Facilitating LNG Application in Landlocked Europe: An Overview of Potentials and Challenges

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Abstract

The importance of natural gas as primary energy carrier is constantly increasing. In this context there is rising interest for LNG, Liquefied Natural Gas. The usage of LNG as fuel for marine and inland navigation and as road fuel is very promising. Furthermore, LNG can be used for industrial applications. In this context, small scale applications of LNG are getting popular. Smaller liquefaction capacities, smaller tankers and vessels distributing LNG and smaller storage and regasification facilities allow the widespread usage of LNG.

Nevertheless, there are some hurdles to be overcome to implement LNG extensively. The biggest barrier corresponds to the often-quoted chicken-and-egg-problem. Infrastructure for LNG technology is not very well developed at the moment, e.g. there are few LNG refueling stations. This can especially be seen in Central Europe. Potential consumers are restricted in the use of LNG therefore and they cannot prove their demand. But without demand, infrastructure will not be provided. Currently, there are a lot of initiatives and projects in order to break this vicious circle. For example, the European Commission requires and supports the construction of LNG bunker stations in all sea and inland ports along the Trans-European Network for Transport (TEN-T) as well as the placement of LNG refueling stations all over this transport network.

However, almost all of these programs refer to coastal areas. LNG application is already quite well known and common in countries like Spain, U.K., France, Belgium, Italy or Portugal. In contrast to this, the aim of this paper is to present the first findings of the evaluation of LNG potential in landlocked regions of Europe. This potential could be exploited by distributing LNG along the Rhine-Main-Danube axis to Central Europe as LNG is ideally suited for being transported by vessel. Benefits and opportunities of LNG usage in this territory should be demonstrated as well as challenges and threats. Hence an extensive literature research has been carried out as a first step. Further research comprises the assessment of different supply chain scenarios and an initial demand survey.

The results of the research study are strongly in favor of LNG application. LNG is not only providing ecological advantages but also economic ones. The ecological benefits are apparent as LNG is able to reduce air pollution and greenhouse gas emissions because it causes about 20%

less CO_2, 80-90% less NO_x and almost zero PM and SO_x. Economic merits include the diversification of the energy mix which leads to a reduction of the gas monopoly power. Nevertheless there are also several obstacles identified which inhibit the dissemination of LNG such as the above mentioned missing infrastructure for LNG. Furthermore there are also regulatory barriers. At present, LNG is classified as dangerous good and there is a separate permission needed to transport it on inland waterways therefore. On the whole, the necessary framework needs to be created urgently to break with the chicken-and-egg-situation described above and to enable Central European regions to participate in and profit from the high potential of LNG applications.

Keywords: LNG, alternative fuels, Central Europe, emissions reduction

1 Problem and Methodology

LNG application is no new phenomenon. The convenience of shrinking the volume of natural gas 600 times by cooling it to about -162°C/-260°F for the purpose of converting it to a liquid form was exploited as early as the 1940s. The first liquefaction plant has already been built in 1941 in Cleveland/Ohio (USA). The UK acted as a pioneer in 1964 by concluding the first commercial LNG deal with Algeria. Since then, LNG is considered to be worldwide accepted in the energy markets [1]. It is remarkable that in 2012, one third of the worldwide traded natural gas volumes took place in the form of LNG [2].

The main reason why natural gas has originally been converted into liquid form was because this allows a comfortable distribution of this energy carrier by all means of transport, especially by sea to travel long distances. Recently, also the usage of LNG as marine fuel or road fuel for heavy duty vehicles becomes popular. A strong argument in favor of LNG as a fuel is its environmental friendliness. Compared to other fuels like diesel, it causes about 20% less CO_2, 80-90% less NO_x and almost zero PM and SO_x [3] [4]. There is also the possibility to use liquefied biogas (LBG) or renewable LNG (rLNG) which consists of bio-methane, e.g. available from landfills or sewage plants, to further reduce emissions [5].
It should be mentioned that there are also economic advantages connected with LNG. Although there are rather high investment costs for implementing LNG, the operational costs are quite low and initial CAPEX can amortize thus [6]. On the other hand, LNG is suitable to diversify a country's energy mix and hence reduce unilateral dependencies on exports. To receive LNG, no gas pipeline connection is needed, therefore it can be delivered from anywhere in the world, which leads to a competitive gas market where the prices are usually lower than in a monopoly or a near-monopoly situation [7] [8] [9].

As the preceding explanations have shown, there are quite a number of benefits associated with the application of LNG. Several users have already recognized this and act as pioneer users in this field. Some successful pilot projects include the well-known parcel delivering company UPS which is operating 112 LNG trucks currently in the USA and planning to expand this fleet to 800 vehicles by the end of 2014 [10]. A Polish municipal transport provider also invested in 31 LNG fuelled buses because of the acute problem of exhaust emissions in Krakow [11]. The U.S. company Waste Management illustrates the manifold application possibilities of LNG vehicles, they own about 500 LNG fuelled garbage trucks [12].

Unfortunately, in some regions there are severe obstacles which impede fleet operators from introducing LNG and keep them from benefitting from the above mentioned advantages. The

main reason for this is simply that the necessary infrastructure is missing there. The Natural Gas Vehicle Association (NGVA) has surveyed natural gas and LNG refueling stations in 83 countries worldwide. The alarming result is that only in 13 of these 83 countries LNG refueling stations are positioned [13]. Figure 1 shows the number and location of European LNG and L-CNG refueling stations.

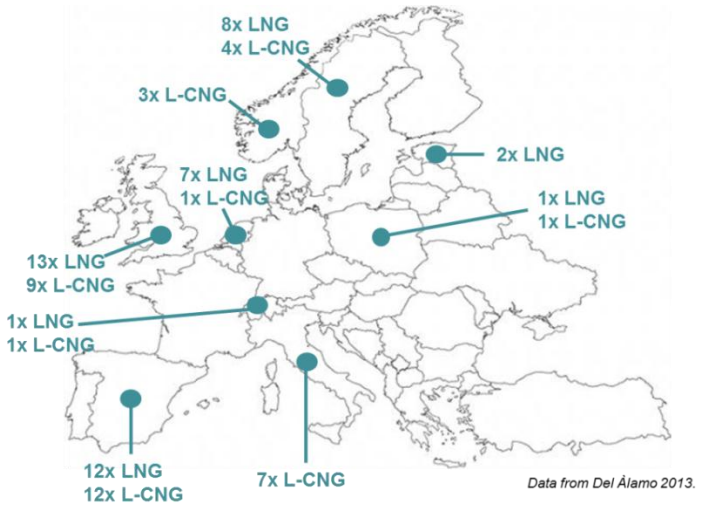

Figure 1: LNG and L-CNG refueling stations in Europe

The map explicitly shows that though there are already several LNG refueling stations existing in Europe, they are almost exclusively located in countries with access to the sea. In landlocked countries like Austria, there is no LNG infrastructure placed.
Besides, Figure 2 shows the amount of European LNG imports. Again, it can be seen that only coastal countries of Europe are depicted.

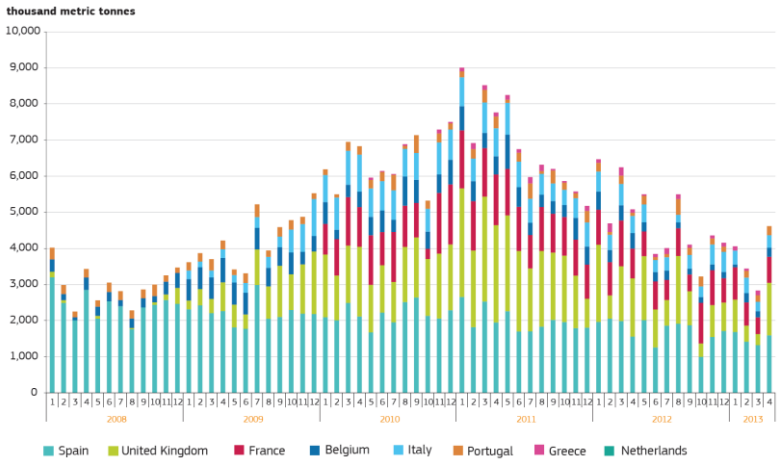

Figure 2: LNG imports in European countries [14]

The aim of this paper is therefore to examine the potential and challenges associated with LNG application in landlocked regions of Europe. For this purpose, the state of Austria will be taken as an example. The applied approach is based on a diligent analysis of the two basic market forces which determine the allocation of a commodity like LNG: supply and demand. The development of these market forces in landlocked Europe is currently characterized by a chicken-and-egg situation. On the one hand, potential customers do not show any demand because there is no infrastructure for using LNG. On the other hand, there is no supply for the necessary infrastructure and for the commodity LNG because there is no sign of demand.
Thus, the methodology used is on the one hand extensive desk research to evaluate possible supply scenarios for Austria. On the other hand, the methodology consists of the accomplishment of semi-structured interviews with companies that have been defined as possible pioneer customers in Austria to analyse the actual demand. The consolidation of this gained information should allow conclusions about the underlying potential of LNG implementation in landlocked Europe.

2 Results

2.1 Analysis of Supply

LNG technology is no rocket science and as mentioned in the introduction, it is already established and proven for a number of decades. The related problem is rather how to distribute LNG and ensure security of supply. Frequently, LNG is regasified and fed into the local pipelines after being shipped to the import terminals. However, in case of using LNG as a fuel, it does not make sense to regasify LNG to liquefy it again later on. Therefore, LNG will be kept in its liquid state and distributed this way. This is no problem for most of the countries where LNG refueling stations already exist (Figure 1) because these coastal countries have easy access to large LNG import terminals. Nevertheless, the situation is quite challenging for landlocked countries like Austria. The nearest LNG terminals are the Gate terminal in Rotterdam/the Netherlands and the Fluxys terminal in Zeebrugge/Belgium, but the distance to both terminals is about 1,000 km from central Austria.

A development which facilitates solving this issue is the trend towards small scale applications. Previously, only the large scale section of the LNG value chain has been focused which includes large liquefying facilities in the export countries, the transport of LNG in huge ocean-going tankers and subsequently the regasification of LNG at the place of destination. In contrast to this, so called small scale LNG projects are emphasized recently. These projects comprise small liquefaction plants, whereby a capacity of less than 0.68 Mtoe per year is considered to be small scale [15]. Furthermore, LNG gets transshipped from large tankers to smaller vessels and trucks, which is also called “breaking bulk”. The storage of LNG as well proceeds in smaller units, so called satellite stations. The small scale market is quite new and still in a stage of development [16] [17] [18].

Now, how can landlocked countries like Austria benefit from this advancement to small scale projects? The positive impact is that distributed LNG volumes become smaller which makes it practical to distribute limited amounts of LNG to remote customers like fleet owners in Austria. For example, a truck can be chartered to carry several tons of LNG to a refueling station in a landlocked area. Which supply chain scenarios in detail become possible is illustrated in Figure 3.

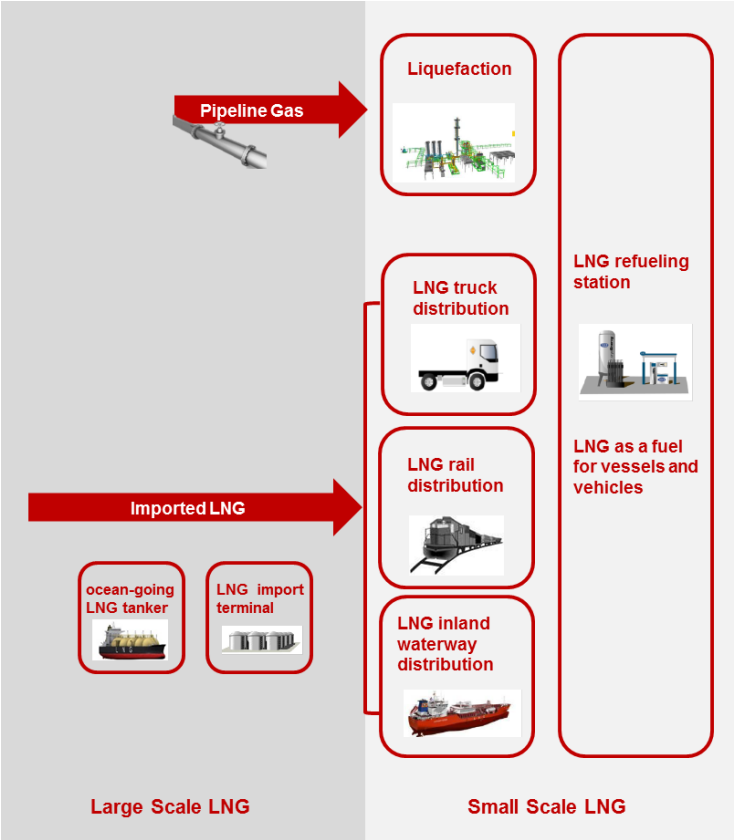

Figure 3: Supply chain scenarios for landlocked Europe (images: Shell)

There are two basic possibilities how to supply an LNG refueling station. The first is to use pipeline gas to produce own LNG, the second is to purchase LNG at an import terminal and transport it to the place of consumption.

The first option might certainly be interesting if the procurement routes for LNG are very long and transportation costs hamper profitability. Anyway it has to be said that a liquefier is the most expensive and most complicated part of the supply chain. Sometimes it is stated that small liquefiers are less efficient than larger ones [19]. Of course there also needs to be excellent access to the natural gas pipelines, but also other sources of gas could be used for this purpose like landfills or sewage plants. Liquefiers can be delivered in a modular design and readily be installed and tested. On the whole, it can be said that producing own LNG presents a significant opportunity to ensure autonomous LNG supply but is probably not advisable for newcomers in the LNG business. There are high investments necessary but in the end it will bring a lot of flexibility.

To establish oneself in LNG application, it might rather be useful to arrange the transport of LNG from an import terminal to the hinterland. For this purpose, there are three possible means of transport, namely by truck, by train or by inland waterway vessel. LNG from the import terminals will most likely come from the largest countries exporting LNG which are definitely Qatar, Malaysia and Australia. For Europe, Algeria and Nigeria are also very important supplying countries [20] [21].

Truck transports are environmentally and economically feasible only for limited distances. Anyway, it is currently the easiest and most viable possibility to transport LNG. Almost any transport service provider offers shipping LNG by truck, the prices for these transport services vary between 11 €/MWh and 14 €/MWh. Road transport is very convenient because the trucks can be directly loaded at the respective LNG terminal and drive straight away to their destination. Either tank trucks or specific ISO containers with tractor units can be used for this. The service of truck loading is possible at LNG terminals in Belgium, the Netherlands, France, Portugal and Spain. Some other terminals, e.g. in Italy, are discussing this possibility at the moment [22].

Second, it is also possible to transport LNG by rail. In Japan, this economic and ecological mode of transport regarding LNG is already very common, much more than in Europe [1]. For large volumes, this is certainly the better solution compared to trucks. However, the supply chain becomes more complex in this case. At Gate and Fluxys terminal, there is no access to rail tracks and there is also no other LNG terminal offering rail loading in Europe at present [22]. For this reason, LNG has to be first transported by truck and then reloaded to the train. A rail container terminal which features the necessary expertise in handling dangerous goods like LNG is located in Moerdijk/the Netherlands which is about 40 km away from the Gate terminal in Rotterdam and 150 km away from the Fluxys terminal in Zeebrugge. Of course, the extra transshipment to allow transportation by rail is inconvenient and costly. Hence, rail loading will only pay off if a block train and not just single wagons are used. Like with truck loading, either tank wagons or ISO containers could be theoretically used, though an appropriate tank wagon is only just being developed at the moment by VTG. These new rail tank cars should be available by the end of 2014 and will innovate European LNG rail transports [23].

Finally, there is also the option to transport LNG on inland waterways. This is certainly the most sustainable way of moving LNG. The Rhine-Main-Danube-axis connects the landlocked countries of Central Europe with the North Sea on the one hand and the Black Sea on the other hand. For the purpose of shipping LNG on vessels, the LNG terminals need to offer reloading or transshipment. Transshipment is the direct transfer of LNG from one vessel into another. A lot of terminals currently offer or consider reloading LNG into vessels but only two terminals, Montoir de Bretagne (France) and Cartagena (Spain), offer transshipment presently [22]. Unfortunately, transport service providers are actually restricted in offering this solution because of legal issues. This is because the European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways (ADN) forbids the transport of LNG via inland waterway tankers at this time. Furthermore, European law prohibits LNG as a fuel for inland vessels at present because it has a flashpoint lower than 55 °C (the flashpoint of LNG is just about -187 °C). Nevertheless, there are three barges operating successfully with a certification of exemption between Rotterdam and Basel [3] [24] [25]. Moreover, several freight forwarders announced that they would offer inland waterway transports in the future when the regulatory issues would be clarified. An important EU-project called “LNG Masterplan for Rhine-Main-Danube” recently also focuses on facilitating the transportation of LNG on the Rhine-Main-Danube axis. The LNG Masterplan is an on-going project which will deliver a set of feasibility studies, technical concepts and pilot deployments of terminals and vessels [26] [27].

2.2 Analysis of Demand

The second market force which inevitably determines the potential of LNG in landlocked Europe is demand. In order to examine demand for LNG, dedicated semi-structured interviews have been

conducted with a representative number of Austrian logistics service providers and other companies with comprehensive transport activities. The sample consists of ten fleet managers and commodity managers of the five largest trucking companies in Upper Austria, a waste collection company, two construction companies with large fleets to distribute their construction material, the transport and logistics division of a significant retailing company and a public transport operator. Thus, a very diverse compilation of interview partners has been selected which makes it possible to analyze very different fields of application of LNG as a fuel, i.e. for conventional trucks, garbage trucks, public buses,… The semi-structured interview type has been chosen because on the one hand it allows to constitute the basic framework of the study by asking each company the same key questions, and on the other hand the respondents are not bound to any answering possibilities so that they can answer frankly and contribute new aspects to the interview.

Interestingly, LNG as a fuel was no completely new issue for some of the interviewed companies although there is no LNG infrastructure at all existing in Austria at the moment. For example, one logistics service provider already conducted a detailed evaluation of several alternative fuelling possibilities. This study also included LNG. Another logistics service provider also carefully examined the opportunity of introducing LNG, the reason for this was that an LNG truck awakened the interest of the responsible fleet manager at a vehicle exhibition. A third Austrian transport company is also assessing the acquisition of LNG fuelled trucks at this time since their customer required them in an audit to do so. However, the response of most of the companies was that they have just heard of LNG but they never considered it as a feasible fuel option for their fleet, in rare cases LNG was even completely unknown.

To summarize the main findings of the interviews, it can be stated that interest for LNG as a fuel definitely exists in Upper Austria, but unfortunately there are still several barriers which are hampering this interest recently. This is evident since two of three companies which already extensively considered the introduction of LNG came to the conclusion that LNG is no viable fuelling possibility for them, at least at present. The remaining fleet owners (which have heard of LNG but didn't assess it in detail) were predominantly open-minded about LNG. Just one responded that LNG is no option at all for them because it is still a fossil fuel and they absolutely prefer renewable energies. Nevertheless, this company claimed that they would be interested in Bio-LNG anyway. The interviewed waste collection company was also susceptible to the issue of Bio-LNG which is very promising because they own several landfills and could function as a supplier for Bio-LNG.

Regarding the reasons why the companies would be willing to switch to LNG as a fuel, the typical economic and ecological advantages have been mentioned most of the time. As it has already been described in the introduction, LNG is cheaper and environmentally friendlier compared to other fuels like diesel. The interview partners also stated other reasons like the intention to look for alternative fuels in order to ensure security of supply or to comply with legislation like emission regulations.

An important part of the research was furthermore to detect the conditions which must be fulfilled to make LNG an attractive alternative fuel. A lot of requirements could be revealed which could hamper LNG application in Austria seriously. Above all, the already quoted problem of missing infrastructure is an obstacle. Anyway, the financial matters are equally important. This means that switching to LNG has to pay off on the whole for the fleet owners. At present, investment costs for LNG technology are significantly more expensive than for example for diesel. This higher capital expenditures need to amortize to make LNG an applicable option. It can be concluded that subsidies will be necessary to ensure certainty of investment for the first

pioneer customers. After some time, when the production volumes of LNG trucks etc. are probably rising, this problem will not be as severe anymore.
It is also important that there is technically mature equipment available on the market. One of the trucking companies which already evaluated LNG had the impression that the truck manufacturer was not ready to meet the requirements of the markets some months ago. But also questions concerning the operation of the trucks are unsettling potential pioneer users. Some of them know about the boil-off-gas issue and are not sure if this could lead to serious troubles. Additionally, they have no experience in terms of maintenance of LNG fuelled vehicles.
Finally, also legal issues worry the interviewed companies. They are aware that the legal framework is still unresolved and require that the EU provides harmonized, coherent regulations related to LNG for all member states.

Basically, it can be assumed that there will be demand for several LNG pilot vehicles initially. After LNG technology gained wide acceptance as the pilot projects were successful, there will certainly be more potential and demand will gradually rise.

3 Conclusion

LNG is a promising alternative fuel for road vehicles as well as for marine vessels. It has been shown that LNG application yields a number of benefits, economic ones as well as ecological ones. Unfortunately, the landlocked regions of Europe are restricted in the use of LNG because they do not have access to the necessary infrastructure. LNG import terminals are located by the seaside, and also LNG refueling stations are rather stationed in those countries where there are import terminals.

The reason for the missing infrastructure in landlocked Europe is that a chicken-and-egg situation is dominating this area. Potential users do not show any demand because there is no infrastructure available. Reversely, infrastructure is not created because there is no demand signalized. To counteract this deficiency, the present paper analyzes the potential and the challenges bound up with LNG introduction in landlocked Europe. For this purpose, the two main market forces have been examined, namely supply and demand. The country of Austria is taken as an example for this.

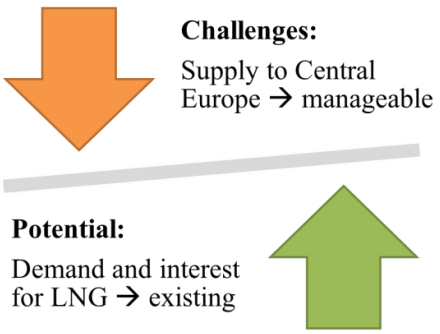

Figure 4: LNG application in landlocked Europe

The results are predominantly in favor of establishing LNG there. The supply analysis emphasized that there are several ways how LNG could be distributed to landlocked regions like

Austria. Presently, transporting LNG by truck is the most convenient and viable way. This is because it allows flexibility and is easy to establish in a first step. Later on, other transport modes will certainly be more economic, namely to distribute LNG by rail or on inland waterways. However, the conditions to put these transport options in place have still to be met. For example, suitable rail tanks to carry large volumes of LNG economically at one time are currently being developed. Moreover, some legal issues have to be clarified to facilitate the shipping of LNG on inland waterways. The paradigm change from large scale LNG to small scale applications further promotes LNG supply to landlocked regions as smaller amounts of this commodity can be distributed now.

The results of the demand analysis are also encouraging the introduction of LNG as a fuel in landlocked Europe. The interviewed companies in Austria mainly showed dedicated interest for LNG as an alternative fuelling option. Despite this, it has to be pointed out instantly that there are several requirements which must be fulfilled to encounter this demand. Apparently, the obligatory infrastructure must be provided to enable the fleet owners pursuing their interest in LNG. Above all, LNG application also has to pay off financially. The ecological advantages are fine but it is still necessary that the investments amortize. Some other conditions have been mentioned as well like legal concerns or issues regarding the operation of the vehicles.

On the whole, it can be said that LNG has potential in landlocked Europe. The first steps to implement it as a fuel have already been taken. Anyhow, there will be still a long way to go to fully establish it as a feasible fuel option there.

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