blue Corridors comes truth. Since the start of the project some NGVs rallies covering the wide spaces of Europe and Russia have been organized. The aim of these events was obvious, i.e. to attract the attention of local authorities, car manufacturers, mass media and general public to the benefits of introducing natural gas into engines. The Russian rallies run from St Petersburg to Moscow (2008), from Moscow to the Olympic Sochi (2009), the rally encompassing the Russian car producing plants (2010), and one more from Ural to Moscow (2011).

In June 2011 the first international NGVs Blue Corridor caravan linked Czech Republic and Germany starting in Prague and finishing at the Baltic Sea shore in Greifswald (landing point of the Nord Stream underwater gas pipeline).



The density of the Italian NG filling stations network (820 stations) allows extending the European Blue Corridors through the entire Italian territory. Very impressive was the rally executed in 2009 by the team of German vehicle tester Rainer Zietlow who started with his NGV Volkswagen Caddy Maxi EcoFuel in Portugal at the Atlantic shore, crossed the entire Western and Eastern Europe, the Russian Siberia and finished at the shore of the Pacific Ocean.



At the same time it is to be noticed that some white spots remain along the “blue” routes considered within the Blue Corridor Project. In particular to permit an interrupted NGVs traffic some more filling stations are to be constructed on the Berlin – Warsaw – Moscow and Moscow – St. Petersburg – Helsinki routes.

Therefore although the Blue Corridor concept has been progressing, its development was restrained in some cases by the impact of the world economic crisis of 2008 as well as by lack of decision of some governments to make their choice in favor of natural gas as a motor fuel. As expected, in the coming years the extension of the European NG filling stations net will be facilitated by the construction and bringing to the full capacity of South and Nord Stream gas pipelines which will provide additional volumes of natural gas to European consumers.

The NGVA Europe LNG Blue Corridors concept and proposal

Manuel Lage, NGVA Europe, Spain

NGVA Europe is working in the preparation of a European Program to develop the concept of European LNG Blue Corridors. The availability of LNG all around the Iberian Peninsula, plus several other points in the European coasts constitutes a good infrastructure to develop a basic infrastructure of L-CNG filling stations in the Blue Corridors we are proposing.

The intention is to define at least three initial pan European routes with strategically placed LNG filling stations that would allow the heavy, long distance truck transport across Europe:
 Portugal-Spain to France, Netherlands, UK
 Portugal-Spain to France, Germany, Denmark, Sweden
 Mediterranean arch to Italy and Slovenia
 These corridors could also be complemented with a transverse one going from UK, Netherlands to Eastern Europe.



Netherlands to Eastern Europe

These initially proposed Blue Corridors will also develop with connection to other LNG distribution initiatives as: Danube Inland Waters Blue Corridor, from Romania to Vienna, and the AGRI (Azerbaijan-Georgia-Romania-Interconnection) project to transport LNG from Azerbaijan to the EU through Georgia and Romania.

Two other and very important inputs will be studied in the project:

LBG (Liquid Bio Gas). This renewable fuel, CO₂ neutral, is also methane, the same composition than the LNG, and as a consequence is fully miscible. The inclusion of LBG filling stations in the study will widen the possibilities of the European Blue Corridors, integrating better all the resources.

In other cases like Poznan (Poland) LNG is produced using the liquefaction process as a mean of depuration of the natural gas coming from a local well, that contains nitrogen and other components that have to be separated.

Program description. Objectives of the project

The main objective of the project is to initiate a European network for sustainable road transport by tackling non-technological barriers to the production of LBG and the use of LBM/LNG in heavy goods vehicles. This will be done through an analysis and development phase, followed by pilot projects and the initiation of a European network of production/fuelling facilities.

The installation of L-CNG stations in nearby urban areas will also help the development of the CNG fuelled inner city transportation.

Analysis & development

The analysis will be aimed at determining the member state and European market barriers. In addition, the differences in legislation, taxation and subsidy programmes will be investigated throughout Europe by the project partners. Moreover, recommendations will be formulated for European policy makers. Finally, an effort will be made to normalise and standardise the various technologies related to both LBG production and application in methane vehicles using LNG/LBG.

Pilot projects & dissemination

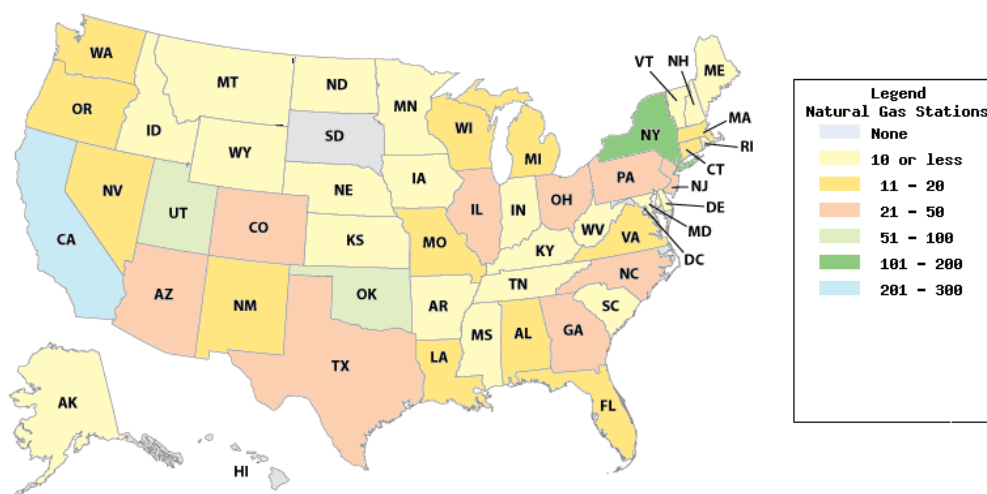
Within the pilot projects, LBM production and identifying strategic supply routes of LNG for application in heavy goods vehicles will be demonstrated in partner countries and several regions being interested to apply the Bio LNG concept in heavy goods transport, functioning as an connector to other regions and big European cities using the same principle, thus creating the Bio LNG Blue Corridor. All pilot projects results will be monitored and disseminated to potential users. The deliverables of the project will be applied to accelerate the development of so-called Blue Corridors. And by testing various marketing strategies to solve the identified barriers, potential users will be inspired by early adopters and will in this way help to boost the market. Typical tools for this approach are workshops, business meetings, conferences and consultancy meetings.

NORTH AMERICA

N. Leclercq, Westport Innovations Inc., Canada

LNG and CNG Stations in the USA: Current Status

In April 2010, there were 825 CNG and 38 LNG refueling stations throughout the United States, according to the Department of Energy, while there are approximately 68,000 stations that sell diesel. The Wall Street Journal also noted that it costs several times as much to build a natural gas fueling station as it does to construct a traditional diesel station. To address this problem, NAT GAS Act provides financial assistance to speed the construction of refueling facilities. The most effective approach is to first target vehicles fueled at central stations and truck stops. A significant portion of heavy- and medium-duty trucks and buses are already centrally refueled. Heavy freight trucks are often refilled at truck stops along interstate highways, which could be targeted for natural gas installation and used to create natural gas refueling corridors. The federal government will have to provide incentives to jumpstart the initial refueling infrastructure expansion, but the costs of natural gas refueling stations will naturally decline due to economies of scale and innovation.



Natural Gas (CNG and LNG) Stations in the USA

Source: U.S. Department of Energy, Alternative Fuels & Advanced Vehicles Data Center

LNG Blue Corridors in the USA: The ‘Natural Gas Highway System’

Clean Energy Fuels Corp. and the LNG Fueling Infrastructure

Chesapeake Energy (CHK), the 2nd largest U.S. natural gas producer after ExxonMobil, has agreed to invest \$150 million in newly issued convertible debt of Clean Energy Fuels Corp (Nasdaq: CLNE).

CLNE will use CHK’s \$150 million investment, plus \$150 million from CHK friends Temasek/Seatown/RRJ, to accelerate its build-out of LNG fueling infrastructure for heavy-duty trucks at truck stops across interstate highways in the U.S., thereby creating the foundation for “America’s Natural Gas Highway System”.

These two investments are projected to help underwrite 250 – 300 LNG truck fueling stations, increasing by more than 20-fold the number of publicly accessible LNG fueling stations and providing a foundational grid for heavy-duty trucks to have ready access to cleaner and more affordable American natural gas fuel along major interstate highway corridors.

CHK believes \$1.5 – 2.0 billion of LNG truck fueling stations (1,000 – 1,250) puts entire heavy truck fuel demand market in reach for natural gas substitution. 8 million American heavy duty trucks consume ~3 million barrels of diesel every day, that’s equivalent to >6 tcf of incremental natural gas demand per year. The effort to move U.S. transportation sector to natural gas is an important element in significantly increasing domestic natural gas demand.

America’s Natural Gas Highway System Objectives

America’s Natural Gas Highway System will deploy LNG fueling stations along every major interstate trucking corridor in the U.S.:

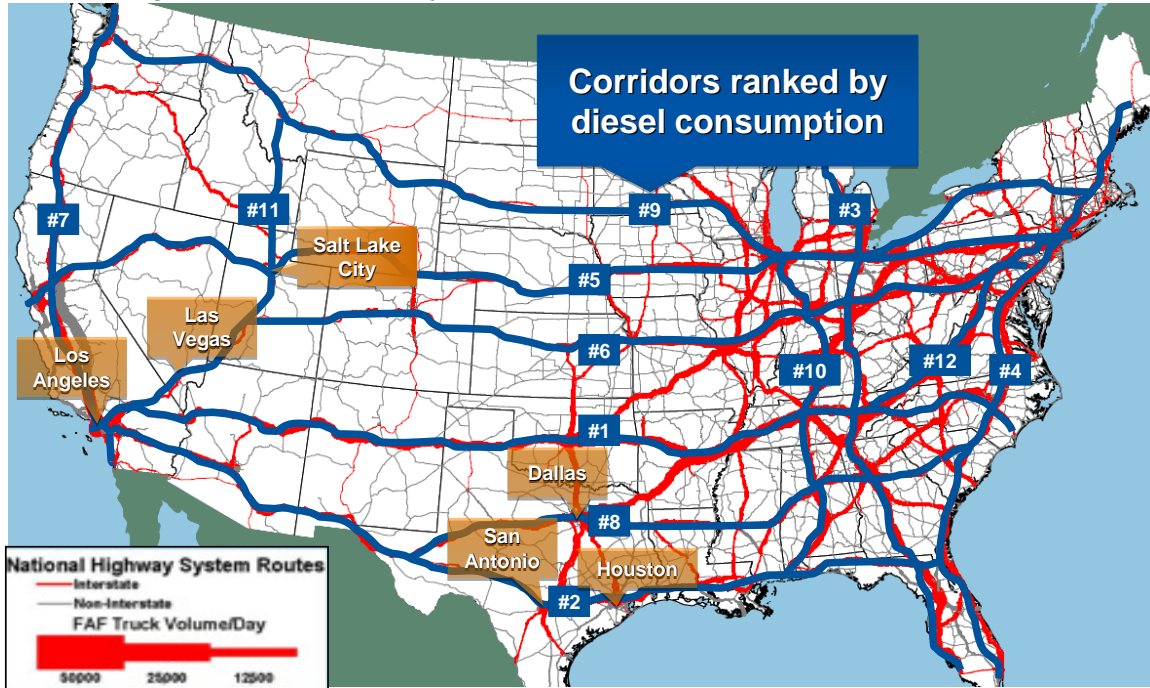
- Focused development along busiest truck routes
- Deploy stations every 250 – 300 miles
- Clear line of sight on Clean Energy Fuels Corp’s first 90 stations creates interstate coverage coast-to-coast and border-to-border
- Next 60 stations planned to expand the network and fill gaps

Natural Gas is Poised for Fast Transportation Market Penetration

The transportation market is poised for rapid adoption of natural gas in medium and heavy-duty trucks:

- Proven success of current deployments
 - Energy industry encouraging/requesting/advising vendors to use natural gas powered equipments (rigs, trucks, compressions, etc.)
 - Heckmann Corp. (NYSE: HEK) announced 200 new natural gas powered trucks to be used for water hauling in the Haynesville Shale in September 2011
- Fully embraced by original equipment manufacturers (OEM)
- Right-size engines entering the market
 - Engine manufacturers are broadening their natural gas powered product offerings, which is enabling more and more commercial consumers opportunities to switch
- Additional technological breakthroughs underway
- LNG is Cheaper, Cleaner, American & Abundant
 - Reliable, attractively priced fuel
 - Natural gas tied to domestic supply and demand factors as compared to crude oil which is susceptible to global influence
 - Known century of supply of natural gas domestically, global crude supplies always questioned
 - Cost savings between natural gas fuel and gasoline/diesel is approximately \$1.00 to \$1.50 per gallon, ~25% to 40% savings annually on fuel
 - Natural gas powered vehicles have superior environmental performance

US Trucking Corridors Ranked by Diesel Consumption



US Highway Corridors Ranked by Diesel Consumption
 Source: Westport Innovations Inc.

America's Natural Gas Highway – September 2011 Actual



America's Natural Gas Highway – September 2011 Actual
 Source: Clean Energy Fuels Corporation

America’s Natural Gas Highway – December 2012 Projected



America’s Natural Gas Highway – December 2012 Projected
Source: Clean Energy Fuels Corporation

LATIN AMERICA

R.Fernandes (ALGNV – Latin America NGV Association)

Abstract

Information and data contained in this paper is basically the result of an evaluating analysis, conducted by the Energy Group of the Institute of Economics from the UFRJ – Federal University of Rio de Janeiro, in March 2005, as contracted by Petrobras Gas Energy and IBP – Brazilian Oil and Gas Institute, through the IBP Committee and ALGNV support, and herein revised and updated by the author.

Introduction

Based upon the concept of Blue Corridors, developed in Europe, where cargo or passenger vehicles fueled by natural gas, could be moved and integrate key economical centers of specific regions, a decision was made to evaluate this opportunity, covering the Southern Latin America. The basic reason behind this decision, was the fact, that, by that time and still today, this region counts with the best served natural gas distribution network in the continent, due to the high concentration of economical centers in the area.

Some four (4) regions have been included in this evaluation: Southern Brazil, Uruguay, Northern Argentine and Chile. This corridor will also allow an important and strategic economical connection for the involved countries: the Atlantic-Pacific Ocean liaison.

Executive Summary

The selection of the routes have been based in the following criteria: a) importance or the highway to integrate the region; b) traffic intensity; c) availability of natural gas distribution networks around the routes. In addition to this, it was estimated that some 34 fueling stations would be required, assuming that those stations will keep a distance between each other of about 200 km. It was found that 4 of those stations could not be served by any gas distribution network. Therefore, they would be supplied by LNG or trucks with CNG tube bundles.

A series of analysis have been made, covering:

- NG Fueling stations construction costs in the Blue Corridor
- Cost of new HD vehicles to operate in the Corridor
- LNG feasibility analysis in the routes
- Social-Economic and Environmental analysis in the Corridor

Based upon the estimated social-economical aspects, it is important to list the following expected results of this project:

- Cost reduction in the operation of cargo and passenger vehicles, of approximately 9% for cargo transportation and 10% for passenger vehicles. This estimate was based upon the assumption, the price of natural gas in the road, will be maintained at a maximum of 70% of the diesel price;
- Increased tourists average flow between Argentine and Brazil, assuming the utilization of identical fueling regulations between the two countries;
- Diesel reduction consumption, that is important for Brazil, once the country is still importing this fuel to meet the local demand;
- Positive impact in the Mercosur economical integration, as long as this will generate an attractive and increased business volume of import-export among the neighborhood countries;
- As social benefits, it is estimated this project will generate some 3.000 permanent jobs when completed and some other 3.500 temporary jobs;
- Significant environmental improvement in the region. Based upon the World Bank data, it was estimated that some US\$ 23 million per year may be saved in healthcare costs, some other US\$ 10 million/year in terms of fixed assets.

The proposed dual-oceanic Blue Corridor is shown in the figure below, and starts in Rio de Janeiro being formed by roads BR 040, BR 116, BR 376, BR 101, BR 290 in Brazil, RN 14 and 9 from Brazil to Argentine, Buenos Aires to Montevideo and the route from Buenos Aires to Santiago, and then down to Valparaiso.



Map of the Dual-Ocean Mercosur Blue Corridor

The execution of this project still depends on a number of measures. Regardless of the number of bi-lateral agreements signed in the past years, the energy integration process in the region, is still going in a gradual way. To count with a completed integrated market, the region still depends on a number of barriers to be removed. This involves strategic, political and economical issues, and it is not simply energy integration.

The European integration experience has been showing that regional energy integration is, in most of the cases, subject to long and multi-dimensional processes, and therefore with completely unpredictable results. In fact, government, local or international energy companies, non-governmental organizations, credit multi-lateral institutions, among others, are permanently trying to influence the decisions to be made. Regardless of the integration benefits, there are many, many barriers to be removed, in order to obtain an agreement that will satisfy all the parts involved. To remove these barriers, it is essential to improve the institutional basis, in each regional country.

Therefore, some efforts are required to develop an energy regulatory model for the involved countries, applied to natural gas, in order to meet all different interests. It is required to recognize the countries have different business interests, different cultural standards, and also collected in the memory, past events between them, that has caused some unpleasant situations. The key objective shall be energy integration in the region, and not only the interest of each individual business or country in the project. To do this, there are some regional organizations that should be involved, such as IIRSA – South American Regional

Infrastructure Initiative, and UNASUL – South America Nations Union, which is similar to the European Union Organization.

No question, there are obstacles to be removed. However, the technical people has proposals to resolve most of those barriers. By the other hand, there is a general feeling that decisions made, use to take a long time to be executed. In some cases, those decisions have been submitted to politicians, who use to give priority to their ideology convictions, instead of the technical interests of the nations involved.

However, there are indications, that apparently this is a good moment, to come up with a sound decision, as long as there is a better understanding today, related to regional energy integration, in line with the purpose to improve the social and economical development, and consequently, the position of the region in the worldwide scenario.

ASIA PACIFIC

Lee Giok Seng, Executive Director, ANGVA

ANGVA Green Highways 2011 Begins Its Journey of A Thousand Miles of Friendship and Cooperation

Background

ANGVA Green Highways, which started in 2007, are implemented by ANGVA every two years to coincide with its biennial conference and exhibition. ANGVA Green Highways are events and activities involving various countries in Asia Pacific which will end in the country where ANGVA biennial conference & exhibition are held.

The objectives of ANGVA Green Highways are:

1. Create awareness and promote NGV, ANGVA and NGV infrastructure.
2. Promote harmonisation of NGV standards and Code of Practices esp. safety standards.
3. Create cooperation and exchange of information and experiences

ANGVA Green Highways are not about driving from points A to B. It is about getting local NGV industry and association involvement, to share and exchange information, experiences and networking. It is also about harmonisation of standards and practices and about creating “NGV and ANGVA Green Highways” to highlight the benefits of NGV in term of energy security and supply, economics and environment.

For ANGVA Green Highways 2011 (AGH2011), the following routes were chosen:



Iran – UAE – Pakistan – India — Bangladesh – Myanmar – China.
 Southern Route Indonesia – Singapore – Malaysia – Thailand – Vietnam – China.
 Japan – Korea – China

All together fourteen (14) countries are involved along the three routes. The AGH2011's torches and message scrolls start its journey from each route to reach Beijing, China in time for the opening ceremony of ANGVA 2011 on October 2011.

Launching of Southern Route

Team Indonesia

The Southern Route started its journey of a thousand miles of friendships and cooperation with the first flag-off of the Southern Route in Jakarta, Indonesia on 12th July 2011, coinciding with the ANGVA Roundtable Indonesia, 12 -13th July 2011 at Sultan Hotel, Jakarta.

The Southern Route flag-off started with a ribbon cutting ceremony by Dr. Herman Agustiawan (member of the National Energy Council) and ANGVA Executive Director (Lee Giok Seng) lined with six (6) natural gas vehicles at the open space of Sultan Hotel, Jakarta.

Team Singapore

Team Singapore, led by Team Leader William Aw, held the flag-off of their leg of AGH2011 in the morning of 15th July 2011 at the Smart Energy's Mandai NGV Daughter Station.

The ribbon cutting and flag-off, involving 5 CNG cars (including 1 CNG car from Malaysia), was conducted by William Aw and ANGVA Executive Director.

The CNG Cars were then driven from the Smart Energy's Mandai NGV station to Union Gas' Toh Tuck Road NGV Station, the world largest NGV station in term of number of dispensing hoses.

Team Malaysia

Team Malaysia held a flag-off ceremony on 20th Sept 2011 in Puchong (near Kuala Lumpur), Malaysia. The flag-off coincided with the ceremony for the official delivery of the first Malaysian Fully Composite CNG Long Tube Trailer by Sime Darby Industrial Sdn Bhd to MISC Logistics Services (the operator of CNG trailers and prime movers for PETRONAS' mother – daughter stations). A total of 19 trailers will be delivered.

Team Thailand

On 21st Sept 2011, Team Malaysia, in a convoy of 3 CNG cars drove all the way up to the Malaysian-Thailand border to hand over the AGH2011 Torch and Friendship Scroll to Team Thailand in the morning of 22nd Sept 2011 at a NGV Refuelling Station in Hatyai. Team Thailand later drove 1000 km from Hatyai all the way up north to Bangkok in 4 CNG cars, to held a flag-off and Safety Forum in Bangkok on 24th Sept 2011 with a “Driving Clean, Driving Safe” theme.

Team Vietnam

Team Vietnam, led by Petrovietnam Gas South and ITO Holdings, hosted the Vietnam’s leg of the ANOVA Green Highways 2011 on 30th Sept 2011. The handover and flag-off ceremony was held at Petrovietnam Gas South’s CNG daughter station in Ho Chi Minh City. This is the first CNG station in Vietnam, located beside a bus depot.

Launching of the Western Route:

Team Iran

The Western Route of the AGH2011 was launched on 24th July 2011 in Tehran, IR of Iran, in conjunction with the Iran NGV 2011 International Conference and Exhibition, 24th – 26th July 2011, Olympic Hotel, Tehran.

The flag-off started with a ribbon cutting ceremony by HE M.J. Mohammadzadeh, Vice President of Iran and also Head of the Iranian Environment Protection Agency, accompanied by HE M. Royanian, Special Representative of the President of Iran and also Head of Transportation and Fuels Management Committee, and Mr. M. Mashayekhi, General Manager of Hamayesh Sanaat Institute and Chairman of Iranian CNG Permanent Secretariat and AGH2011 Team Leader for Team Iran.

Team UAE

Team UAE continued the Western Route journey by conducting the flag-off event in Dubai on 26th Sept 2011. The event, hosted by Emirates Gas (EMGAS), and sponsored by Volkswagen, CG Tech and Emirates Transport, was attended by over 90 key stakeholders including senior management from ENOC, EMGAS, Dubai Municipality, Emirates Airlines, ADNOC Distribution, RTA, Dubai Municipality among others.

Team Pakistan

Team Pakistan successfully held the ANOVA Green Highways 2011 flag-off in Islamabad on 1st October 2011. The event was well attended by major stakeholders of NGV market in Pakistan. Around 25 CNG cars took part in the flag-off rally in Islamabad.

Team Bangladesh

Team Bangladesh, led by Team Leader Mr. Hasin Parvez, CEO of Green Fuel CNG Conversion Center and also ANOVA Country Representative for Bangladesh, successfully held the ANOVA Green Highways 2011 flag-off ceremony in Dhaka on 5th October 2011. The flag-off started with eight (8) cars rallying from MCW CNG Refuelling Station at Mirpur, Dhaka and ended at CIRPAD Auditorium, Dhaka.

Team Myanmar

The flag-off by Team Myanmar (led by Team Leader, Daw Yin Win Thu (Ms. Sandra), Managing Director of M.N.T. Co., Ltd) was successfully held in Yangon with the opening and ribbon cutting ceremonies held at the conference hall of the Myanmar Info Tech and the flag-off at the Parami CNG Station.

Eastern Route

Team Japan

Team Japan, headed by Mr. Toshio Ohashi, General Manager, Natural Gas Vehicle Project Dept., Japan Gas Association (JGA), successfully launched the ANGVA Green Highways 2011 (AGH2011)'s Eastern Route on 6th Sept 2011 at Sagawa Express Company Ltd's depot in Tokyo, Japan. Later the torch and scroll were handed over by Mr. Ohashi to representatives of Sagawa Express to bring it to Nagoya on 18th Sept 2011 and then to Sakaiminato on 24th Sept 2011 to send it by ferry to Donghae, Korea.

Team Korea

Team Korea held the ANGVA Green Highways 2011 (AGH2011) flag-off at the Ferry Terminal of Donghae City on 26th Sept 2011. The AGH2011 was handed over to Team Korea by representative of the DBS Cruise Ferry which had brought over the torch and scroll from Sakaiminato, Japan via ferry to Donghae. At the flag-off ceremony, 2 CNG cars were flag-off at the port area and traveled to the sole NGV Refuelling station in Donghae.

Team China

The last flag-off of the ANGVA Green Highways 2011 was held in the city of Xi'an, China on 15th October 2011 by Team China before proceeding to join the ANGVA 2011 Conference & Exhibition in Beijing, China on 18th October 2011. An NGV Forum for major CNG bus fleet operators and transport officials from various cities in China were held in Xi'an.

The ANGVA Green Highways 2011 Torches and Friendships Scrolls from the three routes (Western, Southern and Eastern routes) were handed over to China Automotive Technology and Research Center (CATARC) at the opening ceremony of ANGVA 2011 on 18th October 2011. Team leaders and representatives of the 13 country teams were present on stage to witness the handover of the torches and scrolls to CATARC, the host and organizer of ANGVA 2011. The ceremony marked the end of the journey of a thousand of miles of friendships, cooperation and enthusiasms demonstrated by all the 13 country teams and the achievement of the objectives of the ANGVA Green Highways 2011.

Eastern Route

Eastern Route: travel from Tokyo to Osaka to Sakaiminato to Donghae, Korea.

The AGH2011's Logo, Torch and Message Scroll

The Logo

The logo was slightly amended from the previous ANGVA Green Highways' logo with the addition of the international symbol for NGV refueling stations for dispensing CNG (Compressed Natural Gas) and LNG (Liquefied Natural Gas).



The Torch

The AGH2011's torch has three spirals moving from the base towards the globe on the top. The three spirals represent the three routes chosen for the AGH2011 i.e. Southern Route, Western Route and Eastern Route. The colour blue represents the universal colour of natural gas, which is clean and environmentally friendly – “Green”. The three spirals were inspired from the DNA double helix, which symbolize that all teams participating in AGH2011 share the same DNA to promote the usage of natural gas as a clean or “Green” fuel for the transport sector.

The Message Scroll

The message scroll captures in writing the friendships, cooperation, and goodwill among all team members along the three routes as they bring the scrolls to Beijing, China to congratulate CATARC on the successful organizing and hosting of ANGVA 2011.



The message on the scroll is written in two languages i.e. English and Mandarin. The following is the message:

Congratulations to China Automotive Technology & Research Center (CATARC) for organizing and hosting ANGVA 2011, Beijing, China, 18 – 20th October 2011. We, the ANGVA Green Highways 2011 Teams bring this message to convey our spirit of friendships and enthusiasms to achieve the vision of making natural gas as a clean fuel for the transportation sector.

The ANGVA Green Highways Teams has embark on the journey of a thousand miles of friendships, enthusiasms and cooperation to achieve the ANGVA Green Highways objectives of

- creating awareness and promoting NGV, ANGVA and NGV Infrastructure,
- promoting harmonization of NGV Standards and Code of Practices especially safety standards, and
- Creating cooperation and exchange of information and experiences.

APPENDIX III: WORLDWIDE NGV STATISTICS, DECEMBER 2011

Claudio Kohan, NGV Communications Group

Country	Natural Gas Vehicles					NGV	Refuelling stations				Refuelling stations	VRA	Monthly gas consumption (M Nm3)			Last update	
	Total	Cars/LDVs	MD/HD Buses	MD/HD Trucks	Others	% of total NGVs in the world	Total	Public	Private	Planned	% of total fuelling stations in the world		Average consumption (actual report)	The consumption in theory	Reported consumption		
Pakistan	2.850.500	2.670.000	500		180.000	19,59%	3.330	3.330			16,10%			491,10	0,0%	July	2011
Iran	2.859.386	2853334	6036	16		19,65%	1.800	1.765	35	465	8,70%		467,00	531,72	87,8%	November	2011
Argentina	2.031.509	2.031.509				13,96%	1.898	1.898			9,18%	32	235,36	365,67	64,4%	September	2011
Brazil	1.694.278	1.694.278				11,64%	1.790	1.790			8,66%	7	163,91	304,97	53,7%	September	2011
India	1.100.000	1.069.380	23.000	715	6.905	7,56%	683	364	319		3,30%		163.211900	262,41	0,0%	July	2011
Italy	761.340	757.840	2.300	1.200		5,23%	858	811	47	38	4,15%	199	62,03	144,27	43,0%	June	2011
China	600.000	370.000	150.000	30.000	50.000	4,12%	2.500	2.300	200	400	12,09%	9		543,10	0,0%	December	2011
Colombia	348.747	325.287	13.800	9.660		2,40%	651	651			3,15%	3	45,00	107,68	41,8%	August	2011
Thailand	267.735	219.423	14.175	32.378	1.759	1,84%	444	419	25		2,15%	0		108,24	0,0%	July	2011
Armenia	244.000	192.000	17.300	34.700		1,68%	345	9	336		1,67%		26,52	114,22	23,2%	September	2011
Ukraine	200.019	10.000	120.000	70.000	19	1,37%	294	102	192	40	1,42%	8	83,00	417,80	19,9%	July	2011
Bangladesh	200.000	137.000	10.000	27.000	26.000	1,37%	600	600			2,90%	13	59,47	77,56	76,7%	September	2011
Bolivia	140.400	140.400				0,96%	156	156			0,75%	46	26,28	25,27	104,0%	April	2010
Egypt	162.000	159.322	1.220	713	745	1,11%	143	139	4	19	0,69%		38,00	32,95	115,3%	November	2011
Uzbekistan	310.000	310.000				2,13%	175	175		50	0,85%			55,80	0,0%	November	2011
Peru	103.712					0,08%	170	170			0,82%		16,30	2,23	730,7%	September	2011
USA	112.000	96.500	13.000	2.500		0,77%	1.100	550	550		5,32%	4.747	105,00	58,37	179,9%	July	2011
Germany	94.890	92.100	1590	1200	0	0,65%	900	720	180	150	4,35%	804	14,60	22,31	65,4%	June	2011
Venezuela	90.000	90.000				0,62%	166	166		300	0,80%	80	8,15	16,20	50,3%	June	2011
Russia	86.000	19.300	43.500	10.400	11.400	0,69%	245	204	41	15	1,21%	4	28,75	29,65	97,0%	December	2011
Bulgaria	61.296	61.000	236	60		0,42%	86	85	1	6	0,42%		15,00	11,74	127,8%	September	2011
Malaysia	48.946	48.400	486	60		0,34%	167	165	2		0,81%	10		10,22	0,0%	June	2011
Japan	40.823	10.560	1.511	21.010	1.742	0,28%	332	286	46		1,61%	612		24,86	0,0%	September	2011
Sweden	36.381	33.575	1.725	1.080	1	0,25%	166	130	36		0,80%	21	9,62	12,08	79,6%	June	2011
Korea	30.443	3.049	26.412	972	10	0,21%	178	173	5		0,86%		93,00	80,56	115,4%	June	2011
Myanmar	26.472	8.178	18.290	4		0,18%	51	51			0,25%			56,35	0,0%	October	2011
Canada	14.205	11.800	199	6	2.200	0,10%	81	71	10		0,39%	500		2,84	0,0%	December	2010
France	13.500	10.200	2.200	1.100		0,09%	332	32	300		1,61%	1.290		9,32	0,0%	July	2011



NATURAL GAS FOR VEHICLES – IGU & UN ECE JOINT REPORT

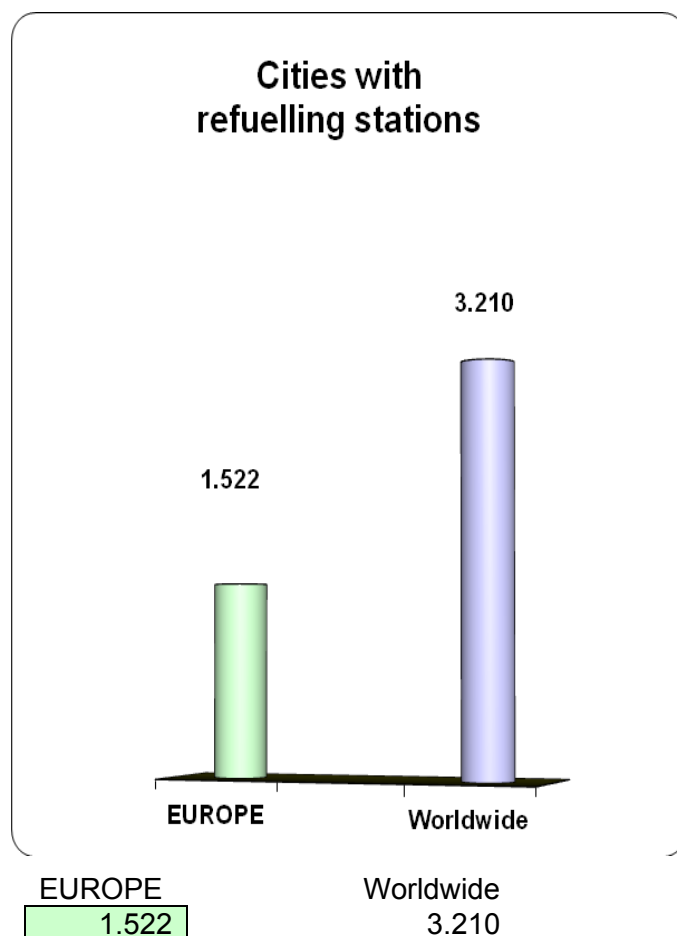


Tajikistan	10.600	10.600				0,07%	53	53			0,26%		4,13	1,91	216,5%	December	2007
Switzerland	9.857	9.547	181	69	60	0,07%	126	123	3	5	0,61%	117	1,59	2,32	68,5%	June	2011
Chile	8.164	8.055	109			0,06%	15	15			0,07%	1	3,20	1,78	180,1%	December	2010
Kyrgyzstan	6.000	6.000				0,04%	6	6			0,03%		0,60	1,08	55,6%	December	2007
Austria	5.910	5.759	133	15	3	0,04%	201	171	30	5	0,97%	12	0,50	1,45	34,5%	June	2011
Singapore	5.567	5.552	15			0,04%	4	3	1		0,02%			1,04436		July	2011
Indonesia	5.520	4.850	400	20	250	0,04%	14	14		4	0,07%			2,10	0,0%	October	2011
Mexico	4.831	4.800	31			0,03%	14	14			0,07%	22	0,02	0,96	2,1%	June	2011
Belarus	4.600	4.600				0,03%	42	42			0,20%		0,65	0,83	78,5%	September	2011
Netherlands	4.300	3.530	590	180		0,03%	85	65	20	40	0,41%	558		2,55	0,0%	June	2011
Australia	3.500	100	1.700	950	750	0,02%	51	4	47	39	0,25%	130		5,92	0,0%	October	2011
Turkey	3.339	1.850	1.489			0,02%	14	8	6		0,07%	35	0,40	4,80	8,3%	April	2010
Czech Republic	3.409	3.012	356	41	70	0,02%	50	37	13	8	0,24%	83	0,85	1,55	54,9%	October	2011
Spain	3.051	574	1.405	1.028	44	0,02%	55	9	46	17	0,27%	21	4,48	5,14	87,1%	June	2011
Georgia	3.000	3.000				0,02%	50	50			0,24%			0,54	0,0%	August	2011
Trinidad & Tobago	3.000	3.000				0,02%	8	7	1		0,04%		0,80	0,54	148,1%	June	2011
Moldavia	2.200	2.200				0,02%	24	24			0,12%		0,40	0,40	101,0%	September	2011
Poland	2.082	1.502	276	4	300	0,01%	33	32	1		0,16%	49		1,12	0,0%	June	2011
United Arab Emirates	1.751	1.750	1			0,01%	17	16	1	18	0,08%	1		0,32	0,0%	September	2011
Dominican Republic	1.614	1.614				0,01%	3	3		40	0,01%		0,09	0,29	31,7%	May	2011
Finland	970	850	85	15	20	0,01%	19	18	1	2	0,09%	10	0,28	0,42	66,5%	June	2011
Slovakia	823	429	334	60		0,01%	11	7	4	2	0,05%		0,96	1,13	85,3%	December	2010
Greece	600	0	520	80	0	0,00%	3		3		0,01%			1,62	0,0%	November	2010
Norway	545	300	198	22	25	0,00%	13	7	6	1	0,06%		4,55	0,67	682,3%	March	2010
Portugal	504	46	354	54	50	0,00%	5	1	4	3	0,02%		1,11	1,12	99,6%	June	2011
Serbia	519	494	25			0,00%	6	4	2	4	0,03%	1	0,027	0,16	16,7%	December	2010
Nigeria	345	260		85		0,00%	6	6			0,03%			0,11	0,0%	November	2011
Mozambique	315	280	35			0,00%	2	2			0,01%			0,16	0,0%	July	2011
Hungary	300	225	75			0,00%	16	2	14	1	%	14	0,13	0,27	47,1%	October	2011
Belgium	241	235		6		0,00%	14	8	6	6	0,07%	12		0,05	0,0%	June	2011
United Kingdom	368	68		250	50	0,00%	14	9	5	5	0,07%	10	3,00	0,13	2379,1%	September	2010
Vietnam	282	280	2			0,00%	3	3		3	0,01%					February	2011
Iceland	255	237	2	16		0,00%	2	2		2	0,01%		0,04	0,06	63,5%	December	2010

Luxembourg	234	199	35			0,00%	6	5	1		0,03%	2	0,06	0,14	39,4%	June	2010
New Zealand	201	19	61	84	37	0,00%	14		14		0,07%			0,26	0,0%	December	2010
Lithuania	195	85	110			0,00%	3	2	1	2	0,01%	5	0,20	0,35	57,9%	September	2011
Croatia	194	133	61			0,00%	1	1		1	0,00%		0,100	0,21	48,3%	December	2010
Estonia	130	121	6	3		0,00%	2	2	0	2	0,01%		0,02	0,04	47,4%	September	2011
Algeria	125	115	10			0,00%	3	3			0,01%			0,05	0,0%	October	2004
Lichtenstein	104	72	31	1		0,00%	3	3			0,01%			0,11	0,0%	December	2009
Philippines	71	11	60			0,00%	3	1	2		0,01%			0,18	0,0%	October	2011
Macedonia	54	7	47			0,00%	1		1	3	0,00%		0,02	0,14	14,8%	January	2011
Ecuador	40	40				0,00%	1	1			0,00%			0,01	0,0%	May	2009
Tunesia	34	32	2			0,00%	1		1		0,00%			0,01	0,0%	October	2007
Tanzania	31	31				0,00%	1	1		2	0,00%			0,01	0,0%	October	2010
South Africa	24	21	2		1	0,00%	2	2			0,01%					August	2010
Bosnia & Herzegovina	21	20	1			0,00%	1	0	1	1	0,00%	2		0,01	0,0%	October	2010
Kazakhstan	20		20			0,00%	10	10			0,05%					December	2010
Latvia	18	18				0,00%	1	1			0,00%		0,003	0,00	79,3%	September	2011
Panama	15	15				0,00%					0,00%					November	2008
Slovenia	8	8				0,00%				2	0,00%	8	0,007			June	2011
Ireland	2	2				0,00%	1	1			0,00%	1		0,00	0,0%	October	2008
Montenegro	1	1				0,00%	1		1		0,00%			0,00		March	2006
Turkmenistan	1	1				0,00%	0	1			0,00%					November	2009
Total	14.550.720	13.581.713	434.133	250.384	284.490		20.681	18.113	2.567	1.692		9.479	1.525,20	3.963,49	38,5%	December	2011

Cities with CNG refuelling stations

Country	Number of cities	Last update
Argentina	334	Jul. '11
Armenia	37	Mar. '08
Australia	3	Nov. '09
Austria	126	Nov. '10
Bangladesh	8	Nov. '05
Belarus	16	Sep. '11
Belgium	8	Jun. '11
Bolivia	6	Apr. '10
Brazil	300	Jul. '11
Bulgaria	41	Sep. '11
Chile	5	Dec. '07
China	74	Sept. '04
Colombia	78	Aug. '11
Croatia	1	Dec. '10
Czech Republic	27	Jun. '11
Egypt	16	Apr. '06
Estonia	2	Sep. '11
Finland	14	Jun. '10
France	26	Aug. '02
Germany	740	Dec. '10
Greece	2	Nov. '10
Hungary	2	Oct. '11
Iceland	2	Jan. '11
India	42	Nov. '10
Indonesia	2	Sept. '08
Iran	597	Nov. '11
Ireland	1	Oct. '08
Italy	150	Dec. '06
Korea	34	May. '05
Latvia	1	Sep. '11
Liechtenstein	1	Sept. '04
Lithuania	3	Sep. '11
Luxembourg	1	Jun. '11
Macedonia	1	Jan. '05
Malaysia	6	Oct. '06
Mexico	2	Jun. '05
Moldavia	13	Sep. '11
Mozambique	2	Aug. '11
Myanmar	4	Oct. '11
Netherlands	16	Dec. '08
Norway	4	Jan. '10
Pakistan	50	Apr. '08
Peru	2	Jun. '11
Philippines	1	Oct. '05
Portugal	5	Dec. '09
Russia	198	Jan. '12
Serbia	3	Dec. '10
Singapore	1	Jul. '05
Slovakia	8	Feb. '10
South Africa	1	Aug. '10
Spain	32	Jun. '10
Sweden	77	Jun. '11
Switzerland	20	Jun. '11
Tanzania	1	Oct. '10
Taiwan	1	Apr. '05
Thailand	39	Aug. '08
Trinidad & Tobago	11	Dec. '07
Tunisia	1	Oct. '07
Turkey	2	Aug. '04
United Arab Emirates	4	Jul. '11
United Kingdom	5	Nov. '04
Venezuela	26	Jun. '11



Worldwide fuel prices

Country	Premium Gasoline (Euro/litre)	Regular Gasoline (Euro/litre)	Diesel (Euro/litre)	CNG (Euro/Nm ³)	CNG price equivalent per litre gasoline	CNG price equivalent per litre diesel	Date
Argentina	0,58	0,53	0,73	0,19	0,17	0,19	Jan 11
Armenia	0,96	0,91	0,83	0,38	0,34	0,39	Sep 11
Australia	0,77	0,72	0,78	0,34	0,30	0,35	Okt 09
Austria	1,41	1,40	1,20	0,62	0,55	0,63	Nov 10
Bangladesh	0,52	0,49	0,34	0,18	0,16	0,18	Sep 09
Belarus	0,66	0,61	0,59	0,19	0,17	0,19	Sep 11
Belgium	1,33		1,01	0,73	0,65	0,75	Jan 10
Brazil	1,27			0,75	0,67	0,77	Jun 11
Bulgaria	1,25		1,25	0,55	0,52	0,58	Sep 11
Canada	0,94	0,93	0,86	0,59	0,56	0,62	Jan 11
China	0,77	0,73	0,68	0,43	0,39	0,44	Mrz 11
Croatia	1,31	1,26	1,16	0,58	0,52	0,60	Jan 11
Czech Republic		1,38	1,32	0,66	0,59	0,68	Okt 11
Dominican Republic	0,77		0,60	0,33	0,30	0,34	
Egypt	0,35	0,23	0,14	0,06	0,05	0,06	Jan 10
Estonia	1,30		1,30	0,68	0,61	0,70	Sep 11
Finland				1,28	1,15	1,31	Jun 11
France	1,35		1,09	0,87	0,78	0,89	Jan 10
Germany	1,63	1,58	1,42	1,15	0,54	1,18	Sep 11
Greece	1,19		1,04	0,65	0,58	0,67	Jan 10
Iceland	1,55	1,46	1,49	0,77	0,69	0,79	Jan 11
India	1,00	0,96	0,59	0,47	0,42	0,48	Jun 11
Indonesia	0,44	0,31	0,33	0,18	0,16	0,18	Jul 10
Iran	0,10	0,07	0,01	0,03	0,02	0,03	Okt 10
Italy	1,05		1,16	0,53	0,50	0,55	Jan 10
Japan	1,44	1,34	1,16	0,79	0,61	0,67	Jul 11
Korea	1,29		1,17	0,60	0,46	0,51	Jun 11
Latvia	1,32		1,28	0,38	0,29	0,32	Sep 11
Lichtenstein	1,20	1,13	1,19	0,92	0,80	0,87	Jun 10
Lithuania	1,32		1,24	0,88	0,79	0,90	Sep 11
Luxembourg	1,11		0,92	0,63	0,56	0,65	Jan 10
Macedonia	1,24		1,04	0,42	0,38	0,44	Jan 11
Malaysia		0,44	0,42	0,16	0,13	0,16	Jul 11
Moldavia	1,05	0,87	1,00	0,45	0,13	0,46	Sep 11
Netherlands	1,44		1,09	0,56	0,50	0,58	Jan 10
Norway		1,84	1,78	0,96	0,86	0,99	Mrz 11
Pakistan	0,91	0,71	0,77	0,55	0,49	0,56	Sep 11
Philippines	0,76		0,60	0,26	0,23	0,27	Jan 10
Poland	1,09		1,00	0,51	0,46	0,52	Jan 10
Portugal	1,35		1,11	0,45	0,40	0,46	Mrz 10
Russia	0,73	0,70	0,69	0,25	0,23	0,22	Jan 12
Serbia	1,24	1,14	1,18	0,58	0,52	0,59	Feb 11
Singapore	0,94		0,67	0,70	0,63	0,72	Mrz 10
Slovakia	1,25		1,15	0,83	0,74	0,85	Dez 10
Slovenia				0,77	0,69	0,79	Jun 11
Spain				0,92	0,72	0,80	Jun 11
Sweden	1,54		1,49	1,44	1,31	1,29	Jun 11
Switzerland	1,40	1,36	1,43	1,11	0,96	1,05	Jun 11
Thailand	1,08	0,87	0,74	0,21	0,19	0,21	Jul 11

Country	Premium Gasoline (Euro/litre)	Regular Gasoline (Euro/litre)	Diesel (Euro/litre)	CNG (Euro/Nm ³)	CNG price equivalent per litre gasoline	CNG price equivalent per litre diesel	Date
Ukraine	0,63	0,59	0,52	0,30	0,27	0,31	Nov 09
United Kingdom	1,27		1,29	0,92	0,82	0,94	Jan 10
Uzbekistan	0,80	0,72	0,68	0,23	0,21	0,24	Okt 11
Vietnam	1,25	1,17	0,92	0,89	0,80	0,91	Mrz 11

Europe NGV statistics

Country	Natural Gas Vehicles					Refuelling stations			
	Total	Cars/LDVs	MD/HD Buses	MD/HD Trucks	Others	Total	Public	Private	Planned
Italy	761.340	757.840	2.300	1.200		858	811	47	38
Ukraine	200.019	10.000	120.000	70.000	19	294	102	192	40
Germany	94.890	92.100	1590	1200	0	900	720	180	150
Bulgaria	61.296	61.000	236	60		86	85	1	6
Russia	86.000	19.300	43.500	10.400	13.400	245	204	41	15
Sweden	36.381	33.575	1.725	1.080	1	166	130	36	
France	13.500	10.200	2.200	1.100		332	32	300	
Switzerland	9.857	9.547	181	69	60	126	123	3	5
Austria	5.910	5.759	133	15	3	201	171	30	5
Belarus	4.600	4.600				42	42		
Netherlands	4.300	3.530	590	180		85	65	20	40
Czech Republic	3.409	3.012	356	41	70	50	37	13	8
Spain	3.051	574	1.405	1.028	44	55	9	46	17
Moldavia	2.200	2.200				24	24		
Poland	2.082	1.502	276	4	300	33	32	1	
Finland	970	850	85	15	20	19	18	1	2
Slovakia	823	429	334	60		11	7	4	2
Greece	600	0	520	80	0	3		3	
Norway	545	300	198	22	25	13	7	6	1
Portugal	504	46	354	54	50	5	1	4	3
Serbia	519	494	25			6	4	2	4
Hungary	300	225	75			16	2	14	1
Belgium	241	235		6		14	8	6	6
United Kingdom	368	68		250	50	14	9	5	5
Iceland	255	237	2	16		2	2		2
Luxembourg	234	199	35			6	5	1	
Lithuania	195	85	110			3	2	1	2
Croatia	194	133	61			1	1		1
Estonia	130	121	6	3		2	2	0	2
Lichtenstein	104	72	31	1		3	3		
Macedonia	54	7	47			1		1	3
Bosnia & Herzegovina	21	20	1			1	0	1	1
Latvia	18	18				1	1		
Slovenia	8	8							2
Ireland	2	2				1	1		
Montenegro						1		1	
Armenia	244.000	192.000	17.300	34.700		345	9	336	
Russia	86.000	19.300	43.500	10.400	13.400	245	204	41	15
Turkey	3.339	1.850	1.489			14	8	6	
Georgia	3.000	3.000				50	50		
Total	1.631.100	1.234.233	238.645	131.984	27.438	4.274	2.929	1.345	376

UN ECE Region NGV statistics

Country	Natural Gas Vehicles					Refuelling stations			
	Total	Cars/LDVs	MD/HD Buses	MD/HD Trucks	Others	Total	Public	Private	Planned
Italy	761.340	757.840	2.300	1.200		858	811	47	38
Uzbekistan	310.000	310.000				175	175		50
Armenia	244.000	192.000	17.300	34.700		345	9	336	
Ukraine	200.019	10.000	120.000	70.000	19	294	102	192	40
USA	112.000	96.500	13.000	2.500		1.100	550	550	
Russia	86.000	19.300	43.500	10.400	13.400	245	204	41	15
Germany	94.890	92.100	1590	1200	0	900	720	180	150
Bulgaria	61.296	61.000	236	60		86	85	1	6
Sweden	36.381	33.575	1.725	1.080	1	166	130	36	
Canada	14.205	11.800	199	6	2.200	81	71	10	
France	13.500	10.200	2.200	1.100		332	32	300	
Switzerland	9.857	9.547	181	69	60	126	123	3	5
Austria	5.910	5.759	133	15	3	201	171	30	5
Belarus	4.600	4.600				42	42		
Netherlands	4.300	3.530	590	180		85	65	20	40
Turkey	3.339	1.850	1.489			14	8	6	
Czech Republic	3.409	3.012	356	41	70	50	37	13	8
Spain	3.051	574	1.405	1.028	44	55	9	46	17
Georgia	3.000	3.000				50	50		
Moldavia	2.200	2.200				24	24		
Poland	2.082	1.502	276	4	300	33	32	1	
Finland	970	850	85	15	20	19	18	1	2
Slovakia	823	429	334	60		11	7	4	2
Greece	600	0	520	80	0	3		3	
Norway	545	300	198	22	25	13	7	6	1
Portugal	504	46	354	54	50	5	1	4	3
Serbia	519	494	25			6	4	2	4
Hungary	300	225	75			16	2	14	1
Belgium	241	235		6		14	8	6	6
United Kingdom	368	68		250	50	14	9	5	5
Iceland	255	237	2	16		2	2		2
Luxembourg	234	199	35			6	5	1	
Lithuania	195	85	110			3	2	1	2
Croatia	194	133	61			1	1		1
Estonia	130	121	6	3		2	2	0	2
Kazakhstan	20		20			10			
Lichtenstein	104	72	31	1		3	3		
Macedonia	54	7	47			1		1	3
Bosnia & Herzegovina	21	20	1			1	0	1	1
Latvia	18	18				1	1		
Slovenia	8	8							2
Ireland	2	2				1	1		
Montenegro	1	1				1		1	
Turkmenistan	1	1				1		1	
Total	1.995.230	1.686.685	166.264	125.990	16.291	5.399	3.524	1.865	402

European fuel prices

Country	Premium Gasoline (Euro/litre)	Regular Gasoline (Euro/litre)	Diesel (Euro/litre)	CNG (Euro/Nm ³)	CNG price equivalent per litre gasoline	CNG price equivalent per litre diesel	Date
Armenia	0,96	0,91	0,83	0,38	0,34	0,39	Sep 11
Austria	1,41	1,40	1,20	0,62	0,55	0,63	Nov 10
Belarus	0,66	0,61	0,59	0,19	0,17	0,19	Sep 11
Belgium	1,33		1,01	0,73	0,65	0,75	Jan 10
Bulgaria	1,25		1,25	0,55	0,52	0,58	Sep 11
Croatia	1,31	1,26	1,16	0,58	0,52	0,60	Jan 11
Czech Republic		1,38	1,32	0,66	0,59	0,68	Okt 11
Estonia	1,30		1,30	0,68	0,61	0,70	Sep 11
Finland				1,28	1,15	1,31	Jun 11
France	1,35		1,09	0,87	0,78	0,89	Jan 10
Germany	1,63	1,58	1,42	1,15	0,54	1,18	Sep 11
Greece	1,19		1,04	0,65	0,58	0,67	Jan 10
Iceland	1,55	1,46	1,49	0,77	0,69	0,79	Jan 11
Italy	1,05		1,16	0,53	0,50	0,55	Jan 10
Latvia	1,32		1,28	0,38	0,29	0,32	Sep 11
Lichtenstein	1,20	1,13	1,19	0,92	0,80	0,87	Jun 10
Lithuania	1,32		1,24	0,88	0,79	0,90	Sep 11
Luxembourg	1,11		0,92	0,63	0,56	0,65	Jan 10
Macedonia	1,24		1,04	0,42	0,38	0,44	Jan 11
Moldavia	1,05	0,87	1,00	0,45	0,13	0,46	Sep 11
Netherlands	1,44		1,09	0,56	0,50	0,58	Jan 10
Norway		1,84	1,78	0,96	0,86	0,99	Mrz 11
Poland	1,09		1,00	0,51	0,46	0,52	Jan 10
Portugal	1,35		1,11	0,45	0,40	0,46	Mrz 10
Russia	0,73	0,70	0,69	0,25	0,23	0,22	Jan 12
Serbia	1,24	1,14	1,18	0,58	0,52	0,59	Feb 11
Slovakia	1,25		1,15	0,83	0,74	0,85	Dez 10
Slovenia				0,77	0,69	0,79	Jun 11
Spain				0,92	0,72	0,80	Jun 11
Sweden	1,54		1,49	1,44	1,31	1,29	Jun 11
Switzerland	1,40	1,36	1,43	1,11	0,96	1,05	Jun 11
Ukraine	0,63	0,59	0,52	0,30	0,27	0,31	Nov 09
United Kingdom	1,27		1,29	0,92	0,82	0,94	Jan 10

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Last thirteen years evolution

Argentina	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
NGVs	365.591	418.916	480.764	544.748	630.548	755.671	879.587	1.164.839	1.348.126	1.459.236	1.429.973	1.678.230	1745677	1.820.601	1927007
Stations	515	570	646	770	871	982	1.049	1.152	1.330	1.494	1.636	1.744	1.806	1.856	1888
CNG sold (MNm3)	1.092	1.270	1.412	1.508	1.681	1.851	2.041	2.649	3.062	3.186	3.061	2.940	2.659	233.892	229,4
Brazil	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
NGVs	...	...	...	...	...	284.751	380.515	642.844	826.364	1.052.295	1.325.823	1.467.219	1.588.331	1.631.173	1.664.847
Stations	...	...	...	...	...	265	506	667	905	1.206	1.411	1.575	1688	1777	1725
CNG sold (MNm3)	...	...	...	...	251	635	959	1.340	1.573	1.937	2.305	2.580	2.341	1.962	154,7
Germany		1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
NGV		1.059	2.040	3.245	(*)	6.829	10.509	14.420	19.105	27.175	38.933	54.772	77.191	85.000	91.890
Stations			30	50	120	130	250	350	400	500	630	720	804	863	900
CNG sold in MWh			132.472	165.127	239.871	325.546	424.697	527.314	685.836	963.204	1.400.000				14.6 MNm3
Italy	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
NGV (LDVs)	260.000	260.000	260.000	263.119	296.358	327.643	344.306	335.205	326.104	358.488	410.000	432.900	523.100	676.850	772.984
Stations	262	276	281	298	323	344	402	456	498	535	589	609	700	770	831
CNG sold (MNm3)	310	330	335	340	400	448	448	442	442	468	520	588	588	62,03	
Sweden	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
NGVs	204	657	1.079	1.374	1.725	2.000	3.309	4.248	5.298	7.897	12.119	14.536	16.900	23.125	32.000
Stations	8	14	19	22	26	31	39	48	65	85	97	115	122	136	169
CNG and CBG sold (Nm3x1000)	4.308	7.137	9.862	11.335	13.950	16.678	20.125	25.434	28.872	35.450	43.856	53.636	58.126	67.000	7.730.000
Switzerland	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
NGVs	20	30	60	80	100	150	350	650	1.250	1.965	3.313	5.830	7.122	8.599	
Stations	3	3	7	13	14	20	26	37	50	64	78	97	112	122	
CNG and CBG sold (Nm3x1000)			220	452	841	995	1.576	1.859	2.281	3.054	4.423	658	10.200	13.150	

APPENDIX IV: ABBREVIATIONS

AEC - Advanced Components Ltd
AET – Almaty Electrotrans
AFV– alternative fuel vehicle
AG - Assemblies of God
AGA – American Gas Association
AGRI - Azerbaijan-Georgia-Romania-
ALGNV - Latin America NGV Association
ANGA - America’s Natural Gas Alliance
ANGVA– Asia Pacific Natural Gas Vehicles Association
ANH - National Hydrocarbon Agency
APG - American Power Group Inc
APGA – American Public Gas Association
API – American Petroleum Institute
APSRTC - Andhra Pradesh State Road Transport Corporation
ARRA - American Recovery and Reinvestment Act
ASA's - Automotive Service Association
ATARC – China Automotive & Research Center
ATEE - Association for Teacher Education in Europe
Bcm – billion cubic meters
BCUC - British Columbia Utilities Commission
BERC - Baltimore Education Research Consortium
BiMe - Liquid methane and methane diesel
BM – biomethane
BMTA - British Motor Trade Association
BRTC - Bangladesh Road Transport Corporation
BS - British Standards
BTL – biomass-to-liquid
BV - Best Value
CAGNC - Argentine Chamber for CNG
CAP– Clean Air Power
CARB - Air Resources Board
Cavenez - Venezuela Automotive Chamber
CBM – Coal-bed methane
CBU - Cognition and Brain Sciences Unit
CDM - Clean Development Mechanism
CE - Conducted Emission
CEC - California Energy Commission
CEN - Center for Electron Nanoscopy
CER - Certified Emission Reduction
CEV - Combat engineering vehicle
CHG - Chlorhexidine
CHP –combined heat and power
CIP - Continuous Improvement Process
CKD - Chronic kidney disease
CMG – compressed methane gas
CNG – compressed natural gas
CNOOC - China National Offshore Oil Corporation
CO – carbon dioxide
COC - Certificate of Conformity
CR – Check Republic
CSG - Coal Seam Gas
CV - check valve

CVO - Commercial Vehicle Operations
DART - Dallas Area Rapid Transit
DDF - Diesel Dual Fuel
DESA - United Nations Department Economic Social Affairs
DING – direct injection natural gas
DICI – direct-injection-compression-ignition
DISI – direct-injection-spark-ignition
DIT - Dar es Salaam Institute
DMA – Danish Maritime Authority
DME – dimethyl ether
DNV - Services for Managing Risk
DOE - Department of Energy (USA)
DoT - U.S. Department of Transportation
EAA - Experimental Aircraft Association
ECA - Emissions Control Area
ECU – electronic control unit
EDE - Empire District Electric
EEC-GNV - NGV Conversion Executing Entity
EEV – enhanced environmentally-friendly vehicle
EFTA - European Free Trade Association
EMGAS - Emirates Gas in United Arab Emirates
EPA - US Environmental Protection Agency
ESI - Emission Solutions, Inc.
EU - European Union
Eurm - European University-Republic of Macedonia
FCH sector - Combined hyperlipidemia sector
FCV – fuel cell vehicles
FSTP - Financial Services Transfer Pricing
FSU - Floating Storage Unit
FYROM - Former Yugoslavian Republic Of Macedonia
GAIL - Gas Authority of India Ltd
Gascop - Gas Comprimido del Perú
GCGF - Global Corporate Governance Forum
GCV - Ground Combat Vehicle
GDF - Gaz de France
GDF Suez - Gaz de France Suez
GDP - Gross Domestic Product
GFS - Gaseous Fuel Systems, Corporation
GHG – green house gases
GHW – Gas HighWay
GIFT - Graduate Institute of Ferrous Technology
GM – General Motors
GSA - Services Administration
GVR – Gas Vehicle Report
H – hydrogen
HCM - Highway Capacity Manual
HCNG – hydrogen/compressed natural gas – Hythane™
HD – heavy duty
HD NG - heavy duty natural gas
HDV - heavy duty vehicle
HFO - Heavy fuel oil
HM - Hindustan Motors
HMC - Horizontal machining center
HMI - Human machine interface

HOV - High occupancy
HP – horse power
HPDI - High Pressure Direct Injection
HYBUS - Bus that works on both compressed natural gas and batteries
IAN - Interactive Autism Network
IANGV – International Association for Natural Gas Vehicles
IATA - International Air Transport Association
ICE – internal combustion engine
ICTC - Interstate Clean Transportation Corridor
ID - Identification Data
IEA - International Energy Agency
IGU – International Gas Union
IKCO - Iran Khodro Company
IMO – International Maritime Organization
ISO - International Organization for Standardization
JGA - Japan Gas Association
kg - kilogram
km - kilometer
KOGAS - Korea Corporation
LL – liquefied-compressed
LBG – liquefied biogas
LBM – Liquefied biomethane
LCA - Life Cycle Assessment
LCMG – liquefied compressed methane gas
LCNG (L-CNG) – liquefied-to-compressed natural gas
LCV - Light Commercial Vehicle
LD – light duty
LDV – light duty vehicle
LH₂ – liquefied hydrogen
LHV - Low Heating Value
LLC - Limited Liability Company
LMCU - Lille Métropole Communauté Urbaine
LMG - Liquid Methane Gas
LNG - liquefied natural gas
L&P CVP - Leggett & Platt Commercial Vehicle Products
LPG – liquefied petroleum gas
LTFRB - Land Transportation Franchising and Regulatory Board
Mcm – million cubic meters
MD – medium duty
MDE - methane gas engine
MD-HD - medium and heavy duty
MDO - marine diesel oil
MGL - Main Gas Line
MIT - Initiative MITEI
MOA - Memorandum of Agreement
MOL - Hungarian Oil and Gas Company
MoPEMR - Ministry of Power, Energy and Mineral Resources
MOU - Memorandum of Understanding
MPG - Miles per gallon
MSE - Ministry of Economic Development (Ministero dello Sviluppo Economico)
MSW - municipal solid waste
MTA - Metropolitan Transit Authority
MTC - Ministry of Transport and Communications (Peru)
MVT - motor vehicle tax

MW - Megawatt
MWh - Megawatt Hours
NAFA - US National Association of Fleet Administrators
NAPT - National Association of Pupil Transportation
Ncm – normal cubic meters
NEPI - Energy Policy Institute
NG – natural gas
NGC – Nigerian Gas Company
NGP - NEOgás do Perú S.A
NGV – Natural Gas Vehicle
NGVA Europe – Natural Gas Vehicle Association Europe
NGVC – Natural Gas Vehicle Coalition
NGVFS - Natural Gas Vehicle Fuelling Stations
NGVI - Natural Gas Vehicles International
NGVPPT - Natural Gas Vehicle Program for Public Transport
NGVRUS – National Gas-Vehicle Association
NIGC - National Iranian Gas Company
NIOPDC - National Iranian Oil Products Distribution Company
NIPCO - Nigerian Independent Petroleum Company
Nm - Normal Meter
NOVA - Normverbrauchsabgabe - duty payable on standard consumption
NREL - National Renewable Energy Laboratory
NTU - Nanyang Technological University
NUS - National University of Singapore
NYCTA - New York City Transit Authority
OBD - similar to Euro 3 norm but less strict
OEM – original equipment manufacturer
OGRA - Oil and Gas Regulatory Authority
OMTK - Omnitek Engineering Corporation
PGNiG - Polish Oil and Gas Company
PLC – programmable logic controller
PM - particulate matter
PNGRB - Regulatory Board
PNOC-EC - Philippine National Oil Company – Exploration Corporation
POGC - Pars Oil and Gas Company
PSPC - Philippians Shell Petroleum Corp
PSV - Platform supply vessel
Pte - Private
PTT - Petroleum Authority of Thailand
PUB - powered public utility bus
QVM - Qualified Vehicle Modifier
RES - Renewable Energy Source
RFF - Resources for the Future
RFID - Radio Frequency Identification
RTA - Regional Transport Authority
RTO - Regional Transport Office
RTP - Red Transporte Pasajeros
SAIC - State Administration of Industry and Commerce
SANBAG - San Bernardino Associated Governments
SCAQMD - South Coast Air Management District
SECA - Sulphur Emission Control Area
SG – Special Group
SNG – synthetic natural gas
SPC – Syrian Petroleum Company

STL - Sales, Trading & Logistics
STTP - Strategy to Task to Technology Process
TAS - Taxi Affiliation Services
TATA - Indian vehicle manufacturer
THB - Thai Baht (Thailand currency)
Tk - Taka (Bangladeshi currency)
TMB - Transports Metropolitans de Barcelona
TMC - Toyota Motor Corporation
TPI - Transpacific Industries
TSI - Trading Standards Institute
UAE – United Arab Emirates
UN ECE – United Nations Economic Commission for Europe
UNFCCC - United Nations Framework Convention on Climate Change
UNG - United States Natural Gas Fund LP (stock symbol)
UPSRTC - Uttar Pradesh State Road Transport Corporation
USA – United states of America
VAM - hicle Allocation Methodology
VAT – value-added tax
VNIIGAZ - Cientific-Research Institute of Natural Gases and Gas Technologies
VVTL - Velmi Vysoky Tlak
YPFB - Yacimientos Petrolíferos Fiscales Bolivianos
WOC – Working Committee
ZETT - zero-emission terminal tractor

APPENDIX V: REFERENCES

1. Snam Rete Gas 2009 annual report
2. Eni 2009 annual report
3. PROCURA project report, “Training Guidelines For Maintenance And Support Of AFVs”
4. CLEAN AIR POWER report: Overview of natural gas as a road fuel in United Kingdom, Germany, Holland, Italy, Spain
5. NGV System Italia, “Il sistema metano: le stazioni di rifornimento”, RG/rg – 9/06
6. R. Gaudio, E. Volpi, “NGVA europe position paper: natural gas and CO2, 2009
7. Peter Boisen, “NGVA europe position paper; NGVA europe position on fuel tax for NG/biomethane powered vehicles, 2009
8. Federmetano, “Il futuro del metano per auto secondo Federmetano”, Metano & Motori, November 2008
9. Trendsetter Report, “Biogas as a vehicle fuel, an European overview”, October 2003
10. Parenti, Pascalizi, “benefici ambientali del metano per autotrazione”, Euromobility-CNR, 2007
11. K. Arnold, “CHG mitigation potential recise? New bottom-up LCA results on the N2O emissions of biogas and suggestions for improvement”, 5th International Symposium on NC GG, Wageningen, 2009
12. E. Hardi, “biogas injection in the natural gas grid”, 2008
13. P. Boisen, “Panoramica del settore europeo dei veicoli a metano”, The Gas Vehicles Report, 2010
14. Biogasmax, “Draft demonstration report on fuel stations including depoloyment strategies and regulatory requirements”, 2009
15. L. Cook, “The role of LNG in a global gas market”, 2005
16. L.R. 31 Maggio 2004, n. 14 (Piemonte)
17. Regione Piemonte, “Report on fuel distribution network in Piedmont”, 2009
18. Eco Motori – www.ecomotori.net
19. NGV System Italia Association – www.ngvsystem.com
20. FIAT group web site – www.fiat.com
21. TORINO METANO – www.met.to.it
22. European Commission web site – <http://ec.europa.eu>
23. Italian Ministry for the Environment, Land and Sea – <http://www.minambiente.it>
24. Liguria Region official website – www.regione.liguria.it/
25. Lombardia Region official website – www.regione.lombardia.it/
26. European Commission, Directorate-General for Energy and Transport: European energy and transport: Trends to 2030, update 2007 (http://bookshop.europa.eu/eubookshop/bookmarks.action?target=EUB:NOTICE:KOAC07001:EN:HTML&request_locale=EN), 2008
27. Etude Biogaz Etat des lieux et potentiel du biométhane carburant Etude réalisée sous l'égide du Groupe de travail Energie-Environnement de l'Association Française du Gaz Naturel pour Véhicules par GDF Suez, l'IFP et l'ADEME
28. ADEME et GDF SUEZ. Analyse du Cycle de Vie des modes de valorisation énergétique du biogaz issu de méthanisation de la Fraction Fermentescible des Ordures Ménagères collectée sélectivement en France. 2007. *Life Cycle Assessment of different uses of biogas from anaerobic digestion of separately collected biodegradable waste in France*

29. Nordic biogas conference 2008. Biogas-optimized yields from energy crops, Swedish University of Agricultural Sciences
30. IEA bioenergy task 37, Biogas from Energy, Crop Digestion, http://www.iea-biogas.net/Dokumente/energycrop_def_Low_Res.pdf
31. Algal Biomass Does it save the world? <http://www.iea-biogas.net/Dokumente/AlgaeBiomass8-09.pdf>
32. ATEE Club biogaz Emplois dans la filière biogaz de 2005 à 2020 (2011) Document finalisé en février 2011
33. IEA bioenergy task 37 Utilisation of digestate from biogas plants as biofertiliser http://www.iea-biogas.net/Dokumente/Digestate_Brochure_12-2010.pdf
34. Future Transport Fuels, European Expert Group on Future Transport Fuel, 2011
35. Analysis of the Greenhouse Gas Emissions for Thermochemical BioSNG Production and Use in the United Kingdom Project Code NNFC 10-009 Study funded by DECC and managed by NNFC
36. Evaluation of ecological impacts of synthetic natural gas from wood used in current heating and car systems, Paul Scherrer Institut, Switzerland, 2007
37. Étude biogaz AFGNV; État des lieux et potentiel du biométhane carburant. 2008
38. AEBIOM (European Biomass Association). A biogas roadmap for Europe. 2009
39. BIOGASMAX, D4.3. Demonstration report on fuel stations including deployment strategies and regulatory requirements. 2010
40. <http://www.ngvaeurope.eu/european-ngv-statistics> , access on January 2011
Biogaspartner, <http://www.biogaspartner.de>, access on December 2010
41. IEA Task 37, <http://www.iea-biogas.net>, access on December 2010
42. Basic Statistics of Indian Petroleum and Natural Gas 2008-09, Ministry of Petroleum and Natural Gas
43. Marcados Energy Markets India Private, 2010, Limited Study on Common Pool Price Mechanism for Natural Gas in the Country for GAIL.
44. Eleventh Five Year Plan, Planning Commission, Government of India
45. Report of the Working Group on Petroleum and Natural gas sector for eleventh Plan, 2007-12
46. World Bank 2004, Towards cleaner urban air in south Asia: tackling transport pollution, understanding sources, Energy Sector Management Assistance Programme of World Bank and United Nations Development Programme, Washington DC, USA,
47. ARAI 2007, *Draft report on* “Emission Factor development for Indian Vehicles “ as a part of Ambient Air Quality Monitoring and Emission Source Apportionment Studies, Pune
48. The Energy and Resources Institute, 2004, *Fuel Choices for Transport and the Environment*, New Delhi 8. Enstrat International Limited 2004, The emission reduction potential of low-sulfur diesel fuel in Asian countries, , UK
49. Frank Dursbeck, Lennart Erlandson, Christopher Weaver 2001, Status of implementation of CNG as a fuel for urban buses in Delhi, CSE, New Delhi
50. Lennart Erlandson, Christopher Weaver, et al 2002, Safety of CNG buses in Delhi: Findings and recommendations, CSE, New Delhi
51. EPCA Report No. 30, March 2007, CNG safety: Progress and action taken report, *Mimeo*
52. EPCA Report No. 26, July 2006, Investigations relating to fire hazards and safety in CNG Buses, *Mimeo*
53. H B Mathur, Report on the fire incidents in a converted CNG Bus, 2006, *Mimeo*

- 2008, *Supply, Distribution And Marketing Of Natural Gas Including Cng And Lng, [Action Taken Report]*, Standing Committee On Petroleum & Natural Gas (2008-09), Ministry Of Petroleum & Natural Gas, 24th Report, Lok Sabha Secretariat, New Delhi, December, p40-41
54. Nils-Olof Nylund & Kimmo Erkkilä 2004, *Transit Bus Emission Study: Comparison Of Emissions From Diesel And Natural Gas Buses*, Paper presented at the NGV 2004, Buenos Aires
 55. Gas Authority of India Limited, 2005, 'Transmission fee — GAIL for uniform methodology for all players', press release, New Delhi, March 10
 56. Anon 2001, International experience with CNG vehicles, south Asia Urban Air Quality Management briefing note No 2, World Bank, Washington DC, USA, World Bank, 2004, *Breath of Fresh Air*, Washington
 57. Michael Walsh et al 2003, Progress towards clean cars, trucks, and buses, International Council on Clean Transportation, San Francisco, The Hewlett Foundation and The Energy Foundation, San Francisco, USA, 23 A Roychowdhury, V Chattopadyayay et al, 2006, *The Leapfrog Factor*, Centre for Science and Environment, New Delhi.
 58. "Blue Corridors: A Study on the Feasibility of NGVs in the South Cone International Roads", IE-UFRJ, Coordinator: Prof. Edmar L.F.Almeida , Rio de Janeiro, March 2005
 59. "Energetic Integration in South America – Motivations, Difficulties and Results" – Renato Queiroz, Thais Vilela, IE-UFRJ , May 2010
 60. http://ec.europa.eu/transport/urban/vehicles/road/clean_transport_systems_en.htm
 61. http://ec.europa.eu/clima/policies/transport/vehicles/index_en.htm
 62. http://ec.europa.eu/clima/policies/transport/vehicles/index_en.htm
 63. CNG and LPG for transport in Germany – environmental performance and potential for GHG emission reductions until 2020. An expertise for Erdgas Mobil, OMV and SVGW. Munich/Ottobrunn, 21 September 2010, p. 77.
 64. Expert Group report on Future Transport Fuels, Brussels, 25th January 2011, p. 5.
 65. Expert Group report on Future Transport Fuels, Brussels, 25 January 2011, Annex 2A, p.72-74.
 66. Expert Group report on Future Transport Fuels, Brussels, 25th January, p. 36.
 67. EN ISO 18453: 2005 norm "Natural gas – Correlation between water content and water dew point." (Gergwater correlation) is used to convert water dew point into water content.
 68. Argonne National Labs (2010) "Well-to-Wheels Analysis of Landfill Gas-Based Pathways and Their Addition to the GREET Model" Report: ANL/ESD/10-3 Available at <http://www.transportation.anl.gov/pdfs/TA/632.PDF>
 69. California Air Resources Board (2009) "California's Low Carbon Fuel Standard" Available at <http://www.arb.ca.gov/regact/2009/lcfs09/lcfsfsor.pdf>
 70. American Gas Foundation (2011) "The Potential for Renewable Gas: Biogas Derived from Biomass Feedstocks and Upgraded to Pipeline Quality" Available at <http://www.gasfoundation.org/ResearchStudies/renewable-gas-2011.htm>
 71. The non-aggressive and aggressive scenarios have the potential to meet between four and ten percent of 2010 natural gas usage in the United States. This assumes a national usage of approximately 24 TCF of natural gas or 24 quadrillion BTU as per http://www.eia.doe.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm
 72. National Grid Paper (2010) "Renewable Gas — Vision for a Sustainable Gas Network" Available at http://www.nationalgridus.com/non_html/NG_renewable_WP.pdf

73. Center for American Progress (April 2010) “Developing Natural Gas for Heavy Vehicles” Available at
http://www.americanprogress.org/issues/2010/04/pdf/american_fuel.pdf
74. Chesapeake Energy – September 2011 Investor Presentation
75. Transportation Energy Data Book – Edition 30, 2011

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