WP6 Data collection and analysis of demonstration activities

**D6.6 Qualitative assessment of the results of the project**

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In deliverable 6.1 (D6.1), we drafted an overview of the aim and evaluation criteria of the project, and set up a list of the data needed for this evaluation. The data were grouped by their origin (vehicles and fleet operators, filling stations and their operators, other stakeholders) and by the frequency they are collected.

In deliverable 6.2 (D6.2), we described the web-based LNG BC Assessment Framework. This framework includes the practical implementation of the data collection and storage. For example, we specified how the data enters VITO’s systems and in which record/table/database the collected data will be stored.

In deliverable 6.3 (D6.3), we provide an intermediate quantitative assessment of the results of the project. The data collection process is also discussed.

In deliverable 6.4 (D6.4), we provide a final and public quantitative assessment of the results of the project.

In deliverable 6.5 (D6.5), we provide an intermediate qualitative assessment of the experiences, opinions, etc. of the project partners. Hereby we rely on the results of questionnaires that were submitted by truck drivers, fleet operators and filling station operators.

In this deliverable (D6.6), we make a final qualitative assessment of the experiences, opinions, etc. of the project partners, after close to 4 years of demonstration activities. Hereby we rely on the results of a set of questionnaires that were completed and submitted by truck drivers, fleet operators and filling station operators. We’ve repeated the same set of questions as for D6.5, and added a small number to reflect the evolution of the market situation. This way we can also assess if opinions have changed over the course of the project.
2 Data Collection

2.1 Introduction

Qualitative data on the evaluation of the demonstration project were collected by means of targeted questionnaires for different types of project partners. Hereby we want to gain more insights in the perception of different parties on the use of LNG trucks and filling stations, both now and in the future. Questionnaires were submitted by the following participants in the demonstration project:

- truck drivers,
- fleet operators,
- filling station operators.

In this chapter we will describe for each questionnaire the main research questions, the survey design and survey distribution. Results are presented in Chapters 3, 4 and 0.

2.2 Truck driver survey

2.2.1 Main research questions

The main research question we want to examine for the truck drivers concerns their willingness to drive LNG trucks in the future. The most important question is therefore:

“If your employer offers you the choice, would you consider driving an LNG truck again in the future?”

Within this survey we further also ask for the perception or experience of the truck drivers regarding factors that might explain their ‘willingness to drive’ LNG trucks, such as:

- A comparison of the truck performance (LNG vs DIESEL)
- Incidents that occurred during truck refueling
- Reactions from other truck drivers
- Main advantages/disadvantages of the LNG truck

In order to distinguish the answers some characteristics of the driver and the corresponding truck were also asked:

- Driving experience (< > 2 years)
- Own truck or shared with multiple drivers
- Truck identification (brand, power and Euro stage)
- General total truck weight

Compared to the intermediate assessment (D6.5), some questions were rephrased to be able to assess the difference between less and more powerful trucks.
2.2.2 Survey design

The questionnaire for the truck drivers was developed in 5 different languages (English, Italian, Spanish, Portuguese, French). A paper version of the questionnaire was provided to the truck drivers. The link to the online (English) version was provided to the fleet operators who were asked to collect all the survey results from all the truck drivers in their company, and fill in the online version for each driver. Screenshots of this online version can be found in Figure 2-1.
Driver's survey
Comparison LNG vs Diesel

8.1. Rate the LNG truck from 0 (very bad performance) to 10 (very good performance). Please consider the 4VECO 400hp truck instead of the 330hp when answering this question, in case you have driven both type of truck.

- Handling hilly roads
- Acceleration
- Noise of the engine when driving
- Noise of the engine when standing still
- Distance you can drive with a full tank
- Time that you need at the fuel station to refill
- Safety of the truck
- Safety when refueling

8.2. Rate the diesel truck from 0 (very bad performance) to 10 (very good performance).

- Handling hilly roads
- Acceleration
- Noise of the engine when driving
- Noise of the engine when standing still
- Distance you can drive with a full tank
- Time that you need at the fuel station to refill
- Safety of the truck
- Safety when refueling
9. In case you have already driven an Iveco 420 hp truck, does this higher power truck offer a solution to the disadvantages of the 330 hp truck?

- Yes
- No
- Other

10. Did you experience any incidents during refueling? (e.g., accidents, fuel leakage, other problems...)

- Yes
- No
- Other

11. Did you have to switch from dual fuel mode (LNG/diesel) to diesel to reach the next LNG fuel station?

- Never
- A few times
- Very often
- I’m not driving a dual fuel truck so this question is not relevant for me

12. What kind of reactions did you get from other truck drivers regarding your LNG truck?

- No reactions
- Positive reactions
- Negative or undesirable reactions

13. What are the main disadvantages of driving this LNG truck according to you? Please consider the IVECO 420hp truck instead of the 330hp when answering this question, in case you have driven both type of trucks. (please select max. 3 answers)

- I do not like the manual gearbox in the LNG truck
- There are not enough LNG fuel stations available
- The LNG truck does not have enough power
- It is difficult to drive the LNG truck on hilly roads
- The refueling process at the LNG fuel station takes too long
- I have to refill the LNG truck too often (LNG tank is too small)
- I do not feel safe when driving an LNG truck
- I do not feel safe when refueling the LNG truck

14. What are the main advantages of driving this LNG truck according to you? Please consider the IVECO 420hp truck instead of the 330hp when answering this question, in case you have driven both type of trucks. (please select max. 3 answers)

- Qualified driving comfort
- Good equipment of interior truck cab
- Low noise levels
- LNG is an environmentally friendly fuel
- Like driving and testing new technologies such as LNG
- Fuel costs are less compared to diesel
- 

15. If your employer offers you the choice, would you consider driving an LNG truck again in the future?

- Yes
- No
- I don't know
2.3 Fleet operator survey

2.3.1 Main research questions

The main research question we want to examine for the fleet operators concerns their willingness to expand their truck fleet with LNG trucks in the future. The most important question is therefore:

"Would you consider to expand your fleet with LNG trucks in the future?"

Within this survey we further also ask for the perception or experience of the fleet operators regarding factors that might explain their ‘willingness to expand’ their future LNG truck fleet, such as:

- The reasons to use LNG trucks at the moment (requirements, costs, environment, ...)
- The usability of LNG trucks on current routes
- The enthusiasm of their truck drivers
- The experienced costs
- The availability of information on LNG trucks

In order to distinguish the answers some characteristics of the transport company were also asked, e.g.:

- Truck fleet composition
- Type of transport (international-national)
- Total truck weight (on average)

Compared to the intermediate assessment (D6.5), some questions were rephrased to be able to assess the difference between less and more powerful trucks.

2.3.2 Survey design

The questionnaire for the fleet operator was developed in 5 different languages (English, Italian, Spanish, Portuguese, French). Only an online version of the questionnaire was provided to the fleet operator.

Screenshots of the English version can be found in Figure 2-2.
Fleet operator survey

Choose the language in which you would like to proceed.

- English
- Français
- Italiano
- Español
- Português

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Fleet operator survey

GENERAL INFORMATION (Transport Company)

1. Respondent name
2. Respondent function
3. Name of the transport company

4.1 Truck fleet composition
   a. Total number of LNG trucks in your fleet
   b. Total number of diesel trucks in your fleet

4.2 LNG truck fleet composition
   - Volvo Dula Fia
   - Iveco Stralis LNG - Euro V 330hp
   - Iveco Stralis LNG - Euro VI 330hp
   - Iveco Stralis LNG - Euro VI 400hp

5a. Type of transport your company generally does with DIESEL trucks: distances
   - national
   - international
   - mixed

5b. Type of transport your company generally does with LNG trucks: distances
   - national
   - international
   - mixed

5c. Type of transport your company generally does with DIESEL trucks: total truck weight on average
   - Less than 30 tons
   - 30 to 40 tons
   - More than 40 tons
   - Mix

5d. Type of transport your company generally does with LNG trucks: total truck weight on average
   - Less than 30 tons
   - 30 to 40 tons
   - More than 40 tons
   - Mix

6. Are you performing regular maintenance and repair on the LNG trucks in your own workshop?
   - Yes
   - No

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7. What are the reasons for your transport company to use LNG trucks for specific routes or customers?
- Total cost per km is beneficial for LNG
- Legislation on the use of environmentally friendly transport (e.g., use of gas truck 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:

8. Please answer the following questions based on your current routes, truck loads, trip distances, and destinations.
- Our dual fuel trucks can be used on all our routes
- What are important factors that prevent the use of dual fuel trucks for all the routes in your transport company?
- Our IVECO LNG 530hp trucks can be used on all our routes
- What are important factors that prevent the use of IVECO LNG 350hp trucks for all the routes in your transport company?
- Our IVECO LNG 400hp trucks can be used on all our routes
- What are important factors that prevent the use of IVECO LNG 300hp trucks for all the routes in your transport company?
- You stated that you have both IVECO 300hp and 400hp trucks in your fleet. Did the 400hp truck offer a solution to the disadvantages of the 300hp truck?
- In terms of power of the truck (acceleration, hilly roads, high speeds…)?
- In terms of range with a full tank?
- No, more power is needed
- Other (please specify):

9. You stated that you have both IVECO 300hp and 400hp trucks in your fleet. Did the 400hp truck offer a solution to the disadvantages of the 300hp truck?
- In terms of power of the truck (acceleration, hilly roads, high speeds…)?
- In terms of range with a full tank?
- No, more power is needed
- Other (please specify):

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

<table>
<thead>
<tr>
<th>very enthusiastic</th>
<th>enthusiastic</th>
<th>neutral</th>
<th>not enthusiastic</th>
<th>not at all enthusiastic</th>
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67%
Figure 2-2. Screenshots of the qualitative fleet operator survey.
2.4 Filling station operator survey

2.4.1 Main research questions

The main research question we want to examine for the filling station operators concerns their recommendation regarding future investments in additional LNG filling stations. The most important question is therefore:

"Would you recommend your company to invest in additional LNG filling stations?"

Within this survey we further also ask for the perception or experience of the filling station operators regarding factors that might explain this recommendation, such as:

- Incidents during truck refueling
- Truck driver training
- Costs (maintenance & repair)
- Refilling of the storage tank (planning of fuel deliveries, ...)
- The occurrence of boil-off situations

In order to distinguish the answers, some characteristics of the filling station we also provided as a separate part of the survey (Part A), asking, e.g. about:

- The volume of the storage tank
- Technical solutions to avoid boil-off
- The type and number of filling/venting nozzles
- Presence of the “Dead man’s button”

2.4.2 Survey design

The filling station survey was divided into two parts. Both parts of the filling station survey (Part A, Part B) were provided to the filling station operators by means of an online questionnaire. Part A of the survey collects data on each filling station whereas part B of the survey asks for the experiences of each filling station operator (over all the filling stations in general).

Screenshots of both parts of this survey can be found in Figure 2-3 and Figure 2-4.
Qualitative survey - part A. FUEL STATION - GENERAL INFORMATION
Fuel station selection

1. Location of the LNG fuel station:
   - VITO Questionnaire test

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50%

Qualitative survey - part A. FUEL STATION - GENERAL INFORMATION
Information on the LNG fuel station

2. Which other fuels are provided?
   - L-CNG
   - Diesel
   - Petrol
   - Other

3. What is the total volume of the LNG storage tank? [ ] m³

4. Number of filling nozzles by type
   - Macrotech
   - JC Carter
   - Parker Kodiak
   - Other

4.1 If other selected in previous question, please specify:
Figure 2-3. Screenshots of the filling station operator survey, part A.
Qualitative survey - part B. FUEL STATION - EXPERIENCES

I. General

1. Respondent name

2. Respondent function

Next page
Qualitative survey - part B. FUEL STATION - EXPERIENCES

II. Truck refueling and safety

3. The number of incidents that occurred during truck refueling (by truck drivers) at the fuel station(s) until now are:
   - Less than you expected (optional: comments)
   - As expected (optional: comments)
   - More than you expected (optional: comments)

4. Did you experience any incidents when trucks refueled at the fuel station(s)?
   - No
   - Yes

4.1. To your opinion, what are the main causes of these incidents
   - Training for truck drivers is insufficient
   - Different procedures, nozzles, ... exist at each fuel station. This makes it difficult for the truck drivers.
   - Technical failures of the refueling system
   - Other

5. Which recommendations or solutions would you propose in order to avoid or reduce the number of incidents at LNG fuel stations in general?
   - Improve training of truck drivers (please clarify)
   - Agree on a standard (e.g. nozzles,...) at the different fuel stations
   - Other

6. Indicate how much time in general is spent on each new truck driver to explain the procedures of your fuel station(s)
   - < 15 min. per truck driver
   - 15 - 30 min. per truck driver
   - 30 - 60 min. per truck driver
   - > 1 hour per truck driver

7. How often do you still need to provide assistance (live or on the phone) during truck refueling for drivers that were already trained?
   - Never
   - Rarely
   - Often
   - Almost always

8. Did the incorrect use of the ‘dead man’s button’ lead to any unsuccessful fillings at your fuel station(s)?
   - No
   - Yes, please specify:

9. Given the overall experience you have with your current LNG filling station(s), do you consider the filling station technology mature and reliable?
   - Yes (optional: comments)
   - No, please specify:
Qualitative survey - part B. FUEL STATION - EXPERIENCES

III. Maintenance & repair

10. The costs for maintenance and repair of the LNG fuel station(s) in general are
   - Less than you expected (please specify)
   - As expected
   - More than you expected (please specify)

IV. Fuel deliveries to the station

11. Refilling of the LNG storage tank needs to be carefully planned to avoid LNG deliveries that can not be stored or to avoid empty tanks. Please indicate which problems already occurred at your fuel station(s) concerning the refill of the storage tank:
   - LNG storage tanks have ran empty before the next delivery took place
   - New LNG deliveries could not be fully stored
   - Other problems, please specify:

12. Indicate how easy (or how difficult) it is to your opinion to plan LNG deliveries:
   - very easy
   - easy
   - neutral
   - difficult
   - very difficult

13. Did you experience any incidents during fuel deliveries to the station(s) (refill of the storage tank)?
   - No
   - Yes, please specify:
Qualitative survey - part B. FUEL STATION - EXPERIENCES

V. Boil-off

14. Did you already experience boil-off situations at the fuel station(s)?
   - [ ] Yes, please specify reason:
   - [ ] No

15. Are the current LNG (or L-CNG) sales sufficient to avoid boil off?
   - [ ] Yes
   - [ ] No

Qualitative survey - part B. FUEL STATION - EXPERIENCES

VI. Future

16. Do you think that under the current market conditions (fuel prices, truck purchase cost, available trucks on the market, ...) the number of LNG vehicles is likely to increase?
   - [ ] Yes
   - [ ] No

17. What are in your opinion the main barriers for an increased market uptake of LNG vehicles? Please indicate the importance of each barrier.

<table>
<thead>
<tr>
<th>Main barrier</th>
<th>not an important barrier</th>
<th>no opinion</th>
<th>very important barrier</th>
<th>extremely important barrier</th>
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<tbody>
<tr>
<td>The current number and location of LNG filling station is insufficient</td>
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<td>Current price difference between diesel and LNG is too small</td>
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<td>Purchase price of current LNG trucks is too high</td>
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<td>Power of current LNG trucks is too low</td>
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<td>Driving range of current LNG trucks is too low and therefore refueling frequency is too high</td>
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<td>The training procedures for drivers is too complex</td>
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<td>The lack of a single nozzle technology</td>
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<tr>
<td>Other</td>
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Figure 2-4. Screenshots of the filling station operator survey, part B.
3 Results: Truck Drivers

3.1 Introduction

In this section, the results from the qualitative survey for truck drivers are presented. We will first describe the respondents (the truck drivers) according to different characteristics and next their answers to the different questions in the qualitative survey are presented. Where possible and relevant a comparison with the intermediate assessment is made.

3.2 Respondents

Before presenting the results of the survey, it is important to first describe the characteristics of the respondents. Results for the truck driver survey are presented for 243 truck drivers from 35 different transport companies (compared to 154 drivers from 23 companies for the intermediate assessment). Since not all questions were answered by all drivers, the number of respondents might differ over the different questions.

As presented in Figure 3-1 the distribution of the truck drivers over the different transport companies is not evenly spread. There is one company where 72 drivers participated, 5 other companies with 10 or more drivers, and 26 with 5 drivers or less. Since we value the opinion of every truck driver, regardless of the transport company, the main results of this survey were not weighed per transport company or per region but reported all together. Of course, regional characteristics or other factors that are related to the transport company might have an impact on the evaluation.

![Figure 3-1. Distribution of the truck drivers that participated in this survey, over different transport companies](image-url)
In order to describe the respondents of the truck drivers survey in general, we can report the following characteristics (see also Figure 3-2): difference

- The vast majority (88%) of the truck drivers are experienced drivers with more than 2 years of truck driving experience (a).
- Almost 9 out of 10 LNG trucks the drivers have driven, are IVECO Stralis Euro IV, the power output almost equally divided over 330hp & 400hp versions (b).
- Most drivers are sharing their truck with other truck drivers (c).
- Total truck weight is mostly (58%) between 35 and 40 tons (d).

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**Figure 3-2. Characteristics of the respondents (truck drivers) that participated in the qualitative drivers survey: a) Drivers experience; b) LNG Truck; c) Shared or own truck; d) Truck weight**
3.3 Results

3.3.1 Truck comparisons

An important aspect of the qualitative evaluation is the perception of the truck driver regarding the driving performance of the LNG truck. In order to evaluate this perception, we asked the truck drivers to rate both the LNG truck and the conventional diesel truck they usually drive, or were used to drive. The performance was rated on a scale from 0 (= very bad performance) to 10 (= very good performance). We made a distinction between the type of trucks (monofuel and dual fuel), and power of the trucks (monofuel 330hp and 400hp). In Figure 3-3 the results are presented for the different type of LNG trucks vs. diesel trucks. The following conclusions can be drawn:

- Monofuel LNG trucks get clearly higher scores than the diesel trucks for noise related aspects ('driving' and 'idling'). The difference was not that clear in the intermediate assessment.
- The only aspect where dual fuel trucks get a higher score than diesel trucks, is for 'noise when idling'.
- Diesel trucks are rated higher for all other aspects, and the difference is highest for power related aspects: acceleration and handling hilly roads. Remarkable is the fact that the dual fuel trucks get the worst rating for 'handling hilly roads'. These trucks normally have higher power than monofuel trucks. The difference in rating between LNG (all 3 types) and diesel trucks has increased compared to the intermediate assessment.
- Compared to the 330hp version, the 400hp gets higher ratings on all aspects, except the time needed to refuel. 400 hp trucks often are equipped with double LNG tanks, which offer greater driving range, but takes more time to refuel.
Figure 3-3. Truck comparison (LNG vs diesel). Trucks were compared by the truck drivers by rating the performance from 0 (= very bad performance) to 10 (=very good performance).
The truck drivers that had experience with 330 and 400 hp trucks, were also asked directly if they thought the 400 hp offered a solution to the main drawbacks of the 330 hp version (see D6.5). The above conclusion was confirmed: a majority of the drivers stated that the 400 hp version main benefit was the higher power, and to a lesser extent also a greater range with a full tank. A minority still stated that the power was insufficient.

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**Figure 3-4. Assessment of the 400 hp monofuel LNG truck compared to the 330 hp version**

3.3.2 Incidents

3 quarters of the truck drivers did not experience any incidents during the refueling of the truck. One fifth declared that they were confronted with incidents, but without ‘dangerous’ situations. 7 drivers reported that they experienced several incidents. The severity or nature of the incidents have not been reported. The overall % of drivers having experienced at least 1 incident, is equal to the previous assessment (+/-25%).
3.3.3 Fuel switch

The possibility to switch from dual fuel to diesel is a great advantage for dual fuel vehicles. It allows to reach the next LNG fuel station in case of LNG fuel depletion. Little over 40% of the drivers stated they never had to switch to diesel only mode. The majority of drivers however, reported that they had to switch to diesel only mode a few times (47%) or very often (12%).
3.3.4 Reactions

The reactions of other truck drivers can play an important role when considering future motivations in driving an LNG truck again. One the one hand, negative reactions could be triggered by the relatively low power of the engine, by difficulties when driving uphill, ... On the other, positive reactions could be the result of the lower noise production, the environmentally friendly character, etc. As presented in Figure 3-7, 3 out of 10 drivers did not experience any reactions from other truck drivers. Negative or undesirable reactions were reported by 55 truck drivers (23%). On the other hand, nearly half of the truck drivers (46%) reported to have experienced positive reactions when they were driving the LNG truck. The latter being clearly higher than during the previous, intermediate assessment. Based on this evolution, we could state that the technology is becoming better known, and more appreciated.

![Reactions](image)

**Figure 3-7. Distribution of the truck drivers regarding the reactions that they experienced from other truck drivers**

3.3.5 Disadvantages/advantages

We asked the truck drivers for the main disadvantages and advantages that they experienced when driving the LNG truck. Drivers were allowed to select no more than 3 options from the list (or add other aspects). Given the difference in technology, the results are presented separately for the monofuel and dual fuel trucks. Within the monofuel trucks, we also make distinction between the 330 and the 400 hp versions. In Figure 3-8 the main disadvantages of the 330 & 400 hp monofuel trucks are ranked according to their selection by the truck drivers. We also the ones most often selected by the drivers:

- ‘The LNG truck does not have enough power’ was by far the greatest disadvantage of the 330 hp truck (almost 2 out of 3 drivers mentioned this), but this was also the main drawback for the more powerful 400 hp trucks (nearly half of the drivers indicated this disadvantage).
• ‘There are not enough LNG fuel stations available’ comes in a close second place for the 400 hp trucks (45%), where this is the third answer for the 330 hp trucks (28%). This difference could be due to the fact that 400 hp trucks are more used on longer routes, where the lack of stations is more of an issue than for trucks that are used more regionally.

• The drivers of the 330hp truck didn’t like the fact that their truck had a manual gearbox (second place with 42%).

• ‘I have to refuel the LNG truck too often (LNG tank is too small)’ comes in 4th place for the 330 hp trucks (20% of the drivers). These were mostly available with 1 LNG tank (range of ±700km), which is probably the reason why it has a high score. In the case of the 400 hp trucks, 4th place (also 20%) is reserved for ‘The refueling process at the LNG fuel station takes too long’. These trucks were often sold with 2 LNG tanks on board, which doubles the range, but also doubles the refueling time.

• 27% of the 400 hp drivers stated there were no disadvantages, where in the case of 330 hp trucks this is only 6%.

• It’s important to note that safety related issues were only mentioned as disadvantages by a very limited number of drivers.

In Figure 3-9 the main advantages are ranked according to their selection by the truck drivers. Based on this figure, we can conclude that there is no difference in ranking of the advantages between the 330 and 400 hp versions:

• ‘LNG is an environmentally friendly fuel’ is considered to be the most important advantage according to 330 and 400 hp truck drivers (resp. 50% and 71%). This came only in second place in the previous assessment.

• Second place is reserved for ‘lower noise levels’ (half of the 330 hp drivers, and 62% of the 400 hp drivers)

• One third of the truck drivers (330 and 400 hp) also favored ‘driving and testing new technologies such as LNG’.

• The aspect ‘Pleasant driving comfort’ was clearly ticked more often by 400 hp drivers (21%), than by 330 hp drivers (3%).

The results of the dual fuel truck drivers are listed in Figure 3-10 and Figure 3-11.

• Surprisingly, the power of the truck seems to be the n°1 problem for dual fuel trucks as well (mentioned by the majority of the drivers, 74%). In the previous, intermediate assessment, this was not an issue for dual fuel trucks. These trucks have higher power than the monofuel trucks.

• An important other disadvantage is related to the lack of LNG fuel stations.

• Safety issues were not listed as a disadvantage.

The most important advantages are the same as in general, only the order has changed a little.
### Main disadvantages of the 330 hp monofuel LNG truck

<table>
<thead>
<tr>
<th>Disadvantage</th>
<th>Number of Truck Drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>The LNG truck does not have enough power</td>
<td>62</td>
</tr>
<tr>
<td>I do not like the manual gearbox in the LNG truck</td>
<td>42</td>
</tr>
<tr>
<td>There are not enough LNG fuel stations available</td>
<td>28</td>
</tr>
<tr>
<td>I have to refuel the LNG truck too often (LNG tank is too small)</td>
<td>20</td>
</tr>
<tr>
<td>It is difficult to drive the LNG truck on hilly roads</td>
<td>15</td>
</tr>
<tr>
<td>The refueling process at the LNG fuel station takes too long</td>
<td>7</td>
</tr>
<tr>
<td>No disadvantages</td>
<td>6</td>
</tr>
<tr>
<td>I do not feel safe when refueling the LNG truck</td>
<td>2</td>
</tr>
<tr>
<td>I do not feel safe when driving an LNG truck</td>
<td>1</td>
</tr>
</tbody>
</table>

### Main disadvantages of the 400 hp monofuel LNG truck

<table>
<thead>
<tr>
<th>Disadvantage</th>
<th>Number of Truck Drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>The LNG truck does not have enough power</td>
<td>53</td>
</tr>
<tr>
<td>There are not enough LNG fuel stations available</td>
<td>50</td>
</tr>
<tr>
<td>No disadvantages</td>
<td>30</td>
</tr>
<tr>
<td>The refueling process at the LNG fuel station takes too long</td>
<td>22</td>
</tr>
<tr>
<td>It is difficult to drive the LNG truck on hilly roads</td>
<td>21</td>
</tr>
<tr>
<td>I have to refuel the LNG truck too often (LNG tank is too small)</td>
<td>17</td>
</tr>
<tr>
<td>I do not like the manual gearbox in the LNG truck</td>
<td>6</td>
</tr>
<tr>
<td>I do not feel safe when refueling the LNG truck</td>
<td>6</td>
</tr>
<tr>
<td>I do not feel safe when driving an LNG truck</td>
<td>2</td>
</tr>
</tbody>
</table>

*Figure 3-8. Number of truck drivers per selected disadvantage (max. 3 answers per driver)*
Figure 3-9. Number of truck drivers per selected advantage (max. 3 answers per driver)
**Main disadvantages of driving the dual fuel LNG truck**

<table>
<thead>
<tr>
<th>Disadvantage</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>The LNG truck does not have enough power</td>
<td>14</td>
</tr>
<tr>
<td>It is difficult to drive the LNG truck on hilly roads</td>
<td>12</td>
</tr>
<tr>
<td>There are not enough LNG fuel stations available</td>
<td>9</td>
</tr>
<tr>
<td>I have to refuel the LNG truck too often (LNG tank is too small)</td>
<td>5</td>
</tr>
<tr>
<td>The refueling process at the LNG fuel station takes too long</td>
<td>1</td>
</tr>
<tr>
<td>I do not feel safe when refueling the LNG truck</td>
<td>1</td>
</tr>
</tbody>
</table>

**Figure 3-10. Number of truck drivers per selected disadvantage (max. 3 answers per driver), including only the dual fuel truck drivers**

**Main advantages of driving the dual fuel LNG truck**

<table>
<thead>
<tr>
<th>Advantage</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>LNG is an environmentally friendly fuel</td>
<td>15</td>
</tr>
<tr>
<td>I like driving and testing new technologies such as LNG</td>
<td>11</td>
</tr>
<tr>
<td>Fuel costs are less compared to diesel</td>
<td>6</td>
</tr>
<tr>
<td>Low noise levels</td>
<td>5</td>
</tr>
<tr>
<td>Pleasant driving comfort</td>
<td>5</td>
</tr>
<tr>
<td>Good equipment of interior truck cabin</td>
<td>2</td>
</tr>
</tbody>
</table>

**Figure 3-11. Number of truck drivers per selected advantage (max. 3 answers per driver), including only the dual fuel truck drivers**
3.3.6 Future

The main research question in this survey wants to examine whether the truck drivers are willing to drive an LNG truck again in the future. Based on the answers in Figure 3-12 we can conclude that:

- When offered the choice, 3 out of 4 truck drivers would consider driving an LNG truck again in the future.
- 17% of the drivers is still doubting on using the LNG truck again.
- 7% of the truck drivers declares that they are not convinced to drive LNG trucks again.

![Figure 3-12. Overview of the number of truck drivers according to their willingness of using LNG trucks in the future](image)

3.4 Discussion and conclusion

The drivers appreciate the lower environmental impact of LNG trucks, and the lower noise production. They also like to test new technologies. The majority does not perceive any safety issues when driving or refueling these vehicles. A quarter of the drivers of 400 hp trucks even mentioned there we no disadvantages at all to driving these trucks. Three quarters of the drivers is willing to drive an LNG truck again in the future. Only a minority is not convinced at all.

However, the drivers also see some drawbacks in the currently available LNG trucks, and the low number of filling stations. The low power (which has an impact on accelerating and driving on hilly roads) is the main disadvantage of current vehicles, but this is slightly less relevant for the 400 hp version. Compared to the 330hp version, the 400hp gets higher ratings on all aspects, except the time needed to refuel. 400 hp trucks often are equipped with double LNG tanks, which offer greater driving range, but takes more time to refuel.
4 Results: Fleet operators

4.1 Introduction

In this section, the results from the qualitative fleet operator survey are presented. We will first describe the respondents (the transport companies) according to different characteristics. Next the answers of the fleet operators to the different questions in the qualitative survey are presented.

4.2 Respondents

We asked all participating fleet operators with LNG trucks on the road, to complete the survey. This survey was sent to 36 active fleet operators, of which 35 completed the survey.

Before presenting the results of the survey, it is important to first describe the characteristics of the respondents. The results for the fleet operator survey are present for 35 different transport companies. Each company fully completed the survey.

The total LNG and diesel truck fleet per transport company is provided in Figure 4-1. The names of the transport companies are not shown. The codes below the vertical bars are those of the transport companies as they are being used in the LNG BC reporting system.

Only fleet operators with ID 374 and 375 already had experience with LNG trucks before the start of this project, nearly all other trucks were purchased during the course of the project. It is clear from the total number of LNG trucks, that only for a relatively small part of the trucks subsidies from the LNG Blue Corridors project were used (+/-25%). This means the majority of the LNG trucks were bought without any financial compensation from the project. In the intermediate assessment, only a minority of the total number of trucks was bought without project funding. It’s fair to state that (a.o.) thanks to the experiences gained in the LNG Blue Corridors project, the total number of LNG trucks among the project fleet operators is now a multiple of the original number.
Figure 4-1. Total truck fleet composition (diesel + LNG) per transport company

<table>
<thead>
<tr>
<th>Transport company</th>
<th>IVECO V</th>
<th>IVECO VI 330hp</th>
<th>IVECO VI 400hp</th>
<th>Volvo Dual</th>
</tr>
</thead>
<tbody>
<tr>
<td>374</td>
<td>1</td>
<td>1</td>
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<td>478</td>
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<td>0</td>
</tr>
<tr>
<td>482</td>
<td>1</td>
<td>0</td>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 4-1. Composition of the LNG truck fleet per transport company

In Table 4-1 we’ve listed the type and number of LNG trucks that are being operated by the fleet operators.
These are the main characteristics of the fleet operators and the LNG trucks they are using:

- Less than 10% of the fleet operators use their LNG trucks mainly for <30 tons transport (total truck weight), another 40% for 30-40 tons transport, 20% for > 40 tons transport and the remainder has a mix of these categories. The majority of the fleet operators use the LNG trucks for the same type of transport as their diesel fleet (in terms of total vehicle load), only a few use their LNG trucks for other type of loads (generally lower load categories). Details can be found in Figure 4-2.
- 60% of the fleet operators only operate their LNG trucks nationally, where the diesel truck fleet is used more often for international transport (see Figure 4-3).
We also asked them for the reasons why they are using LNG trucks (see Figure 4-4). 80% of the fleet operators indicated that their company wants to lower its environmental impact. 74% stated that their customers request environmentally friendly transport. Little over half said that they use it as a marketing argument to acquire new customers. Only 43% chose the lower cost per km as one of their reasons for using LNG trucks.
4.3 Results

4.3.1 Usability

The practical usability of the LNG trucks on current routes is important to take into account when considering future investments. We therefore asked the fleet operators whether it could be possible to use their LNG trucks on all of the current routes, considering truck loads, trip distances and destinations. This can be highly dependent of the type of truck, so we took this into account. As presented in Figure 4-5, a majority of fleet operators stated that they can use their dual fuel and 400hp monofuel trucks on all of their current routes. Only in the case of the 330hp monofuel, nearly 2 thirds stated that these trucks cannot be used on all of their current truck routes. We also polled for the factors preventing them to use these trucks on all of their current routes. The result is presented in Figure 4-6.

- The lack of fuel stations is the main reason why some fleet operators prefer diesel trucks over their dual fuel vehicles, or 400hp monofuel trucks.
- In the case of 330 hp monofuel trucks, the main reason was the fact that (parts of) the route were too hilly, followed by heavy truck loads.

We also asked the fleet operators that had experience with the 330 and the 400 hp IVECO trucks, if the 400 hp version offered a solution for the disadvantages of the 330 hp version. 75% listed the higher power, half said the range with a full tank was an advantage (see Figure 4-7).
Figure 4-5. Usability of LNG trucks considering current routes, truck loads, trips distances and destinations.
Figure 4-6. Factors preventing the use of LNG trucks on current routes (only when answered 'No' to usability)

Figure 4-7. Advantages of the 400 hp vs. the 330 hp IVECO
4.3.2 Reactions from truck drivers

According to little over half of the fleet operators, their truck drivers are (very) enthusiastic to drive the LNG trucks (Figure 4-8). Compared to the previous assessment, this share remains stable. What is remarkable, is that the current share of drivers labeled as ‘not (at all) enthusiastic’, has halved compared to the intermediate assessment. Instead of being negative about LNG as a transport fuel, they are now taking a neutral stand. This has probably to do with the fact that they are now used to using LNG trucks, whereas in the intermediate assessment the fuel and technology was relatively new. The fact that the initially negative perception of LNG by some of the drivers, has changed to a neutral position, could indicate the project facilitated the acceptance of LNG as a transport fuel.

![Figure 4-8. Reactions of the truck drivers, on a scale from “not at all enthusiastic” to “very enthusiastic”](image)

4.3.3 Cost comparison (LNG vs diesel)

The impression of the fleet operator on the Total Cost of Ownership (TCO) of the LNG trucks is very important information for further uptake of LNG as a transport fuel. We therefore asked to evaluate these costs compared to a conventional diesel truck. The components of the TCO were polled separately. Based on the results (see Figure 4-9), we can report the following observations:

- The purchase price of an LNG truck is assessed as (much) more expensive than of a diesel truck. This is the case for more than 90% of the fleet operators.
- Little over 70% indicates that the maintenance and repair costs for LNG trucks are more expensive than for diesel trucks. Insurance costs are perceived as similar.
- Only regarding fuel (and AdBlue) costs, over 80% of the fleet operators report that the LNG trucks are cheaper than diesel.
- Nearly half of the fleet operators (46%), state that the TCO of LNG trucks is beneficial compared to diesel trucks. Close to one third reports higher overall costs for LNG trucks. This is a clear shift compared to the intermediate assessment, where 2 thirds of the fleet operators stated that LNG trucks had (much) higher overall costs per km to operate than their diesel counterparts.

![Cost comparison (LNG compared to diesel trucks)](image)

Figure 4-9. Cost comparison (LNG compared to diesel), on a scale from “much cheaper than diesel” to “much more expensive than diesel”

### 4.3.4 Information availability

We asked the fleet operators how easy it was/is for them to find relevant information concerning LNG truck implementation. Hereby we focused on the locations of the fuel stations, but also information on the trucks that are available on the market (brands, types) and finally also legal information concerning the use of LNG (permits, training, ...).

According to 2 thirds of the fleet operators (see Figure 4-10), information on the location of fuel stations is currently (very) easy to find. Information on the availability of trucks in the market is a little less known. And for information on the legal aspects only a quarter of the fleet operators report that it is easy to find the necessary information, nearly half state that it’s even difficult. There hasn’t been any
improvement compared to the intermediate assessment, so there's still a demand for more and easily accessible information.

<table>
<thead>
<tr>
<th></th>
<th>Location of LNG stations</th>
<th>Available trucks on the market</th>
<th>Legal aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>very difficult</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>difficult</td>
<td>7</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>neutral</td>
<td>7</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>easy</td>
<td>21</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>very easy</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

*Figure 4-10. Indication of how easy it is to find relevant information regarding LNG trucks, on a scale from “Very easy” to “very difficult”*

### 4.3.5 Important future factors

We asked the fleet operators to indicate the importance of a list of factors when considering additional LNG trucks in the future. A scale from ‘not important’ to ‘extremely important’ was suggested. However, as presented in Figure 4-11, none of the fleet operators selected the ‘not important’ option, indicating that all suggested factors were considered to have some influence. Based on the answers of the fleet operators, we can report the following observations:

- All the factors that were suggested, were considered important for fleet operators to take into account when considering future LNG fleet expansion.
- The purchase price, together with fuel cost savings, are the 2 most important aspects.
- The availability of LNG fuel stations (number and locations) is also very important.
- The environmental benefits come in close to the top 3 influencing factors.
- More powerful trucks, with a larger driving range, should become available.

There is not much difference with the intermediate assessment, except for the fact that more importance is attributed to ‘Maintenance and repair capabilities’ (from truck dealers, internal workshop, emergency roadside assistance services, ...).
4.3.6 Future fleet expansion

The main research question in this fleet operator survey wants to examine whether the fleet operators are willing to expand their truck fleet with LNG trucks in the future. Based on the answers in Figure 4-12, we can conclude that:

- Nearly 90% of the fleet operators are considering future LNG fleet expansion,
- 8% (or 3 out of 35 fleet operators) is doubting,
- Only 2 fleet operators are not convinced.
4.4 Discussion and conclusion

Total number of trucks

The number of LNG trucks that are being operated by the project fleet operators, is much higher than the number of trucks that have received subsidies from the project. Nearly all of these additional trucks were purchased during the course of the project, without any financial compensation from the project. This was not the case during the previous assessment, so it’s fair to state that (a.o.) thanks to the experiences gained in the LNG Blue Corridors project, the total number of LNG trucks among the project fleet operators is now a multiple of the original number.

Use of the trucks

The majority of the fleet operators use the LNG trucks for the same type of transport as their diesel fleet (in terms of total vehicle load), only a few use their LNG trucks for other type of loads (generally lower load categories). A majority of fleet operators stated that they can use their dual fuel and 400hp monofuel trucks on all of their current routes. Only in the case of the 330hp monofuel, nearly 2 thirds stated that these trucks cannot be used on all of their current truck routes. The lack of fuel stations is the main reason why some fleet operators prefer diesel trucks over their dual fuel vehicles, or 400 hp monofuel trucks. In the case of 330 hp monofuel trucks, the main reason was the fact that (parts of) the route were too hilly, followed by heavy truck loads. The LNG trucks are more often limited to national use, where diesel trucks operate more often internationally.

Motivations

We also asked them for the reasons why they are using LNG trucks. Most frequently cited motivations (in order of popularity), were

1. The transport company wants to lower its environmental impact.
2. Their customers request environmentally friendly transport.
3. The trucks are a marketing argument to acquire new customers.

Less than half of the fleet operators chose the lower cost per km as one of their reasons for using LNG trucks.

Drivers

Compared to the previous assessment, the share of (very) enthusiastic drivers remains stable. What is remarkable, is that the current share of drivers labeled as ‘not (at all) enthusiastic’, has halved compared to the intermediate assessment. Instead of being negative about LNG as a transport fuel, they are now taking a neutral stand. This could indicate the project facilitated the acceptance of LNG as a transport fuel.

TCO

Nearly half of the fleet operators, state that the TCO of LNG trucks is beneficial compared to diesel trucks. Close to one third reports higher overall costs for LNG trucks. This is a clear shift compared to the intermediate assessment, where 2 thirds of the fleet operators stated that LNG trucks had (much) higher overall costs per km to operate than their diesel counterparts.
Information

There hasn’t been any improvement compared to the intermediate assessment, meaning there’s still a demand for more and easily accessible information (mainly regarding legal aspects such as training requirements, permits, etc., and regarding the LNG trucks available on the market).

Future

When asked which factors are important when considering additional LNG trucks in the future, the fleet operators indicated the purchase price of the trucks, the fuel price difference between LNG and diesel, and the availability of LNG filling stations as very to extremely important. The environmental benefits, the maintenance capabilities, the power and the driving range of the trucks are also decisive. It is in fact important to note that none of the factors listed were considered to be of no importance. Nevertheless, nearly 90% of the fleet operators are considering future LNG fleet expansion. This is higher compared to the intermediate assessment.
5 Results: Filling station operators

5.1 Introduction

In this section, the results from the qualitative filling station operator survey are presented. Since the beginning of the project, 12 LNG filling stations have started operations within the framework of the LNG Blue Corridors project (Table 5-1). The operators of these filling stations (8 operators) were questioned about their experiences so far. In order to collect more descriptive data on the different filing stations, two different surveys were distributed: part A (on the characteristics of the filling stations) and part B (on the experiences). In this section, the results from both surveys are presented.

We will first describe the respondents (the filling stations) according to different characteristics and next the answers of the filling station operators to the different questions in the qualitative survey are presented.

<table>
<thead>
<tr>
<th>Location</th>
<th>Responsible partner</th>
<th>Start</th>
<th>Participated in the survey</th>
</tr>
</thead>
<tbody>
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<td>SGA</td>
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</tr>
<tr>
<td>Piacenza, Italy</td>
<td>ENI</td>
<td>April 2014</td>
<td>Yes</td>
</tr>
<tr>
<td>Antwerp, Belgium</td>
<td>Drive Systems</td>
<td>May 2014</td>
<td>Yes</td>
</tr>
<tr>
<td>Carregado, Portugal</td>
<td>Dourogas</td>
<td>September 2014</td>
<td>Yes</td>
</tr>
<tr>
<td>Barcelona, Spain</td>
<td>GNF</td>
<td>December 2014</td>
<td>Yes</td>
</tr>
<tr>
<td>Nîmes, France</td>
<td>GNVert</td>
<td>July 2015</td>
<td>Yes</td>
</tr>
<tr>
<td>Rungis, France</td>
<td>GNVert</td>
<td>January 2016</td>
<td>Yes</td>
</tr>
<tr>
<td>Elvas, Portugal</td>
<td>Dourogas</td>
<td>May 2016</td>
<td>Yes</td>
</tr>
<tr>
<td>Lyon, France</td>
<td>GNVert</td>
<td>July 2016</td>
<td>Yes</td>
</tr>
<tr>
<td>Matosinhos, Portugal</td>
<td>GALP</td>
<td>July 2016</td>
<td>Yes</td>
</tr>
<tr>
<td>Pontedera,</td>
<td>ENI</td>
<td>October 2016</td>
<td>Yes</td>
</tr>
<tr>
<td>Berlin, Germany</td>
<td>Uniper</td>
<td>March 2017</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Table 5-1. Overview of active LNG Blue Corridors filling stations

5.2 Respondents

Before presenting the results on the experiences of the filling station operators (Part B), this section will describe the characteristics of the filling stations, resulting from the first part of the survey (Part A).
The answers of Part A of the survey are available for 12 filling stations owned by 8 different filling station operators (see Table 5-1). Dourogas operates 2 filling stations, and GNVert operates 3 filling stations.

Concerning the other fuels that are available at the fuel stations, results are available for all filling stations (Table 5-2). Each of these stations, besides Nîmes and Berlin, declare that they provide also L-CNG. At Barcelona, Matosinhos, Örebro and Piacenza, also diesel and petrol (the latter not in Örebro) are available. The total volume of the LNG storage tank is generally ± 60 m³, except for Antwerp (70 m³), the temporary station of Nîmes (20 m³), Elvas (10 m³) and the mobile station in Berlin (42 m³) (Table 5-3). The type and number of filling and venting nozzles in each filling station is presented in Table 5-4. In each filling station one filling nozzle (almost all of the type JC Carter) and one venting nozzle (all Macrotech) is present, except for Carregado where 2 of each are available. In Piacenza, The station operator of Piacenza is currently “analyzing how to increase sales capacity through adding an LNG dispenser, introduction of 24h self-service and added storage.” This mainly because the number of trucks refilling at the station has increased greatly over the past months, and is reaching its limits regarding number of trucks serviced.

The current LNG station in Nîmes is still a temporary one. The future fixed station will have a storage tank of 60m³ and will offer L-CNG as well.

Regarding the somewhat unusual storage tank of 10 m³ of Elvas, the operator stated: “The choice of the capacity of the tank is a compromised between the estimated consumption and distances required to install the tank. If you can see this station is an “halfway” point for supply between Madrid and Carregado we have most of the times LNG supply’s to guarantee that the truck have autonomy to go to Lisbon.”

<table>
<thead>
<tr>
<th>Filling stations</th>
<th>Diesel</th>
<th>L-CNG</th>
<th>Petrol</th>
<th>Other</th>
<th>Only LNG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antwerp</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barcelona</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carregado</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Elvas</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Lyon</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Matosinhos</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Nîmes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Örebro</td>
<td>1</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Piacenza</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rungis</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Pontedera</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Berlin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

Table 5-2. Overview of the other fuels that are provided at the filling stations besides LNG
Concerning the available technical solutions to avoid boil-off, different options are present as shown in Table 5-5. Almost all have L-CNG production. In Carregado a boil-off gas (BOG) recovery system is available with a low pressure tank storage, odorization, compressor and CNG buffer. In Nimes, the technical solution includes condensing the BOG from the trucks in the liquid phase. Antwerp is the only station where gas can be injected to a local gas distribution network, and Örebro has active cooling.
In Berlin, there is a guaranteed minimum withdrawal of 1750 kg per day. Therefore the operator claims that the critical pressure to oblige venting will not occur. No technical solution to prevent venting is installed.

<table>
<thead>
<tr>
<th>Filling stations</th>
<th>Active cooling</th>
<th>Injection of gas phase to a gas distribution network</th>
<th>L-CNG production</th>
<th>Venting</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antwerp</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barcelona</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Berlin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Carregado</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Elvas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lyon</td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Matosinhos</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nimes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Örebro</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piacenza</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Rungis</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Pontedera</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

Table 5-5. Technical solution to avoid boil off

A so-called “Dead man’s button” is present in 8 out of 12 filling stations. In Barcelona, Carregado, Elvas and Piacenza, such a system is not existing. It is worth mentioning that Piacenza is the only ‘full-service’ station, the rest is unmanned. The button’s procedure differs between the 8 stations. In Nîmes and Örebro, truck drivers need to press the button the entire duration of the refueling process. In the others, truck drivers need to press the button only at predefined intervals.
5.3 Results

This section presents the experiences of 8 different filling station operators with their LNG stations (Part B of the survey). Results are presented for all filling station operators in order to provide more insights on their general experiences and future recommendations.

5.3.1 Truck refueling and safety

Several questions were asked to gain more insights in the experiences of the fuel station operators concerning the truck refueling process and occurrence of incidents.

Only 2 of the 8 respondents indicate that they experienced incidents at their LNG fuel station. The number of incidents is as expected, or even less. This means that progress has been made, since at the time of the intermediate assessment, a majority indicated that incidents had occurred at their stations.

The respondents indicated that the main causes for these incidents, were the different procedures and standards at the different fuel stations, technical failures and shortcomings in the driver trainings. A solution for the first type of incidents is to agree on a standard at the different fuel stations. The improvement of truck driver training is also mentioned as a recommendation. The example of the universal LNG refueling instruction from the 'Nationaal LNG Platform' (The Netherlands) is specifically mentioned.
Did you experience any incidents when trucks refueled at the fuel station(s)?

<table>
<thead>
<tr>
<th></th>
<th>Number of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>6</td>
</tr>
<tr>
<td>Yes</td>
<td>2</td>
</tr>
</tbody>
</table>

The number of incidents that occurred during truck refueling (by truck drivers) at the fuel station(s) until now are:

<table>
<thead>
<tr>
<th></th>
<th>Number of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>As expected</td>
<td>4</td>
</tr>
<tr>
<td>Less than you expected</td>
<td>4</td>
</tr>
</tbody>
</table>

To your opinion, what are the main causes of the incidents at LNG fuel stations?

<table>
<thead>
<tr>
<th>Cause</th>
<th>Number of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Different procedures, nozzles,... exist at each fuel station. This makes it difficult for the truck drivers.</td>
<td>1</td>
</tr>
<tr>
<td>Technical failures of the refueling system</td>
<td>1</td>
</tr>
<tr>
<td>Training for truck drivers is insufficient</td>
<td>1</td>
</tr>
</tbody>
</table>

Solutions or recommendations to reduce the number of incidents at LNG fuel stations

<table>
<thead>
<tr>
<th>Solution</th>
<th>Number of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree on a standard (e.g. nozzles,...) at the different fuel stations</td>
<td>3</td>
</tr>
<tr>
<td>Improve training of truck drivers</td>
<td>3</td>
</tr>
<tr>
<td>Roll-out of the universal LNG refuelling instruction from the Nationaal LNG Platform (The Netherlands)</td>
<td></td>
</tr>
<tr>
<td>new user training + retraining</td>
<td></td>
</tr>
<tr>
<td>Dispose Interactive screen display</td>
<td></td>
</tr>
<tr>
<td>Other:</td>
<td>3</td>
</tr>
<tr>
<td>fully automated station, operation manuals and safety procedure as well as remote monitoring</td>
<td></td>
</tr>
<tr>
<td>Spare EPI’s. We had to buy spare EPI’s since we had some cases of trucks without them.</td>
<td></td>
</tr>
</tbody>
</table>

Table 5-8: Experiences of the filling station operators with truck refueling and safety aspects. Overview of related questions

Concerning the assistance that is provided to the truck drivers, half of the respondents indicate that 30 to 60 minutes are spent per truck driver to explain the procedures of the fuel station. The other half spends less time per truck driver. Once these drivers are trained, further assistance is rarely required. An incorrect use of the dead man’s button resulted in unsuccessful fillings for only one respondent.

Compared to the previous assessment, some differences appear. The driver training takes more time, and the dead man’s button doesn’t lead to as many unsuccessful fillings as before. Apparently, the right correcting measures were taken to reduce the nuisances caused by an incorrect use of the dead man’s button.
**Table 5-9. Experiences of the filling station operators with truck driver trainings and the dead man’s button. Overview of related questions**

### Indicate how much time in general is spent on each new truck driver to explain the procedures of your fuel station(s)

<table>
<thead>
<tr>
<th>Time Duration</th>
<th>Number of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 15 min. per truck driver</td>
<td>2</td>
</tr>
<tr>
<td>15 – 30 min. per truck driver</td>
<td>2</td>
</tr>
<tr>
<td>30 – 60 min. per truck driver</td>
<td>4</td>
</tr>
<tr>
<td>&gt; 1 hour per truck driver</td>
<td>0</td>
</tr>
</tbody>
</table>

### How often do you still need to provide assistance (live or on the phone) during truck refueling for drivers that were already trained?

<table>
<thead>
<tr>
<th>Assistance Needed</th>
<th>Number of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never</td>
<td>2</td>
</tr>
<tr>
<td>Rarely</td>
<td>6</td>
</tr>
<tr>
<td>Often</td>
<td>0</td>
</tr>
<tr>
<td>Almost always</td>
<td>0</td>
</tr>
</tbody>
</table>

### Did the incorrect use of the “dead man’s button” lead to any unsuccessful fillings at your fuel station(s)?

<table>
<thead>
<tr>
<th>Incorrect Use</th>
<th>Number of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>4</td>
</tr>
<tr>
<td>Yes:</td>
<td>1</td>
</tr>
<tr>
<td>The drivers did not press continuously</td>
<td></td>
</tr>
</tbody>
</table>

### The costs for maintenance and repair of the LNG fuel station(s) in general are:

<table>
<thead>
<tr>
<th>Cost Description</th>
<th>Number of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>As expected</td>
<td>7</td>
</tr>
<tr>
<td>Less than you expected</td>
<td>1</td>
</tr>
<tr>
<td>“Not that much, but regular attention is needed (visit 1-2/week).”</td>
<td></td>
</tr>
</tbody>
</table>

**Table 5-10. Experiences of the filling station operators with costs for maintenance and repair.**

5.3.2 Maintenance and repair

7 out of 8 respondents indicate that the costs for maintenance and repair of the LNG fuel station are as they expected. One respondent indicated that the costs were less than expected.

5.3.3 Fuel deliveries to the station

Refilling of the LNG storage tank needs to be carefully planned to avoid LNG deliveries that cannot be stored or to avoid an empty storage tank. Concerning the planning of these fuel deliveries several respondents indicate that there were some problems. As a result, in some occasions new LNG deliveries could even not be fully stored. Other problems related to the refill of the storage tank are mentioned in Table 5-11. Half of the respondents didn’t encounter any problems, and state that the planning is neither difficult, nor easy. There were no incidents during the refill of the storage tanks.
Indicate which problems already occurred at your fuel station(s) concerning the refill of the storage tank:

<table>
<thead>
<tr>
<th>Problem Description</th>
<th>Number of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>New LNG deliveries could not be fully stored</td>
<td>3</td>
</tr>
<tr>
<td>We have not experienced any problems concerning the refill of the LNG storage tank.</td>
<td>4</td>
</tr>
<tr>
<td>LNG storage tanks have ran empty before the next delivery took place</td>
<td>1</td>
</tr>
<tr>
<td>Other problems:</td>
<td>4</td>
</tr>
<tr>
<td>1. When the tank is nearly empty, refuelling can be more difficult, or not succeed from the first attempt. This has happened a few times.</td>
<td></td>
</tr>
<tr>
<td>2. A 4000t/year station like Piacenza is quite hard to reliably supply with a 65m³ storage tank</td>
<td></td>
</tr>
<tr>
<td>3. Sometimes we need to refill the storage to cool down the storage, even if the logistic is not optimized. It means that sometimes we pay a full cost of transport to offload only a little quantity of LNG. It can happen especially during the first weeks of operation.</td>
<td></td>
</tr>
<tr>
<td>4. The temperature of the NG refilled. Since we had lack of consumption in the first months the temperature of the NG was critical for us to avoid Boil-Off.</td>
<td></td>
</tr>
</tbody>
</table>

Table 5-11. Experiences of the filling station operators with fuel deliveries to the station. Overview of related questions

5.3.4 Boil-off

Only 2 respondents reported in this assessment they already had boil-off situations (remark: these situations do not necessarily lead to venting of methane since almost all stations are equipped with a technology to prevent venting). In the previous assessment, this share was higher. The reasons for these situations are mainly related the low LNG sale rate at the startup phase. All respondents indicate that their current LNG (or L-CNG) sales are sufficient to avoid (future) boil-off situations.
operation.
  o Yes, but we recover with Boil Off Gas recovery system

<table>
<thead>
<tr>
<th>Are the current LNG (or L-CNG) sales sufficient to avoid boil off?</th>
<th>Number of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Yes</td>
<td>7</td>
</tr>
<tr>
<td>• No</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 5-12: Experiences of the filling station operators with boil-off situations. Overview of related questions

Only one operator was able to give an estimation of the amount of boil off: in 2015, due to boil off + - 13% of the LNG supplied to the station was injected into a gas distribution network to prevent it from being vented. In 2016, this has decreased to less than 3% thanks to increased LNG- and L-CNG sales. Since 2017, this has been reduced to near zero, due to a sufficiently high LNG and L-CNG turnover.

5.3.5 Market barriers for LNG vehicles

When asked for their opinion regarding the main barriers for an increased market uptake of LNG vehicles, a majority of the filling station operators stated that these were (very) important barriers:

1. Purchase price of current LNG trucks is too high
2. The current number and location of LNG filling station is insufficient

In addition, half of the fleet operators stated that the current price difference between diesel and LNG is too small.

A majority of the respondents didn’t think the following barriers to be of importance:

- The lack of a single nozzle technology.
- The driving range of current LNG trucks is too low and therefore refueling frequency is too high.
- The training procedures for drivers is too complex.
- The power of current LNG trucks is too low.

The last barrier in the list was considered a very important barrier in the previous assessment. Since then, more powerful trucks came on the market, such as the IVECO 400 hp, and very recently the IVECO monofuel 460 hp and the Volvo dual fuel up to 460 hp.

The following additional barriers were mentioned by the filling stations operators in the field ‘Other’.

- An LNG terminal for truck loading from oceanic vessels on Italian soil is still missing
- Some procedures with government administration.
5.3.6 Future

The main research question in this filling station operator survey wants to examine whether the filling station operators would recommend future investments in additional LNG filling stations. Based on the answers in Table 5-13 we can conclude that:

- The overall experiences of the fuel station operators with LNG seem to be quite positive. The filling station technology is perceived by all respondents as mature and reliable. During the intermediate assessment, there was only 1 operator that didn’t agree with this statement.
- Under the current market conditions, all of the filling station operators expect an increase of the number of LNG vehicles. This means an increase compared to the intermediate assessment, where only little over half agreed with this statement.
- A minority would have done something differently, given the overall experience they have with their current LNG filling station(s). This ranges from a bigger storage tank, to being more customer oriented, etc. In the intermediate assessment, a majority would have done something differently.
- When asked for their recommendations regarding future LNG stations, all respondents are likely to recommend their company to invest in future LNG stations. This was not the case during the intermediate assessment, where 1 participant didn’t agree.

<table>
<thead>
<tr>
<th>What are in your opinion the main barriers for an increased market uptake of LNG vehicles?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current price difference between diesel and LNG is too small</td>
</tr>
<tr>
<td>not an important barrier</td>
</tr>
<tr>
<td>no opinion</td>
</tr>
<tr>
<td>very important barrier</td>
</tr>
<tr>
<td>extremely important barrier</td>
</tr>
</tbody>
</table>

Figure 5-1. Main barriers for an increased market uptake of LNG vehicles

<table>
<thead>
<tr>
<th>Given the overall experience you have with your current LNG filling station(s), do you consider the filling station technology mature and reliable?</th>
<th>Number of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>8</td>
</tr>
<tr>
<td>No</td>
<td>0</td>
</tr>
</tbody>
</table>
### Do you think that under the current market conditions (fuel prices, truck purchase cost, available trucks on the market, ...) the number of LNG vehicles is likely to increase?

<table>
<thead>
<tr>
<th>Number of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>No 0</td>
</tr>
<tr>
<td>Yes 8</td>
</tr>
</tbody>
</table>

### Given the overall experience you have with your current LNG filling station(s), is there something you would have done differently? (eg. station dimensions, location, etc.)

<table>
<thead>
<tr>
<th>Number of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes 3</td>
</tr>
<tr>
<td>No 5</td>
</tr>
</tbody>
</table>

- Yes:
  - Storage tank of at least 80 m3
  - Systematic redundancy on LNG dispensers and pumps.
  - To be more customer focus oriented

- No:
  - Now there is newer technology (e.g. on-the-fly-saturation), but at the time of construction, the station was state of the art.

### Are there other viewpoints or recommendations on future LNG development you would like to share?

<table>
<thead>
<tr>
<th>Number of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

### Given the overall experience you have with your current LNG filling station(s), would you recommend your company to invest in additional LNG filling station(s)?

<table>
<thead>
<tr>
<th>Number of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>No 0</td>
</tr>
<tr>
<td>Yes 8</td>
</tr>
</tbody>
</table>

- Yes:
  - The overall experience is that LNG sales are growing, and there is a big potential, if at least the price of the fuel and the trucks can remain/become reasonable.
  - Yes. The demand for this type of fuel is increasing at a good pace
  - Excellent ROI
  - with received EU funding
  - The market is growing and demanding more filling station in order to increase the number of LNG vehicles.
  - Growing business, expanding market. Aga has experience
  - Strategy, competitive, sustainable, and environmental

---

Table 5.13. Recommendations of the filling station operators regarding future investments. Overview of related questions
5.4 Discussion and conclusion

All 8 partners that are operating LNG filling stations in the project, participated in the survey. They represent 12 stations, of which one temporary that will eventually be replaced with a permanent one, and a mobile station. Nearly all provide, or will provide, L-CNG, which also serves as a way to avoid boil off.

Safety

Only 2 of the 8 respondents indicate that they experienced incidents at their LNG fuel station. The number of incidents is as expected, or even less. This means that progress has been made, since at the time of the intermediate assessment, a majority indicated that incidents had occurred at their stations. A solution for the first type of incidents is to agree on a standard at the different fuel stations. However, the operators don’t consider this to be an important barrier for a further uptake of LNG. The improvement of truck driver training is also mentioned as a recommendation. The example of the universal LNG refueling instruction from the ‘Nationaal LNG Platform’ (The Netherlands) is specifically mentioned. But it also appears that once the drivers are trained, further assistance is only rarely required.

Boil off

Only 2 respondents reported in this assessment they already had boil-off situations (remark: these situations do not necessarily lead to venting of methane since almost all stations are equipped with a technology to prevent venting). In the previous assessment, this share was higher. The reasons for these situations are mainly related the low LNG sale rate at the startup phase. All respondents indicate that their current LNG (or L-CNG) sales are sufficient to avoid (future) boil-off situations.

Future

Under the current market conditions, all of the filling station operators expect an increase of the number of LNG vehicles. This means an increase compared to the intermediate assessment, where only little over half agreed with this statement. During the intermediate assessment, the low power of the trucks was considered to be a very important barrier. This is no longer the case: more powerful trucks came on the market, such as the IVECO 400 hp, and very recently the IVECO monofuel 460 hp and the Volvo dual fuel up to 460 hp. However, the (higher) purchase price of current LNG trucks and the lack and location of LNG filling station are considered to be important barriers, as well as the price difference between diesel and LNG. These are exactly the same as the main barriers indicated by the fleet operators.

The overall experiences of the fuel station operators with LNG seem to be quite positive. The filling station technology is perceived by all respondents as mature and reliable. During the intermediate assessment, there was only 1 operator that didn’t agree with this statement. Only a minority would have changed something in the setup of their station, if they could turn back time. This is progress compared to the intermediate assessment, where a majority would have changed something. When asked for their recommendations regarding future LNG stations, all respondents are likely to recommend their company to invest in future LNG stations. During the intermediate assessment, 1 participant didn’t agree.
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