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**INTRODUCTION OF LNG AS A FUEL FOR VEHICLES IN THE
NETHERLANDS**

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ABSTRACT

This report details the work undertaken by the Rolande LNG group during the last two years in order to establish the first LNG refueling station for vehicles in The Netherlands. The LNG is meant as a fuel for trucks for longer ranges to operate in a more environmental way, concerning the greenhouse, ecological and health related emissions and more over to save money. The result of the work is based on the experience with the licensing authorities and the knowledge about this subject from countries practicing since longer times as there are USA, Spain and England. This result may serve as a guideline for entrepreneurs in this field how to start LNG-business in a successful way regarding legal procedures.

The subjects dealing with starting LNG-fuelling stations are:

- Design aspects for stations and trucks
- Legal aspects for LNG stations
- Legal aspects for trucks
- Common misunderstandings
- Market Characteristics

Also we attempted to join in a special framework for CO₂ savings, to be considered for subsidy. The first reaction was negative based on misunderstandings. This might be very instructive in general to know what to stress in dealing this matter.



Fig.1 Privat LNG refuelingstation in Barcelona Spain for 35 refuse trucks as an example.

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1. Introduction

Due to air quality and raising transport costs, there is a need for using LNG for truck transport since CNG energy-density is a problem for the longer ranges.

One of Europe's largest transporting companies, Vos Logistics, took the initiative together with Rolande LNG, to establish a LNG station on their site and to equip trucks with a LNG installation. This happens to be the first time for using LNG as a fuel in traffic situations in Holland.

To establish a LNG fuelling station for the first time in a country, you have to cope with several drawbacks as there are:

- No legal base for safety and environmental regulations for allowances, both for stations and for trucks
- Lack of knowledge concerning LNG in general
- Legal considerations for banning LPG stations out of urban areas and sharpening all safety regulations for other allowances since severe events happened in a firework plant.
- Replacing diesel oil at large is not a popular message for the oil industry
- Missing dues on cheaper fuels is another unpopular issue for administration.

In the Netherlands everything is forbidden what is not explicitly allowed by law, against everything is allowed what is not forbidden, what could have made things easier.

All above mentioned facts are expected to make introduction of LNG not an easy target.

This paper pretends to be a guidance for those dealing in similar situations for introduction of LNG as a vehicle fuel leading to answers on:

“ How to start LNG-business in a successful way considering the local situation”.

We all know while starting LNG sales for vehicles, you have to cope with high initial investments coupled with chances in market developments, but above all you have to fulfil the demands for safety even when rules are not in place. This, we consider as the main reason, for hesitation to go into that business, whether it concerns gas - and oil companies or others. In this case the initiators are all close related to the transportation sector, and their only relation with energy is the application and the transportation.

2. Design aspects

Transport company Vos Logistics owns about 5000 trucks, operating all over Europe with the main office in the city of Oss in the south of the country. Ranging up to 1200 km after one refuelling is a common feature. They have their own diesel service station and do cleaning and maintenance on their site. Their demand for using LNG should match the same features. This means that using CNG is absolutely out of the question!

LNG, available by road transport from a nearby terminal in Zeebrugge Belgium, has a 98% methane content, what makes it excellent for vehicles due to low ethane content and much higher calorific grade as the common L-gas from Slochteren Holland. This means that calorific value per m³ is even 10% higher than diesel and combined with the fact that the trucks are mainly driven in highest gear, the assumption is justified not to raise LNG consumption over diesel for reasons of the lower efficiency for spark ignited engines. Since 1 litre LNG equals about 0,6 m³ gaseous matter, we calculate in the ratio 0,6 : 1 or 1 : 1,67 for fuel consumption ratio in litres. Consuming 600 litres of diesel oil means 1000 litres of LNG, stored in two containers is enough for the range as a roundtrip. For transit drives, more stations on points of support will be necessary in the future.

To start with 50 trucks makes a weekly consumption of 80.000 litres of LNG. The average daily consumption makes a daily supply with one LNG truck suitable and a storage vessel of 1,5 x this amount at the station means a 30.000 litres container. Making bigger storage would mean relatively lower LNG turnover causing rather boil off circumstances.

The possible boil off gas will be caught in a blow down vessel and stored as CNG to avoid venting in the atmosphere, at the same time some LNG will be vaporised in order to store this for use as H-grade CNG for use as a fuel in their vans and/or passenger cars.

3. LEGAL ASPECTS FOR A LNG FUELLING STATION

The first question was, can we make a quick start by using a temporarily station, while waiting for the approval of the final design? Thoughts are to use the disconnected LNG container from the supply truck and replace him periodically. The answer was, that it turns out as much work to fulfil all demands for doing this as it will be for the final station, so we decided to go for the final station at once.

The next step is to find out if such a station could be fitted in the industrial area where Vos is situated, by administration in Oss, regarding local development plan, nuisance act, environmental and safety issues and construction rules. In view of the fact that Vos is a main employer for the area, officials are very willing to support the idea, but they have to deal with all regulations and doubts where no regulations are settled. We decided to establish the station on another location, now in use as a parking place, in stead of where the trucks are fuelled with diesel, to avoid any interference with both fuels for safety matters. But this means some change in logistics for refuelling and parking. It took nine month to supply the authorities with all necessary forms and answers on the questions and new questions until we went into the official stage of application.

3.1 Development plan

The plan is an official state of the art for the purpose and usage of all areas in a municipality. In our case it says that this area is meant for industry, this means no possible selling point for third parties of fuel is allowed. Since there are also some dwellings, special attention is paid for traffic consequences and noise. A specialized bureau did the investigation around expected noise. The outcome is, after tracing all possible sources, that the noise level will be below the legal limits for such an area between 2 and 20 dB(A) lower on all 25 checkpoints during day, evening and night. The fact that LNG fuelled trucks will cause much less noise (3-6 dB (A)) was not taken into account. The license for the area where diesel trucks fuel and park is reduced for allowable noise production as a consequence for the partly change into LNG vehicles going to another fuelling site.

3.2 Safety issues

We have to fill out forms to answer questions about environmental consequences, as there are about chemicals usage, soil polluting chances, operating hours, sound production, energy and water demand, air pollution, hazardous situations and measures for limiting events and education for personnel. Also a complete operating description is needed. For employees with judging responsibilities, it is hard to assume that properties of LNG are such that its impossible that LNG will emerge into the bottom soil. For us its hard to show them we are right. Such things make it more difficult to apply for allowances.

3.2.1 Impounding basin

Although it is not said in regulations here that we need a basin to collect all possible spilled or leaked LNG we choose for this feature, and made this big enough for possible extensions in future. The LNG container will be situated upright in order to profit gravity while refuelling. Reason for an impounding basin is to let the spilled LNG vaporize under control on one spot and prevent that the LNG streams away to other areas or into the nearby canal. To avoid water contact we have to care that water from rain and condensed water from the vaporizer will be removed by periodically opening valves.

3.2.2 Boil off

In spite of the double walled vacuum isolated container, there will be some vaporizing, special when the LNG is not refreshed by new loads. This will cause a higher pressure of some bars. At the level of 10 bars the gas will be captured in a blow down vessel outside by an automatic overrun system. This gas will be compressed after a while and stored in CNG bottles for application in CNG driven cars. In case this system is overruled in whatever way and the pressure rise comes over 19 bars the boil off is vented into the atmosphere as an ultimate safety feature. In general it is not expected that there will be any boil off considering the amount of LNG turnover.

3.2.3 CNG storage

Having some gas as CNG from the boil off source, we think its wise to produce more CNG as a regular fuel for some CNG vehicles, for those vehicles are needed for boil off consumption, but will

be poorly supplied if this would be the only source. So the LNG is pumped through a heat exchanger, designed to produce sufficient gas under pressure (300 bars) for storage in CNG bottles. Gas-quality will be much better than the common L-gas, so the cars are estimated to drive 25% longer range. Problem is the absence of odorant. Since odorant is not applicable in the cold LNG, it could be added separately afterwards into the CNG. But since odorant is an aggressive chemical well used in large systems to be injected into the gas, we judge the application on this very small scale not opportune. When one drop of this chemical would be spilled, the whole environment gets the feeling that they should be evacuated by recognizing this smell making believe a tremendous gas leakage. To prevent uncontrolled gas leakage from CNG cars or storage, there will be methane detectors inside the parking garages and storage building.

3.2.4 External safety distances

In case of an emergency, during fuelling, loading or whatever event, the influence on nearby people in surrounding factories, facilities or dwellings should not be exposed over a chance of 1 to 1 million to be a casualty as a group or individual.

For this reason we hired an engineering's bureau familiar in this matter, to make the calculations considering that we have safety features as flow limiting valves and stop leakage valves a.t.l. to prevent longer flows than 7 seconds of LNG in case of leakage. Also the CNG storage and refuelling is taken into account.

The result in this case is that the external distance is 55 meters. The Oss administration added to this that neighbours could build facilities against their site boundaries, meaning that this distance should be completely available on our own site, what was not a problem in this case.

(Compared to LPG there is a rule for external distance of 85 meters, gasoline and diesel about 25 meters and unofficially CNG is 15 meters!) Due to lack of officially determined external distances for LNG (as well as CNG) a calculation will be needed in any new case. The Dutch administration happens to be in a program to establish all external safety distances, which are not settled yet, so we hope this might match with our starting-point. The Oss administration couldn't judge the outcome of the so called QRA (Quantitative Risk Analyses) and consulted another engineering's bureau for help. It took some time to match the conceptions. Anyway a direct contact between both bureaus is a necessity.

3.3 Construction

Besides fulfilling the nuisance act and the environmental requirements, we have also to apply for a building-license. To start that procedure, you first have to wait for a positive result for the first mentioned combination. This license controls the composition and styling of the construction in relation to surroundings.

4. LEGAL ASPECTS FOR TRUCKS

In this chapter is described how progress is made for having the LNG equipment on the truck licensed. As earlier said: everything is forbidden what is not allowed, implicates that you have to win an approval for using unknown unauthorized equipment needed on the trucks in order to drive them safely and legal on the road. Since LNG equipment is not yet applied on vehicles in The Netherlands, you go to the competent national authority RDW for discussing the possibilities. First reaction was like; there is already CNG, isn't that difficult enough? So, how serious is this? After some discussion they start asking documents from elsewhere, and after this again other documents. Even with the aid of truck dealer contacts it seems to be hard to make decisions based on all the facts from the suppliers and applicants from other countries. We still have no official paper showing that there is a kind of license, but we are allowed to equip the first trucks with an international applied type of LNG tank. Besides one or two tanks there is a vaporizer present on the truck, controlled by the gas handle. Trucks could stand still for several days without boil off problems, but then should the gas either used or vented. For parking garages and repairshops, a draft regulation is written based on the existing regulation for CNG cars.

RDW demands for larger scale application that an official regulation is made. Since The Netherlands is the fifth country in new Europe with LNG application, would this be attainable.

5. COMMON MISCONCEPTIONS

In order to make the start of such a project more achievable, we applied for subsidy at a newly established national framework called UKR. This Unique chances arrangement was made specially for all projects dealing with fuels to promote more efficiency and sustainability related to CO2 production.

Out of 20 applicants we were recognised and rewarded with 11th position; however there was only money for the first seven! Among them three CNG projects with buses.

The UKR was said to be very keen on projects with a high degree of self employment after a single support and should differ from the usual course.

So we thought that our LNG project would fit perfectly in those demands. No wonder that we were very surprised to learn that we ended lower then the busprojects special for the above mentioned reasons and the given motivation. That made clear what kind of misconceptions you have to cope with in general:

1. Isn't it better to use CNG in the trucks? LNG costs a lot of extra energy for the deep cooling, so will there be CO2 advantage left for the whole chain?
 2. Are you aware of the safety implications
 3. Prices of LNG are so high that in case of fuel taxation this fuel might lead to a non financial viability
- *Concern 1:* CNG is of course not a proper fuel for long range trucks; not supposed to refuel every 300 km and claiming 4 times more infrastructure then. So the most relevant concern is, if LNG is still better then the fuel to be replaced: diesel? The table below makes clear that refining oil or cooling to LNG costs about the same energy as well as the vessel transport does. So the tank to wheel advantage for LNG compared to diesel is not affected. Actually transport of LNG is even better then oil regarding that the carrier fuel will be LNG. CNG is some better then LNG and should be corrected in volume since we compare with L-gas.

	Production	Transport	Compression
Diesel	7-8%	2%	-
LNG	7%	2%	-
CNG (H-gas equiv.)	-	1%	2,5-5%

Table 1. Comparison of energy consumption in % due to Well to Wheel analyses for CO2.

- *Concern 2:* Awareness is self-evident there as our transport company happen to be a company with 5000 trucks all over Europe where transporting all kinds of chemicals is common business and where the fuelling station initiator has a main business in LNG tankers over the road in Spain. Besides that, all investigations and calculations are done and checked by independent engineering bureau's.
- *Concern 3:* Worrying about viability for tax reasons is only necessary if there is a clear view about tax levels, which are fully unknown for natural gas at the moment. Right now there is even a consensus growing that for CNG there will be a tax exemption for more years and the level will be carefully guided for CNG; isn't it obvious that there is no reason for another regime for LNG. Anyway, a tax on current LPG level was already taken into account, so we don't worry.

6. CONCLUSIONS

NG will be more and more important in a liquefied condition all over the world, since oil production reached peak level and the need for transportable energy is growing. In many cases LNG has to come from remote (>4000 km) and/or overseas countries and could be shipped more cheap and easier rather than piping of the gas. Natural gas is already used for heating, cooking and power-generation purposes, but since air quality and oil independency are today's issues, natural gas is more and more used as a vehicle fuel.

Application in long range trucks does really matter, if it comes to saving substantial amounts of CO2, not mentioning all other emission savings, for instance in comparison with other vehicle sectors. Most obvious for LNG could be another diesel consumer as buses. Local and regional buses could go easy on this fuel due to range. But comparing fuel market share of buses and long range trucks we find a ratio of 1 : 30 ! This means that important changes in the global emission of CO2 are made by opening the truck market for LNG.

If you want to introduce LNG as a vehicle fuel in your country, learn from the experience of companies in this field who are practising for a long time, like we did. Collect local regulations and see what is applicable under your circumstances and share your knowledge with the authorities to familiarize the subject. We use less mileage costs as a driver in the first place, to help economy growing and get better environment as a free gift for your beloved people for they will surely need this.

Finally it is our common concern to organize growth in this sector; if you want to make a start we are prepared to help you but your input is important then in achieving goals like common European acts on LNG by participating in working-groups. Together we can make it!

7. PROSPECT

With respect to our subsidy application we can tell that this year the UKR is extended, in spite of the initial planning to stop. So we apply once more and see if we spread around enough information to show the importance of this approach more clearly. However if the project would be rejected again, we still proceed with the station but in a slower pace. So I hope to tell and show you in June what we established.

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APPENDIX 1

LIST OF ABBREVIATIONS

NGV =	Natural Gas Vehicle
CNG =	Compressed Natural Gas
IGU =	International Gas Union
OEM =	Original Equipment Manufacturer
LEL =	Lower Explosive Limit
LPG =	Liquefied Petroleum Gas
LNG =	Liquefied Natural Gas: also extremely suitable for NGV's due to less storage space on board; giving 3,5 x more range.
LCNG =	Liquid & Compressed Natural Gas: LNG is the base energy in the station where by vaporizing natural gas under pressure is made without a compressor. Such stations deliver both LNG and CNG.
H-Gas =	High Caloric Gas
L-Gas =	Low Caloric Gas
VAT =	Value Added Tax
M m ³ =	Million cubic metres
IANGV=	International Association for Natural Gas Vehicles
ENGVA =	European Natural Gas Vehicle Association
Quick-fill =	refuelling in same timeframe as gasoline and diesel.
Slow fill =	over several hours i.e. at night; capacity might vary from small home appliances for private cars to huge compressors serving complete bus-fleets overnight.