WP5: Support to the LNG trucks during the demonstration

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REVISION HISTORY AND STATEMENT OF ORIGINALITY

Revision History

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<td>0.1</td>
<td>24-04-14</td>
<td>Eve Grenon-Lafontaine</td>
<td>WESTPORT</td>
<td>Initial Draft</td>
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<tr>
<td>0.2</td>
<td>25-04-2014</td>
<td>Curt Ganeles</td>
<td>ERDGAS</td>
<td>First review –changed formatting &amp; added content</td>
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<td>0.3</td>
<td>28-04-2014</td>
<td>Christina Eriksson</td>
<td>VOLVO</td>
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<td>Hans Michiels</td>
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<td>0.6</td>
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<td>21-08-2015</td>
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<td>Review and additional content</td>
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<tr>
<td>0.9</td>
<td>22-10-2015</td>
<td>Nadège Leclercq</td>
<td>WESTPORT</td>
<td>Review and additional content based on input from fleet operators: AFC ADPO, Logicompany, Mattheeuws, Ninatrans, Paulo Duarte, TIEL and VOS Logistics.</td>
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<td>1.0</td>
<td>26-10-2015</td>
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<td>29-10-2015</td>
<td>Philippe Desrumaux</td>
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<td>30-10-2015</td>
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<td>1.6</td>
<td>27-01-2016</td>
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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This deliverable contains original unpublished work except where clearly indicated otherwise.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 Corridors project is committed to supporting the fleet operators involved in the project in the best possible way. Such support does include preparations prior to the demonstration as well as support to the LNG trucks and daily operations during the demonstration.

The purpose of this report is to describe current and best practices as well as identify gaps and suggest improvements to ensure functionality of the entire value chain and optimal support to the fleet operators, driven by the commitment to make this demonstration project as successful as possible.

Preparations prior to the demonstration include the following aspects:

- Fleet operators’ management and appropriate departments (e.g. operations, quality, health, safety and environment, training, finance, etc.) should be supported in defining and implementing all relevant processes related to the use of LNG as a fuel for trucks;
- Drivers should be trained in order to be able to properly and safely operate LNG trucks and stations;
- Truck dealer (and potentially fleet operator) technicians should be trained and certified for LNG vehicle repair and maintenance;
- Workshops servicing LNG vehicles should be outfitted and equipped with appropriate tooling;
- Local first responders should be informed and prepared to deal with accidents involving LNG.

In addition to these preparations, each vehicle manufacturer (or system supplier) should provide all necessary LNG truck maintenance schedules to the certified dealers (and/or workshops) that will perform maintenance. LNG truck maintenance schedules should cover all the aspects that require different maintenance than diesel trucks, i.e. the engine and the natural gas fuel system. The required maintenance will vary greatly depending on the natural gas engine technology, engine manufacturer and fuel system manufacturer.

Contingency plans should also be clearly defined with each fleet operator, who should know exactly what to do in case an LNG truck breaks down or runs out of fuel, or in case of incident at an LNG station.

- In order to prepare for LNG truck breakdowns, fleet operators should subscribe to a 24/7 emergency roadside assistance service and/or have a list of European certified dealers and a document containing all necessary information for towing companies and non-certified repair shops;
- In order to prevent LNG trucks from running out of fuel, drivers should be trained and regularly reminded of their tasks (e.g. planning routes appropriately, knowing vehicle range and when to refuel, knowing LNG stations’ locations, etc.);
- In order to be prepared in case LNG truck runs out of fuel, each fleet operator should have a defined process (which will vary depending on the LNG truck model); in addition, certified dealers and fuel station operators should consider purchasing the required tooling or equipment to transfer LNG to a stranded truck;
In order to prepare for incidents at LNG stations, stations should keep an inventory of some key components, make a list to prepare for possible malfunctions and have procedures in place to obtain replacement parts quickly.

For the needs of the LNG Blue Corridors project, on-board monitoring devices are mounted on the LNG trucks involved in the demonstration. The monitoring device is mounted as unobtrusively as possible. It does always work in 'listen-only' mode and does therefore not interfere with the vehicle’s normal operation. Once in operation, all regular maintenance and software updates are performed remotely. In case of malfunctioning, a troubleshooting procedure is established.

The main recommendations and suggestions for further improvement that are identified in this report can be summarized as follows:

- Create a knowledge sharing centre and forum for fleet operators (which could be hosted on the LNG Blue Corridors project Intranet), where fleet operators could:
  - Find all useful information to help them establish their QHSE procedures (available online);
  - Find contact details for other truck operators involved in the project (available online);
  - Easily contact other LNG truck operators in Europe, either individually or collectively via the forum, in order to discuss various topics and share best practices related to LNG truck and stations;
  - Gather for workshop sessions focused on optimization of LNG truck operations, enabling fleet operators to compare their business cases and share best practices for LNG truck operations;
- Schedule regular individual meetings with fleet operators to assist them in the analysis and improvement of LNG truck operations and payback; this task could be facilitated by the use of data collected from trucks and operators for the purpose of the project;
- Establish standard driver training programmes for LNG stations and LNG trucks in order to avoid unnecessary repeats for fleet operators that are working with several LNG suppliers, station operators and/or truck manufacturers;
- Establish a standard European first responder training programme and guidelines;
- Define and implement appropriate European 24/7 emergency roadside assistance service for LNG trucks;
- Define and implement a standard process to enable any LNG truck operator to refuel at any European LNG station as easily as possible; this could include a common identification platform of all LNG trucks and certified drivers; payment process should also be considered;
- Consider improving availability of LNG stations by having redundant LNG fuelling infrastructure, opening stations 24/24 and enabling LNG self-service (only applicable to manned stations).

An action plan for the implementation of these suggestions is available in the Conclusions of this report.
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1 Introduction

The use of natural gas as a road fuel offers several strategic, technical, and societal advantages. When used as vehicle fuel, natural gas can reduce pollutant and greenhouse gas emissions, reduce noise emissions, lower fuel costs, and offer an effective alternative to the use of imported oil in transportation. In Europe, the use of natural gas engines in transportation applications has been well established in passenger cars and in short-range heavy-duty vehicles. However, the availability and use of natural gas in long-distance transportation has been very limited.

Liquefied natural gas (LNG) is the only real alternative to diesel fuel for use in heavy duty vehicles today. Although it delivers the environmental, economic and political advantages described above, there is a large obstacle to its utilization: the availability of a fuelling network across the EU’s motorways. This has resulted in a ‘chicken and egg’ problem: logistics and trucking companies will not adopt alternative fuel vehicles without a reliable and widespread fuelling infrastructure, yet no filling stations will be built without guaranteed fuel turnover at the stations.

The DG-MOVE FP7-funded LNG Blue Corridors project is designed to overcome these challenges by facilitating the simultaneous roll-out of vehicles and filling stations along major traffic corridors across the EU. By establishing 13 filling stations and partially funding the extra investment costs for LNG trucks, the project lays the groundwork to establish LNG in European road transport and to analyse its impacts over a three year demonstration period.

The widespread introduction of any new technology requires that all relevant aspects of the value chain be educated and prepared for its use. Before LNG trucks are put into regular service on an international scale, truck drivers, fleet managers, OEM dealers, mechanics, roadside assistance personnel and emergency responders, among others, must be made familiar with the operational and safety-related specifics of LNG trucks and associated infrastructure.

However, in a demonstration project, it is most important to prepare and support the actual vehicle users. The LNG Blue Corridors project is expressly committed to always showing fleet operators the best way. This means that the project participants who have purchased trucks must always be supported in their daily activities, especially as they are the ones who take the greatest financial risk while generating the data needed to conduct the project’s analysis. The goal of this deliverable is to account for factors that should be taken into account when supporting LNG trucks in the demonstration, using past experiences from existing truck operators and recommendations from OEMs.

Using input from OEMs and current users of LNG trucks, this deliverable discusses:

- Recommended preparations prior to the demonstration
- Differences in expected maintenance between mono-/dual-fuel LNG trucks and conventional diesel models
- Contingency plans in the event of incident in the field
- Access to LNG fuelling infrastructure
- Installation and functioning of the on-board monitoring device
- Analysis and optimization of LNG truck operations
The key to success in this demonstration project will be ensuring the functionality of the entire value chain. This means that trucks, maintenance facilities, fuelling stations and the monitoring devices must always be ready for use, and there must be a clear procedure to correct any problems should they arise.

In-depth qualitative telephone interviews have been conducted with seven of the fleet operators involved in the LNG Blue Corridors project. The objective was to gather their feedback and recommendations based on their experience with LNG trucks. The LNG Blue Corridors project partners would like to thank the fleet operators AFC ADPO, Logicompany, Mattheeuws, Ninatrans, Paulo Duarte, TIEL and VOS Logistics for their valuable input to the content of this report.
2 Preparations prior to the demonstration

In order to run a successful LNG truck demo programme, many of the participants must receive appropriate training. There are many differences that relate to the operation of a LNG truck versus a diesel truck, namely how to plan routes, how to fill the truck with fuel, how it is maintained, how emergency first responders must approach the scene of an accident involving an LNG-powered vehicle, just to name a few. Both the truck operators and the OEM dealers will need to be well prepared and aware of the following technicalities.

2.1 Fleet operator preparation

2.1.1 Best practices

There are a number of aspects on which fleet operators must be prepared before operating LNG trucks and supported during – especially at the beginning – of operations. Company management and appropriate departments such as operations, quality, health, safety and environment, training, finance, etc. should be involved in these preparations.

It is important that the industry stakeholders (fuel suppliers, truck manufacturers, etc.) support fleet operators in preparing for LNG truck operation in the best possible way. Some of the topics that do require such support are listed here:

- Specifying vehicles and fuelling requirements (part of the sales process);
- Defining most appropriate routes for LNG trucks (return to base, etc.) and planning routes;
- Defining and implementing refuelling practices for LNG trucks, e.g. when to refuel, making sure drivers don’t forget to refuel, etc.;
- Establishing and implementing appropriate internal quality, health, safety and environment (QHSE) procedures related to LNG trucks and station, informing and involving local first responders as needed, especially for fleet operators who do have QHSE certifications such as ISO 9001, ISO 14001, OHAS 18001 and others;
- Tracking and analysing fuel consumption of LNG trucks;
- Eco-driving LNG trucks, i.e. training drivers to help them reducing their fuel consumption performance with LNG trucks. Main focus should be adapting existing eco-driving programme for companies that do have such a programme in place for diesel trucks;
- Implementing best practices to maximize LNG truck drivers’ satisfaction and ensure drivers have a good image and feel proud of driving LNG trucks;
- Supporting fleet operators on any other topic related to the implementation of LNG as a fuel for trucks.

Fleet operators’ management and appropriate departments (operations, health & safety, training, etc.) also have to be involved in the preparation of driver training as well as in the actual dispensing of training when appropriate.
2.1.2 Recommendations for further improvement

Establishing and implementing appropriate internal quality, health, safety and environment (QHSE) procedures related to LNG trucks and station can be a complex process for a fleet operator. One of the interviewed fleet operators mentioned he would welcome further support in this activity. This fleet operator had to gather information from various national and international organizations in addition to the information provided by the fuel supplier and truck manufacturer. The company is also in contact with other fleet operators to exchange best practices and with local first responders to establish emergency guidelines for LNG trucks.

It would be very helpful for such fleet operators to:

- Have access to a kind of online knowledge centre where they could find all useful information to help them establish their QHSE procedures;
- Be able to easily contact other LNG truck operators in Europe (e.g. via an online forum and contact database of LNG truck operators) in order to discuss various topics and share best practices related to LNG truck and stations.

Both these knowledge centre and online forum could be implemented within the LNG Blue Corridors project via the project intranet.

2.2 Driver training

2.2.1 Overview

Before the LNG trucks are put on the road, the drivers who will be operating them must attend a training session, which should include the following presenters and information:

- The vehicle manufacturer or dealer, who will cover all the truck related aspects:
  o Security measures such as operation of the methane detection system and do a walk around of the vehicle, etc.
  o How to drive the vehicle, i.e. how to properly shift with the engine, what to expect in terms of noise levels, optimum RPM for best fuel economy, in-cab driver display explanations, etc.
  o How and when to refuel the vehicle, parking safety measures, how to isolate the LNG tank from the fuel system in the case of an emergency situation, etc.
- The fuel provider or fuel station operator, who will cover all the station related aspects:
  o Provide general training and recommendations on LNG such as basics about what is natural gas and LNG, recommendations in case of leakage, fire or other emergency situation;
  o Walk drivers through operating the fuelling station and refuel a vehicle;
  o Explain the safety measures to follow at the station such as wearing the appropriate PPE (personal protective equipment), etc.

Driver training is very important, obviously because drivers must know how to behave with LNG trucks, but also because they need to be reassured. Before the training, many truck drivers don’t really know
what LNG is and can be scared. The training is therefore also important to show drivers that LNG is not as dangerous as they may think, that it doesn’t explode (they’re not “driving a bomb”), etc.

All the aspects of driver training are considered equally important by fleet operators. The interviewed fleet operators are keen on having their drivers well trained for the operation of LNG trucks and stations.

The right balance has to be found between reassuring the drivers and at the same time pointing on the importance of handling LNG appropriately (e.g. with protections etc.), without giving drivers the impression that the safety procedures are much more stringent for LNG trucks than for diesel trucks. It is important to create LNG truck drivers enthusiasm – make drivers happy to drive LNG trucks – while also ensuring their safety.

Refuelling, and especially “when to refuel”, is a topic that fleet operators constantly have to remind to their drivers. Due to the limited number of LNG stations, the fact that LNG trucks have to be refuelled every day (or even twice a day in some cases) is seen as one of the main particularities of LNG trucks. Moreover fuel metering in the current LNG trucks is not as precise and reliable as in diesel trucks, which can be due to a mix of natural gas in liquid and gaseous forms in the tank. So the drivers must be aware of it and understand how to make sure they won’t be running out of fuel.

In some countries like Italy, where there is no self-service LNG fuelling, fuel station operation training is not needed (or reduced to a minimum).

Even though this is called “driver training”, it can be appropriate for other employees of the fleet operator involved in the operations of LNG trucks (e.g. company management, health and safety department, workshop employees, etc) to follow the same training. This is a case by case decision and depends on the internal organization of each fleet operator.

For a list of recommendations for LNG truck drivers, please refer to deliverable D4.4.

2.2.2 Current training practices

Training sessions are organized on a case by case basis, depending on fleet operators’ needs. Driver training can either be split in several sessions (e.g. one vehicle training session by the truck manufacturer, one station training session by the fuel station operator) or conducted in a single session (together with the truck manufacturer and the station operator).

The common practice in Europe currently is to provide:

- Initial LNG truck training when the first trucks are delivered (the appropriate number of drivers to be trained is defined on a case by case basis by the truck operator)
- Initial LNG station training prior to the start of LNG truck operation
- Additional LNG truck training when more LNG trucks are added to the fleet (this training is focused on the specifics of the new trucks)
- Additional LNG station training if the truck operator is refuelling at several stations (one training session per station)
This seems appropriate for the early stages of market development. However a more coordinated and optimized approach will be required as the market grows. Truck operators who are already operating LNG trucks of different brands and refuelling at several LNG stations state that the current process is too heavy (takes too much time and reduces actual driving time) and tends to be boring for the drivers who hear similar messages in each training session.

Truck training is usually dispensed at the fleet operator's premises or at the LNG station. LNG station training is always dispensed at an LNG station.

For the initial training, fleet operators consider that this is valuable to have both the truck manufacturer and the station operator attending the whole training (i.e. LNG truck and station training).

There is no common practice for training updates yet. From fleet operators' point of view, the need for regular (e.g. yearly) updates is not obvious, even though few of the interviewed fleet operators think yearly training repetition and technological update would be beneficial. This should be discussed with fleet operators on a case by case basis. Truck dealers and LNG station operations should periodically check the need for training updates with their fleet customers. They should also ensure fleet operators are informed of any change related to the LNG trucks and/or stations.

Training can also be provided by 3rd party instructor (instead of truck OEM and/or station operator). This is not common practice in Europe currently, but may develop as the market grows. Even though truck operators seem to appreciate being trained directly by the truck manufacturer and station operator, involving 3rd party instructors should not cause any problem as long as these instructors are well trained by truck manufacturers and station operators.

An interesting practice is the training of internal fleet operator's instructors or other qualified internal resources (e.g. experienced driver who also acts as an internal coach for other drivers). Such resources do (and should) not have the mandate to substitute themselves entirely to the truck OEM and/or the station operator for the initial training, but they should actively participate in training sessions and they are an internal point of contact for any question related to LNG trucks and stations.

Each company (fuel supplier or truck manufacturer) does have its own training programme and material, focused on its own stations and/or vehicles. Printed training material is usually given to the trainees, which is good since it does enable them to look at it again at any time when needed. This is the case for both LNG station training material and LNG truck training material. Some LNG station operators also provide video training. Fleet operators like it since the drivers can also look at the videos again whenever they need.

It is also reassuring for the fleet operators to have a fuel station operator's employee assisting drivers for LNG fuelling during the first week(s) of operation and when a driver does refuel at a given station for the first time.
At this stage, there is no regular training session opened to any LNG truck operator in Europe. This might become appropriate when the LNG truck market grows, but is not needed yet. It is worth mentioning, though, that several third parties are already offering CNG vehicle training and are also offering or could offer LNG truck driver training when there is demand. Such third parties include NGV associations e.g. GASNAM (Spain - http://gasnam.es/acuerdo-de-formacion-entre-gasnam-y-grupo-fortrans/) and NGVA Europe (http://www.ngvaeurope.eu/ngva-europe-training-institute) as well as private companies (training institutes, independent consultants, etc.) e.g. TÜV (TÜV Saarland automobil GmbH - TÜV Rheinland Group - Competence Center Alternative Fuels), Clean Vehicles Training Institute EEIG (http://www.cleanvehicletraining.com/), RAP Clean Vehicle Technology (http://www.rap-cleanairproducts.nl/), Mouthon Formation (http://www.mouthon-formation.org/) and others. In Canada, work is underway to establish a national training programme for natural gas vehicles (http://www.gowithnaturalgas.ca/getting-started/training/). Several other training institutes offer LNG vehicle related training in North America. One of them is the Natural Gas Vehicle Institute NGVi in the USA, which is offering LNG vehicle training for technicians (http://www.ngvi.com/vehicle_training.html).

Each training session usually comprises both theoretical and practical training. This is considered important by truck operators in order to ensure the drivers are getting familiarized with the operations. For example, LNG station training will start with theoretical training and then each driver will practice refuelling at least once.

A sample fuel station safety and operation video for Gas Natural Fenosa’s LNG stations is available on the LNG Blue Corridors website (http://lngbc.eu/videos).

Figure 2-1: Screenshot of the Gas Natural Fenosa LNG Video. Source: Gas Natural Fenosa
A sample North American driver training video is available on the WestportDotCom YouTube Channel (https://www.youtube.com/user/WestportDotCom), covering the operation of the Westport 15L engine and the Westport LNG fuel system, as well as security measures. Link to the video: https://www.youtube.com/watch?v=iXcMkw0jHjc.

Figure 2-2: Screenshot of the Westport 15L Engine and LNG Fuel System Training Video. Source: Westport

2.2.3 Recommendations

General feedback from interviewed truck operators about driver training is good. Fleet operators consider that their drivers are very well trained on LNG trucks and stations operations and that the training enables them to conduct all LNG related operations safely and comfortably.

However some fleet operators also insist on the fact that driver training should be kept as simple as possible. The main recommendation is to homogenize training programmes in order to avoid unnecessary repeats. Even though training material doesn’t necessarily have to be the same for several LNG station operators / fuel suppliers or truck manufacturers, some coordination would be beneficial.

LNG station operators should agree on the driver training programme covering general information about LNG and refuelling instructions, in order to make it easier for fleet operators who use several LNG stations. There should be just one main training session at an LNG station. For other stations used by the same drivers, the additional training should be focused on the specific layout of the stations and the operational differences with other stations. This additional training would preferably be done at the fleet operator’s location (instead of having the drivers going to each station for a separate training session), with photos, pictures and/or videos that show the station and explain how drivers
should operate it. Ultimately, a driver should be able (and allowed) to refuel at any LNG station in any European country after a single training session.

Similarly, truck manufacturers should agree on the LNG truck driver training programme, at least for the generic part of it. Then, when new trucks are delivered to fleet operators who already have LNG trucks from another manufacturer, the truck manufacturer should know what has already been covered in previous driver training and focus on the specifics of the new truck model.

### 2.3 Certified technician training

#### 2.3.1 Dealers

When a LNG truck is delivered in a territory or region, it is the vehicle manufacturer’s responsibility to ensure that their certified dealers’ territory coverage is adequate for the customer needs. This means that the vehicle manufacturer must make the necessary modifications to its nearby dealer location(s) that could potentially have to maintain or repair a LNG vehicle, as well as have at least one OEM-trained and certified technician per shift. A dealer location must, at a minimum, have one certified technician on every shift to be considered “certified” to work on LNG equipment. For an international demonstration project such as the LNG Blue Corridors, it is critical that vehicle manufacturers can support fleet operators with trained personnel in all regions through which the trucks will travel.

Ultimately, when the LNG truck market further develops in Europe, one will expect each vehicle manufacturers’ certified dealer network to cover the entire European territory. However the main – and more realistic – expectation from the interviewed fleet operators at the current early stage of market development is for each fleet operator to have at least one well trained technician at the closest OEM dealership. This dealer is the fleet operator’s main point of contact for any LNG truck related issue.

The interviewed fleet operators report that, when they start operating their first LNG trucks, their local truck dealer is rarely sufficiently trained, unless he has already been working with other LNG truck operators for some time. Given that they are involved in a demonstration project, most fleet operators seem to understand and accept this situation even though it’s not ideal. However they do expect their local truck dealer to quickly become knowledgeable and able to maintain and repair LNG trucks with a good level of expertise. A satisfactory level of service should be achieved within a year or so. Fleet operators also recognize that it would be beneficial if the dealers could be trained more in advance, in order to be efficient in LNG truck repair and maintenance from the beginning of LNG truck operations.

The training class for technicians is usually provided by the vehicle manufacturer and does last between 2 to 5 days. Third parties (such as those mentioned in the Driver training section above) will likely increasingly offer LNG technician training according to future demand.

In the coming years, efforts will have to be taken to ensure that there is a reasonably dense infrastructure of maintenance facilities and trained (certified) personnel along a given route (LNG corridor) that corresponds to the number of LNG trucks in operation.
As the market develops, fleet operators will also expect to have more certified technicians available locally in order to have back-up solutions in case their usual certified dealer is not available for any reason.

2.3.2 Fleet operators

At this stage, LNG truck maintenance and repair is essentially done by vehicle manufacturers’ dealers. Most of the interviewed fleet operators state that they don’t want to become involved in any LNG-specific maintenance and repair activities, neither now nor in the future when their fleet of LNG trucks grows, because it would require specific equipment and knowledge in which they’re not planning to invest. Therefore vehicle manufacturers currently rarely provide technical LNG truck training for fleet operators’ workshops and this situation is not likely to change drastically in the coming years.

Some fleet operators however do mention interest in performing their own LNG truck maintenance in the future when they have more LNG trucks in their fleet. In this case these fleet operators’ workshop technicians would have to follow the same training class as the dealers in order to become certified technicians (see above section).

2.4 Shop outfitting & tooling

2.4.1 Dealers

There are a number of special requirements that should apply to workshops servicing LNG vehicles. The recommendation is that consideration is given to the revision of ECE R115 to document these requirements.

In the United States, safety regulations pertaining to maintenance shops can be found in U.S. regulations NFPA 88B ('Standard for repair garages') and NFPA 30A ('Code for motor fuel dispensing facilities and repair garages').

The safety requirements for shop modifications vary greatly by country, province and even by town and are usually controlled by the local authorities (i.e. fire marshals, health & safety government agencies, etc.). Each dealer location must verify the requirements with its local authorities, but in general, modifications should include a list similar to this one:

*The shop in this example is equipped with three roll-up service bay doors and takes up to five trucks at the same time. Shop is used only for NGV and PDI’s on regular trucks:*

- Six sensors spread around the shop:
  - Two NO2 sensors about 5’ off the floor on the wall
  - Two CO sensors about 5’ off the floor on the wall
  - Two CH4 sensors mounted under the roof
  - One control panel mounted close to the entrance door monitors the six sensors
  - Two red alarm lights (mounted on opposite inside shop wall)
• Center roll-up service bay door is equipped with explosion proof electric overhead door opener
• Electric disconnect panel mounted on back wall beside main breaker panel
• Exhaust fan mounted on roof top in center of shop

Should sensors register a dangerous level of NO₂/CO/CH₄, the power to the main breaker panel in the shop will be disconnected (everything is shut off). The red warning light is activated and the emergency lights come on, while simultaneously, the center roll-up door opens and the roof exhaust fan starts up.

Dealership locations must also purchase all required tooling for the truck manufacturer.

In practice, dealership workshop modifications are monitored by each truck manufacturer, who knows what specialized equipment is required for each workshop and can provide assistance to reach an agreement with local authorities on safety requirements and procedures.

2.4.2 Fleet operators

For fleet operators that wish to perform their own maintenance (but not warranty work), the shop modification requirements can possibly be less complex than those suggested above (depending on the type of maintenance operations they want to perform on LNG trucks), but again, this will be up to the local authorities. Often, a basic precautionary procedure provides enough safety to complete simple LNG truck maintenance and inspections. This procedure can consist, for example, of isolating the LNG fuel tanks and purging the high pressure gas lines that feed the engine. For fleet operators that wish to be able to perform similar LNG truck maintenance as dealer workshops, the shop modification requirements will likely be the same as for dealer workshops.

As for dealership workshop modifications, each vehicle manufacturer will have specific recommendations; however, local authorities will still need to be consulted to verify what minimal shop modifications are needed, if any.

2.5 First responder training in case of accidents

First responders (fire fighters, police, emergency medical services, vehicle recovery services, etc.) that are working in the area where LNG trucks will be operating need to receive special training so they are prepared to deal with an accident involving LNG and high pressure gas. Specific requirements and regulations will vary by country.

The vehicle manufacturers (or dealers), fuel suppliers and station operators should be responsible for ensuring that local first responders receive appropriate information and training, which should include at least:

- Names, locations and contact details of companies operating LNG trucks;
- Location of LNG stations and station operator’s contact details;
- LNG training in order to be prepared to deal with any incident involving an LNG truck and/or LNG station.

This should be part of the standard preparation process prior to the operation of LNG trucks and/or opening of an LNG station.

Training could be performed by vehicle manufacturer or dealer, fuel supplier, station operator and/or third party instructor. It could also be beneficial to involve fleet operators in this process (e.g. have first responders visiting fleet operator and LNG station). Some of the training institutes and consultants mentioned in the “Driver training” section above do already offer or could potentially offer first responder LNG training. Such organizations could therefore be mandated by a vehicle manufacturer and/or station operator to perform this training.

In preparation for further market development, it would also be useful to work with fire schools in order to ensure any newly trained fire fighter will get basic CNG and LNG information as part of its initial training.

It is also important that the vehicle manufacturer (or dealer) and fuel supplier / station operator inform LNG truck fleet operators of the information and/or training provided to first responders in their area. The interviewed fleet operators either report that they don’t know if first responders in their area are trained for LNG or that they believe or know first responders are not trained nor prepared to deal with LNG trucks – or even not informed about LNG trucks being operated in the area.

It would also be beneficial for the industry to establish a standard European first responder training programme and guidelines (or check-list) of all the important topics that should be covered in such training. Even though the detailed training programme and material may vary slightly from one instructor to another and from one country to another (due to specific national requirements and regulations), this would at least ensure that a number of basics are covered in any first responder LNG training. First responder units that have been trained could also receive a training certificate and LNG sticker.
3 LNG truck maintenance

LNG trucks require different maintenance than a diesel truck on two fronts; the engine and the natural gas fuel system (i.e. the LNG tanks and its subcomponents, linking the tanks to the engine). The maintenance itself can be done either at a vehicle manufacturer’s certified dealer or by the customer at his location, provided that the vehicle manufacturer allows it and that the shop in which the maintenance will be performed is adequately adapted to receive LNG-powered vehicles.

3.1 Engine maintenance

The required maintenance will vary greatly depending on what type of natural gas engine is used, and per engine manufacturer.

- For spark-ignited engines, spark plugs need to be changed at a regular interval and a specific natural gas engine oil grade needs to be used. Oil change intervals will be shorter than for a diesel truck. The vehicle or engine manufacturer will have specific recommendations.
- For conventional dual-fuel engines, recommended maintenance varies little from a conventional diesel-powered truck; indeed, most of the recommended procedures are inspections and do not require large-scale replacement of parts.
- For HPDI engines, the maintenance is very similar to that of a diesel engine. The vehicle manufacturer will publish its own maintenance schedule; however one can expect that oil changes will be as long - or even longer - than that of a diesel truck. Regular engine oil can be used.

3.2 Fuel system maintenance

Fuel system maintenance and inspection must be conducted according to ECE R110 regulation requirements as well as national requirements for Periodical Technical Inspection (minimum content harmonized in 2009/40/EC). Maintenance and inspection recommendations shall be provided by the fuel system manufacturer. The required maintenance will vary greatly depending on the fuel system manufacturer. LNG tanks normally do not require maintenance; however, other components of the fuel system will require at least regular visual inspections.
3.3 Sample maintenance schedules

A sample recommended maintenance schedule from Clean Air Power (as used in Volvo Methane-Diesel Euro V trucks) is shown below:

Every 50,000 km:
- Inspect natural gas connections for leaks
- Drain coalescing filter bowl and replace primary filter element
- Clean secondary (‘last chance’) filter
- Drain vent stack water trap
- Carry out visual inspection of Dual-Fuel system components
- Verify correct operation of pressure gauges and fuel level gauges (LNG)
- Verify correct operation of gas fill point warning light, buzzer, and start inhibitor
- Carry out basic Dual-Fuel system functionality check
- Check and record fault codes
- Clear stored fault codes
- Road test, check for repeat fault codes, and rectify

Additionally every 100,000 km:
- Replace secondary ‘last chance’ filter
- Test for black smoke output under free acceleration (refer to vehicle manual)

Additionally every 200,000 km:
- Clean shutoff valve (SOV)
- Replace gas injectors


Figure 3-1: Sample Maintenance Schedule for Clean Air Power Dual Fuel System. Source: Clean Air Power
A sample maintenance schedule is available for a Westport 15L engine and Westport LNG fuel system.

**Figure 3-2: Sample Maintenance Schedule for Westport 15L Engine and LNG Fuel System (North America). Source: Westport**
4 Contingency plans in the event of incident in the field

4.1 What to do in case truck breaks down

4.1.1 Current practices

According to the interviewed fleet operators, the process to follow in case an LNG truck breaks down is to contact their local vehicle dealer or manufacturer. Most of these fleet operators do have 24/7 emergency roadside assistance service contracts with their vehicle manufacturers (e.g. Iveco ANS – Assistance Non-Stop, Volvo Action Service, etc.) that do cover vehicle breakdowns in the field, whether they happen to diesel or LNG trucks. Therefore they do consider that their local dealer will solve any issue that may arise. The local dealer is their single point of contact for all LNG truck related issues.

It is worth mentioning that the process to follow in case of LNG truck breakdown should be explained to the drivers during LNG vehicle training session.

The current process does work well for the current operations and routes covered by LNG trucks, because these trucks are dedicated to a limited number of well-defined routes (based on available refuelling facilities). However some of the interviewed fleet operators are worried about how this process will evolve when broader LNG fuelling infrastructure will be available and LNG trucks will run longer and more diverse international distances. They will then expect their vehicle manufacturers to offer an appropriate international assistance service for LNG trucks even though the certified dealer network will not be as dense as that for diesel trucks. They don’t want to continue to rely exclusively on their local truck dealer for abroad LNG truck emergencies because the distances will prevent them from providing an efficient international assistance service. In any case, fleet operators would like to be informed by their truck manufacturers or dealers regarding how international roadside emergencies will be handled for LNG trucks.

4.1.2 Recommendations

As international LNG corridors further develop and the number of LNG trucks in operation increases across Europe, truck manufacturers will have to define and implement an improved 24/7 emergency roadside assistance service for LNG trucks in order to offer a similar level of service and customer satisfaction for LNG trucks as for diesel trucks.

The fleets that are operating LNG trucks and do not have a 24/7 emergency roadside assistance service contract with their vehicle manufacturer should receive a list of European certified dealers from their vehicle manufacturer so that in case of a break down, they can direct the towing company to the nearest certified dealer. If there is no certified dealer in a particular region, any non-certified repair shop must be informed about the details and hazards of an LNG truck. The truck should be worked on outdoors. It is extremely important that towing companies that pick up LNG trucks do not store trucks
indoors. A warning label to this effect should be developed and applied near any towing hook or interface that is likely to be noticed by such a technician. If a truck must be worked on indoors, the LNG tank must be first isolated and/or emptied. A document with all necessary information for towing companies and non-certified repair shops should be provided by the truck manufacturer and kept in each LNG truck. Drivers should also be aware of these requirements in order to check that their LNG truck is being handled appropriately by the towing company.

These documents (list of certified dealers in Europe plus important information for towing companies and non-certified repair workshops) could also be useful for fleet operators that do have a 24/7 emergency roadside assistance service contract with their vehicle manufacturer, even though in this case it is the truck manufacturer’s responsibility to ensure the LNG trucks are being handled appropriately by towing companies and repair workshops.

In addition, further use of remote online diagnosis of LNG truck failures could also be considered in order to facilitate repairs.

4.2 What to do in case truck runs out of fuel

4.2.1 Current practices

The interviewed fleet operators feel their drivers are well prepared in case an LNG truck runs out of fuel. This topic is covered in the initial driver training. The drivers are well aware that they need to refuel LNG trucks more often than diesel trucks. In some companies, drivers get a notification every morning and/or evening to remind them they have to refuel. The result is that none of the interviewed fleet operators ever had an LNG truck running out of fuel.

With the LNG trucks currently in operation within the LNG Blue Corridors project, running out of LNG would actually not be a huge issue. Indeed, all these vehicles are equipped with a back-up fuel solution, which is only used in case of emergency.

- The Iveco Stralis LNG does have both LNG and CNG tanks. In case they run out of LNG, drivers can still drive on CNG up to the closest LNG or CNG station and refuel.
- The Volvo MethaneDiesel Euro V does have the capability to run on 100% diesel in case it does run out of LNG. In this case, drivers can therefore drive on diesel to the closest LNG station and refuel.
- The Hardstaff OIGI dual fuel system also has the capability to run on 100% diesel, similarly to the Volvo MethaneDiesel Euro V.

When the LNG fuelling infrastructure will become denser in Europe, new LNG truck models may have more limited or no back-up fuel capability. Mono-fuel LNG trucks might not be equipped with CNG tanks any longer. LNG trucks using the High Pressure Direct Injection (HPDI) technology do have the ability to run on 100% diesel, but only in emergency mode, at reduced load. This may not be sufficient to drive the truck to the nearest LNG station.
Running out of fuel with an LNG truck might therefore become a more significant issue in the future. However the current LNG trucks’ back-up fuel capabilities do enable the market to prepare for such future conditions.

4.2.2 Recommendations

The driver of a LNG truck must always carefully plan his/her route so that the locations of LNG stations are known. The local fuel providers can provide drivers with an up-to-date list of these locations. The fuel stations’ map available on the LNG Blue Corridors website can also help drivers locating LNG stations. Ideally the map would show all the LNG and CNG stations in Europe and indicate in case a station is exceptionally closed or doesn’t have LNG (or CNG) anymore. There might be a specific mobile phone application with the LNG & CNG stations’ map and information in order to facilitate access for drivers.

Should a truck run out of fuel, the truck can either be towed to the nearest LNG station, or alternatively, the nearest certified dealer or fuel station operator can deliver LNG to the stranded truck. Certified dealers and LNG station operators should consider purchasing and having available a small portable LNG vessel such as this one (see image, right). Some LNG systems (e.g. using Chart and Westport tanks) can also be fuelled from another tank using specific tooling. Tooling does consist in a hose with specific fittings on each end to connect both tanks to each other. A minimum delta pressure of 1.7 bar is needed between the two tanks. Such LNG tank transfer tooling is currently not used in Europe but could become an interesting option as the market grows.

4.3 What to do in case of incident at station

Stations should keep an inventory of components that are likely to fail or wear out suddenly. This is especially important because there is unlikely to be redundant infrastructure should a station malfunction. Stations should also make a list to prepare for possible malfunctions, and there should be procedures in place to obtain new parts quickly in the event of incident (e.g. fuelling hose, should a truck drive off without disconnecting the nozzle from the fuel tank).
5 Access to LNG fuelling infrastructure

Refuelling LNG trucks has been raised by the interviewed fleet operators as one of their main issues related to the LNG Blue Corridors project. Even though they do acknowledge that building an entire LNG fuelling network covering all major countries along key European corridors will take time, they have also expressed some concerns and suggestions that are applicable to the current LNG stations and appear worth being tackled by the LNG Blue Corridors project. The recommendations in this section are essentially based on this feedback from fleet operators.

5.1 Ability to refuel in any LNG station

5.1.1 Current situation

Being able to refuel LNG trucks anywhere in Europe is a major concern for fleet operators. The issue is that it is still difficult to truly operate LNG trucks on international long haul. Of course, this is partially due to the fact that some countries still have limited refuelling infrastructure. The good news, though, is that building the LNG Blue Corridors network is work in progress and it is already possible to drive LNG trucks on some of the first long distance corridors, e.g. from Spain to Italy or Belgium.

In the meantime, it is currently complex for fleet operators involved in the demonstration to be able to refuel at any station of the LNG Blue Corridors’ project. Indeed, a fleet operator who would like to be able to refuel at a given station would have to set up an agreement with the station operator, train his drivers for this specific station, agree on a way to identify the drivers and trucks that can refuel at this station and of course agree on fuel price and payment process.

5.1.2 Recommendations

It should be mentioned that the issue regarding the difficulty to refuel at any station was only raised by one of interviewed fleet operators. However, as the European network of LNG stations grows, implementing an easy process to enable LNG truck fleets to refuel (and pay) will be a key aspect for further market development. The LNG Blue Corridors project does offer a perfect platform to define and test a standardized process.

Further discussions are needed between all the station operators involved in the LNG Blue Corridors project in order to define a standardized process, taking into account fleet operators’ expectations (which also need to be further analysed).

One suggestion so far is to create a common identification platform (software) that would ultimately be used by all LNG station operators across Europe to easily identify LNG trucks and trained (“certified”) drivers. The company Mattheeuws, involved in the LNG Blue Corridors project as fleet operator, does have its own platform for this purpose (used at the Veurne LNG station in Belgium). This platform could be used by the LNG Blue Corridors project.
5.2 Availability of LNG stations

5.2.1 Current situation

In addition to increasing the number of LNG stations and making it easy for fleet operators to use them, one of the interviewed fleet operators suggested that current LNG stations’ availability could be increased. Suggested improvements are related to redundancy of LNG fuelling infrastructure, opening time and self-service. It should be mentioned that this issue is to some extent specific to the countries that only have manned LNG stations, such as Italy.

5.2.2 Recommendations

In order to improve availability of LNG stations, it is suggested to:

- Have redundant LNG fuelling infrastructure, i.e. at least two LNG dispensers per station;
- Open LNG stations 24 hours a day;
- Enable LNG self-service for trained drivers.
6 Installation and functioning of the on-board monitoring device

In order to enable the project partners to perform a thorough quantitative evaluation of the demonstration activities within the LNG Blue Corridors project, on-board monitoring devices are installed by VITO in the vehicles involved in the demonstration. The monitoring device is designed and operated in a way to minimize fleet operators’ involvement in data collection. The purpose of this section is to describe the installation, operation, update and troubleshooting processes for this monitoring device.

6.2 Installation and updates

The VITO GPRS monitoring device will be mounted as unobtrusively as possible on the truck. Each truck is equipped with a data logger and a GPS antenna. The data logger will be neatly installed behind a dashboard cover (e.g. close to the fuse box), and a GPS antenna will be attached to the logging device and fixed to the windscreen (inside). Once the VITO GPRS device is built in and connected to the CANbus, all regular maintenance and software updates will be performed remotely. Any initiative for a software update comes from VITO, and could include e.g. changing a logging frequency or changing the parameters to be logged.

6.3 Troubleshooting

When the loggers are properly installed, no malfunction should occur under normal operating conditions. In case of malfunctioning of the data logger, VITO will always try to solve the problem remotely first. However, when (exceptionally) a malfunctioning cannot be solved remotely, VITO will come to the operator and repair or determine whether the device needs to be replaced. In case of replacement, the truck operator will need to order a new device (or call on the manufacturer’s warranty). In a later phase of the project, when VITO has built up some experience in connecting the device to different types of trucks, a manual could be drafted that enables the fleet operators to check and reconnect the wiring, reset the device, or worst case replace the device themselves in case of a major failure. The new device (with the necessary programme code installed) will then be sent to the fleet operator by mail. However, we do not expect this to be necessary.

6.4 Overriding

The VITO logger connects to the CANbus, but always works in ‘listen-only’ mode. This means that the original CAN messages of the OEM are not influenced. This is true for all current trucks in the project (Iveco, Volvo and Hardstaff). Initially it was thought that for the Volvo trucks we would need to send OBD-requests to get data from the CAN which can be a tricky thing. Tests on the vehicles themselves
and information received from the supplier of the dual fuel system led to the conclusion that this will probably not be necessary. We will now connect to 2 separate CAN, one original Volvo CAN (diesel consumption, engine speed, etc.) and one for the Dual fuel system (data related to gas consumption).

Should the device act unusually or interfere with normal operation of the vehicle, the logging device can easily be disconnected. Therefore, on the rare occasion that an original CAN message is disturbed, the truck driver can completely disconnect the logging device him/herself.
7 Analysis and optimization of LNG truck operations

Project partners, e.g. truck manufacturers and fuel station operators, should make every possible effort to provide support to fleet operators in their daily operations. In addition to preparations prior to the demonstration, it is also important to analyse and optimize LNG trucks’ daily operations and make this demonstration as satisfactory as possible for fleet operators.

The interviewed fleet operators expressed concerns about the financial attractiveness of LNG truck operations. Increased support from the project partners to help fleet operators make the business case work better would be beneficial. This is therefore another important factor to take into account when supporting LNG trucks in the demonstration.

7.1 Information collected for the purpose of the project

A lot of data need to be generated to conduct the project’s analysis. The collected data are primarily meant to be used to conduct quantitative and qualitative evaluation of demonstration activities within the LNG Blue Corridors project and formulate recommendations for broad LNG truck market development. However some of these data might be shared with fleet operators and used to help them better analyse and improve their LNG truck operations. This section does describe the information collected from the trucks and fleet operators for the project’s analysis. There is currently no defined process to use this information to provide advice to fleet operators during the project.

7.1.1 On-board data collection

The VITO logging device is the main tool used to collect data from the vehicles involved in the LNG Blue Corridors demonstration. It is used to collect trip information for every trip and more detailed information through detailed monitoring campaigns conducted on a limited number of trucks and for a limited period of time. Collected data may include:

- Trip information:
  - Trip distance
  - Fuel consumption
  - Fuel level in the tank

- Detailed monitoring campaigns:
  - Fuel rate
  - Engine speed
  - Vehicle speed
  - Trailer weight
  - Engine coolant temperature
  - Ambient air temperature
7.1.2 Truck operator feedback

The vast majority of vehicle data will be captured by the ‘on-board data collection’, i.e. using the VITO logging devices. However, not all types of data are available through the CANbus of the vehicle, for example certain operational characteristics. Therefore, a web form is currently being designed by VITO in order to capture fleet operator’s experiences with vehicle safety, maintenance needs and technical maturity & reliability. This web form will only be accessible from the partner area of the LNG Blue Corridors website and will have to be completed by the partner involved on a quarterly basis. Each truck operator will have to make a user profile on the website and for each type of profile (e.g. fleet operator, filling station owner), a separate set of web forms will be available (only those that are relevant for the type of profile chosen). E-mail notifications will be sent each time a fleet operator is expected to provide input. The parameters which will be included in the web forms are provided in the table below (excerpt from D6.1).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>unit</th>
<th>Reporting frequency</th>
<th>Reporting method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of incidents related to the vehicle</td>
<td>Number of incidents due to technical failure or human factors, causing injury to people, and/or damage to property and environment. Seriousness of incident to be reported separately.</td>
<td>number + reporting on specific problems</td>
<td>Quarterly</td>
<td>Web forms</td>
</tr>
<tr>
<td>Number of incidents related to refueling</td>
<td>Number of incidents due to technical failure or human factors, causing injury to people, and/or damage to property and environment. Seriousness of incident to be reported separately.</td>
<td>number + reporting on specific problems</td>
<td>Quarterly</td>
<td>Web forms</td>
</tr>
<tr>
<td>Material &amp; labor cost of scheduled maintenance</td>
<td>Cost of material and labor for scheduled maintenance</td>
<td>EUR</td>
<td>Quarterly</td>
<td>Web forms</td>
</tr>
<tr>
<td>Material &amp; labor cost of non-scheduled maintenance</td>
<td>Cost of material and labor for non-scheduled maintenance (repairs)</td>
<td>EUR</td>
<td>Quarterly</td>
<td>Web forms</td>
</tr>
<tr>
<td>Technical failures</td>
<td>Technical failures when starting from the depot / garage</td>
<td>number</td>
<td>Quarterly</td>
<td>Web forms</td>
</tr>
<tr>
<td>Road calls or failures during operation</td>
<td>number</td>
<td>Quarterly</td>
<td>Web forms</td>
<td></td>
</tr>
<tr>
<td>1. Days in regular use</td>
<td>number</td>
<td>Quarterly</td>
<td>Web forms</td>
<td></td>
</tr>
<tr>
<td>2. Days in special service (e.g. for demo’s)</td>
<td>number</td>
<td>Quarterly</td>
<td>Web forms</td>
<td></td>
</tr>
<tr>
<td>3. Not in operation because of operational schedule</td>
<td>number</td>
<td>Quarterly</td>
<td>Web forms</td>
<td></td>
</tr>
<tr>
<td>4. Not in operation because of scheduled maintenance</td>
<td>number</td>
<td>Quarterly</td>
<td>Web forms</td>
<td></td>
</tr>
<tr>
<td>5. Not in operation because of breakdown and/or repairs of parts of the vehicle</td>
<td>number</td>
<td>Quarterly</td>
<td>Web forms</td>
<td></td>
</tr>
<tr>
<td>6. Not in operation because of unavailability of the fuel</td>
<td>number</td>
<td>Quarterly</td>
<td>Web forms</td>
<td></td>
</tr>
</tbody>
</table>

In addition to the ‘vehicle-related web forms’, VITO is also setting up ‘targeted questionnaires’ for a.o. fleet owners & drivers, in which we do a qualitative follow-up of some socio-economic aspects such as user experience, perception and acceptance, viewpoints on future LNG development, etc.
7.1.3 Driver feedback

Drivers of LNG trucks will be asked for feedback on a regular basis by means of online surveys. These surveys will be used to collect data regarding the experiences with and practical implications of driving LNG trucks, also in comparison with conventional diesel trucks. Topics will be power of the vehicles (hilly roads, acceleration, trailer weight), range of the vehicles, the refuelling process, advantages and disadvantages, possible recommendations, etc.

We cannot expect all drivers to be able to read or write English, so the survey will be translated in the language of the participating countries. In order to have an as high as possible response rate, the survey will be kept concise and easy to interpret.

7.2 Recommendations

The concerns expressed by fleet operators with regards to optimization of LNG truck operations are related to two main areas:

- Prices: price of LNG (and price differential between LNG and diesel), price of LNG trucks (and price differential with diesel trucks), financial incentives from public authorities for the acquisition of new LNG trucks, etc.
- Assistance with operations’ analysis and optimization

As for prices, industry and public stakeholders are making efforts to reduce equipment prices. Discussing potential price reductions and agreements is out of the scope of this deliverable.

As for assistance with operations’ analysis and optimization, the following actions can be suggested:

- Fuel suppliers and vehicle manufacturers could help fleet operators further analysing their payback / Total Cost of Ownership (TCO) calculations as well as LNG trucks’ and stations’ operations and provide advice to help them improve operations and payback. Such analysis is already done by fleet operators, usually with support from their fuel supplier and/or truck manufacturer. Increasing and improving this support could be done via formal meetings (fleet operator with his main LNG fuel and truck suppliers, at least once a year).
- In order to go deeper in this analysis, some of the data collected for the purpose of the project (described in the previous section, especially truck data collected by the logging device) could be compared and analysed (with a number of ratios). Each fleet operator could have access to his own ratios and the average ratios of all fleets. This would help fuel suppliers and truck manufacturers identifying improvement areas for each fleet involved in the demonstration.
- It would also be helpful to provide fleet operators with a platform to compare their business cases and share best practices for LNG truck operations, e.g. as in the “Powering Logistics 2020” project in Belgium. In order to do that, the LNG Blue Corridors project Intranet would be useful but not sufficient. In addition, a physical gathering (during 1 or 2 days) of fleet operators for a workshop session focused on optimization of LNG truck operations could be very beneficial, both for the LNG Blue Corridors project and for the fleet operators.
8 Conclusions

It is important for the LNG Blue Corridors project to ensure fleet operators receive appropriate support prior to and during LNG trucks’ demonstration. This report identifies and suggests a number of practices and actions to help reaching this goal.

A check list identifying preparations that should be made by the fuel supplier and vehicle manufacturer for each fleet operator prior to the demonstration is available in the table below (table 8-1). It is the responsibility of each fuel supplier and vehicle manufacturer to ensure that these preparations are made before a fleet operator starts the actual demonstration activity within the LNG Blue Corridors project. The check list should also be used for the fleet operators that are already operating LNG trucks in the project, in order to identify any missing action and implement corrective actions when needed. Westport will be responsible for monitoring this activity. Target deadline for implementation is Q1 2016.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Proposed action (according to identified best practices)</th>
<th>Who is in charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support to fleet operator’s management and various departments</td>
<td>Support fleet operators in preparation activities for LNG truck operations, e.g. specify vehicles and fuelling requirements, planning routes for LNG trucks, defining and implementing refuelling practices, establishing and implementing QHSE procedures, tracking and analysing fuel consumption, eco-driving LNG trucks, maximising LNG truck drivers’ satisfaction, etc.</td>
<td>Fuel supplier and OEMs</td>
</tr>
<tr>
<td>Driver training</td>
<td>Train each LNG truck driver to LNG truck and station related aspects. Common harmonized standards are needed between all EU countries in this regard. This should be tackled in meetings at European level taking into account national authorities.</td>
<td>European Commission, National and European Associations like NGVA or SGA, Technical European committees like CEN</td>
</tr>
<tr>
<td>Technician training</td>
<td>Train and certify truck dealer (and/or fleet operator if appropriate) technicians for LNG vehicle repair and maintenance. Currently they are trained relying on national guidelines depending on the OEM/market that generally are not 100% the same. Therefore it should be necessary to create common minimum standards to be commonly applied, making sure that are equally restricting.</td>
<td>OEMs, European Associations, Technical European committees like CEN</td>
</tr>
<tr>
<td>Workshop upgrading</td>
<td>Outfit workshops servicing LNG vehicles and equip them with appropriate tooling</td>
<td>OEMs, national authorities</td>
</tr>
<tr>
<td>First responders’</td>
<td>Inform local first responders and prepare them to deal with</td>
<td>Fuel supplier</td>
</tr>
</tbody>
</table>
The main recommendations and suggestions for further improvement identified in this report are summarized in the action plan below (table 8-2), with partners in charge of coordination and monitoring as well as proposed timing. This action plan is primarily focused on the activities that can be performed by the LNG Blue Corridors project in short term. Westport will be responsible for monitoring the realisation of the whole action plan.

As a next step, a broader implementation of similar actions outside of the LNG Blue Corridors project (e.g. at European scale) will also be considered and may be recommended towards the end of the project (recommendations will be included in the qualitative assessment of the project in D6.6).

<table>
<thead>
<tr>
<th>Topic</th>
<th>Proposed action</th>
<th>Suitable recipients</th>
<th>Partner in charge*</th>
<th>Proposed deadline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge sharing centre and forum for fleet operators</td>
<td>Create an online knowledge sharing centre and forum for fleet operators on the LNG BC project Intranet</td>
<td>Fleet operators / LNG BC WP5</td>
<td>VITO</td>
<td>January 2016</td>
</tr>
</tbody>
</table>

Table 8-2 Action plan for further improvement of the support to the LNG trucks prior to and during the demonstration
<table>
<thead>
<tr>
<th>Topic</th>
<th>Proposed action</th>
<th>Suitable recipients</th>
<th>Partner in charge*</th>
<th>Proposed deadline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fleet operators’ workshop</td>
<td>Organize a first workshop session for fleet operators, focused on optimisation of LNG truck operations</td>
<td>Fleet operators / LNG BC WP5</td>
<td>IDIADA</td>
<td>Q2 2016</td>
</tr>
<tr>
<td>Fleet operator meetings</td>
<td>Schedule at least an annual individual meeting between each fleet operator, its truck manufacturer and/or fuel supplier to assist him in the analysis and improvement of LNG truck operations and payback</td>
<td>Fleet operators / LNG BC WP6</td>
<td>VITO</td>
<td>Q1 2016</td>
</tr>
<tr>
<td>Driver training programme</td>
<td>Establish standard European driver training programmes for LNG stations and LNG trucks</td>
<td>European Commission / LNG BC WP6</td>
<td>NGVA, SGA</td>
<td>Q2 2017</td>
</tr>
<tr>
<td>First responder training programme</td>
<td>Establish a standard European first responder training programme and guidelines</td>
<td>European Commission / LNG BC WP6</td>
<td>NGVA, SGA</td>
<td>Q2 2017</td>
</tr>
<tr>
<td>Emergency roadside assistance service</td>
<td>Define and implement appropriate European 24/7 emergency roadside assistance service for LNG trucks</td>
<td>Iveco, Volvo</td>
<td>Q2 2017</td>
<td></td>
</tr>
<tr>
<td>Identification of LNG trucks and drivers</td>
<td>Implement a common identification platform of all LNG trucks and certified drivers (e.g. Mattheeuws’ platform) within the LNG BC project</td>
<td>All LNG BC fuel suppliers / station operators</td>
<td>NGVA, Idiada</td>
<td>Q1 2016</td>
</tr>
<tr>
<td>LNG stations’ user authorisation process</td>
<td>Define and implement a standard process to enable any LNG BC truck operator to refuel (and pay) at any LNG BC project station</td>
<td>All LNG BC fuel suppliers / station operators</td>
<td>NGVA, Idiada</td>
<td>Q2 2016</td>
</tr>
<tr>
<td>LNG stations’ availability</td>
<td>Propose solutions to improve availability of LNG stations (e.g. redundant LNG fuelling infrastructure, 24/24 opening, self-service, etc.), identify barriers and next steps for implementation</td>
<td>All LNG BC fuel suppliers / station operators</td>
<td>NGVA, Idiada</td>
<td>Q3 2016</td>
</tr>
</tbody>
</table>

* The indicated partners are in charge of coordinating and monitoring the proposed actions.
<table>
<thead>
<tr>
<th>Topic</th>
<th>Implementation monitoring</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge sharing centre and forum for fleet operators</td>
<td>Vehicle-related web data form for quarterly reporting of quantitative data from fleet operators (WP6 task) finalized and available online (January 2016) – See Appendix 1 and <a href="http://lngbc.eu/report">http://lngbc.eu/report</a></td>
<td>Completed January 2016</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Targeted questionnaire (web survey) for qualitative information gathering from fleet owners (WP6 task) finalized and available online (January 2016) – See Appendix 2 and <a href="http://lngbc.eu/report">http://lngbc.eu/report</a></td>
<td>Completed January 2016</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Targeted questionnaire (web survey) for qualitative driver feedback (WP6 task) finalized and available online (January 2016) – See Appendix 3 and <a href="http://lngbc.eu/report">http://lngbc.eu/report</a>. Drivers will be asked to complete this survey twice: first in January/February 2016 or later when they have min. 3 months of experience with LNG trucks, then about 6 months before the end of the project (lead: VITO).</td>
<td>Completed January 2016</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Knowledge sharing centre and forum for fleet operators finalized and available (January 2016) – See Appendix 4 and Fleet operator section <a href="http://lngbc.eu/fleet-operator-section">http://lngbc.eu/fleet-operator-section</a>. Access to the fleet operator section is restricted to the project partners (login and password protected).</td>
<td>Completed January 2016</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fleet operators will be informed by email about the creation of the knowledge sharing centre and forum in February 2016. Initial best practices will be collected from fleet operators and added to the Fleet operator section in February and March 2016. At the same time fleet operators will be encouraged to initiate and participate in forum discussions as well as add other best practices during the course of the project. Lead: VITO, supported by IDIADA and Westport.</td>
<td>In preparation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The most relevant fleet operators’ experiences and best practices mentioned in the forum will be disseminated publicly, especially among European fleet operators, via newsletters and/or other social and/or traditional media. Timing for these dissemination activities will be decided by the end of Q1 2016. Possible format and content will be discussed during the LNG Blue Corridors’ project General Assembly meeting in March 2016. Lead: NGVA, supported by IDIADA and Westport.</td>
<td>Not started yet</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fleet operators’ workshop</td>
<td>First workshop session for LNG truck operators will take place the same week and location as the LNG Blue Corridors’ project General Assembly meeting in March 2016 in France. Email invites will be sent to fleet operators in February 2016.</td>
<td>In preparation</td>
</tr>
<tr>
<td>Item</td>
<td>Description</td>
<td>Status</td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
<td>--------</td>
</tr>
<tr>
<td>Fleet operator meetings</td>
<td>First meetings are expected to also take place the same week and location as the General Assembly meeting. They will be scheduled once fleet operators’ attendance at the General Assembly will be confirmed.</td>
<td>In preparation</td>
</tr>
<tr>
<td>Driver training programme</td>
<td>NGVA and SGA should propose an approach to establish training programme by end of Q1 2016.</td>
<td>Work in progress</td>
</tr>
<tr>
<td>First responder training programme</td>
<td>NGVA and SGA should propose an approach to establish training programme by end of Q1 2016.</td>
<td>Work in progress</td>
</tr>
<tr>
<td>Emergency roadside assistance service</td>
<td>This will be discussed at the General Assembly meeting in March 2016.</td>
<td>Not started yet</td>
</tr>
<tr>
<td>Identification of LNG trucks and drivers</td>
<td>A specific meeting covering identification and authorisation process will take place the same week as the General Assembly meeting in March 2016.</td>
<td>In preparation</td>
</tr>
<tr>
<td>LNG stations’ user authorisation process</td>
<td>A specific meeting covering identification and authorisation process will take place the same week as the General Assembly meeting in March 2016.</td>
<td>In preparation</td>
</tr>
<tr>
<td>LNG stations’ availability</td>
<td>This will be discussed at the General Assembly meeting in March 2016.</td>
<td>Not started yet</td>
</tr>
</tbody>
</table>
Appendix 1: Vehicle-related web data form
Final English version (January 2016)

<table>
<thead>
<tr>
<th>Fleet operator selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>For which fleet operator would you like to report?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Period selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>For which period would you like to report?</td>
</tr>
<tr>
<td>- January 1st - March 31st</td>
</tr>
<tr>
<td>- April 1st - June 30th</td>
</tr>
<tr>
<td>- July 1st - September 30th</td>
</tr>
<tr>
<td>- October 1st - December 31st</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Follow-up of safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have there been any incidents with the LNG vehicles?</td>
</tr>
<tr>
<td>- No</td>
</tr>
<tr>
<td>- Yes</td>
</tr>
<tr>
<td>- Number of incidents related to the vehicle</td>
</tr>
<tr>
<td>- Short description of incidents</td>
</tr>
<tr>
<td>- Number of incidents related to refueling</td>
</tr>
<tr>
<td>- Short description of incidents</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Follow-up of maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total material &amp; labor costs...</td>
</tr>
<tr>
<td>- ... of scheduled maintenance</td>
</tr>
<tr>
<td>- ... of non-scheduled maintenance</td>
</tr>
</tbody>
</table>
Follow-up of technical maturity and reliability

**Total number of technical failures...**
- ... when starting from the depot / garage
- ... during operation or road calls

**Total number of days not in operation because of...**
- ... operational schedule
- ... scheduled maintenance
- ... breakdown and/or repairs of parts of the vehicle
- ... unavailability of the fuel

Appendix 2: Targeted questionnaire for fleet owners
Final English version (January 2016)

**GENERAL INFORMATION (Transport Company)**

1. **Respondent name:**

2. **Respondent function:**

3. **Name of the transport company:**

4. **Truck fleet composition:**
   a. **Total number of LNG trucks in your fleet:** (number)
      - Including
      i. Mono fuel: (number, brands)
      ii. Dual fuel: (number, brands)

   b. **Total number of diesel trucks:** (number)

5. **Type of transport your company generally does (trucks only):**
   a. **Distances (select the answer that matches the best with your situation):**
      i. national
      ii. international
      iii. mixed

   b. **Total truck weight on average (select the answer that matches the best with your situation):**
      i. less than 30 tons
      ii. 30 to 40 tons
      iii. more than 40 tons – mix
6. **Are you performing regular maintenance and repair on the LNG trucks in your own workshop?**
   - Yes
   - No

**MOTIVATIONS**

7. **What are the reasons for your transport company to use LNG trucks for specific routes or customers? (multiple answers possible)**
   - Total cost per km is beneficial for LNG
   - Legislation on the use of environmentally friendly transport (eg. only gas driven trucks allowed in city centers, …)
   - Our current customers request for environmentally friendly transport
   - It’s a marketing argument to acquire new customers
   - Our transport company wants to lower its environmental impact
   - Our transport company likes to experiment with new fuels and technologies
   - Other:

**EXPERIENCES (‘practical usability)***

8. **When you look at your current routes, truck loads, trip distances and destinations, could it be possible to use LNG trucks on all these routes?**
   - Yes, LNG trucks could be used for all routes that we are currently driving
   - No, LNG trucks could not be used for all routes that we are currently driving

9. **(only if 8b) What are important factors that prevent the use of LNG trucks for all the routes in your transport company? (multiple answers possible)**
   - Some of the routes are too hilly to be covered by LNG trucks
   - The total load of the trucks on some routes is too high for LNG trucks
   - There are no (or not enough) LNG stations on some of the routes
   - The opening hours of the LNG stations are not sufficient
   - Others…
### EXPERIENCES (drivers)

10. How enthusiastic are truck drivers in your transport company regarding driving the LNG trucks:

   - Very enthusiastic – enthusiastic – neutral – not enthusiastic – not at all enthusiastic

### EXPERIENCES (costs)

11. Indicate your impression on the costs of the LNG truck compared to a conventional diesel truck:
   ("much cheaper than diesel" – “cheaper than diesel” – “similar to diesel” – “more expensive than diesel” – “much more expensive than diesel”)

   a. The purchase price of the truck (excluding LNG Blue Corridors subsidies)
   b. Maintenance & repair costs
   c. Insurance costs
   d. Fuel & add blue costs
   e. Overall cost per km (all aspects included, but excluding LNG Blue Corridors subsidies)

### EXPERIENCES (information)

12. How easy can you find information regarding:
   ("very easy” – “easy” – “neutral” – “difficult” - “very difficult”)

   a. Location of LNG fuel stations
   b. Available LNG trucks (brands, types,...) in the market
   c. Legal aspects concerning the use of LNG (permits, training, ...)

---
FUTURE

13. Would you consider to expand your fleet with LNG trucks in the future?
   o Yes
   o No
   o I don’t know

14. Indicate the importance of the following factors when considering additional LNG trucks in the future: (‘not important’ – ‘neutral’ – ‘slightly important’ – ‘very important’ – ‘extremely important’)
   a. Availability of LNG (location and number of LNG stations)
   b. Fuel cost savings (price difference between diesel and LNG,...)
   c. Purchase price of LNG trucks
   d. Power of LNG trucks
   e. Driving range and refueling frequency of LNG trucks
   f. Environmental benefits of LNG trucks (emissions, noise,...)
   g. Maintenance and repair capabilities (from truck dealers, internal workshop, emergency roadside assistance services,...)
   h. Complexity of training procedures (for drivers, maintenance staff,...)
   i. Complexity of LNG implementation (QHSE procedures, route planning, ...)

15. Are there other viewpoints or recommendations on future LNG development you would like to share? (open answer)
To: Fleet operators or other persons in contact with truck drivers of the LNG Blue Corridors project

Dear,

As part of the European research project ‘LNG Blue Corridors’, a survey is developed to gain more insights in the experiences of truck drivers driving an LNG truck. We would like to ask you to provide this survey to all the truck drivers within your company that have driven an LNG truck of the LNG Blue Corridors project (multiple users per truck are possible). Filling in all the questions of this survey would take approximately 5 minutes per driver.

The survey can be completed on paper or online by e-survey (only available in English). We would like to ask you to collect the answers of all the drivers of your company (eg. on paper), and fill in the e-survey for each driver via this link: http://lngbc.eu/reporting. The e-survey is in English, but uses the same numbering as the paper version, so it should be easy to find the corresponding questions. To log in into the website use the user name and password provided in the email.

If you prefer to submit the paper version, you can provide this document by post/email to the contact person at VITO (contact details below).

The opinion of the truck drivers regarding the LNG truck is very important to us! Your answers are very valuable and will be handled with discretion. Filling in this survey is also part of the effort that the project requests from the fleet operators, in return for the funding for the trucks.

We would appreciate if you could complete this survey by the end of January 2016. Thank you for your cooperation!

Tobias Denys – Project manager at VITO (Flemish Institute for Technological Research)

Contact: VITO - Tobias Denys – Boeretang 200 - 2400 Mol (Belgium) (tobias.denys@vito.be / +3214335862)
Appendix 4: Screenshots of knowledge sharing centre and forum for fleet operators

Screenshot 1: Fleet operator section http://lngbc.eu/fleet-operator-section
### Fleet operator forum

<table>
<thead>
<tr>
<th>Topic / Topic starter</th>
<th>Replies</th>
<th>Last post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sticky: Welcome to the fleet operator forum</td>
<td>0</td>
<td>by <a href="mailto:tom.sneyers@vito.be">tom.sneyers@vito.be</a> Fri, 2016/01/29 - 16:17</td>
</tr>
<tr>
<td>Difficulties found when refueling trucks new</td>
<td>0</td>
<td>by <a href="mailto:tom.sneyers@vito.be">tom.sneyers@vito.be</a> Fri, 2016/01/29 - 13:57</td>
</tr>
<tr>
<td>Comments about LNG facilities network new</td>
<td>0</td>
<td>by <a href="mailto:tom.sneyers@vito.be">tom.sneyers@vito.be</a> Fri, 2016/01/29 - 13:58</td>
</tr>
<tr>
<td>Price of LNG compared to diesel new</td>
<td>0</td>
<td>by <a href="mailto:tom.sneyers@vito.be">tom.sneyers@vito.be</a> Fri, 2016/01/29 - 13:57</td>
</tr>
</tbody>
</table>

**Screenshot 2: Fleet operator forum** [http://lngbc.eu/forum/40](http://lngbc.eu/forum/40)

**Screenshot 3: Fleet operator forum discussion** [http://lngbc.eu/node/434](http://lngbc.eu/node/434)