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## Revision History

<table>
<thead>
<tr>
<th>Rev</th>
<th>Date</th>
<th>Author</th>
<th>Organization</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
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<td>12.03.2015</td>
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<td>IDIADA</td>
<td>Initial Guidelines of topics to be covered</td>
</tr>
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<td>NGVA</td>
<td>Initial draft</td>
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<td>FLUXYS</td>
<td>Suggested additional content</td>
</tr>
<tr>
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<td>28.04.2015</td>
<td>Xavier Ribas</td>
<td>IDIADA</td>
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</tr>
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<td>30.04.2015</td>
<td>Matthias Maedge</td>
<td>NGVA</td>
<td>Taxes comments</td>
</tr>
<tr>
<td>0.6</td>
<td>30.04.2015</td>
<td>Flavio Mariani</td>
<td>NGVA</td>
<td>General review</td>
</tr>
<tr>
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<td>IDIADA</td>
<td>Final review</td>
</tr>
</tbody>
</table>

## Statement of originality:

This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.
Executive Summary

The LNG Blue Corridor project is focused on demonstrating the use of LNG as truck fuel and to define a road map for future large scale development of the market. This report is the first deliverable of the Work Package 7.

In the Work Package 7 the analysis of all data will be carried out, supplying the necessary knowledge to a later big picture approach of the European necessities. The two main porpoise are

• To analyse the results to understand the future deployment of additional corridors/interaction with new routes

• To state what the main recommendations are for a future LNG strong growth in Europe by means of a position paper. The following topics are discusses on this document.

  • Retrofit market
  • Fuel quality
  • Transport of Dangerous Goods
  • Regulations for LNG and LCNG stations
  • LNG nozzles and receptacles
  • LNG labelling
  • Technology used: Pressure and temperature
  • Training for LNG truck drivers
  • Boil off
  • Taxation on Natural Gas and Biomethane as a vehicle fuel
  • Bunkering
  • Barriers for the fleet operator’s mobility

Some of these issues are deeply analysed in additional reports within this project.

Detailed examples of these topics are D3.2 Gas Quality or D3.5 Market harmonization proposal already made in the first half of the project.

Taking into account that most of these issues and LNG technology are rather new and are being discussed short time ago, this document states what the BC view is at this moment for a further development, the situation in the future can change, though, being used different technologies than current described.
# Contents

Revision History ....................................................................................................................................... 2

Executive Summary ................................................................................................................................. 3

1 Introduction ........................................................................................................................................... 5
  1.1 LNG Blue Corridors project .............................................................................................................. 5
  1.2 Aim of this deliverable ...................................................................................................................... 6
    1.2.1 What this document aims ......................................................................................................... 6

2 Current LNG Framework ...................................................................................................................... 7

3 Current LNG issues ................................................................................................................................... 8
  3.1 Retrofit market ................................................................................................................................. 8
  3.2 Fuel quality ........................................................................................................................................ 10
  3.3 Transport of Dangerous Goods (over the road) ............................................................................ 12
  3.4 Regulations for LNG and LCNG stations ....................................................................................... 13
  3.5 LNG nozzles and receptacles ......................................................................................................... 14
  3.6 LNG labelling ................................................................................................................................. 15
  3.7 Technology used: Pressure and temperature ................................................................................. 16
  3.8 Training for LNG truck drivers ...................................................................................................... 16
  3.9 Boil off ........................................................................................................................................... 17
  3.10 Taxation on Natural Gas and Biomethane as a vehicle fuel ......................................................... 18
  3.11 Bunkering ..................................................................................................................................... 19
  3.12 Barriers for the fleet operator’s mobility ...................................................................................... 20

Summary table ......................................................................................................................................... 22

List of figures ......................................................................................................................................... 25
1 Introduction

1.1 LNG Blue Corridors project

The LNG Blue Corridors project’s aim is to establish LNG as a real alternative for medium- and long-distance transport—first as a complementary fuel and later as an adequate substitute for diesel. Up to now the common use of gas as fuel has been for heavy vehicles running on natural gas (NG) only for municipal use, such as urban buses and garbage collection trucks. In both types of application, engine performance and autonomy are good with present technologies, as they are well adapted to this alternative cleaner fuel.

However, analyzing the consumption data, the equivalence in autonomy of 1 liter of diesel oil is 5 liters of CNG (Compressed Natural Gas), compressed to 200 bar. Five times more volume of fuel prevents the use of CNG in heavy road transport, because its volume and weight would be too great for a long-distance truck. This opens the way for LNG (Liquefied Natural Gas), which is the way natural gas is transported by ship to any point of the globe. NG liquefies at 162° C below zero, and the cost in energy is only 5% of the original gas. This state of NG gives LNG the advantage of very high energy content. Only 1.8 liters of LNG are needed to meet the equivalent autonomy of using 1 liter of diesel oil. A 40-ton road tractor in Europe needs a tank of 400 to 500 liters for a 1,000 km trip; its equivalent volume with liquid gas would be 700 to 900 liters of LNG, a tank dimension that could easily be fitted to the side of the truck chassis. LNG therefore opens the way to the use of NG for medium- and long-distance road transport.

LNG has huge potential for contributing to achieving Europe’s policy objectives, such as the Commission’s targets for greenhouse gas reduction, air quality targets, while at the same time reducing dependency on crude oil and guaranteeing supply security. Natural gas heavy-duty vehicles already comply with Euro V emission standards and have enormous potential to reach future Euro VI emission standards, some without complex exhaust gas after-treatment technologies, which have increased procurement and maintenance costs.

To meet the objectives, a series of LNG refueling points have been defined along the four corridors covering the Atlantic area (green line), the Mediterranean region (red line) and connecting Europe’s South with the North (blue line) and its West and East (yellow line) accordingly. In order to implement a sustainable transport network for Europe, the project has set the goal to build approximately 14 new LNG stations, both permanent and mobile, on critical locations along the Blue Corridors whilst building up a fleet of approximately 100 Heavy-Duty Vehicles powered by LNG.

This European project is financed by the Seventh Framework Programme (FP7), with the amount of 7.96 M€ (total investments amounting to 14.33 M€), involving 27 partners from 11 countries.

This document corresponds the first deliverable within work package 7. This document will be available at the project website: http://www.lngbluecorridors.eu/.
1.2 Aim of this deliverable

1.2.1 What this document aims

The purpose of this document is to provide the official position of the LNG Blue Corridors project Consortium, which is formed by 27 partners representing the OEM’s, LNG fuel suppliers, LNG fuel distributors, fleet operators experienced in the use of LNG for the medium and long distance transportation as well as from Research Centers and Associations. The document is based on the experience gain in the two first years of this project. Specific position about aspects that the LNG Blue Corridors considers as key and extremely important for the LNG market development in Europe are given.
2 Current LNG Framework

Natural gas and bio-methane represent the easiest, most practical and most realistic way to reduce pollution coming from transportation.

The development of the NGV market in Europe is nowadays the focus of the European Authorities, also supported through the launch of initiatives such as the DAFI (Directive on Alternative Fuel Infrastructure). Moving this market ahead is all but easy, as demonstrated by the slow pace of increase in Europe over the last few decades. Despite the active approach of some markets, for example Italy, Germany, Sweden, Austria, Switzerland, nowadays the NGV share in the Europe’s transport sector is still far below 1%. However the target for NGV penetration is as high as 5% by 2020, so it is important to understand what are the factors impeding or relenting the growth of this market in Europe. It is also very interesting to compare Europe’s slow growth with faster growing markets, in terms of LNG, such as United States or China.

Two years ago, at the beginning of the Blue Corridors project, the LNG market was a quite promising alternative to substitute diesel on the long term. However several matters were not sufficiently clear at that time for the major actors. And even if LNG was a widespread and well known fuel for maritime applications, it was not commonly used for vehicles on road.

On the other hand, CNG was, and still is, considered very often as a mainstream fuel option for clean urban mobility. The use of natural gas and renewable biomethane to fuel public fleets of buses and cars will gain ground in the next 10 years, allowing for cost effective CO2 reduction in European cities. In this regard, gas as a fuel is already widely used and in particular buses running on CNG are highly popular in Europe’s city centers, combining low running costs with improved air quality due to substantially reduced emissions of nitrogen oxides and particulate matter. Over 15,000 CNG buses are operating throughout Europe, representing a commercially competitive and technologically mature solution, as opposed to other alternative drives that are still in stages of demonstration or subsidized operation.

Therefore it can be concluded that the beneficial aspects of the use of Natural Gas (NG), in its different states and applications, are generally well known and even they are the main choice when it is time to carriage goods by ship and to transport passengers in urban areas. Nevertheless there are still some points concerning Liquefied Natural Gas that remain not unified and clear enough, that need further analysis.

Some of those issues will be listed and analyzed below. In each point, a neutral and objective position is presented with the consensus from all Blue Corridors partners participating. Bearing in mind that the Blue Corridors project is the first initiative in Europe that deals with LNG for vehicles on road, this should be considered as the pathway to be followed in order to guarantee a proper and homogenized LNG development.
3 Current LNG issues

3.1 Retrofit market

The retrofit market is clearly one of the most important issues ongoing regarding development of the transition from diesel to gas as a fuel for trucks. The lack of extended refuelling infrastructure in Europe is a burden for discouraging some vehicle manufacturers to invest strongly in natural gas truck solutions for the time being. Therefore, vehicles retrofitted from diesel to Dual-Fuel (a small pilot injection of Diesel is used to ignite the premixed natural gas) play a very important role as bridge on this as they can still run on diesel alone only in places where the CNG refueling infrastructure is missing while can provide high powerful solutions (up to 560 HP) with more than 50% diesel replacement per gas. At the same time some low power engines, (with a spark ignition solution) are available from OEM’s like IVECO and SCANIA.

Currently there is one unified UNECE (to be defined) group who is in charge of working on the regulation for such converted vehicles.

On one hand, the informal group on Gaseous Fuelled Vehicles (GFV) has the mandate to review all new amendments and new work items proposed for consideration at the GRPE (to be defined). Some Blue Corridor project partners are active in all the activities of this working group. The status of the GFV group is that the Secretariat of the Informal group is supporting new actions to create new regulation for Heavy Duty Dual-Fuel Retrofit Systems, including LNG.

On the other hand, in the Heavy Duty Dual-Fuel Task Force, a new regulation will include the requirements for the type approval of retrofit systems intended for installation on a Heavy Duty diesel vehicle to enable its operation either in diesel mode or in dual-fuel mode. Only Euro IV, Euro V and EEV vehicles are included. Until now the principle and the structure of the new regulation have been discussed. In some countries like Unitated Kingdom, Italy, Spain and The Netherlands, the use of retrofitted solutions became popular in the last 2 years and is expected to grow as far as more LNG stations become available as well as new solutions for Euro V and Euro VI vehicles become available at commercial level.

Current topics under discussion:

- Regulation for type approval of systems for retrofitting diesel vehicles to dual fuel operation, but references to R49: type approval of engines.
- Level playing field for both retrofit system manufacturers and engine/vehicle manufacturers.
- Euro IV, V and EEV diesel engines have limited diagnostic functionality and no NOX closed loop control (difference with R115 for LDV’s).
- CH4 emissions:
- The procedure of the emission tests must be feasible, hence some retrofit specific procedures have been developed in order to take into account specific difficulties without compromising the required effectiveness.
- The emissions shall be measured with engine bench tests, using a demonstration engine equipped with the retrofit system in both diesel mode and dual fuel mode:
  - European Transient Cycle (ETC)
  - European stationary Cycle (ESC)
During the last meetings, the group has completed the amendments to UNECE R.49 for HD D-F Vehicle manufacturer (hereafter OEM) Euro VI and V.

Last issues covered: unique or multiple application ranges; “complete” and “completed” system approvals versus “engine system approval”; CH4 emissions: this is a real issue for diesel - CNG/LNG dual fuel retrofit systems.

Issues still pending solution:

There is the need to maintain the desired environmental level after the retrofit, not compromising polluting or greenhouse gas emissions; need to have a good feasible retrofit system in order to permit the diffusion of the retrofit technology; for dual fuel mode requirements, the manufacturer of the retrofit system could choose between two options:

- (1), all emission limits for dual-fuel mode as specified in the applicable R49 series of amendments apply.
- (2), the NOX, PM and CO emission limits for dual-fuel mode as specified in the applicable R49 series of amendments apply; the NMHC emissions shall not exceed the R49 limit (or those of the engine before retrofit); the retrofit CO2 ratio (back-to-back test):
  - CO2 + CH4 (as CO2 equivalent) ≤ CO2 of the original Diesel engine

Many topics still need more investigation and discussion. Monthly meetings are scheduled. GFV have the following targets in order to complete the task:

- Informal document to next GRPE (June 2015)
- Formal document to GRPE in January 2016.
Action recommended:

- Finalize the formal document which is now being drawn up with the agreement and strong support from all bodies involved – mainly from the OEM side -.
- Approve those retrofit systems which do demonstrate good engineering practices (i.e. include a CH4 catalyst in the system) and which demonstrate at least more than 15% diesel replacement in a WHTC hot test (WHTC ger) and do demonstrate they operate with realistic Diesel replacements in the WHSC.

### 3.2 Fuel quality

Natural Gas is normally not subject to refinery or treatment processes, except filtering, desulphurisation and drying at well head, when required. Apart from this, it is a fuel ready ‘as is’. Every NG field provides gas with its own composition, and the composition of NG as a result is variable from point to point of the NG grid, and is also variable in time, as a result of different flow rates in the different branches of the pipeline network, at different seasons and times of day. This aspect is controlled by the requirements of the Network Codes, which limit the variability range, so that the gas composition keeps well inside the interchangeability, field to ensure the appropriate safety and efficiency level to all industrial, residential and commercial applications of Natural Gas. This situation in general has been acceptable so far, for the industrial, residential and commercial applications, whereas the applications of Natural Gas on automotive engines, in the opinion of engine manufacturers, need for more stability of composition, and above all, need for a higher minimum level of some characteristics and components, e.g. minimum content of methane CH4, minimum methane number MN, and need for a lower maximum content of Sulphur, and maximum content of gaseous hydrocarbons such as ethane, propane, butane. But so now there is the need to foster interchangeability and interoperability, by creating a new spec for natural gas, to put some reasonable limit to variations in composition and characteristics of the traded Natural Gas. This topic is being addressed in the committee CEN/TC234/WG11, and in the CEN/PC408.

In other words, the general requirements contained in the present specs of NG, suit the needs of all the application fields in the industrial, commercial and residential sector of the NG market. Even though the activity of CEN/TC234/WG11 is improving the variation in gas quality, it is not enough in the case of the application of NG as fuel for vehicles. This sector requires tighter specifications of natural gas in order that the engines can take full advantage of the superior characteristics of NG as an automotive fuel.

Issues - still pending solution:

There are features relevant to the composition and physics of Natural Gas that need to be addressed by the present norms, to meet the needs of the automotive market. Some examples are:

- The anti-knocking power of NG, represented by the methane number (MN), and the content of components such as ethane, propane, butane, and other higher hydrocarbons, which have a reducing effect on MN, or the content of inert gases (i.e. CO2, nitrogen, helium), some of which have an opposite increasing effect on the anti-knocking power.
- The moisture content, which may have a detrimental effect on steel cylinder integrity, especially in association with CO2 and some sulphur compounds.
- Sulphur content, to which engines are far more prone compared to all the other applications of NG.
The NG specs which have been in application so far for NG, were aimed mainly at ensuring the gas in all the pipeline network to be compatible and interchangeable, in terms of parameters such as net heating power, Wobbe Index and density. A water content corresponding to a dew point of -5°C at 70 bar, and a sulphur content of 30 mg/Sm3 are for the present specs acceptable. Engines require a more stringent limitation of these parameters and other, and this led to the formation of a working group inside CEN to prepare a specification for NG to be used as automotive engine fuel. Furthermore, in Europe the specs for the liquid fuels have been in application since long now; they are:

- EN 228 - Gasoline
- EN 590 - Diesel
- EN 589 – LPG

There still is no spec for LNG (not for CNG either); and as they are now shifting rather quickly from the condition of “alternative fuels” to that of “fuels”, this is a normative gap to be filled.

This activity started inside the CEN/TC234/WG9 Injection of non-conventional gases into the natural gas network. Later, as consequence of the creation of the new technical committee CEN/PC408, with the mandate (M/475) to prepare specs for bio-methane for grid injection and for automotive application, this scope was transferred from CEN/TC234/WG9 to CEN/PC408.

Action recommended:

- Create a unique common reference numbers or range of them in which gas engines, including both compression ignition and spark ignition engines technologies, can guarantee a good performance. They have to come from the committees mentioned above.

Despite of the difficulties to merge particular interests from the gas suppliers and the vehicles/engine manufacturer, the following values can be considered as recommended to guarantee a good engines performance at this moment:

**Hydrogen**: associated fragility (embrittlement) issues due to the high solubility of hydrogen molecules, especially at high pressures. It sets a limit of 2% molar to prevent this aspect.

**Hydrogen Sulphide**: associated corrosive issues and combustion by-products sticking engine valves. It sets a limit of 5 mg/m³ for safety/corrosion.

**Methane Number**: critical parameters affecting the internal combustion engines. It describes the knock behavior of gaseous fuel. The lower limited to be observed for the methane number of the gases distributed in Europe is 65, but usually methane number are higher than 70 MWM, therefore this has to be considered as the lowest level. As a methane number high grade has to be considered 80 MWM.

**Wobbe index**: It is used to identify the interchangeability of different gases at the burner of gas appliance. Two gases with the same Wobbe index are deemed to be interchangeable concerning their combustion properties. The LHV has to be 44,7 MJ/Kg and HHV has to be something to value from gas specification EASEE (46-54 MJ/Kg).

**Sulphur**: different effects may occur with high sulphur level.

- Poisoning effect on after-treatment systems.
- Creation of sulphur oxides which can wear valves surfaces, cylinder covering and bearings.
For the reasons explained above, the recommendable value would be 10 mg/m³. **Siloxanes**: its combustion by-products create problems in the engine, generates deposits, e.g. on valves, lambda oxygen sensors and cylinder walls, causing abrasion, exhaust gas misalignment or blockage of pistons and cylinder heads, respectively. Maximum contamination limit of 0.1 mg /m³ biomethane is required by vehicles equipped with switching λ-sensors. Higher silicon contents misalign sensors cause false signal about the oxygen content in the exhaust gas reducing their durability.

- The EU Commission should invest in the technologies for heavy duty vehicles that include Fuel Quality Sensors, or similar self-adaptive fuel control systems in order to allow the Dual-Fuel and Spark Ignited engines to react as per the quality of fuel available.

### 3.3 Transport of Dangerous Goods (over the road)

This topic is covered in the group WP15 ADR. The ADR Regulation has been successfully amended (will be in application in 2017), to allow LNG propulsion for ADR-certified vehicles, except vehicles of type EXII and EXIII (i.e. for transport of explosives) for which only compression ignition engines are admitted, propelled by fuels having a flash point at or higher than 55°C (i.e. diesel oil). An earlier adoption can be allowed as from 2015 depending on member states or multi-lateral agreements.

LNG Blue Corridors partners have been, and still are, involved in the preparation of the new ADR Working Document to allow CNG propulsion for ADR-certified vehicles, which is currently not specified as allowed in the ADR regulation. A new proposal has been subjected for examination to GRPE in June 2015, to solve some problems (such as fuel leaking on the ground without coming in contact with hot parts of the engine or with the load).

**Issues still pending solution:**

- Embrittlement of parts in contact with cryogenic liquid
- CNG containers mounted in some LNG trucks

**Action recommended:**

- Approval from all EU countries on the multilateral agreement M276 regarding the allowance of trucks powered by LNG technology to transport ADR goods.
- Inclusion of CNG components and trucks into the ADR document amended. This is important since some OEM’s LNG solutions still include CNG tanks.
3.4 Regulations for LNG and LCNG stations

It seems clear that the lack of harmonization in Europe has slowed down the construction of LNG and L-CNG stations. Experience has shown that the lack of common standards within the European Union is the main obstacle for a wide deployment of heavy-duty vehicles powered by liquefied natural gas (LNG).

This topic has already been addressed in the group ISO/PC 252 Natural Gas Fuelling stations for vehicles.

This project committee has responded to a request from European stakeholders who failed to complete European standards for natural gas fuelling stations within CEN before the group’s mandate expired. The first ISO standards are expected to be published no later than April 2016.

PC252 is composed of two working groups: WG1 for CNG stations and WG2 for LNG and L-CNG stations.

Next steps:

Finish the revised drafts of ISO/DIS 16923.2 CNG fuelling stations and ISO/DIS 16924.2 LNG fuelling stations, according to the alignment of both standards agreed at the last meetings. Submit all documents to ISO Central Secretariat for ballot. In 2015 the PC252 will have to deal with the comments received during the new ballot and prepare the final drafts for a last enquiry. The three new items will generate, if approved, new standardization work. PC252 has also presented a proposal to transform the Project Committee into a Technical Committee. NGV Global assists in preparing the business plan that has to be forwarded to ISO.

The EC, by means of the DAFI, mandates the editing of a set of European standards to support the development of the infrastructure of alternative fuels: As consequence of this mandate, the CEN/TC326, so far dormant, has been created that resumed. It will follow the main topics described below; for each one of them a European standard will be edited:

- WG1 CNG refuelling stations
- WG2 LNG refuelling stations
- WG3 LNG for maritime applications
- WG4 operational issues for NGV (e.g. parking, tunnels, ship boarding)

Structure:

- WG1 CNG filling stations
- WG2 NGV on board fuel systems (delegated to ISO/TC22/SC41)
- WG3 Road vehicle operations – CNG
- WG4 LNG filling stations
- WG5 Road vehicle operations – LNG
- WG 6 maritime applications (under debate; to be confirmed)
- WG 7 VRA

The aim of the WG1 group is to edit a European norm for CNG refueling stations. Ideally it will base the new document on the ISO norm: ISO 16923, as previously described. One of the main issues in
doing this work, is incorporating in the text of the international norm all the additional requirements which must be met in Europe, enforced by European Directives such as:

- Directive 94/9/CE of 23 March 1994 ATEX – installations in environments with potentially explosive atmospheres,

The aim of the WG4 group is to edit a European norm for LNG refuelling stations. Ideally it will base the new document on the ISO norm: ISO 16924.

In all these groups, the partners belonging the Blue Corridors Project are strongly participating.

Action recommended:

- Creation both ISO and CEN document recommendation for the construction of LNG and LCNG stations with the same kind of requirements for all markets, considering the inputs of the LNG Blue Corridors WP4.
- Propose solutions with a good cost efficient solution, in order to reduce the costs of the LNG stations, which is one of the main barriers that prevent fuel companies to invest in LNG stations
- Include the monitoring of the fuel quality in the regulations for LNG stations
- Make mandatory the fulfillment of the R110 for nozzles and receptacles
- Harmonize the service conditions, namely LNG delivery pressure (at present there are a number of different service conditions for LNG, ranging mainly from 3 bar to 18 bar)
- Make sure a good agreement between LNG station & OEM’s.

3.5 LNG nozzles and receptacles

There is no European or International standard that ensures the compatibility of LNG nozzles and receptacles. There is ongoing work for the standardisation of a given LNG receptacle dimension (upcoming ISO Standard ISO/DIS 12617, which will then be incorporated in the UNECE R110 regulation), but this work does not cover the compatibility between nozzles and receptacles.

As was already described in the document 4.3 within this Project, there are three main types of nozzles and receptacles: JC Carter, Parker Kodiak and Macrotech.
There are compatibility issues in two cases:

- Between Parker Kodiak nozzles and JC Carter receptacles; and
- Between Parker Kodiak nozzles and Macrotech receptacles.

On one hand, a Parker Kodiak nozzle requires a Parker Kodiak receptacle because it relies on Parker’s unique twist clamping, whereas a JC Carter or a Macrotech nozzle can fill any receptacle. On the other hand, any nozzle can fill the Parker receptacle, whereas JC Carter and Macrotech receptacles can only be filled by JC Carter or Macrotech nozzles (JC Carter nozzles and Macrotech receptacles are compatible, as well as Macrotech nozzles and JC Carter receptacles). It is also important to note that “adaptors” between different types of nozzles and receptacles are illegal in the EU for safety reasons.

JC Carter nozzle is the de facto standard in North America and China. There are hundreds of JC Carter nozzles in service across the world. Macrotech and JC Carter receptacles (which are fully compatible with JC Carter nozzles) are the most common in North America and China. There is a lot of experience globally with the JC Carter nozzles connecting to the Macrotech receptacle.

Action recommended:

- Since nearly all the LNG stations built in Europe in recent years use JC Carter nozzles (and Macrotech for gas return), the Blue Corridors consortium recommends the utilization of JC Carter and Macrotech as nozzle at the future LNG stations, but not the Parker Kodiak since it is not compatible.

### 3.6 LNG labelling

In order to show a common image of LNG as fuel at all European stations, a CEN group have recently been created.

This group is important since the image and identification by the clients of LNG is essential. Although most of the clients who usually refuel LNG are quite accustomed to use it (since the trucks drivers are supposed to be trained professionals and thus perfectly know how to indentify and refuel LNG at stations).
This group, called CEN PC 441 fuel labeling, aims to develop standards that provide a harmonized graphical expression of the labeling requirement for marketed liquid and gaseous fuels. The expression shall include a colour-coding scheme and be simple and easy to understand while ensuring clear and consistent labeling of existing and new market fuels.

The requirements set in the standard shall be based on real information needs of consumers regarding the fuel- and vehicle-compatibility which they need when they arrive at a filling station, fuel outlet or recharging point.

Action recommended:

- Discuss the labeling requirements of article 7 of the deployment of alternative fuels infrastructure Directive (DAFI) and clarify some of the issues raised by stakeholders in relation to the development of European standards on fuel labeling.
- Unification, based on the outcome from the meeting described above, of the LNG image at stations. It would be recommendable that, even if in some countries LNG is referred to with particular national names (like Metano in Italy or Fordongas in Sweden), the acronym LNG is shown for an easier identification process for international drivers.
- Use the Logo of LNG Blue Corridors (Blue, with a Truck) as reference image for the LNG in automotive applications.

3.7 Technology used: Pressure and temperature

Refuelling pressure is not harmonized in Europe and limitations are not established in any regulation. Main delivery pressure in practice is 8 bar, but there are some special cases; for instance in Portugal and Spain, where the pressure is 16 bar. In Sweden it is also possible to encounter a delivery pressure from 6 bar to 12.5 bar and in The Netherlands from 3.7 and 18 bar.

Action recommended:

- To define a roadmap of 5 years to reduce the maximum pressure of the LNG tanks of the vehicles. The aim is tank pressure is the lower as possible and therefore the LNG station do not need pumps (cryogenic and expensive systems). This will make the systems cheaper (at the LNG station).
- The EU Commission and stakeholders, promote OEMs to develop solutions to increase the gas pressure in their injection systems if they need higher injection pressure. Todays solutions from OEM’s and retrofit systems can easily operate with LNG tanks at 7-8 bar, while some systems as Wesport iCE tanks do build up the necessary pressure with a LNG cryogenic pump inside the tank, thus avoiding the need to have high pressure in the LNG tanks of the stations.

3.8 Training for LNG truck drivers

Before delivering a LNG truck, different safety and technology specific aspects have to be taken into account. A correct training has to be addressed to different stakeholders:

- Drivers of the trucks
- Fleet operators in charge of operating private refueling stations
- Fleet technicians maintaining the NG trucks.
Unfortunately there is not a common guideline provided by the vehicles manufacturer or the gas entities to the clients. Each company teaches, according its own knowledge and experience acquired, to its’ public who will deal with LNG.

Action recommended:

- Although the current recommendations provided by the different companies are quite similar to each other and all of them cover the majority of the most important topics – mainly in terms of safety – it would be recommendable that, those actions following an uniform and European agreed guideline, could be presented to any LNG user. Therefore, a consensus between all implicated parties, about the items covered during a training, is required.
- Follow LNG Blue Corridors training guidelines as reference
- The EU Commission to invest on a full training programme at all levels of the society to remove the barriers of general awareness of LNG as fuel for the trucks, including trainings supported by National Governments

The following aspects have certainly to be included on that training.

- Provide the trainers Europe wide with a uniform training material regarding the use of LNG Refuelling solutions.
- Highlight of the hazards and risks associated with the process. Recommend Personal Protective Equipment (PPE) like cryogenic gloves, faceshield, goggles, long sleeves, trousers ...
- Provide an overview of refuelling process
- Certify the users of LNG trucks and include them a new level in the driving license. They can be trained by selected driving schools and pass an exam demonstrating they know the refuelling process and that are aware of all the safety regulations, protections, etc

3.9 Boil off

Natural gas is, amongst other benefits, a cleaner alternative fuel compared to diesel, both on greenhouse gasses as on air pollution particles. To guarantee that the full chain, from well to wheel, in the natural gas refueling business has optimal performance to air quality and climate change, the stations have to be designed to have the lowest emission possible. Venting of natural gas is hazardous for the environment and should thus be reduced to zero or as close to zero as possible.

LNG is boiling at -162 °C at atmospheric pressure. As such, due to the warmth exchanged with its environment, LNG is permanently boiling and forming natural gas, causing pressure build up in the tank. To avoid venting several technical solutions are available depending on the technology of the station and the frequency of use.

The most common solutions are:

- Combine the LNG station with a CNG station. The boil off gas can then be compressed and stored in a CNG buffer which can be used to refuel heavy duty vehicles or passenger cars. A minimum CNG off-take is required to consume all the boil-off. This is an expensive solution as compressing gas to get CNG is demanding far more energy than pumping LNG with the same target.
• Send the boil off gas to an industrial site in the close surroundings. By preference this site is using natural gas for a process and not only for heating to make sure that in summer, when additional heat is causing for boil off, enough off take is guaranteed to consume the boil off.
• If the station is used with a high frequency, the boil off is cooled at each reloading of the tank and will re-condensate. The pressure will thus be decreased at each reloading. In a developing market in the starting phase of the different corridors, it is not guaranteed that reloadings will happen frequently enough to avoid venting.
• The boil off gas can be reliquefied by cooling it with liquid nitrogen and injected again in the tank. This is an expensive but very effective and reliable solution.
• The boil off gas can be compressed and then released in the tank. At decompression, the temperature of the gas will decrease and the gas will partially liquefy. This solution is suitable for limited boil off quantities.

As Blue Corridor consortium, there is no preference for one of the above technologies. Venting of natural gas has to be avoided, but the technology used has to be chosen in line with the refueling technology and the rate of usage of the station.

Action recommended:

• The EU Commission to perform a detailed study of the LNG stations available with LNG venting recovery and evaluate the economical efforts necessary to retrofit this facilities
• The EU Commission should find the funds to retrofit the existing LNG stations without LNG venting and promote the new LNG stations only have such devices installed to avoid any venting to the atmosphere

3.10 Taxation on Natural Gas and Biomethane as a vehicle fuel

A favorable tax treatment of Natural Gas and Biomethane is needed in order to achieve key policy objectives in transport, such as GHG emissions reduction, energy diversity, increased use of renewables and reduced oil dependence. Lower taxes versus diesel are essential for customers and investors in the built up phase of CNG and LNG infrastructure and to give room for technology investments and provide an incentive to fleet operators to switch to gas. The level of support would be determined by the price differential versus diesel. In order to ensure competitiveness and NGV growth, an adequate transitional period for derogation or a preferential treatment of energy taxation for Natural Gas and Biomethane must be considered within the scope of 2030.

The recent and unsuccessful debate on revising and harmonising energy taxation across Europe has shown that it is too early to discuss a tax rise on gas as motor fuel. It seems furthermore inappropriate to give higher importance on energy content, rather than on CO2 and pollutant emissions advantages, air quality was not playing a role in the debate at all. Europe would need a more sustainable and smart approach in this regard, while taking into account that all Member States of the European Union have perused different strategies and use different tax regimes for gas in transport (see graph).
In fact 16 Member States currently tax Natural Gas as a motor fuel below the set minimum recommendation of 2,60 €/GJ. At the same time, it would be fundamentally important to take the market share of Natural Gas Vehicles on a national level, which is normally less than 1%, into account. Any technology would only be able to withstand higher fuel taxes once a minimum market share of 10% would have been reached. Finally, Natural Gas stands for an increased use of biomethane, one of the main pillars to reach the mandatory 2020 RES target of 10% biofuels in transport. The development of biomethane is linked to that of Natural Gas Vehicles and hence a favourable tax treatment allowing the development of methane refuelling infrastructure, which will ensure to achieve the 60% GHG emission reduction target by 2050 as outlined in the White Paper on Transport.

3.11 Bunkering

Next to LNG for trucking purposes, LNG is certainly a perfect replacement for bunker fuel for ships, as well for inland shipping as for seagoing ships. Today, most seagoing ships run on heavy fuel oil. This is a cheap fuel but with bad environmental characteristics, mainly with regard to sulphur exhausts. With the stronger limitations in the Sulphur Emission Control Areas (SECAs), where most European coastal waters are included to, alternative solutions need to be adopted. The most common alternative is the use of low sulphur marine oil, which is expensive. Some ships install scrubbers on ships to remove the sulphur from the exhausts, but this is an expensive and not so clean solution. The perfect solution for new ships within the SECA zone, which is ready for current and future emission regulations is the use of LNG as a ship fuel.

Inland ships are today mainly running on diesel and analogue to LNG for trucks, LNG can be an economical alternative as a ship fuel with benefits for climate and environment.

The few LNG barges that are already sailing today are mainly bunkered truck to ship. The LNG trailer is parked along the quay and with flexible hoses the LNG is pumped into the LNG barge fuel tanks.

To accommodate more and bigger vessels additional infrastructure needs to come in place:

- Bunker ships that can load LNG in the import terminals (e.g. Zeebrugge terminal is finishing a 2d jetty to accept smaller bunker vessels) and refuel other vessels.
- Intermediate storage in a port where ships can refuel directly or where local bunkerships can be reloaded to on its’ turn reload LNG driven vessels. These intermediate storages are filled by feeder ships that reload their LNG at the import terminals.
- Local bunker ship of a size of 2 000 to 6 000 m³ LNG that can bunker end users ship-to-ship. Several are currently being constructed, ready to be used as from 2016.
Intermediate storages in ports are typically ideally placed to combine with a truck fueling station. Ports are highly frequented by heavy duty trucks and the infrastructure for the ship refueling can partially been used for the truck loading installation.

3.12 Barriers for the fleet operator’s mobility

Nowadays there are some obstacles that LNG truck drivers are facing.

It turns out clear that the lack of LNG infrastructure now makes European fleet operators cannot run their trucks in long hauls. Over the time more and more LNG stations are built trying to connect all European countries in the best way possible – that means runnable distance by truck.

However, apart from this, there are other barriers that fleet operators run up against when it is time to cross borders and run long distances.

For instance, concerning traffic through tunnels, national regulations must been taken into account. In the case of France, the Ministerial Order of 2007 set the technical conditions to ensure safety in road tunnels. Guidelines for proper protection and evacuation are established.

In other cases, like Eurotunnel, its policy does not permit gas-powered vehicles to use Le Shuttle (see table below). This is really an important barrier to use LNG dedicated or dual-fuelled vehicles in international routes between UK and the rest of Europe.

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![Figure 3-3 Primary fuel type versus secondary fuel type](image-url)
Action recommended:

- Common policies in all Europe, regardless the country. Creation a shared rules concerning tunnels and the possibility to be gone across by a LNG trucks. In this way, drivers will not be concerned when it is time to go to unknown areas.
- To allow the transport of NG vehicles, mainly LNG trucks, through certain key places in Europe, like the Eurotunnel.
- Based on the two prior points, as action, adapt tunnels and areas which are currently restricted to be crossed by LNG trucks.
### Summary table

<table>
<thead>
<tr>
<th>Standardization issue</th>
<th>Proposal</th>
<th>Suitable recipient</th>
<th>Partner in charge</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>LNG nozzles and receptacles</td>
<td>To take into consideration ISO 12617. LNG fuelling connector consists of, as applicable, the receptacle and its protective cap (mounted on the vehicle) and the nozzle.</td>
<td>CEN/TC 326 “Gas supply for Natural Gas Vehicles”</td>
<td>Iveco / WESTPORT</td>
<td>ISO 12617 published last 18th March 2015.</td>
</tr>
<tr>
<td>Regulation LNG and LCNG stations</td>
<td>Publication of a CEN document recommendation for the construction of LNG and LCNG stations with the same kind of requirements for all markets.</td>
<td>One group was already specifically created: CEN/TC 326 “Gas supply for Natural Gas Vehicles”</td>
<td>NGVA, GNF</td>
<td>This committee just started. It is supposed to finish at the end of 2016 with a unique European stations regulation.</td>
</tr>
<tr>
<td>Type approval of dual-fuel retrofit systems at Euro IV, V and EEV.</td>
<td>The adoption of an interim regulation by all European countries is required in order to enable LNG HDV market penetration in the short term.</td>
<td>Working Party on Pollution and Energy (GRPE) - GFV</td>
<td>WESTPORT / NGVA</td>
<td>Postures from different European countries are different.</td>
</tr>
<tr>
<td>ADR issues</td>
<td>Approval from all EU countries on the multilateral agreement M276 regarding the allowance of trucks powered by LNG technology to transport ADR goods.</td>
<td>ECE - Inland Transport Committee - Working Party on the Transport of Dangerous Goods</td>
<td>NGVA</td>
<td>The ADR Regulation has been successfully amended (will be in application in 2017), to allow LNG propulsion for ADR-certified vehicles. LNG Blue Corridors partners have been, and still are, involved in the preparation of the new ADR Working Document to allow CNG propulsion for ADR-certified vehicles.</td>
</tr>
<tr>
<td>Fuel quality</td>
<td>Main LNG quality specification in order to meeting the demands from the automotive industry: Sulphur: max. 10mg/m³; Net Wobbe Index between 44.7 and 49 MJ/m³; Methane number, high grade min. 80 MWM; Methane number, regular grade min. 70 MWM;</td>
<td>CEN/TC 408: “Natural gas and biomethane for use in transport and biomethane for injection in the natural gas grid”</td>
<td>Volvo</td>
<td>CEN/TC 408 and CEN/TC 234: “Gas infrastructure - Quality of gas - Group H” are already working on this issue</td>
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<tr>
<td>Topic</td>
<td>Description</td>
<td>Responsible Parties</td>
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<tr>
<td>Refuelling pressure and temperature</td>
<td>Particle contamination 10 mg/L(LNG) max; siloxanes max. 0.1 mg/m³; H₂S + COS max. 5 mg/m³. To ensure a common MN calculation method.</td>
<td>UNECE Group of experts on Gas (Task Force D), Working Party on General Safety Provisions (GRSG)</td>
<td></td>
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<tr>
<td>LNG labelling</td>
<td>To promote OEMs to develop solutions to increase the gas pressure in their injection systems if they need higher injection pressure. To reduce the maximum pressure of the LNG tanks of the vehicles. The aim is tank pressure as lower as possible.</td>
<td>SGA, NGVA</td>
<td></td>
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<td>LNG labelling</td>
<td>Discuss the labelling requirements of article 7 of the deployment of alternative fuels infrastructure Directive (DAFI) and clarify some of the issues raised by stakeholders in relation to the development of European standards on fuel labeling. Unification of the LNG image at stations. Use the Logo of LNG Blue Corridors (Blue, with a Truck) as reference image for the LNG in automotive applications.</td>
<td>NGVA</td>
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<td>Training for LNG truck drivers</td>
<td>It would be recommendable that those actions following an uniform and European agreed guideline, could be presented to any LNG user. To invest on a full training programme at all society levels to remove the barriers of general awareness of LNG, including trainings supported by National Governments.</td>
<td>UNECE Group of experts on Gas (Task Force D), Natural &amp; bio Gas Vehicle Association (NGVA), European Commission, National Authorities</td>
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<td></td>
<td>A depth analysis of this issue is currently under development in Deliverable 3.5 Market harmonization proposal.</td>
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<td></td>
<td>To be discussed and addresses in the TC 441. This unification discussion of LNG image will be carried out beside the EC (DG Move).</td>
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<td></td>
<td>A document about the future recommendation for LNG drivers has been developed by NGVA. Deeper action have to be carried out at both European and national level.</td>
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<tr>
<td>Barrier for Mobility</td>
<td>Policy or Action</td>
<td>Responsible Bodies</td>
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<td></td>
<td>CEN TC 236 “Gas supply for Natural Gas Vehicles”, UNECE Group of experts on Gas (Task Force D)</td>
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<td></td>
<td>European Commission, NGVA</td>
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<tr>
<td>• Coupling of NG with LPG unacceptable (1.70 €/GJ higher average taxes for LPG vs Natural Gas) • 16 EU Member States tax NG below set minimum recommendation of 2.60 €/GJ (EU average 2.15 €/GJ, weighted average 0.75€/GJ). • NG vs Diesel: average Diesel tax 11,60 €/GJ =&gt; Council proposal 11,09 €/GJ</td>
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<td>To perform a detailed study of the LNG stations available with LNG venting recovery and evaluate the economical efforts necessary to retrofit this facilities. To find the funds to retrofit the existing LNG stations without LNG venting and promote the new LNG stations only have such devices installed to avoid any venting to the atmosphere.</td>
<td></td>
<td>European Commission, CEN/TC 326 “Gas supply for Natural Gas Vehicles”, Fluxys, NGVA</td>
</tr>
<tr>
<td>Stations have to be designed to have the lowest emission possible. Venting of natural gas is hazardous for the environment and should thus be reduced to zero. This topic is already being dealt in the CEN/TC 326 “Gas supply for Natural Gas Vehicles”</td>
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</table>

This topic is dealt in some European committees: TC 236 and Task Force D are supposed to cover it.
References

List of figures

Figure 1-1. Impression of the LNG Blue Corridors.................................................................5
Figure 3-1. The three main type of nozzels and receptables....................................................15
Figure 3-2 EU Energy taxes as of July 2013, Natural gas used as motor fuel..........................19
Figure 3-3 Primary fuel type versus secondary fuel type.......................................................20
<table>
<thead>
<tr>
<th>Partners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applus+ IDIADA</td>
</tr>
<tr>
<td>EIHP</td>
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<tr>
<td>galp energia</td>
</tr>
<tr>
<td>HAM</td>
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<td>TransGas Monfort INTERNATIONAL I.R.A</td>
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<tr>
<td>VOLVO</td>
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