NATURAL GAS VEHICLE MARKET IN 2010 – 2020: TRENDS OF STRATEGIC DEVELOPMENT

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Background

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%.

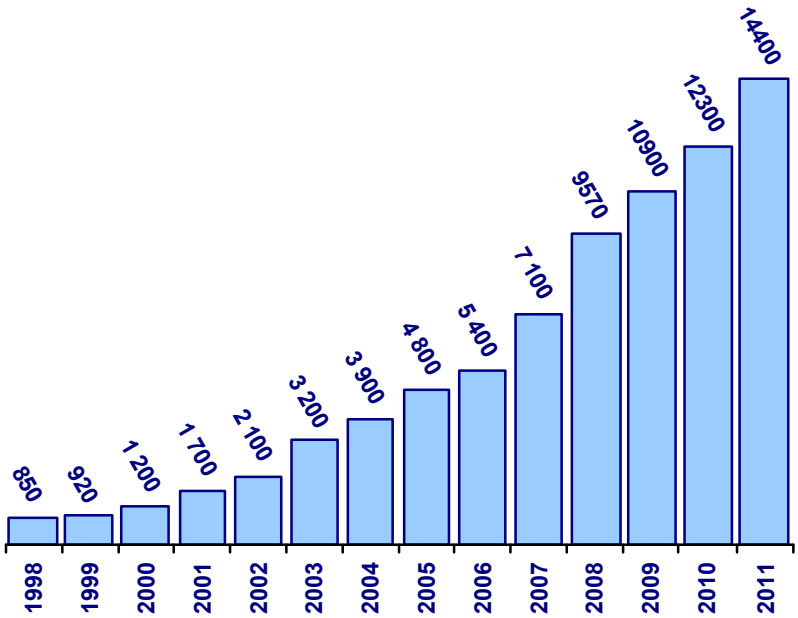

Figure 1: World NGV population growth, NGVs * 1000

Aims

NGV technologies have rooted into all segments of the world transportation industry. NGV diversity ranges from on-road vehicles to railroad locomotives, aircraft, sea ships, communal vehicles, agricultural tractors, forklifts and even ice resurfacers.
The paper aims to answer the key question: What strategic trends will politically, legally, technologically, financially and socially dominate the world NGV market in the coming decade?
Another goal is to understand/recommend synergy of natural gas and other fuel alternatives. In what way and to what extent biomethane, e-gas, hydrogen, hybrid, gas fuel cells, and other will contribute to the development of natural gas market?

Methods

This analysis is based on the data and information provided for in official statistics, studies of governmental & private agencies and international organizations, interviews with private

businesses and individual experts. This analysis also incorporates outcomes of the in-depth desk research and databases developed as part of the regular activities of IGU WOC 5 S.G 5.3 in order to 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 and strategic documents issued etc.

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 raise 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.

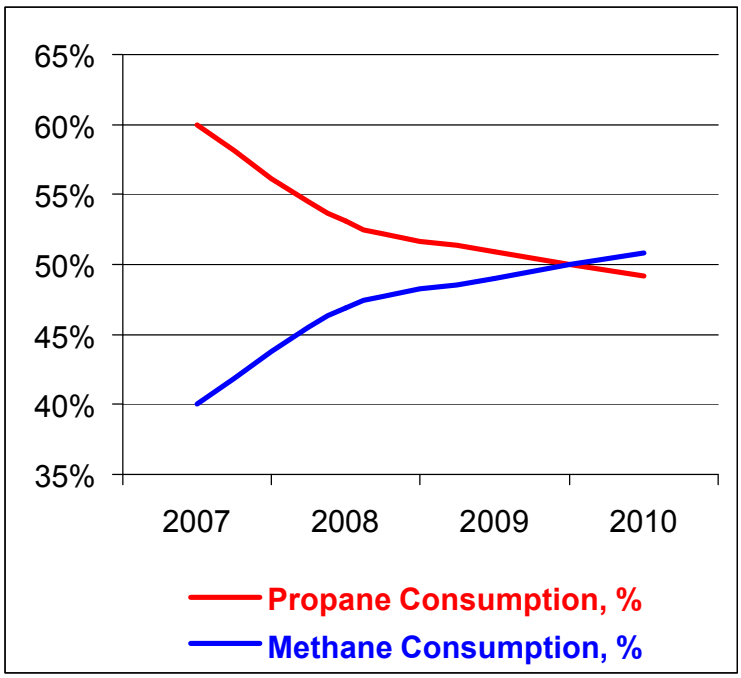

Figure 2: CNG/LPG relationship in the gaseous fuel alternatives basket

- 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 H_2 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 CO_2 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 CO_2 emissions from road vehicles setting emission performance standards for new passenger cars requiring a fleet average emission of 130 g CO_2/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 taxies), 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 then 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

Figure 3: 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 CO_2 value of 86 g/km. As a BlueMotion Technology version the natural gas-powered version attains a low CO_2 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 NOx. 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.

Figure 4: European Blue Ring for Methane boats and ships

- **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.
- **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.

Figure 5: 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.

Results

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.

Conclusions

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.

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Graduated at the University on Petroleum, Geology and Mining (RGN) in Zagreb / Croatia. In 2001, achieved Master of Science degree on RGN.
Started career in Zagreb Gas Distribution Company (GPZ) on the development of the new natural gas distribution projects and on the project of the first NGV station in Croatia.
In 1995 joined Energy Institute Hrvoje Pozar (EIHP) in Zagreb / Croatia, a non profit consulting company, being responsible for the natural gas and transport sector development projects, as consultant to the Croatian Government, relevant Ministries and gas industry, in the fields of feasibility analyses, market studies, tariff systems development and implementation and legal framework development in the natural gas upstream, midstream and downstream sector and LPG. Also, was a co-ordinator of the national program of energy efficiency in transport in Croatia.
In January 2007, joined OMV, through establishment of the new company OMV Gas Adria, in Zagreb / Croatia, 100% owned by Austrian Oil and Gas Company OMV Gas & Power, with the task to support with the aim to support natural gas activities of OMV G&P in Croatia and the region.
Vice-president of Croatian Gas Association and part-time teacher at the Faculty of Economy at Zagreb University.

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