Interreg

Danube Transnational Programme

DAPhNE

LNG as cargo in the Danube ports

D.5.4.2

Work Package 5

Activity 5.4

PDI

[Date: 29/06/2018]

[Version Final 1.0]

Project co-funded by European Union funds (ERDF, IPA)

Document History

Version	Date	Authorised
Draft 01	06.02.2018	
Draft 02	04.05.2018	
Draft 03	18.05.2018	
Draft 04	26.06.2018	
Final 1.0	29.06.2018	

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1 Executive Summary

At a time where the transport sector in Europe represents almost a quarter of greenhouse gas emissions and is highly depending on oil with 94%, natural gas in a liquefied state of matter and as the most environmentally friendly fossil energy source, which can be used as fuel can bring improvements for the European transport sector. Moreover, as an alternative in the supply chain of natural gas, it can also increase the supply security of the important energy carrier in general. Therefore, in order to gain new and innovative market opportunities for inland ports in the Danube Region, the DAPhNE project is investigating in the fields of the upcoming alternative fuel Liquefied Natural Gas (LNG) as cargo.

Worldwide trends show that natural gas usage grows strongly including continuing expansion of supplies by liquefied natural gas (LNG), which is also increasing the global availability of natural gas. In Europe, LNG will make the gas market more flexible: it can be traded on spot-markets and is in competition with the existing long-term contracts of the pipeline gas. The general situation on the natural gas market in Europe is, that domestic gas production is set to roughly halve over the Outlook (BP Energy Outlook 2018) causing the share of imported gas in total consumption to increase from around half in 2016 to three-quarters by 2040.

Furthermore, for the future development, it is also important that LNG will get an “bio” component in the future and production of liquefied bio-gas (LBG) will become the state of the art. LBG produced from bio-gas can improve the CO2 performance in the transport sector significantly (up to 80 percent compared to diesel). Based on those performances LBG can help to increase the politic support on national, regional as well as on European level. (The share of renewables in the European energy mix continues and should be 27% in 2030 according to the plans for the upcoming Renewable Energy Directive II.)

For these eco-political reasons, measures have to be taken on different levels: public funding opportunities and financing support for fleet owners and investors in infrastructure, political support and stricter environmental regulations on European as well as on national level for polluting fuels in order to facilitate LNG/LBG. Moreover, education & training as well as research in the field of LNG technologies should be even more promoted on country level and promoted to the general public as well as to fleet owners.

There are already some projects ongoing in the Danube Region (development of infrastructure in Germany, Austria, Slovakia, Hungary, Bulgaria, Rumania, etc.), in order to meet the requirements of EU Directive 2014/94/EU "on the deployment of alternative fuels infra-structure". As an example, for a good integration into the regular business of ports, the port of Enns (Ennshafen) has started to develop LNG infrastructure on their property together with a regional gas provider as partner. Based on the built-up of infrastructure (storage and

fuelling station for trucks) it is envisaged to make further steps into bunkering of inland vessels and becoming a hub for LNG cargo traded in the Danube region.

The dynamic worldwide market development and the ongoing actions taken in various regions of Europe let expect, an increase of LNG equipment produced worldwide, which will decrease the unit costs from the currently relatively high production costs. In addition to the expected stronger competition in LNG/LBG supply, the economies of scale for cryogenic equipment will widen the market potentials for LNG as a transport fuel as well as a cargo for inland waterway transportation.

Finally, on the one hand both the European road transportation sector and the inland navigation sector will make steps forward in the right direction for a more environmental friendly transport industry and on the other hand, supply diversity and flexibility of natural gas will be increased with LNG deployment. However, the timing and speed of implementation in single countries will strongly depend on European as well on national alternative fuel supportive policies together with targeted deployment projects.

2 Introduction

At the present times the transport sector in Europe represents almost a quarter of greenhouse gas emissions and the transport sector is moreover highly depending on oil with 94%. Between 1990 and 2015 greenhouse gas emissions were slightly decreasing in general, though in the transport sector they were increasing with approximately 16% during the same period. Therefore, it is important to identify and focus on alternatives for the European transport systems, such as the usage of natural gas as transport fuel, to reduce dependencies as well as air emissions. In line with EU policies, Danube countries have started to push towards achieving a low carbon economy.

In order to use natural gas as fuel it has to be compressed to CNG (1:200 volume reduction) or liquefied to LNG (1:600); The liquid state of matter of natural gas makes it possible to transport relatively large quantities by conventional transport methods and to use it as a fuel for transportation. In addition, to use LNG as competitive fuel, an economically viable, comprehensive infrastructure including reliable supply chains have to be deployed. For this purpose, various projects are being developed, which have the common goal of implementing LNG in the European fuel and energy sector. All EU member states had to develop a national "alternative fuels roadmap" to meet the EU Directive 2014/94/EU "on the deployment of alternative fuels infrastructure". Moreover, the EU aims to integrate LNG in the energy supply within the "Sustainable Energy Security Package" and as part of the "EU strategy for liquefied natural gas and gas storage". However, not all countries implemented explicit measures for LNG development yet.

To gain new and innovative market opportunities, the DAPhNE project will investigate in the fields of the upcoming alternative fuel Liquefied Natural Gas (LNG).

Liquefied Natural Gas is a clear, non-corrosive, non-toxic, cryogenic (-162 °C) liquid at normal atmospheric pressure, moreover, it is, same as natural gas, odourless so that's the reason why odorants must be added to methane. LNG is only flammable if, following evaporation, it comes into contact with an ignition source and the level of gas in the air is between 5% and 15%. Moreover, Natural gas is the most environmentally friendly fossil energy source, for energy production as well as for the usage as fuel in liquid state of matter for trucks, vessels as well as for locomotives.

According to the European Commission, LNG can also contribute to mitigate supply crisis problems in Europe and reduce the dependency on pipeline gas supply from Russia, with "additional spot cargoes delivered to the closest terminal" to the affected countries. Those spot cargoes should be transported most economical and efficient in order to find acceptance in the demand market, which is a good basis for the Danube Ports and inland waterborne transport in order to position themselves as hubs for efficient LNG logistics in the Danube Region.

Within this report a status quo and trend analysis regarding LNG in the Danube Region will be made, as well as specific conditions for ports to be prepared for the new market, will be elaborated. The potential integration of Danube ports into the value network of small scale LNG infrastructure and the benefits of further usage of LNG as transport fuel, will be highlighted particularly.

3 Background Information

In the following chapter the status quo of LNG and worldwide trends as well as the European development, supply and demand analysis for the Danube Region and future market opportunities of LNG will be described.

3.1 Status Quo and Trend Analysis

In the following the status quo of LNG development and interesting market trends for the future in the LNG market on worldwide, European as well as regional level are illustrated.

Worldwide natural gas usage grows strongly, supported by broad-based demand, strong increases in low-cost supplies, and continuing expansion of supplies of liquefied natural gas (LNG) increasing the availability of gas globally. The constant increase of the natural gas trading in the future can be seen in the following Figure 1 which was done by BP for their yearly published "Energy Outlook" in 2018. LNG exports are dominated by the US and Qatar, which account for almost half of global LNG exports by 2040. But substantial increases are also projected in Australia, as existing projects are completed, in Russia and in East and West Africa.

Europe remains a key market for natural gas provider, both as a potential market for surplus LNG cargo and as a key hub of gas-on-gas competition between LNG and pipeline gas.

The mobility of LNG cargo and their ability to be diverted in response to price signals causes the gas market to become increasingly integrated, with movements in global gas prices becoming more synchronized. The easy movable gas, which can be traded on spot-markets is in competition with the existing long-term contracts of the pipeline gas. Thereby the gas market becomes more flexible (20 % of the global LNG is traded on the spot-market and in short-term contracts), if LNG can be transported and traded as cargo within Europe. [1] [2]

In the Danube Region the experiences gained in the LNG Masterplan for Rhine-Main-Danube flagship project (TEN-T 2013-2015) opened up the way for several other ambitious projects within the region meant to close up the gap in the small-scale LNG supply chains. There are numerous challenges to be dealt with when promoting the use of natural gas (liquefied or compressed) as a fuel and as cargo, but Austria, Slovakia, Hungary, Bulgaria and Romania are

[1] Energy Security and Natural Gas Markets in Europe (Tim Boersma)
[2] Energy Outlook 2018, BP

making important steps in this direction (relevant projects are listed in chapter 0) in line with the Directive 2014/94/EU on the deployment of alternative fuels infrastructure.

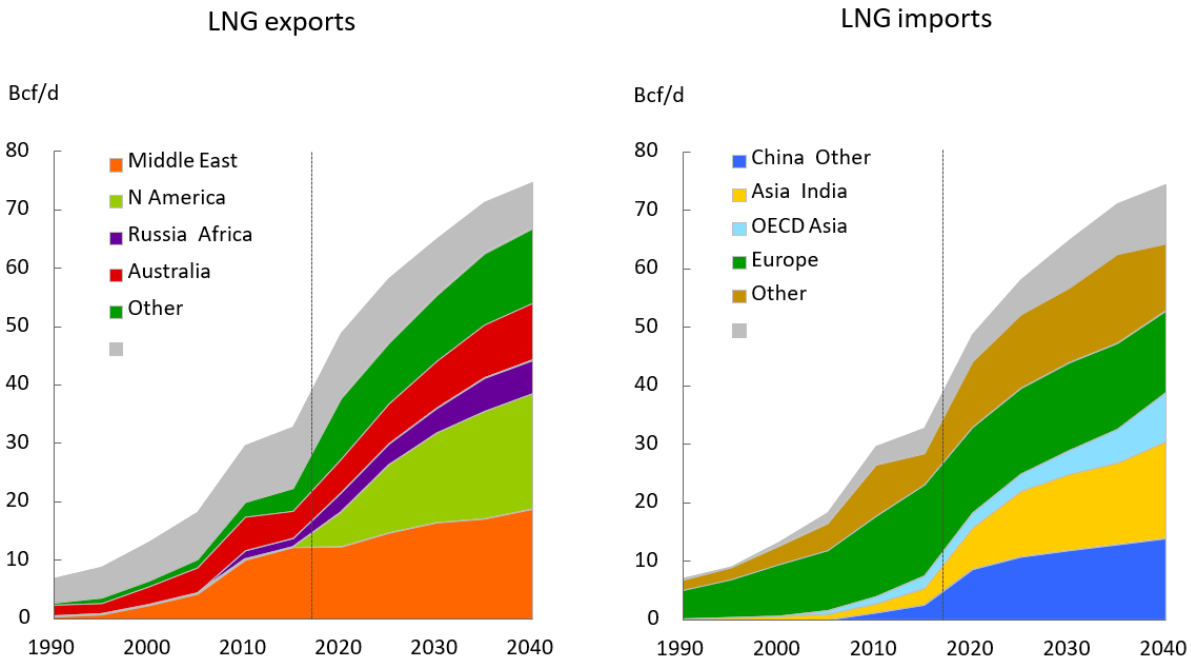

Figure 1: LNG Supply & Demand
Source: BP, 2018

Another interesting fact on the trend of LNG is, that the sustainable growth in global LNG supplies significantly increases the availability of gas around the world (also in European Regions with limited dense network of gas grids), with LNG volumes overtaking interregional pipeline shipments in the early 2020s.

The general situation on the natural gas market in Europe is, that domestic gas production is set to roughly halve over the BP Energy Outlook 2018 causing the share of imported gas in total consumption to increase from around half in 2016 to three-quarters by 2040. In the ET scenario (Evolving Transition scenario: assumes that government policies, technology and social preferences continue to evolve in a manner and speed seen over the recent past.), the development of a globally integrated gas market limits European concerns about becoming overly dependent on gas imports from Russia, allowing Russia to broadly maintain its share of European gas imports. As such, the share of Europe's total gas consumption met by Russian exports increases from around a third currently to almost half by 2040. See also the following chapter 3.2.1.

In this context it is also interesting, that on European level the energy mix continues to evolve, with renewables' share increasing from 9% in the year 2016 to 27% in 2040.

This rapid growth in renewables in the future is driven accordingly to BP Energy Outlook mainly by wind (4.8% p.a.) and solar (4.9% p.a.). Therefore, the EU will meet 15% of its energy demand by wind, with solar and biomass accounting for 5% each and Biofuels will account for less than 1% of demand by 2040. [2] Details can be seen in the table (Table 1) below.

	Shares		Change (%)	
	2016	**2040**	**1990 - 2016**	**2016 - 2040**
Total			-2%	- 11%
Oil (excl. biofuels)	37%	26%	- 9%	- 37%
Gas	24%	27%	29%	1%
Coal	15%	6%	- 48%	- 64%
Nuclear	12%	9%	6%	- 31%
Hydro	5%	6%	19%	7%
Renewables (incl. biofuels)	9%	27%	>1000%	160%

Table 1: Primary energy consumption in the European Union
Source: BP Energy Outlook, 2018

The detection of enormous increase of LNG as a cargo in the worldwide gas distribution, as shown in the figures before, can also be gathered from Shell´s "LNG Outlook 2018" (Figure 2 on the following page): e.g. one of the most conspicuous information in this figure is the increase of global gas supply by LNG imports up to 31% compared to pipeline imports with 7% in 2035.

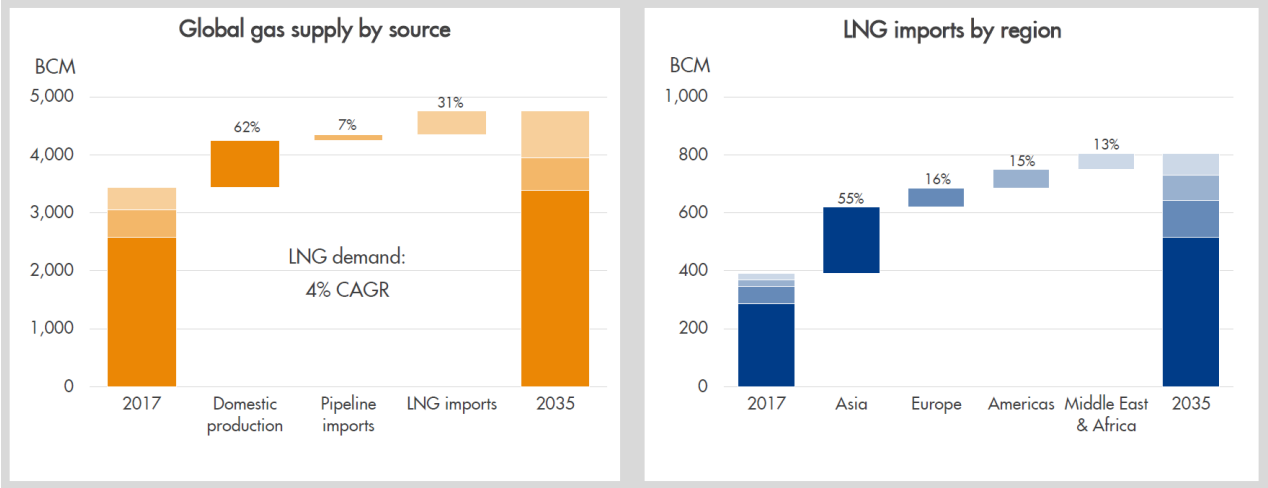

Figure 2: Global gas supply & LNG imports by region
Source: Royal Dutch Shell plc

3.2 LNG Supply and Demand Analysis / Attractiveness of the market

In the following chapter the demand and supply of the LNG market should be described, including potential challenges in the market as well as the potential of LNG in the future.

3.2.1 Supply Analysis

According to the BP Energy Outlook, 2018, the supply of natural gas to Europe happens mainly via pipeline from Russia, which has also an increasing supply in the future, conversely, the production of natural gas in Europe will decrease and the volumes partly absorbed by LNG imports. (Figure 3)

However, besides the fact that more LNG will be imported to Europe, also domestic liquefaction of natural gas is an increasing topic within different projects in the Danube Region, especially in landlocked countries. Further information to already implemented infrastructure and projects can be found in chapter 6: Available Small Scale LNG Infrastructure in the Danube Region

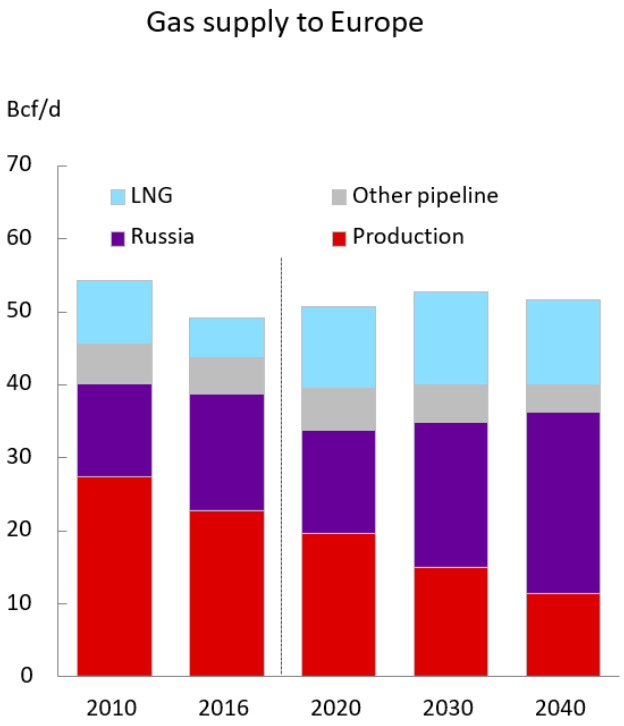

Figure 3: Development of European gas supply market
Source: BP Energy Outlook, 2018

The figures below (Figure 4 and Figure 5) show the most important existing and planned terminals close to the Danube Region. However, most of the terminals are only suitable for regasification and therefore no LNG can be obtained for further transportation. (As for example the Porto Levante terminal in Italy or in the planed terminal in Krk, Croatia.)

From these terminals highlighted in the second figure (Figure 5), LNG can theoretically be transported anywhere in the region by truck, rail, inland vessel or multimodal via container.

In particular, onward transport from the LNG terminal in Rotterdam or in the future coming from the Black See offers an interesting alternative to own production in the Danube Region, since in future (if demand is increasing), transport by inland waterway on the Rhine-Main-Danube waterway can also be an option.

Figure 4: GIE Map LNG Terminals
Source: GIE

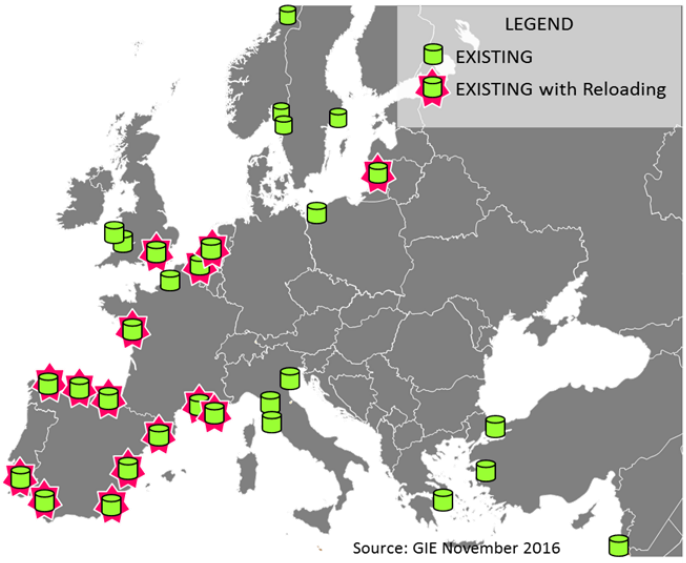

Figure 5: GIE Map LNG Terminals with reloading possibility in Europe
Source: GIE

3.2.2 Demand Analysis

The demand of LNG in the Danube Region varies between the countries, due to the different market development and infrastructure implementation activities. Therefore, the demand analysis will be separated in the following:

Germany

For the demand of LNG in Germany there were studies done in the project LNG Masterplan. They propose a highly rising demand in all modes of transport until the year 2035.

Another major study was done by Fraunhofer for the port of Brunsbüttel in 2015 (dealing with regional as well as supra-regional LNG demand), with the conclusion that a LNG terminal in Brunsbüttel is highly recommended to meet the rising needs of the market in the future.

LNG ships demanding LNG are already existing in Germany: the car ferry MS Ostfriesland and the projected LNG-electric ferries between Jork and Wedel.

Bunkering possibilities are in Mannheim already available and are planned in Regensburg and Cologne in the future in order to meet the EU requirements.

Moreover, in the road transport sector there is a rising demand for LNG fuelling stations in Germany; 6 fuelling stations are planned to have a basic LNG supply, the first one was opened in Ulm in 2016 and the second one in Berlin in the year 2018. Furthermore, LIQVIS, powered by Uniper, was awarded for EU funding for to build up 14 LNG fuelling stations in Europe: eight new fuelling stations are planned by 2019 at central locations in Germany such as Hanover, Cologne and Munich, while Belgium and France will each get three new fuelling stations to provide LNG.

Austria

In the road transportation sector, LNG demand is about to develop starting from the end of 2017 due to the first LNG fuelling station which is under operation in the port of Enns and very important to make a step to overcome the chicken and egg situation of LNG supply and demand in the region. For inland navigation, no demand is expected in the short term.; however, if there is an increase of demand, the port of Enns will be flexible to handle it.

Slovakia

Currently there is no operating LNG facility in Slovakia and therefore also no measurable demand; however, there are projects ongoing for IWT as well as for the road sector in order to implement LNG as a fuel in Slovakia. Most important project is the one of SPP – the state

owned “Slovak Gas Industry”, who is the national gas provider and which will bring a small-scale liquefaction plant to the port of Bratislava by the end of 2019. Moreover, a network of LNG fuelling stations and bunkering option is planned, which will rise the demand of LNG in the future. (Details to the projects in Slovakia are listed in chapter 6)

Hungary

In Hungary the demand analysis is focusing on potential natural gas supply via LNG in supply diversification plans since 1990. However, the infrastructure has not been realized for this so far. For LNG as transport fuel there have been analysis made within the LNG Masterplan project, arguing with the Diesel – LNG price gap (LNG would be estimated to around the price of natural gas in Hungary). However, it is important to mention that the price levels and gap has changed since the analysis was made. Although a fast market penetration is depending on the ongoing EU financed projects in regard of LNG (see also chapter 6 for the list of ongoing projects).

Croatia

In Croatia it can be assumed that there is a rising demand for LNG as transport fuel in the future; for LNG as energy supply there is a LNG Import Terminal planned in Krk to satisfy the rising energy / natural gas demand in the region. Although phase one is planned to develop a pure regasification of the imported LNG (via FSRU - Floating Storage and Regasification Unit), there is a supply option planned in a second phase, to further distribute liquefied natural gas for the use as a transport fuel. (See also chapter 6)

Romania

Currently (first half of 2018) there is no supply infrastructure for road vehicles or ships available in Romania. Romanian stakeholders made investigations on possible installation of LNG infrastructure for ships and the Ministry of Transport took note of the need to implement the EU Directive on alternative fuel in its strategic document “Master Plan of Romania's Transport”. In the development plans of Port of Constanta two potential projects are taken into consideration with locations in the port area: "Realization of LNG terminal on the southern dock of Constanta port" and "Realization of power station LNG Berth D99 and stationary platforms".

According to EU alternative fuels directive (Directive 2014/94/EU) LNG supply infrastructure for inland vessels have to be developed until 2030. Therefore, also the Galati river& seaports will have to be equipped with a LNG supply system according to the implementation plan of the Romanian Ministry of Transport.

Bulgaria

In Bulgaria the situation is similar to Romania; the actual demand is not quantified, but there is strategic interest to develop a nationwide LNG fuelling infrastructure. To build up the LNG infrastructure, Bulgaria elaborated a "Strategy for the Development of the Transport System of Republic of Bulgaria". The Strategy's overall goal is to significantly reduce the use of fossil fuels by introducing new energy sources, as LNG but also electricity, hydrogen, etc... A further LNG demand is based on the plans to reduce dependency on Russian natural gas imports via the pipeline transferred trough Ukraine. (The Bulgarian domestic natural gas production is just approximately 12 – 15%, with rising natural gas demand in the country.)

The national objective and time plan for infrastructure implementation is based on the EU Directive 2014/94:

The first required LNG filling stations in the Bulgarian inland waterway ports is already prepared within the LNG terminal in Ruse, which is also including an operational truck fuelling infrastructure and LNG Storage. (Both developed within the LNG Masterplan project.)

The necessary LNG filling stations in the Bulgarian seaports Varna and Burgas should be constructed by 31 December 2025.

Moldova

In Moldova there are currently no activities to facilitate LNG demand and supply projects neither in road nor in the navigation sector.

3.3 Market opportunities

Besides increasing market flexibility for adjustable natural gas demand, as mentioned in the chapter before, LNG as cargo in the Danube ports can bring further benefits to the Region.

LNG contributes to the European energy security by terms of diversification, especially of the gas supplier (supplying regions), with regasification unites. In the Danube Region there is nowadays just one LNG Terminal in Ruse, but a development can be seen in the future (see also chapter 3.2.1) as example with the planned Floating Storage and Regasification Unit (FSRU) in Krk, Croatia.

The usage of LNG as fuel for heavy transport and IWT can bring socioeconomic benefits to the Danube Region. One of the key success factors of LNG will be the raising demand as alternative fuel in order to reduce the environmental impact in the transport sector. In Table 2 the benefits of air emission reduction are pointed out (for trucks the data are based on "on board emission measurements" compared to Diesel Euro VI); in addition to that also the noise emissions can be reduced by the usage of LNG (noise emissions for trucks can be reduced to 72 dB).

Emissions	LNG fuelled truck	LNG fuelled vessel
NO_x	- 54%	- 85%
CO_2 (depending on Bio-Methane share)	- 10% to - 80%	- 25% to – 80 %
Particle emission	- 100% / Not measurable	- 100% / Not measurable

Table 2: Ecological benefits of LNG
Source: Iveco for trucks & LNG Masterplan for vessels

In addition, also more and more truck manufacturers have natural gas fuelled models available, which have an economical as well as environmental benefit compared to diesel trucks. Natural gas fuelled models are produced by the following manufacturers (2016/2017):

- Iveco: Stralis: NP CNG, NP CLNG, NP LNG, Eurocargo Natural Power
- Scania: P/G 280/340 CNG, -LNG
- Mercedes: Econic NGT
- Renault: D Wide CNG
- Volvo: FE CNG; FH LNH

3.4 Danube Ports integration into the LNG value network / Ennshafen as good example for inland ports as future hubs for LNG distribution

Ennshafen as good example for LNG market development

Ennshafen, the port of Enns, can be seen as a good example for the development of LNG infrastructure in the area of an inland port: The first Austrian fuelling station for trucks was already built up in September 2017 and further investments are planned, as example the option for inland vessels to bunker LNG as a fuel. All LNG activities in the port of Enns are done in cooperation with RAG (ROHÖL-AUFSUCHUNGS AG), which is a regional exploration, production and gas storage company, with Europe`s fourth-largest gas storage capacity.

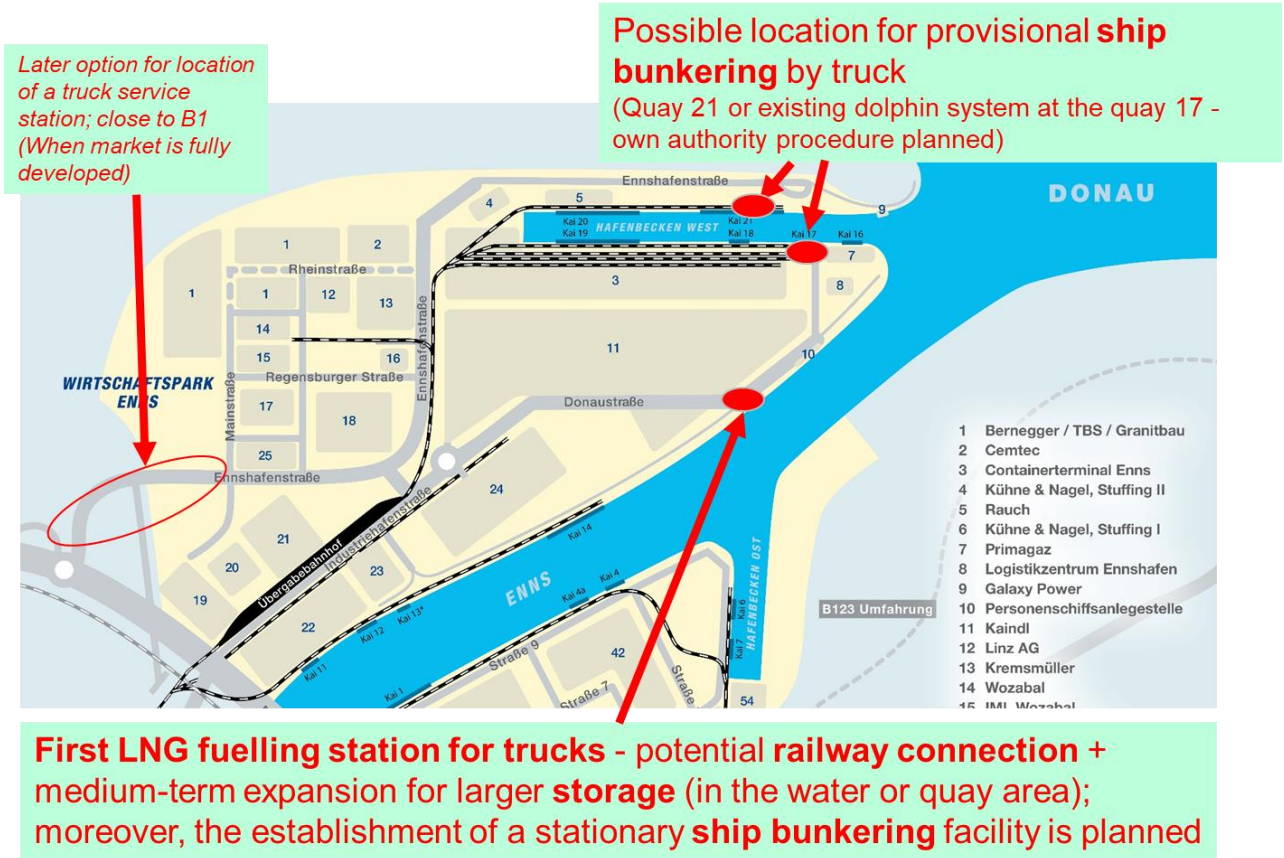

Figure 6: LNG activities in the port of Enns
Source: Ennshafen

Furthermore, there is a storage planed in the port of Enns, which will have capacities for the regionally produced LNG, which is needed for efficient distribution operations. A map including the LNG activities of the port can be seen in Figure 6. The port and neighbouring business parks in Upper Austria and Lower Austria form the largest contiguous industrial zone in the Upper Danube region, with an area of over 350 hectares. As a result of extensive investment in infrastructure and state-of-the-art technology, the port has become a logistics hub for three different modes of transportation, and an important business location for the whole region (metallurgy, automotive-, chemical-, foot- industry, etc.). Port of Enns is an ideal location on Europe's main traffic axes opening up direct transportation routes and facilitating the implementation of multi-modal logistics solutions and therefore a natural hub for future LNG storage, transhipment and bunkering/fuelling activities.

The planned storage capacities of LNG will be built subsequently in the future, in order to be prepared to become a transition point and a hub for further LNG distribution in the Region. Further to this, works to make inland vessels bunkering possible in the port of Enns will be done in two-step approach:

1. Truck-to-ship bunkering and
2. Storage/terminal-to-ship bunkering.

In the medium and even in short-term, LNG containers will be an option for the flexible transportation of LNG in the Danube Region, without waiting time for the infrastructure implementation.

The transportation of LNG via containers is already a proven technology, as example Chart Industries is providing a 40 ft. intermodal container with a payload between 19 and 22,5 tons LNG. A picture of such a container can be seen in the following Figure 7. A very important reference point for LNG transportation is the "hold time", which is in case of the chart container approximately 65 days at a pressure level of 10 bar. The price for a 40'ISO LNG container is approximately 150.000 to 160.000 Euro. [3]

Based on those facts it can be assumed that "LNG ISO container" will be a basic component in the LNG distribution in the Danube Region in the following years. On this basis the Danube ports have an excellent starting point in order to act as a hub for LNG in the different regions.

Figure 7: LNG ISO Container
Source: Chart Industries

[3] Chart Industries

4 Legal framework & Safety requirements

The following chapter describes background information on the legal framework, which makes the use of LNG necessary and accelerates the speed of infrastructure development and provides more information on the safety requirements, which are necessary when handling LNG as cargo and as fuel.

4.1 Clean Power for Transport Package

The clean power for Transport package is the European strategy for alternative fuels. A strategy for the transport sector to gradually replace oil with alternative fuels and build up the necessary infrastructure could bring savings on the oil import bill of € 4.2 billion per year in 2020, increasing to € 9.3 billion per year in 2030, and another € 1 billion per year from dampening of price hikes. Furthermore, support to the market development of alternative fuels and investment in their infrastructure in Europe will boost growth and a wide range of jobs in the EU. Research convened by the European Climate Foundation finds that 'greening' cars could generate about 700,000 additional jobs by 2025.

The long-term strategy is based on a comprehensive mix of alternative fuels for all transport modes without any preference to any particular fuel.

The final directive was adopted by the European Parliament and the Council on the 29th September 2014 (Directive 2014/94/EU on the deployment of alternative fuels infrastructure) and is described in the following chapter 4.2.

Mode / Fuel / Range		Road-passenger			Road-freight			Air	Rail	Water		
		short	medium	long	short	medium	long			inland	short-sea	maritime
LPG		■	■	■	■	■	■			■	■	
Natural Gas	LNG	■	■	■	■	■	■		■	■	■	■
	CNG	■	■	■	■	■						
Electricity		■			■				■			
Biofuels (liquid)		■	■	■	■	■	■	■	■	■	■	■
Hydrogen		■	■	■	■	■			■	■		

Figure 8: transport modes and travel range by the main alternative fuels
Source: European Commission

As it is highlighted in Figure 8, which describes the relevant fuels in the clean power for transport package of the European Commission, for inland navigation there are only a few types of alternative fuels with particular importance: such as LPG, LNG and hydrogen, whereas biofuels can also be considered as types/sub-types of others (e.g. LNG produced from biogas). However, on the one hand LPG does not require any additional infrastructure or adaption on the vessels side, on the other hand it does not have the required ecological benefits as the other alternatives and is also not economically advantageous. Therefore, the Clean Power for Transport package does not even foresee Member State actions in setting up LPG filling infrastructure.

In the case of Hydrogen, there are no relevant commercial projects registered in the medium-term forthcoming in the Danube Region. It can be expected that the use of Hydrogen in the Danube region for fuelling heavy duty vehicles and inland vessels will not go beyond the research & demonstration stage within the next 5-10 years.

4.2 Directive 2014/94 on the deployment of alternative fuels infrastructure

Based on successful technical development and demonstrations of alternative fuels the European Parliament developed the Directive 2014/94 - with the following main goals:

- Member States have been required to develop national policy frameworks for the market development of alternative fuels and their infrastructure;
- The use of common technical specifications for recharging and refuelling stations are foreseen;
- The way for setting up appropriate consumer information on alternative fuels, including a clear and sound price comparison methodology should be paved.

Those requirements are based on a timeline which can be found in the following table. Moreover, the **Member States have had two years to submit their national policy frameworks**, which will then be assessed by the Commission (till 18 November 2016).

	Coverage	**Timings**
Electricity in urban/suburban and other densely populated areas	Appropriate number of publically accessible points	by end 2020
CNG in urban/suburban and other densely populated areas	Appropriate number of points	by end 2020

CNG along the TEN-T core network	Appropriate number of points	by end 2025
Electricity at shore-side	Ports of the TEN-T core network and other ports	by end 2025
Hydrogen in the Member States who choose to develop it	Appropriate number of points	by end 2025
LNG at maritime ports	Ports of the TEN-T core network	by end 2025
LNG at inland ports	Ports of the TEN-T core network	by end 2030
LNG for heavy-duty vehicles	Appropriate number of points along the TEN-T core network	by end 2025

Table 3: Directive 2014/94- Timings
Source: European Commission, Directive 2014/94

4.3 Directive 2009/28/EC on the promotion of the use of energy from renewable sources (RED)

The directive 2009/28/EC creates a common set of rules for the use of renewable energy in the EU so as to limit greenhouse gas (GHG) emissions and promote cleaner transport.

It sets national binding targets for all EU countries with the overall aim of **making renewable energy sources account by 2020 for 20% of the total EU energy use** and for **10% of energy specifically in the transport sector** (both measured in terms of gross final energy consumption, i.e. total energy consumed from all sources, including renewables).

In terms of the total energy consumption in the EU there are different goals based on the status quo (gross final consumption of energy in 2005) in the specific countries; Table 4 will give an overview over the different national overall targets. (e.g. Romania 17,8 % to 24 % in 2020, Slovak Republic 6,7 % to 14 % in 2020.)

For further improvement after 2020, RED II is already being prepared by the EC: On 30 November 2016, the Commission published a proposal for a revised Renewable Energy Directive to make the EU a global leader in renewable energy and ensure that the target of at **least 27% renewables in the final energy consumption in the EU by 2030** is met.[4]

[4] European Commission: https://ec.europa.eu/energy/en/topics/renewable-energy/renewable-energy-directive

Based on these information, it can be seen that there have to be a "bio" component of LNG in the future to meet the requirements of the directive and to gain political support and public acceptance on the other side.

	Share of energy from renewable sources in gross final consumption of energy, 2005 (S_{2005})	Target for share of energy from renewable sources in gross final consumption of energy, 2020 (S_{2020})
Belgium	2,2 %	13 %
Bulgaria	9,4 %	16 %
Czech Republic	6,1 %	13 %
Denmark	17,0 %	30 %
Germany	5,8 %	18 %
Estonia	18,0 %	25 %
Ireland	3,1 %	16 %
Greece	6,9 %	18 %
Spain	8,7 %	20 %
France	10,3 %	23 %
Italy	5,2 %	17 %
Cyprus	2,9 %	13 %
Latvia	32,6 %	40 %
Lithuania	15,0 %	23 %
Luxembourg	0,9 %	11 %
Hungary	4,3 %	13 %
Malta	0,0 %	10 %
Netherlands	2,4 %	14 %
Austria	23,3 %	34 %
Poland	7,2 %	15 %
Portugal	20,5 %	31 %
Romania	17,8 %	24 %
Slovenia	16,0 %	25 %
Slovak Republic	6,7 %	14 %
Finland	28,5 %	38 %
Sweden	39,8 %	49 %
United Kingdom	1,3 %	15 %

Table 4: National overall targets for the share of energy from renewable sources in gross final consumption of energy in 2020
Source: European Commission, Directive 2009/28/EC

4.4 NAIADES II

The NAIADES II "Towards quality inland waterway transport (IWT)" (COM(2013)623 final) addresses among several key areas of intervention, as well "Environmental quality through low emissions" requesting that the IWT sector must become greener and more sustainable in order to remain a viable alternative to other transport modes and for society to keep benefitting from its advantages that IWT has to offer in comparison to road and rail transport modes which made much progress in reducing emissions over the past decades, in particular NOx and particulate matter (PM). In this respect, LNG with its high-energy density offers a cost-efficient alternative to diesel for waterborne activities with low air pollutant and CO2 emissions.

4.5 Regulation and Requirements for LNG -powered Vessels

EU-Directive (EU) 2016/1629 laying down **technical requirements for inland waterway vessels**, amending Directive 2009/100/EC and **repealing Directive 2006/87/EC**

The replaced EU Directive 2006/87/EC had following requirements: [5]

- Annex II, Article 8.01 (3): Only internal-combustion engines burning fuels having a flashpoint of more than 55° C may be installed.
- Only way to get a Community Certificate: Recommendation in accordance with Article 19 (Committee procedure)
- Practically impossible due to unclear administrative procedures
- Workaround: Rhine vessel certificate with recommendation in accordance with § 2.19 of Rhine Vessels Inspection Regulation

The new EU-Directive (EU) 2016/1629 has following kay facts for the LNG usage:

- Annex II replaced by reference to ES-TRIN
- No comitology procedure for derogations but implementing act of the European Commission in accordance with Article 25 (1)
- Regular Union Certificate without need for derogation possible
- Transposition date for new Directive: 07.10.2018
- Regular Union Certificate without need for derogation possible

[5] Dipl.-Ing. Bernhard Bieringer (ZT-Kanzlei Dipl.-Ing. Richard Anzböck)

Reference to ES-TRIN 2017/1:

- Chapter 30 – Special provisions applicable to craft equipped with propulsion or auxiliary systems operating on fuels with a flashpoint equal to or lower than 55° C
- Annex 8 - Section 1 – Liquefied Natural Gas:
  - Classification of hazardous areas on board (zones 0, 1 and 2)
  - LNG containment system separated from engine room
  - LNG containment system with secondary barrier
  - Engine rooms – three options: Gas safe engine room; Explosion safe engine room; ESD (emergency shut-down) protected engine room
  - Double-walled piping system
  - Water spray system for LNG fuel tanks
  - Electrical equipment of appropriate type according to hazard zones
  - Gas warning equipment mandatory

4.6 Guidelines for ports regulations

Since 2015 inland LNG tank vessels and bunker vessels are allowed on inland waterways in the EU according to the United Nations Economic Commission for Europe (UNECE) "European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways" /16/ (in short ADN).

For bunkering of vessels as well as for truck fuelling there are standards from the International Organization for Standardization (ISO) available:

- ISO 20519:2017(en) Ships and marine technology — Specification for bunkering of liquefied natural gas fuelled vessels[6]
- ISO 16924:2016(en) Natural gas fuelling stations — LNG stations for fuelling vehicles[7]

For LNG establishments that fall under the scope of Seveso /18/ (e.g. onshore establishments which hold more than 50 tonnes of LNG) each country has adopted different methodological approaches in their legislation to determine and assess external safety (distances) in land use planning (LUP) due to their own implementation of the Seveso directive. The approaches and

[6] https://www.iso.org/standard/68227.html
[7] https://www.iso.org/standard/57960.html

(risk) criteria have generic applicability and can in principle be used for the storage, handling of any dangerous good in Seveso establishments including LNG.

Moreover, critical events dealing with LNG have been analysed relating to possible risks; these risks are mainly related to significant leakages of liquefied natural gas (LNG), caused for example by crash, cracks or other reasons. The following general conclusions can be made, when dealing with LNG in ports during critical events:[8] At release of liquefied natural gas in the environment may occur different by nature and intensity emergency situations. The emergency situations accompanied with occurrence of so called „domino effect" is difficult to be prognosticated and determined due to uncertainty of course of initial event, the size and strength of the incurred damages especially the ones of other facilities, storing hazardous chemical substances.

[8] LNG Masterplan: http://www.lngmasterplan.eu/

5 Target audience & training needs

The following chapter will give an overview over the training needs of staff handling with LNG and will provide an elaboration of potential entities which will maybe use LNG in the future and can be seen as future customers.

Personal handling with LNG on operational level as well as on operational level in all kind of sectors (e.g. gas businesses, logistic service provider, freight transport companies in all modalities, consumers, responsible authorities etc.) should have basic knowledge of the main topics in order to increase safety conditions for all stakeholder in the supply chain.

[The following suggestions are based on the LNG Masterplan findings, the curricula is downloadable from the project website: www.lngmasterplan.eu. The lessons materials are subject of the Intellectual Property Rights and might be requested from relevant project partners that elaborated the lessons material.]

Main topics which should be addressed, according to the elaborate Curricula and lessons material in regards of "LNG as cargo", are the following:

- Specific characteristics of LNG (low temperature)
- The impact of these characteristics on the design and structure of vessels
- Understanding the need of protecting the structure of the vessel against brittleness of steel
- Knowledge regarding cargo tanks, pressurized tanks and membrane tanks
- Knowledge of isolation types and reasons to protect isolation
- Knowledge regarding heat transmission coefficients
- Knowledge of the 'holding time' principle
- Understanding the functioning of safety relieve valves
- Being able to calculate the 'holding time' for each journey with a LNG cargo within the correct
- parameters
- Knowledge how to start up, cool down and shut down the LNG equipment for a shipyard visit
- Use of correct PPE
- Safety procedures and Emergency scenarios

Furthermore a "table of competences" was developed for the employees involved in transporting LNG, summarised in the following:

1. Basic Knowledge of LNG
   1.1. Main physical properties of LNG
   1.2. Environmental properties of LNG
   1.3. Risk accompanied with the characteristics of LNG
   1.4. Background information: the world of LNG
   1.5. Background information: Markets
2. Safety
   2.1. Dangerous situations and adequate countermeasures
   2.2. Safety plan
   2.3. Security plan
   2.4. Safety devices during bunkering
   2.5. MSDS [Material Safety Data Sheet]
   2.6. The use of PPE [Personal Protective Equipment]
   2.7. Safety culture
3. Equipment
   3.1. General Equipment
   3.2. Operation of the equipment
4. Maintenance and checks
   4.1. Maintenance
   4.2. Assist manufacturers personnel when shutting down/starting up the installation for major repairs/overhaul
5. Documents and regulations
   5.1. Applicable international and national regulations
   5.2. Reception/loading (bunkerage log book) documents
6. Communication & Cooperation
   6.1. Definition of the roles and responsibilities

6 Available Small Scale LNG Infrastructure in the Danube Region

The chapter should describe the available LNG infrastructure in the Danube Region and will lead into necessary steps for a further deployment in the ports in the following. In addition, also ongoing projects in Austria, Hungary Bulgaria, Romania, Slovakia and Croatia will be described, in order to get an overview over the ongoing activities in the field of LNG and to see the potential of the new type of cargo and fuel in the future.

6.1 Status Quo of Small Scale LNG Infrastructure

In the following map (Figure 9) the existing infrastructure for LNG in the Danube Region is highlighted and condensed information is listed below:

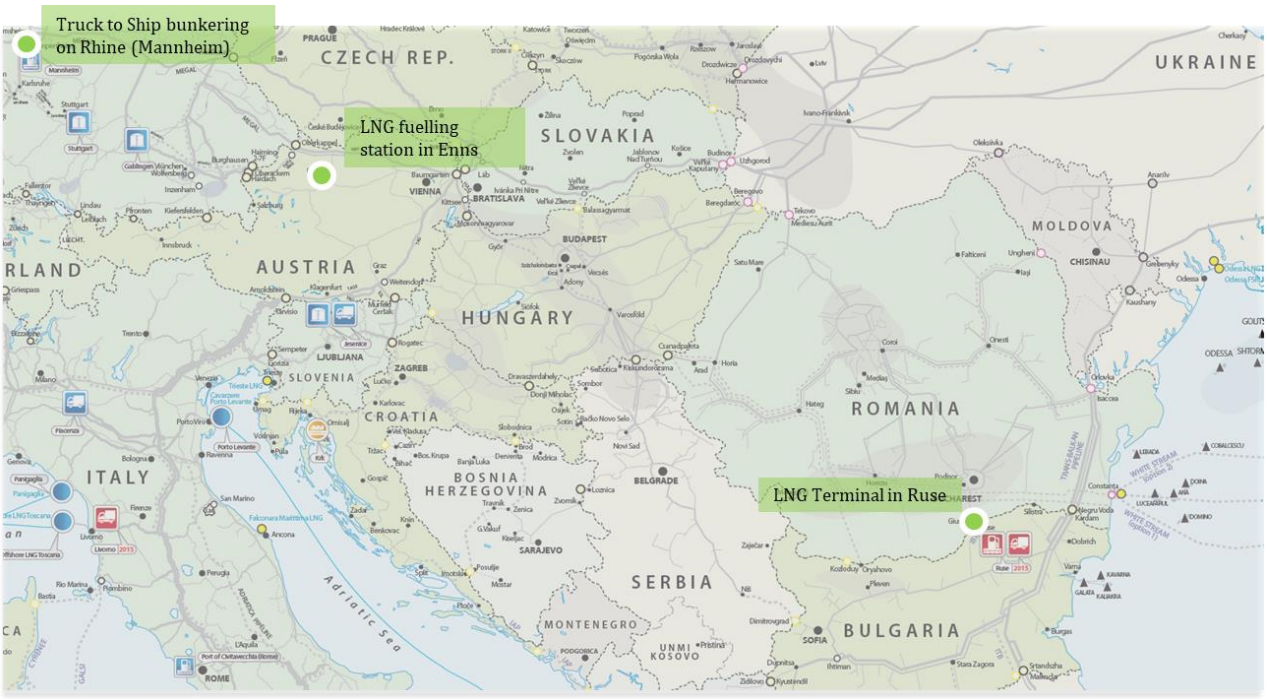

Figure 9: Existing LNG infrastructure in the Danube Region

Enns / Ennshafen: Existing LNG infrastructure in Austria

- LNG fuelling station for trucks since 2017
- Plans for further development of LNG infrastructure in Austria (5 LNG & 2 LNG/L-CNG stations) and development of bunkering facility in Enns
- Natural gas liquefaction of domestic gas in Austria

- Further information is available under following link: http://www.rag-erdgas-mobil.at/en.html

Ruse: Existing LNG infrastructure in Bulgaria

- First port on the Danube equipped with LNG infrastructure developed in 2016
- Executed within the LNG Masterplan by Bulmarket DM Ltd.
- LNG Storage in the port (4 vertical tanks of 250 m3 of LNG)
- Vessel unloading and loading facility
- Truck-loading station, truck & vessel fuelling station

Mannheim: Existing LNG infrastructure in Germany close to the Danube (Rhine)

- The location "Mannheim" is mentioned, because it is the closest good example where "truck to Ship" bunkering is under operation next to the Danube Region
- Bunkering on the Rhine close to the Danube
- Further information is available under following link: http://en.hafen-mannheim.de/en/home.html

6.2 LNG in the Danube Region (focus on AT, HU, SK, RO, HR projects & related costs)

In addition to the existing infrastructure, the following map (Figure 10) and the subsequent list of projects are providing information on potential locations for the future LNG implementation in the Danube Region.

Figure 10: Existing and planned LNG infrastructure in the Danube Region

LNGAFT: LNG project in Slovakia

- Time plan: October 2016 till December 2019
- 1 LNG-fuelling open access point for road transport
- 15 LNG mono-fuelled buses
- Further information is available under following link: https://ec.europa.eu/inea/en/connecting-europe-facility/cef-transport/projects-by-country/slovakia/2015-sk-tm-0348-s

fueLCNG: LNG project in Slovakia

- Time plan: July 2017 till December 2020
- Small scale LNG production plant (of assumed 1,25 ton/h production capacity)
- 3 large LNG stations for filling vehicles along the core TEN-T corridors with LNG fuel

- 14 L2CNG stations along the TEN-T core corridors on D1 and D2 highways.
- Pilot fleet with 50 LNG fuelled vehicles
- Mobile LNG supply for "Truck to ship" bunkering
- Slovak SPP - national gas operator executes the project to fulfil Directive 2014/94/EU
- Further information is available under following link: http://www.fuelcng.sk/

PAN LNG: LNG project in Hungary

- Time plan: June 2015 till September 2019
- Small scale liquefaction plant based on fossil gas wells & bio-methane sources
- Pilot deployment of 5 LCNG fuelling stations
- Further information is available under following link: https://ec.europa.eu/inea/en/connecting-europe-facility/cef-transport/projects-by-country/hungary/2014-hu-tmc-0629-m

PAN LNG 4 Danube: LNG project in Hungary

- Time plan: June 2016 till September 2019
- Making LNG available for Danube IWW transport at Csepel Freeport by deploying a fixed LNG refuelling station
- Fuelling station for trucks and possibly for locomotives
- Retrofitting of existing vessels for LNG propulsion
- Further information is available under following link: https://ec.europa.eu/inea/en/connecting-europe-facility/cef-transport/projects-by-country/hungary/2015-hu-tm-0349-m

Bio LNG - Fuelling Renewable Transport in Visegrad Countries: LNG project ongoing in the Visegrad Countries

- Project awarded in July 2017 for CEF Transport Call 2016
- Liquefied Bio-gas (LBG) and Liquefied Natural Gas (LNG) production facility
- Network of 6 LCNG fuelling stations — 3 located in Slovak Republic, 3 located in Czech Republic
    - Slovakia (Kosice, Zilina, Bratislava)
    - Czech Republic (Brno, Rozvadov, Usti nad Labem)
- Fleet of 75 LNG and LCNG trucks

LNG Terminal in Krk: LNG project in Croatia

- Time plan: Start-up Date was planned for 2020, but the project is delayed: "It was necessary to revise the technical characteristics and capacities of the initially requested FSRU to reduce the initially planned capital costs of the project and enable the realization of the project with a lower capacity booking," LNG Croatia
- LNG import Terminal (receiving, storing, reloading, regasification of LNG)
- Potential market of eight countries for further deployment of the planned FSRU
- The Krk LNG import project would be developed in two phases:
  - First phase includes setting up of the FSRU
  - Second phase entails the construction of a land-based LNG import facility, according to LNG Croatia.
- Further information is available under following link: http://www.lng.hr/en/

LNG Terminal in Vidin & Burgas: Potential future LNG infrastructure locations in Bulgaria

- Time plan: latest 2030
- Possible location of LNG infrastructure on the core TEN-T port network to fulfil Directive 2014/94/EU according to Bulgarian strategy framework for alternative fuels development

LNG for Constanta: Potential future LNG infrastructure location in Rumania

- Project in preparation: estimated to be ready in 2025
- Integrated project including fuelling stations & vehicles (LNG fuelled buses and trucks) and an LNG Terminal including bunker station for maritime and inland vessels
- LNG-fuelled ferries to Georgia as part of the concept

LNG for Galati: Potential future LNG infrastructure location in Rumania

- Project in preparation: estimated to be ready in 2030
- Integrated project including fuelling stations & vehicles (LNG fuelled buses and trucks) and an LNG Terminal including bunker station for maritime and inland vessels
- Small Scale liquefaction based on biomethane sources

The following table should give an overview over the assumed potential of LNG as cargo in the Danube Region, based on the previous mentioned information collected in this report.

Countries	Potential of LNG as Cargo
Germany	+++ Very high potential in Germany (due to high demand from the road transport sector; currently there are no known projects within Danube Ports in Germany)
Austria	+++ Very high potential due to infrastructure development in the Port of Enns (which requires LNG for truck fuelling and foreseen bunkering services)
Slovakia	+++ Very high potential based on the projects ongoing in Slovakia (based on the planned liquefaction units by SPP)
Hungary	+++ Very high potential based on the projects ongoing in Hungary (based on planed liquefaction unit and specially in Csepel Freeport – due to ongoing EU project)
Croatia	++ High potential for further transportation of LNG after realisation of Krk LNG terminal
Serbia	Low potential due to missing infrastructure development
Rumania	+++ Very high potential for LNG due to projects in Constanta and Galati (as well as reloading of potential maritime imports in the future)
Bulgaria	+++ Very high potential for LNG transportation, due to already existing infrastructure on the Danube Port in Ruse (first infrastructure in the Danube Region)
Moldova	Low potential due to missing infrastructure development

Table 5: Potential of LNG as Cargo

7 Policy plan for LNG development in the Danube Region

In order to implement a consistent LNG infrastructure in the Danube Region, some further steps have to be done in different fields to develop an alternative environmental friendly fuel infrastructure, an alternative and more independent natural gas supply and at the same moment a new business for ports, which can benefit from their available infrastructure. (Project engineering across the transport modes and together with the energy sector can may also benefit from different funding options on national and European level.)

However, measures have to be done in the Danube Region, which can increase the speed and quality of an LNG implementation. It is important to organise information campaigns for fleet owners and for the general public in the whole region, to overcome possible bottlenecks in the supply. Those campaigns can may be developed by strategic platforms in the Region.

Moreover, it is important, that LNG will get an "bio" component in the future and production of "Bio-LNG" will become the state of the art. LNG produced with bio-gas can improve the CO_2 performance in the transport sector significantly (up to 80 percent compared to diesel). Based on those performances Bio-LNG can help to increase the politic support on national, regional as well as on European level. Potential political support can be based on following measures:

On national level funding programs supporting transition of fleets (vessels, trucks) must step in, as example to provide a national subsidization for initial investment of fleet owners. In addition, it is also important to develop sufficient training/ educational infrastructure concerning LNG as well as further research projects based in the respective countries.

On European level the Connecting Europe Facility (CEF) can play a continuously play a key role for further implementation with evolving focus – from pilot to "works". CEF can expedite the deployment of a sufficient infrastructure in Europa including the deployment of co-funding for vessels and truck fleets, if they are following the requirements of the specific calls (e.g. roll-out character, maritime link, "innovative" character, etc.). In addition to the funding, also regulations, which facilitate the LNG deployment can bring supplementary benefits for the implementation efforts of private companies.

Following on from these measures, it can be expected, that there is an increase of LNG equipment produced worldwide, which will decrease the unit costs from the relatively high production costs based on the technologically sophisticated equipment and high safety standards.

An additional informative and interesting information is based on case studies of pipeline gas, oil and iron ore trading show that sophisticated trading markets develop when there are following points developed: A crisis or dramatic change in the market, such as a supply overhang or new technology (such as LNG as fuel), followed by appropriate government action which sets the environment for markets to develop the market, and then left to itself to develop. The EU has already brought about important drivers for effective LNG trading markets to develop, including the ban on destination clauses and ship fuel regulations. (The LNG industry considers that the industry is working fine and there is no need for further EU level intervention, nevertheless EC have identified some areas for further development.)[9]

[9] European Commission „Follow-up study to the LNG and storage strategy“

8 Conclusion

For the development of sufficient LNG infrastructure and a relevant market penetration in the Danube Region, a coordinated European LNG Deployment Strategy and project initiative is needed to speed up the LNG implementation. With the mentioned preconditions in the region, Danube Ports can have a leading role to ensure LNG baseload in the region as well as to provide an efficient infrastructure for the supply chain.

In regards to the potential future customer (transport as well as energy sector) it is important to ensure LNG baseload for the grid or power stations respectively sufficient infrastructure in the Danube region, to enable an efficient LNG supply. European and national funding programmes can support the development with financial instruments, focused on environmental friendly and sustainable infrastructure development.

Due to the framework conditions, the rapidly rising share of LNG in the natural gas trading and demand market as well as an ongoing expansion of the infrastructure, it can be expected that there will be a higher standardisation process in the industry which will decrease the equipment costs in the future.

It can be concluded, that there are significant benefits for the usage of liquefied natural gas measurable and necessary infrastructure should be available in the Danube Region in medium-term. The integration and development of LNG in the energy as well as in the transport policy will be inevitable. In Europe, both the road transportation sector and the inland navigation sector can also make a step forward in the right direction for a more environmental friendly transport industry.

However, the timing and speed of implementation in the single countries will strongly depend on European as well on national alternative fuel supportive policies and the availability of public funding for LNG infrastructure projects.