BINNENVAART
Deployment in Inland Waterway Transport

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Breakthrough LNG Deployment in Inland Waterway Transport

4.3 Consultation of stakeholders and research the market potential of LNG vessels

Stakeholder consultation report

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Scenarios for the deployment of LNG in Inland Waterway Transport

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Colophon

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1 Summary

Making use of LNG as an alternative fuel for diesel is an important way for the inland waterway transport (IWT) sector to expand the existing environmental benefit over other transport modalities. Using LNG as compared to diesel, will especially have a positive effect on the local air quality. LNG is also beneficial for climate targets – explaining why local, regional and national governments as well as the European Union are supporting the further roll out of LNG in the IWT sector. LNG plays for example an important role in the Energy report[1] of the Dutch government, a report which was published in the spring of 2016.

Currently there are just six inland vessels which are sailing on LNG, given the Dutch fleet of over five thousand inland vessels and total European fleet of over twelve thousand vessels. In addition, Shell initiated an investment for an additional number of thirty LNG driven inland tanker vessels. However, in order to meet the air quality ambitions of the Dutch government, it will be necessary to realize more than 900 LNG driven inland vessels on the long term. This implies a yearly construction of more than 60 large vessels, because especially the vessels with a yearly fuel consumption of over 500m3 will benefit economically from using LNG. These 900 vessels make up approximately 16 percent of the total Dutch fleet but are responsible for a transport performance – the amount of tonne-kilometres carried – of 50 percent in the IWT sector. A strong transition towards LNG in the IWT sector will be realized on condition that the mentioned amount of 900 LNG driven vessels will be completed by 2030.

It appeared from expert consultations that an LNG driven inland shipping fleet comprising 15 percent of the total fleet is being regarded as the absolute upper limit for the penetration of LNG in the IWT sector. However, this upper limit does not seem to be achievable by 2030 – even the yard infrastructure is far from being sufficient for such amounts. Furthermore, the expansion of the existing fleet with such an amount will have strong negative effects on the economic health of the sector.

The abovementioned scenario is based on a future in which the local air quality is an important starting point in the policies. This first scenario will therefore be called ‘Air quality’ (see table below).

But, it is also possible that ‘Climate’ will be a starting point in policies – this is the second scenario. Caused by external circumstances, a severe stringent climate policy can be put on the agenda. Consequently, LNG as currently applied will only play a limited role in this scenario and investments should be made in bio-LNG, biodiesel and possibly hydrogen: the share of bio-LNG in the fleet will be 5 percent in 2030 and 18 percent in the total tonne-kilometres carried by the IWT sector.

The third scenario comprises the situation in which the Action Plan Shipping, as described in the vision on sustainable fuels for transport[2], a report related to the ‘Energy Report’, will be applied.

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[1] https://www.rijksoverheid.nl/documenten/rapporten/2016/01/18/energierapport-transitie-naar-duurzaam
[2] http://www.energieakkoordser.nl/~/media/files/energieakkoord/nieuwsberichten/2014/brandstofvisie/sustainable-fuels-transport.ashx

In this scenario a total number of 300 vessels will be added to the fleet and 18 percent of the transport performance in 2030.
These three include a strong emphasize on building new LNG driven vessels. However, a fourth scenario is also possible in which scale and financial benefits will create support for a 'refit' solution, and that a great number of existing vessels will be refitted to LNG.

Table 1: Overview scenarios LNG deployment in IWT in 2030.

Scenario	Air quality	Climate	Energy Report	Refit
LNG-fleet IWT	922	460[a]	300	600
Share LNG in total fleet	16%	3% 5% [b]	5%	10%
Share LNG in transport performance	50%	7% 18% [b]	18%	35%
Yearly addition LNG driven vessels	60	30 [a]	20	40
Share newbuild	80%	80%	80%	20%
Share refit vessels	20%	20%	20%	80%

(a=including bio-LNG, b=bio-LNG)

2 Introduction

LNG has the potential to improve the already strong environmental performance of the IWT sector. The successful deployment of this relatively clean fuel means an improvement of the competitiveness of IWT as compared to road transport and will result in environmental benefits as compared to the situation in which traditional fuel (diesel) is being used. The mentioned environmental benefits can especially be related to local air quality – less particulate matters and nitrogen, and with that direct consequences for health and life expectancy – however, the benefits of LNG are limited when it comes to climate improvement targets. This characteristic plays an important role in this report.

There a couple of bottlenecks hindering the desired deployment of LNG in the IWT sector, such as financial bottlenecks or alternative technologies. Therewith it is far from certain how the deployment of LNG in the IWT sector will exactly take place. Various scenarios are conceivable and four of them are described in this report. These scenarios are developed based on a short stakeholder consultation (see appendix 1).

Problem statement

LNG is an example of an environmental friendly alternative for diesel in the IWT sector. It is a fuel by which the sector can comply with coming more stringent emission norms. A characteristic of LNG is that various undesirable components, such as sulfur compounds and others, are being eliminated during the liquification process, resulting in relatively clean emissions. Furthermore, also less noise is being produced and LNG driven vessels require less maintenance, and using LNG results generally in economic benefits.

There are two configurations of LNG in IWT:

a. Dual-fuel vessels, sailing on a combination of diesel and LNG;
b. Vessels with 100% LNG driven electric generators.

Examples of LNG driven inland vessels are:

- Argonon of Deen Shipping (dual-fuel – 80% LNG)
- Eiger Nordwand of Danser Shipping (refitted vessel: dual-fuel – 95-99% LNG)
- Greenstream and Greenrhine of Interstream Barging (single fuel: LNG-electric)
- Ecoliner, developed by Damen and operated by Deen Shipping (single fuel: LNG-electric)
- Sirocco of Chemgas (dual-fuel)

The deployed LNG driven vessels are mostly newbuild. However, it is also possible to refit existing vessels to LNG drive vessels. The current overcapacity in various IWT market segments does make it relatively more attractive on the short term to refit vessels instead.

Currently, the LNG bunkering infrastructure is in a strong development phase, whereby the 'breakbulk' Gate-terminal on the Maasvlakte in the port of Rotterdam plays an important role. It is possible to perform LNG truck-to-ship bunkering in various (inland) ports[3] and Shell will deploy an LNG bunker vessel in 2017. Also an LNG terminal will become available in Köln this year and a contract is signed for the construction and exploitation of an LNG bunker station.

[3] For example the new inland port of Doesburg (Containerterminal Rotra geopend, Nieuwsblad Transport, 18 april 2016).

The Port of Rotterdam Authority (PoR) sees LNG as an important means to make IWT more sustainable and thinks that regarding the transition towards LNG the port can lead by example – also due to the role of the port in supplying the extensive hinterland. One of the important indicators managed by PoR for the state of affairs concerning LNG is the number of LNG bunkerings in the port area, 43 bunkering activities were performed in 2014 (in the period from 01-07-2013 to 31-12-2013 a total of 23 bunkerings were registered).

It is the question whether LNG will become the new fuel standard for IWT and whether there is indeed a wide transition from diesel towards LNG in the IWT sector. It is also possible that LNG is merely an intermediate fuel towards other alternative fuels, such as hydrogen and biofuels and that in the future LNG will only play a limited role due to a number of hindrances. Especially the limited positive effects of LNG on climate targets plays a role.

Policy makers see an important deployment of LNG in IWT

Despite the abovementioned dilemma it is not only PoR which sees a bright future for LNG. The European Commission (EC) shares this vision and formulated targets to make LNG available in seaports located along the TEN-T network by 2020 and also in European inland ports by 2025. The EU facilitated the LNG Masterplan in the period of 2013-2015: a comprehensive project of governments and stakeholders from the transportation sector and industry intended for the implementation of LNG in IWT and harmonization of regulation in Europe – specifically on the Rhine-Maas-Donau sailing areas. Also the Central Commission for the Navigation of the Rhine (CCNR) worked on the development regarding regulation for the use of LNG in IWT and on the stimulation of cost-effective greening of the sector. The Energy report published in 2016 indicates that also the Dutch government focuses on a transition towards LNG.

Decentral governments, like the Dutch provinces, with intense IWT flows within their borders, have in many cases an active strategy directed towards stimulating the use of LNG. For example, the province of Gelderland has its so-called 'smart mobility' strategy in which LNG is being stimulated as fuel for shipping and the province of South-Holland is a lead partner in the European consortium Clean Inland Shipping (CLINSH). The most important target of CLINSH is improving local air quality in urban areas through realizing an accelerated emission reduction in IWT. Within CLINSH the performance of various emission reducing techniques, such as that of alternative fuels and cold ironing, will be assessed on 30 vessels. The impact of these techniques on emissions (NOx and PM) will be tested under 'real life' circumstances. The measured results will be collected into a database, which will become an important tool for local, regional, national and European governments for the development of (new) policies regarding the greening of waterways. The intention is also to provide insight to inland shipping companies concerning the most cost-effective environmental measures they can take. The CLINSH consortium wants to clarify the effectivity of greening measures in the IWT sector, to stimulate the actual deployment of greening techniques, and it wants to contribute actively to an improvement of local air quality.

Key role EU

The EU does attach great importance to the abovementioned type of studies in which the real impact on air quality is measured for the various practices in the sector including the quantification of effects. The emission problems caused by the IWT sector are very urgent because the sector has significant negative effects on air quality in river cities like Rotterdam, Duisburg or Nijmegen. Measuring the effects in cities can even amplify the benefits of LNG and other alternatives to diesel. The availability of indicators and benchmarks is thereby crucial.

Besides the importance of air quality and the climate goals, the ability of the sector to realize an actual transition through innovation is an important point of engagement for the EU and DG MOVE.

The starting point for the EU is a focus on market driven innovation. DG MOVE is strongly committed to the optimization of this market driven innovation - consequently, one is not occupied with realizing scientific research as is the case in Horizon 2020 but with improving the innovation potential of the market, under which IWT. Thereby it does not only concern technological innovation but for example also the realization of improved earning models in the sector. It appeared from consultation rounds with EU sources that the LNG theme has a good scorecard regarding innovation given the intense activity of companies on this theme, think of suppliers of engines, fuels and terminals, and due to the fact that most innovation calls experience an exceeding application – for example, the last innovation call resulted in 80 projects.

Policy is oriented at giving necessary financial support and knowledge dissemination through which promising innovation can overcome the profitability threshold – the break-even point. Only ‘real-life trials’ qualify for funding whereby it mostly concerns concrete pilots for ‘real companies’, and therefore projects in their initial phase still on the drawing board or demos are excluded. With that, two considerations play a role, firstly: is there a technical driven break-even point whereby a solution in the market is clearly within sight and secondly the potential for roll-out; can the innovation play a positive role for especially the many SMEs in various sectors? The last mentioned point is naturally of great importance for IWT which has a significant share of SMEs. The roll-out of innovations is an important criterion, while in general the financial foundation will be better in case there are more users. A second factor is the optimization of technology in actual relations between businesses – IWT and shippers for example – which plays an important role. The EU stimulates a market driven approach for innovations between networks of companies.

The EU is reluctant with providing funding and is not in favor of disturbing the financial infrastructure of existing financiers. It is however identified that European IWT is, from a business economic perspective, in a vulnerable position with many SMEs having difficulties in realizing heavy investments and facing a reluctant role of banks. Furthermore, IWT is part of the broader transportation sector which is being regarded as a priority by the EU, related to the comprehensive TEN-T projects and Corridors as important axes of transport on a European scale – the core-network. Innovation in the sector knows a couple of spearheads, like the development of IWT as a means of transport between seaports and the hinterland, the development of an LNG-infrastructure for the various inland transport modes, and the development of multimodal transport including IWT.

The EU has various possibilities for LNG-related funding in the area of transport, infrastructure and energy; such as a yearly a specific sector call, cohesion funds, a Connecting Europe Facility, the Juncker-fund (European Fund for Strategic Investments) and with riskier large-scale projects there are possibilities at the European Investment Bank (EIB). The EU sources being consulted for this report are strongly convinced that EU funding for LNG-related projects in IWT – on basis of abovementioned principles – can usually be no problem. An active role of large-sized companies is thereby encouraged.

In addition, there are interesting and promising synergy possibilities between the different dominant policy themes of transport and energy. An example is wind energy. If windmills have a problem with supplying the generated energy due to an oversupply, then this energy can be used for producing hydrogen. The produced hydrogen can in turn be utilized in the transport sector. The EU sees a lot of potential for the roll-out of such synergy projects around networks, corridors or regions.

There are many smaller projects in Europe under the umbrella of DG MOVE – small means an amount of less than 25 million euros – instead of several very large projects. The issues in various parts of Europe – southern or northern countries, water energy versus wind energy, different TEN-T corridors – are often structurally different. The ambition though in Europe, is to connect all the innovative minds on these themes and to learn of this diversity of projects.

This is no exhaustive list with policy initiatives: efforts are also being made in other programs, such as the various European structural funds and INTERREG-projects. The starting point is and will always be the subsidiarity principle. Despite policy efforts, investment in the LNG capacity in previous years were very limited. This also appears from the current operational LNG fleet. Several barriers are responsible for this situation.

Barriers hindering the development of LNG as alternative fuel for IWT
The transition towards LNG in IWT currently experiences a rough course. Causes for this rough course are among others:
a. the current low price of conventional fuels as compared to the price of LNG,
b. high refit costs for existing vessels and insufficient possibilities for financial support for the refit,
c. Uncertainty about future emission norms for IWT,
d. Alternative fuels, techniques and possibilities for LNG to comply with future norms,
e. The weak position of many companies in the IWT sector which makes it difficult to finance the costs for a refit,
f. Customers/shippers which do not want to pay for the extra costs made by the IWT company,
g. LNG-bunkering infrastructure along the waterway nodes is currently under development but for the moment still lacking,
h. Uncertainty concerning laws and regulation for LNG,
i. Complex technology and knowledge requirements.

Shell's investment in 30 vessels is an attempt to force a breakthrough and solve the chicken and egg problem which emerged due to the lacking LNG infrastructure along waterways as result of the lacking LNG driven vessels, which in turn is a result of the mentioned infrastructure bottleneck. Besides that, EICB has proposed a pilot for 6 vessels in which also existing vessels will be refitted to LNG in order to accelerate the transition towards LNG.[4] The large scale of the project will make it possible to benefit from cost advantages and also an attractive demand for LNG will arise by which the realization of the infrastructure can be accelerated. The advantage of the proposal is that the existing overcapacity in the sector will not further increase.
The focus in next sections will be on abovementioned issues. First a short description will be given concerning the chosen approach in this document.

[4] ie: https://ec.europa.eu/inea/en/connecting-europe-facility/cef-transport/projects-by-country/netherlands/2014-nl-tm-0394-s

3 Approach

This report is a quick scan particularly based on expert opinions (annex 1). These experts are – with one exception – selected by the EICB. Conversations are held with the experts during which the opinions are inventoried with respect to:

a. general development of the LNG market in transport and IWT and important uncertainties in this market,

b. expectations with respect to the application of LNG as fuel in the sector and the importance of competing fuels,

c. expectations with respect to the way of introducing LNG in IWT: the most probable transition path including a time horizon,

d. characteristics of the IWT sector which are relevant for the deployment of LNG,

e. possibilities to boost the transition,

f. the question which stakeholders will experience the largest impact with the deployment of LNG.

The general expectations with respect to the deployment of LNG in IWT are described in chapter 4.

Four scenarios are composed – described in chapter 5 – based on a short literature scan about the deployment of LNG in IWT. Most involved experts also gave feedback concerning the four scenarios. The scenarios are presented in chapter 6.

Finally, in chapter 7 a concluding overview is given about the requirements for success for the deployment of LNG in IWT which is done by means of a framework for the deployment of new fuels in transport markets (Allen, 2015). The report ends with an epilogue.

4 Relevant developments for the deployment of LNG in IWT

How will the IWT fleet look like in 2030, differentiated to the used fuel? This is an uncertain question which depends on a couple of forces and developments. These developments are interrelated and reinforce each other. The consulted experts indicated that the following developments are the most relevant ones for the future deployment of LNG in IWT.

Policy as a driver for LNG deployment

a. Policy is the most dominant driver: low emission zones

Within the IWT sector policies contribute to the creation of sense of urgency for the transition towards new and alternative fuels, such as LNG. However, regulation ought to be clear and should not be reversed or weakened. In order to realize a fast transition towards LNG, companies in the IWT sector should be brought together through strong measures by which ideally a sector-wide initiative can be initialized.[5]

However, the necessary pressure for such a sector-wide initiative is currently lacking in the sector. This could change if the Port of Rotterdam authority will actually hold on to the proposed ban from 2025 on, which will apply to vessels not complying with the CCR2 norms – or when the regulation becomes even more stringent. The pressure will especially build up when other ports and regions will follow this initiative. It is also expected from the European Commission to come up with such environmental zones which will only be accessible for low-emission transport. In short, clear regulation related to the accelerated deployment of LNG in IWT is a very important drive, however this will require a clear and achievable course which will lead the sector to the intended purpose.

b. Financial incentives

European policies put a strong emphasis on financial instruments in order to stimulate the deployment of LNG. Financial incentives – "Environ-mental Port Charging"- should stimulate the 'greening' of the sector, among others by means of an active commitment to a 'European Shipping Index' for a clean IWT sector, in which de IWT fleet will be differentiated to different classes based on emissions, whereby relatively cleaner vessels will receive discounts and other facilities.

c. Local air quality versus climate policies

Using LNG only has a limited contribution to the climate targets due to methane emissions (methane slip) which arise when using LNG. Tackling the methane issue is currently an important policy priority for the further roll-out of LNG. LNG does though have clear positive effects on improving local air quality due to significantly lower PM and NOx emissions. The emphasis which will be put by policy makers on either local air quality or climate policy is a very important but yet uncertain development for the future deployment of LNG. The consulted policy makers though

[5] An example are the tour vessels in Amsterdam whereby the total fleet aimed to sail with zero emission by 2015. This means an investment of 40 million euro and refitting 120 vessels in 5 years (20/30 each year). This refit could take place after a development phase of 4 year in which the details were developed (battery types, charging locations, newbuild or refit, etc.). This initiative was preceded by a clear political signal with a clear deadline.

state that LNG can be an important transition fuel to bio-LNG; bio-LNG combines the positive characteristics for improving the local air quality as well as the climate. The developed logistics infrastructure, such as terminals, build for LNG can also be used for bio-LNG.

Alternatives for IWT to meet the climate targets

d. Improving efficiency makes a major contribution – in particular with new vessels
It appeared from the consultation rounds that improving the efficiency of IWT vessels and adjusted sailing behavior can deliver the largest contribution to the greening of IWT. The design of more efficient vessels by an adjusted energy-efficient design and improved engines, the synchronization of logistics between the terminal operations and sailing, real-time monitoring of vessel performance (continuous on board analysis and diagnosis), sailing with the right speed – in many cases: slower – and adjusting the sailing behavior are all important elements which will together contribute to the reduction of energy use by 30 up to 40 percent.[6] This efficiency improvement can especially be realized by new vessels and to a lesser extent by existing vessels which can realize an efficiency improvement by maximum 15 up to 20 percent. The limited efficiency gains for existing vessels puts a certain pressure on the existing vessel fleet.

e. Alternatives for LNG
After-treatment (catalytic converters and filters) is an important alternative for LNG. It is characterized by significant lower CAPEX as compared to LNG however in contrast to LNG the OPEX will increase. Another alternative is gas-to-liquid (GTL). The advantage of GTL – a clean synthetic fuel made out of gas – is that it can be used in existing diesel engines without any necessary investments as is the case with the costly LNG installation. This makes GTL especially attractive for relatively smaller vessels. Using GTL though results in relatively higher CO2 emissions and realizes only a limited NOx and PM reduction as compared to LNG, making it an unattractive solution to meet air quality and climate targets. The second fuel alternative are biofuels including bio-LNG. Biofuels are already being mixed with diesel, but in order to realize a complete transition a very large quantity of biofuels will be necessary. The necessary local infrastructure for bio-LNG, infrastructure suited for the gasification of bio-based raw materials, is currently not present. Nevertheless, bio-LNG certainly has the potential and it is expected that this market will develop itself in the future – especially because bio-LNG contributes to a much larger extent to the climate targets as compared to LNG. Hydrogen is a third alternative, but for the long run (2050).

European policies clearly indicate that there no preferences for a particular alternative and that LNG is only one of those promising alternatives for the ‘greening’. Betting on only one technology will not be wise from a strategic point of perspective. The starting point is an open approach, whereby the effects on both air quality and the climate eventually matter, and it also applies to “refit where possible”.

[6] In accordance with the vision on sustainable fuels for transport (Deelrapport Brandstoftafel Scheepvaart, 2014).

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Sector and demand characteristics in IWT

f. Demand characteristics of influence in IWT

The expected market share of LNG in IWT will have an upper limit of 10 up to 15 percent of the total fleet. This concerns relatively large vessels which accounts for a large share of the total transport performance – up to a share of 50 percent in the total transport performance (table 2). The reason for this relatively small market share is mainly due to the demand characteristics of the sector. The demand of an inland vessel for LNG is limited as compared to the demand of a seagoing vessel. An inland vessel does not require a lot of LNG making it in turn necessary to realize a substantial amount of vessels in order to set up a supply infrastructure. A solution is to combine the supply infrastructure for IWT with LNG stations for road transport. A second reason is the extensive waterway network with many small vessels sailing on it for whom LNG is not suitable due to their annual fuel consumption below the threshold of 500m3 to make it an economically interesting alternative.

Table 2: Dutch IWT fleet composition between 2010-2014 differentiated to loading capacity, absolute number based on division in loading capacity and percentage share.

	Year				
Loading capacity in tonne	**2010**	**2011**	**2012**	**2013**	**2014**
Up to 1.000	3.418	3.441	3.295	3.272	3.213
1.000 to 1.500	834	816	781	769	753
More than 1.500	1.906	1.985	1.927	1.925	1.929
Total	6.158	6.242	6.003	5.966	5.895
Up to 1.000	56%	55%	55%	55%	55%
1.000 to 1.500	14%	13%	13%	13%	13%
More than 1.500	31%	32%	32%	32%	32%
Total	100%	100%	100%	100%	100%

Source: Annual report Infrastructuurfonds (2014)

g. Sector characteristics of influence in IWT

Serial production of LNG engines will benefit from economies of scale and consequently lower costs, making the deployment in turn more attractive. Relevant for a serial production is the fact that a significant share of Dutch companies active in the IWT sector (nearly 90%) operates only one vessel and only a very small number of companies operates more than 20 vessels – or more than 20 employees.[7] A large company with a relatively large fleet (for example Danser or Chemgas) can benefit from those economies of scale in case it switches to LNG.

[7] There are no recent overviews of the sector's structure. Most recent overviews regarding the number of vessels per company dates from 2002.

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Furthermore, it is found that there is traditionally a limited preparedness for cooperation in the sector. While it is exactly the common investments/procurement which could force a breakthrough, thus making cooperation an essential requirement for the facilitation of the LNG deployment in the sector. This cooperation can take place either horizontal or vertical. Horizontal cooperation concerns cooperation in the sector with a focus on common knowledge development ("Expertise Centre LNG") and procurement. An example of vertical cooperation is between suppliers of LNG and the service providers. Cooperation with inland ports for example is necessary in order to realize LNG infrastructure. There is though only a limited number of ports required while vessels can sail over great distances with one full LNG tank.

Table 3: European IWT fleet, classified into vessel type, numbers, percentages and share in realized tonne-kilometres per vessel.

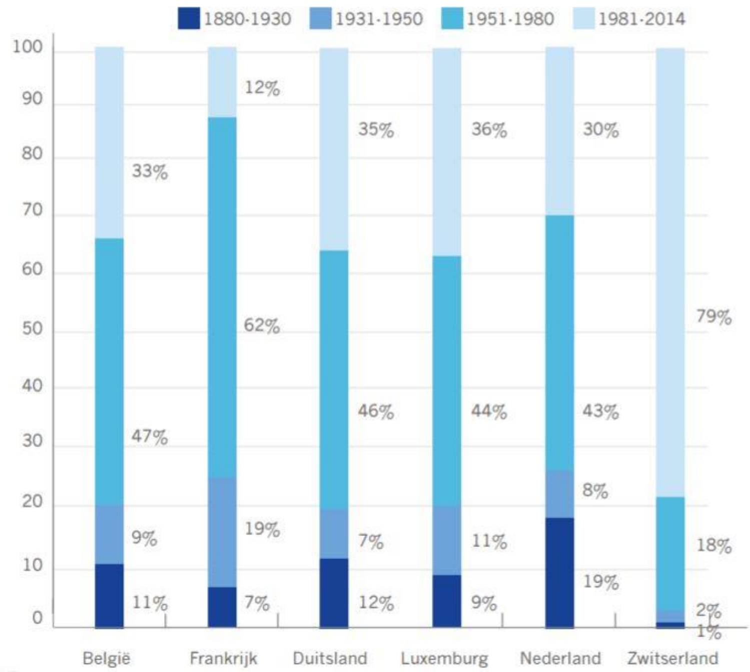
Vessel	Number	Share number of vessels %	Share tonne-kilometre %
Push boat (<500 kW)	890	9.2%	1%
Push boats (500-2000 kW)	520	5.4%	18%
Push boats (≥ 2000 kW)	36	0.4%	9%
Motorvessel dry cargo (≥110m length)	610	6.3%	19%
Motorvessel liquid cargo (≥110m length)	602	6.3%	14%
Motorvessel dry cargo (80-109m length)	1802	18.6%	17%
Motorvessel liquid cargo (80-109m length)	642	6.7%	5%
Motorvessel (<80m length)	4463	46.0%	10%
Coupled convoys	140	1.4%	7%
Total	9710	100%	100%

Source: SPB (2015), own elaboration

The image of the sector is another bottleneck. The IWT sector sees itself as a clean modality while the outside world has a different view encompassing merely old vessels sailing with polluting engines without any treatment in the past 40 years. The sense-of-urgency lacks in the sector. The image of the sector is being described by the outside world as conservative with a wait-and-see attitude.

It is also relevant to look at clients, large clients as ThyssenKrupp or Shell may require from their logistics providers to switch to LNG. Next to it, a truck is being replaced every 5 up to 7 years while inland vessels have a relatively long lifetime (figure 1) which is an important disadvantage for the sector. The disadvantages of equipping a relatively old vessel with a new and expensive LNG installation have already been pointed out. However, it is normal in the sector to equip an old vessel with a new engine.

Figure 1: Year of construction of IWT fleet per country.

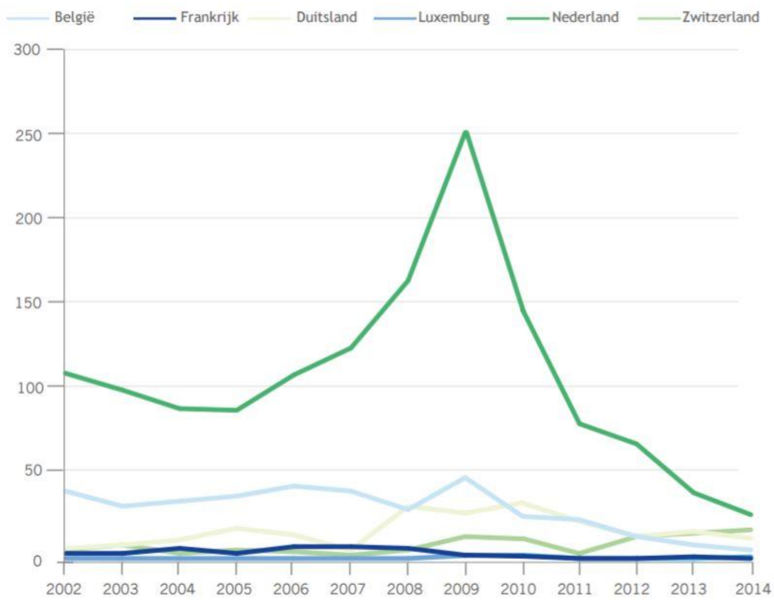


Source: IVR/BVB (2015)

h. Timing is currently not optimal for the sector

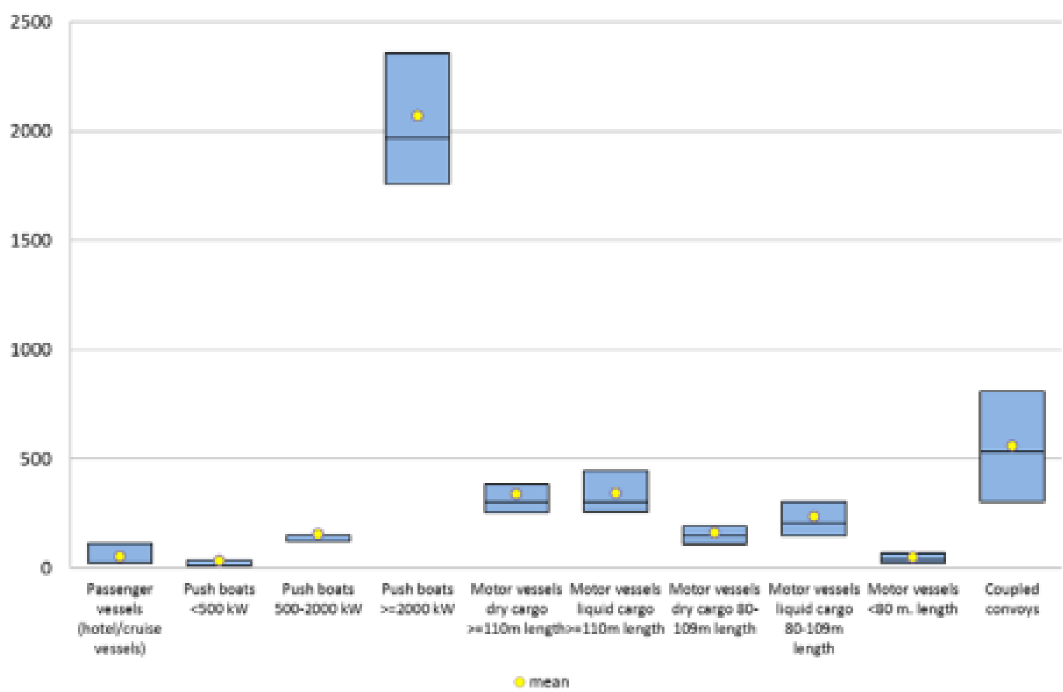
The IWT sector is currently still suffering from the effects of the crisis. The West European IWT fleet strongly expanded in the period between 2005 and 2014 with approximately 1700 new vessels of which 65% sails under the Dutch flag – with a peak of 350 new vessels in 2009 (figure 2). The expansion concerns mainly relatively large vessels with a length of >110m which are due to their relatively high annual fuel consumption attractive for a switch to LNG (figure 3). However, the overcapacity as result of the expansion has eroded the financial position of many companies making it unfeasible for them on the short term to switch to LNG without any stimulus. It appears from table 1 and 2, and figure 3 that the largest part of the IWT fleet consists of relatively small vessels with a limited annual fuel consumption for whom an LNG installation has no return on investment – this part of the fleet is merely suitable for after-treatment, hybrid propulsion and to a lesser extent gas-to-liquid. It appears from figure 3 that push boats with a high installed power, coupled convoys and large motor vessels have a high annual fuel consumption which makes them suited for a switch to LNG. The fact that a large share of the fleet consists of relatively small and old vessels is a characteristic of the sector hindering the realization of possible economies of scale. The timing for a large scale introduction of new capacity – or refitting – is difficult for the sector due to the effects of the crisis.

Figure 2: Number of new vessels in West European IWT.



Source: IVR/BVB (2015)

Figure 3: Annual fuel consumption (m3) for different vessel types.



Source: SPB (2015)

i. Technique available: knowledge of technique is a barrier

LNG technology is available but refitting existing vessels is a complex operation which is not only costly but also requires a lot of knowledge. This knowledge is only limited present at many skippers of existing vessels. Large companies do have a clear advantage in this over relatively smaller companies due to the possibility of specialized personnel (see also: Karaarslan, 2015:44).

Business case LNG unattractive for in particular existing vessels

j. Costs LNG versus conventional diesel
The oil price is currently low as is also the case with the LNG price. The price difference between diesel and LNG is the relevant variable – the gap between both energy sources is widening due to the relatively faster falling oil price which is in the disadvantage of LNG, however this is a dynamic development. The price difference is currently not substantial enough to earn back the investments made in an LNG installation. The logistics costs (supply chain costs) form the actual comparison regarding the price difference while in addition to the gas price there are also costs being made for the distribution of LNG. The price development of LNG is difficult to influence while it is related to geopolitical factors and developments on the world markets. A quantitative analysis is performed to the effects of the price difference between diesel and LNG on investments in LNG. These results are presented in the sub-report: 'Quantitative analysis LNG potential West-European IWT fleet'.

k. Costs newbuild relatively low at the moment
The price for newly built vessels is relatively low at the moment. A large dry cargo motor vessel is currently roughly 40% cheaper as compared to the period when the expansion with new vessels experienced a peak. This means that efficiency gains in the OPEX of newly built vessels (design, sailing behavior) is also enhanced by lower CAPEX. The cost advantages become even more attractive by realizing new vessels in serial production such as Shell currently initiated. Consequently, the business case for refitting an existing vessel with an expensive LNG installation becomes less attractive. Furthermore, there are also other economic disadvantages for old vessels which make a refit operation relatively expensive. There are various types of vessels which make it difficult to standardize the refit operation because each case is custom work. The search is for a solution by which the sector can renew without having negative consequences for the existing fleet. The challenge is to create a 'tipping point' in the sector that can ensure the switch to LNG.

l. Economies of scale LNG installations in serial production
The costs of an LNG installation for an existing vessel are significant and amount to 1.3-1.5 million euros per ship – an amount that among others applies in the mentioned EICB project for six pilot vessels. The extra costs for such an installation forms a significant barrier for a large scale deployment of LNG in the sector. However, economies of scale arise when such installations are produced serially[8] which can reduce the investment costs by 25 up to 30%, but despite these cost reductions it will continue to be difficult for earning back the investment. The IWT sector is a relatively small market[9] for engine manufacturers and consequently there is no priority for those

[8] For example cost savings on test procedures for engines which are at the moment relatively expensive.
[9] If yearly 100 vessels were to be equipped with new engines this would mean 10 up to 20 new LNG engines. A large provider like Cummins produces 15.000 engines per year in various types and sizes for various sectors.

manufacturers to develop for example a special engine for the IWT sector.[10] Serial production could change this. It is however the question on which technology the serial production should be based: dual-fuel or mono-fuel? Economies of scale with serial production is one of the backgrounds of the current construction of 30 vessels (two batches of 15 vessels each). Serial production is an additional advantage for the LNG business case, for newbuild vessels as for refit operations.

m. Customers do not pay more for a LNG driven vessel

Customers/shippers are unwilling to pay more for the use of an environmental friendly vessel (see also: Karaarslan, 2015:42) making it impossible to earn the investment in LNG back by higher tariffs. This is confirmed by the experts consulted for this study. An external stimulus is therefore required in order to achieve a positive business case. Below, some suggestions are presented for innovative forms of financing. In addition – as mentioned before – the price difference between LNG and diesel is currently too small for a positive business case. Because customers do have a clear strategy towards the further greening of logistics – also over water – is 'doing nothing' a risky strategy for the sector. The sector could lose markets by doing nothing – especially while road transport is committed to green their modality. This makes a breakthrough of LNG in the IWT sector very relevant.

n. Dutch banks are locked down: there is a need for innovative financing

The role of banks in the IWT sector can be described as problematic due to the aftermath of the crisis and the significant amount of outstanding mortgages. Especially the financing of new vessels is difficult and thus requires innovative solutions. The government, either on EU or national level, may act as a guarantor to banks for the financing of LNG engines, similar to the Dutch national mortgage guarantee program. Another suggestion is the application of a 'Subat' like regulation. This is an arrangement in the Netherlands in which oil companies surcharge one cent on top of the fuel price from which soil remediation is paid while gas stations and garages in the Netherlands are obliged to remediate the soil. Such a regulation may also be applied in the IWT sector. Another option is the creation of a fund which will be filled with extra tariffs obtained from polluting vessels – for example via the port dues – and in turn be used for investments in clean technology. Norway created the NOx fund with the same objective as mentioned above. Another way is to lower port dues for clean vessels based on an emission rating, however in such a case the port dues should be significantly lower in order to have a notable effect. The 30% discount granted by the Port of Rotterdam authority[11] is a shot in the right direction however the background for this discount rate is unknown and it also uncertain whether this is percentage discount is sufficient for a positive business case.

[10] It appeared from various sides that there no technical barriers for engine technology exist. There is a number of large and experienced providers - the limited number of engine suppliers is however a potential problem, as well as the limited number of suppliers of LNG (two oligopolistic markets). Safety is not an issue, there is however an image problem adhering to the safety of LNG.

[11] This discount is given to inland vessels with engines 60% cleaner than prescribed by the CCNR II regulation and / or vessels with a Green Award certificate after June 17, 2014 with a score of 400 points or more for the main engines.

Bunkering infrastructure LNG

o. Bunkering infrastructure LNG is no barrier on the short term

The infrastructure for LNG is developing rapidly. Relevant developments at the moment are; the construction of an LNG bunkering vessel, the break-bulk terminal in the port of Rotterdam which opened in December 2016, the development of a bunkering station in Köln and the operations in various inland ports in order to improve the availability of LNG. The same infrastructure for bio-LNG is currently not available and the amount of (locally) available bio-LNG is another point of concern. Technical possibilities are no bottleneck, however the demand for it is lacking.

Organization of the transition towards LNG

p. Shell boost: positive reactions by experts

The current investment in 30 new LNG driven vessels initiated by Shell receives severe criticism from the IWT sector due to the existing overcapacity and low growth expectations for the sector. The consulted experts, however, consider it an important stimulus for innovation of the fleet which is necessary to deploy LNG in the market – a particular stimulus contributes to the necessary innovation in the sector and the breakthrough in the chicken and egg debate, while it will generate sufficient demand for LNG in order to realize the supporting infrastructure. It is a 'first-move' which can become a good example for other parties in the sector. Of course this has to go hand in hand with the necessary flanking policies for the sector.

In conclusion, there are a number of bottlenecks hindering the roll-out of LNG in IWT: alternative possibilities in order to meet air quality and climate targets, economic bottlenecks due to factors like an unattractive business case for LNG and the negative consequences for the sector in case of large-scale newbuilding.

However, there are on the short term only limited alternatives for LNG, which also appears from under which the recently published Energy Report. This will be discussed in the next chapter.

5 Background fleet development

Energy report and vision on sustainable fuels for transport: commitment to LNG
A lot of attention is paid to the development of a future fuel mix vision during the preparation of the 'Energy report – transition to sustainability'. The report 'A vision on sustainable fuels for transport' (Een duurzame brandstofvisie met LEF) contains a development path for the IWT sector which is used as input for the Energy report. This development path consists of three phases:

a. A development path for the short term in which improving the efficiency plays a prominent role, partly by adjusting the sailing behavior (slow steaming) which promises a lot; up to 40% energy savings and CO2 reduction. In addition, blending biofuels with conventional fuels will be relevant. However, conventional fuels will remain dominant.
b. A development path for between 2020-2030 with an emphasis on LNG and biofuels (biodiesel and bio-LNG), and Gas-to-liquids (GTL). Efficiency improvements are tightened up further.
c. A development path for after 2030 until about 2050 in which the importance of bio-LNG and biodiesel increases considerably.

The vision on sustainable fuels for transport puts the focus mainly on a transition towards LNG whereby it is noted that LNG has especially a positive effect on reducing pollutant emissions and to a much lesser extent on reducing GHG emissions due to the methane slip problem. The fuel vision puts a strong focus on climate effects only for the scenario after 2030.

900 (bio)LNG driven vessels in 2030
A starting point for the 'Fuel table shipping' report (Deelrapport Brandstoftafel Scheepvaart), a sub-report of 'a vision on sustainable fuels for transport', is that more than 900 vessels will consider a switch to (bio)LNG until 2030 (table 4). Assuming a fleet of about 5.800 vessels in 2014, this number of potential LNG driven vessels represents 16 percent of the total fleet. It appears from the sub-report that the current Dutch fleet size of about 5800 vessels will likely remain unchanged in 2030 and 2050. An important feature of the fleet in 2030 will be the existence of significant economies of scale. The proportion of large vessels will slowly increase (as also appears from table 2) as will also be the case with the scale of the vessels for each vessel type (table 5). For example, in the period between 2009 and 2015 the loading capacity of vessels passing through the Volkerak Lock increased with 16%, the carried cargo per vessel increased with 17% and the carried number of containers per vessels increased with 11%. According to the expectations, the scale of a large Rhine vessel or tanker (Class Va) will increase the coming years with 20 tons per year on average.

The ambition of 900 LNG driven vessels has been reduced in the 2015 version of the main report 'A vision on sustainable fuels for transport' (table 6) to 300 vessels. It appears from the consultation rounds that the mentioned amount of 900 (bio)LNG driven vessels is an absolute upper limit – an amount of approximately 450 vessels in 2030 is more likely. However, these vessels do account for a much larger share in the realized tonne-kilometers on waterways as compared to an average ship, as discussed earlier and shown in table 3.

An important starting point for the use of LNG in IWT is the threshold of 500m3, while LNG will only be an economically interesting alternative for diesel in case the vessel consumes at least

500m3 of diesel in one year. It is not possible to realize a positive business case for vessels with an annual fuel consumption below this threshold. Based on the current annual fuel consumption of various segments only four of them will meet the threshold (as shown in figure 3): large push boats, coupled convoys, large motor vessels for dry and liquid cargo. These four segments form together 14% of the total fleet in number of vessels, however they are responsible for 49% of the total transported ton-kilometres in European IWT (table 3). For the transition towards LNG it is important to put the focus on the relatively large vessels, not only because those vessels have a relatively high fuel consumption and consequently a positive economic business case, but also because they are responsible for a large share in the total transport performance. From the environmental effectiveness point of perceptive, the transition should especially start with the large push boats or the large motor vessels for dry and liquid cargo which have old and relatively polluting engines on board.

Table 4: IWT fleet composition in 2030 and 2050 based on type of fuel consumption for propulsion (absolute numbers).

	2030	2050
Diesel	3440	2108
Biodiesel	563	835
GTL	617	1120
LNG	574	874
Bio-LNG	348	650
CNG	83	0
Solar	0	19
Battery-Electric	193	166
Total	5800	5800

Source: Deelrapport Brandstoftafel Scheepvaart. Visie Duurzame Brandstoffenmix, 2014.

Table 5: Increase of average loading capacity in the IWT fleet in tons per year.

CEMT Class	Present-2020	2021-2040
Class II	0	0
Class III	10	5
Class IV	15	8
Class Va	20	10
Class Vb	25	13
Class VIb convoy (4)	30	15
Class Vic convoy (6)	40	20

Source: RWS-DVS (2010)

Table 6: Inland vessels, action plan shipping.

Inland vessels	2020	2030
LNG	40	300
Right-sized	200	400
VoortVarend Besparen (Energy Efficient Navigation)	2000	4000
Hybrid	100	350
7% blending	4500	5000
HVO/Biodiesel	250	250
GTL	250	250

Source: Een duurzame brandstofvisie met LEF, kosten en effecten van de actie-agenda: inschatting van de potentie (2015)

6 Scenarios for the deployment of (bio)LNG in IWT

Government regulation is leading

According to the consulted experts the most important driving forces, which are inventoried in chapter 4, are: (a) expected regulation of various governments, (b) characteristics of the IWT sector, and (c) the feasibility of the LNG business case for companies in the sector considering a switch to LNG. These three developments are principal for the development of the four scenarios and the estimation of the fuel mix. There is much confusion about it but probably more stringent norms will apply as of 2025 in Rotterdam.

The scenarios below are determined for 2030 while it is possible to technically oversee this period – after 2030 other alternatives like hydrogen will play a more prominent role.

Environmental regulation contains two perspectives which are relevant for the deployment of LNG, on the one hand local air quality and climate targets on the other. As discussed, LNG is especially relevant for improving local air quality and to a lesser extent for meeting climate targets. The emphasis on regulation is thereby an important factor for the choice of scenarios. The scenarios presented below are based on the methodology used in this study (table 7 & 8):

a. *Local air quality is leading*
   This is a scenario in which there is a full commitment to (bio) LNG. This scenario is based on the deployment of 922 vessels as described in the fuel table shipping (2014). This means that LNG driven vessels will have a 16% stake in the total fleet (table 7) and 50% in the total carried tonne-kilometres. The contrast between both percentages can be explained by the relatively large loading capacity and size of these potential LNG driven vessels. GTL will have a stake of 20% in the total number of vessels and 15% in the transport performance. Diesel will remain as most used fuel in IWT, but will only have a 33% stake in the total transport performance. The deployment of 922 vessels means a demand for 60 vessels each year of which 80% will be newbuild and 20% refitted vessels (table 8).

b. *Climate targets are leading*
   This is a scenario in which bio-LNG will play a prominent role whereas LNG and GTL will play a limited one. However, due to the large scale of the vessels which will be deployed, LNG will still have a reasonable share of 7% in the total transport performance. In this scenario the combined demand for bio-LNG and LNG driven vessels will be 460 (30 per year) and will concern 80% newbuild and 20% refitted vessels. Biodiesel will also play an important role in this scenario, both as alternative for diesel as for blending with diesel.

c. *Energy Report is leading*
   This scenario is based on the action plan shipping as being described in the 'Vision on sustainable fuels for transport' (2015). This scenario contains a number of 300 LNG driven vessels with bio-LNG forming an option for the period after 2030. Next to LNG there will

also be a deployment of Hybrid (350 vessels), biodiesel (250 vessels) and GTL (250 vessels). The remaining large number of conventional vessels will especially focus on taking efficiency measures (Energy Efficient Navigation), rightsizing and blending of biodiesel (7%). De ratio newbuild and refit will remain 80-20.

d. *Refit is leading*
In this scenario the sector manages to collect the necessary financial resources for a large-scale refit operation, resulting in significant economies of scale and in addition there will arise attractive fiscal advantages. Consequently, 600 vessels will be equipped with an LNG installation whereby the ratio newbuild and retrofit will be 20-80. The LNG fleet will increase yearly up to 2030, on average with 40 vessels (table 8). Due to the attractive LNG business case in this scenario, there will be less focus on other alternative fuels except for biodiesel. Blending biodiesel with conventional diesel will be another important 'greening' source in this scenario.

Table 7: Four LNG scenarios, share in fleet and in tonne-kilometres per fuelmix. Share in percentages.

<table>
<tr><th>Scenario / Fuel</th><th colspan="2">Air Quality</th><th colspan="2">Climate</th><th colspan="2">Energy Report</th><th colspan="2">Refit</th></tr>
<tr><td></td><td>Vessels %</td><td>Tkm %</td><td>Vessels %</td><td>Tkm %</td><td>Vessels %</td><td>Tkm %</td><td>Vessels %</td><td>Tkm %</td></tr>
<tr><td>Diesel</td><td>62</td><td>33</td><td>68</td><td>51</td><td>81</td><td>68</td><td>81</td><td>55</td></tr>
<tr><td>Biodiesel</td><td>1</td><td>1</td><td>15</td><td>15</td><td>4</td><td>4</td><td>4</td><td>4</td></tr>
<tr><td>GTL</td><td>20</td><td>15</td><td>2</td><td>2</td><td>4</td><td>4</td><td>4</td><td>4</td></tr>
<tr><td>LNG</td><td rowspan="2">16</td><td rowspan="2">50</td><td>3</td><td>7</td><td rowspan="2">5</td><td rowspan="2">18</td><td rowspan="2">10</td><td rowspan="2">35</td></tr>
<tr><td>Bio-LNG</td><td>5</td><td>18</td></tr>
<tr><td>CNG</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Solar</td><td>0</td><td>0</td><td>2</td><td>2</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Battery-Electric</td><td>1</td><td>1</td><td>5</td><td>5</td><td>6</td><td>6</td><td>1</td><td>1</td></tr>
<tr><td>Total</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td></tr>
</table>

Table 8: Four LNG scenarios, size of LNG-fleet in 2030 (number of vessels), addition of LNG vessels subdivided into newbuilding and refit (in percentages).

Scenario	Air quality	Climate	Energy Report	Refit
LNG-fleet IWT	922	460[a]	300	600
Yearly addition LNG driven vessels	60	30 [a]	20	40
Share newbuild	80%	80%	80%	20%
Share refit vessels	20%	20%	20%	80%

(a=including bio-LNG)

7 Evaluation of scenarios for the deployment of LNG in IWT

Energy transitions in IWT: will LNG become the dominant fuel?

The deployment of LNG is not a unique event in IWT; various fuel transitions took place in the past 100 years. In the Netherlands the first coal-fired steam engines for vessels became operational around 1820 and replaced the sailing and horse-drawn vessels. After World War I the first motor vessels were deployed which used petroleum and the diesel engine was introduced around the 1930s. The success of the relatively cheap diesel engine caused the (almost) complete disappearance of the preceding techniques. The work of Filarski (2014) indicates that it can take many decades before a conventional technique is abandoned – for example, sailing vessels were built until the 1930s and steam vessels formed part of fleet until the 1950s. It becomes clear that the IWT sector has a dominant energy source for particular periods of time, making in turn the introduction of a new technology, by definition, a long trajectory. This observation still applies today which can also be seen from figure 1, a relatively small though significant share of the operational European IWT fleet is been built in the period between 1880 and 1930. It appears from the developed four scenarios in the previous chapter that LNG can become a dominant fuel before 2030 in at least one of the scenarios (scenario Air Quality).

General experiences for the introduction of new fuels

Based on recent experienced with fuel transitions in road transport, Allen (2015) shared a number of learning experiences which will also be relevant for the similar transition in the IWT sector. Four factors are identified which will be highly relevant for a successful energy transition:

a. *100% commitment* of all the stakeholders related to the energy transition.
   This general lesson is not yet applicable to the case of LNG in IWT, especially the dilemma between newbuild and refit is an important point of disagreement among the various stakeholders.

b. *The right timing* is crucial for the deployment.
   There are different views on this point which is closely related to the first lesson mentioned above. The current overcapacity in the sector is a reason to postpone a large-scale newbuilding operation, while this will only worsen the negative consequences of the current overcapacity. On the other hand, relatively low newbuilding and LNG prices offer currently great benefits for an accelerated deployment of LNG.

c. Take *existing users* into account.
   This is crucial for the deployment of LNG, as mentioned above with the necessity for 100% commitment of all stakeholders related to the energy transition.

d. *Availability of information* is also of great importance.
   The necessary information is available at a central point thanks to the close involvement of different branch organizations and EICB with large-scaled initiatives like the aforementioned LNG-Masterplan and the initiatives of CCNR. However, the available information can be valued in a different way by each individual company active in the

sector. Though, it appeared during this research that the available information is clearly presented and that many possibilities exist to acquire detailed information.

The general experiences already provide a number of issues related to the deployment of LNG in IWT: currently there is a lack of commitment in the whole sector, the timing is an important consideration as well as the position of existing users. The overriding background for the picture outlined above is the current capacity situation in the sector.

Seven success factors for the deployment of LNG: the 7 "C's of Success"

Additionally, Allen (2015) gives seven success factors for the deployment of LNG. These factors are successive, the first factor is the most crucial one and the factors coming next to it will only be of any relevance in case the first factor shows that conditions are favorable for the introduction of LNG (see table 9).

Only when the first, most crucial, success factor shows that conditions are favorable for the introduction of LNG, the following factors will become relevant (see Table 9). These success factors are described on the following pages.

1. Fundamental Market CONDITIONS have to be in place.

There are two basis conditions: (a) the technology has to be available and suppliers of the technology should deliver this without any problems, and (b) regulations should not hinder the transition towards LNG.

According to the consulted experts, LNG in IWT has met the two basic conditions or is working hard to meet both conditions on the short term. The technology is still in development and not yet standardized, but will crystallize out in case of a large-scale demand: however, this is no bottleneck. The regulatory framework is an important priority which is not being considered as a bottleneck.

Next to technology and regulation, (c) the necessary scale of LNG operations for further investments and (d) the price development of LNG for existing businesses are two relevant factors for the desired transition. The initiative of Shell may be the first step into the direction of realizing economies of scale. However, the price development of LNG currently does not justify a positive business case for existing businesses. The availability (e) of LNG is a last important factor. Developments are ongoing regarding this factor and experts do not experience this as a bottleneck for the roll-out of LNG.

Concluding, the most important success condition is not met yet in order to realize the roll-out of LNG in IWT. This concerns in particular the economic benefits of LNG which are simply not present. Benefits from economies of scale are also limited while the 30 vessels being built on behalf of Shell will not be commissioned altogether and there are also other parties investing in similar series of vessels.

Table 9: *Seven success factors for deployment of LNG (7 "C's of success")*

Success factors	Score
1. Fundamental market **conditions** have to be in place:	
a. technology available	+/++
b. regulation for LNG available	+/++
c. minimum necessary scale for operations available	0
d. positive business case for existing IWT companies	-/--
e. product availability LNG	+/++
2. The power to **convene**	++
3. Promoting **cooperation**	0
4. Understanding for the **challenges** faced by various stakeholders	+
5. **Conceptualize** the solution	++
6. Developing the **commercial** case	-/--
7. **Conducting** the Orchestra	?

Source success factors: Allen (2015), score ++ = very positive effect on the deployment of LNG in IWT, - - = severe bottleneck hindering the deployment of LNG in IWT. Score estimated by the author based on the information obtained in this study.

2. The power to CONVENE

It is very important to have an independent party with a market vision which is able to bring a sufficient number of parties together in order to develop the LNG market. This organization should be able to bring organizations along the whole LNG chain together, for example production, distribution, technology, etc., and to actually mobilize them. A good example of an organization which has taken on this role at the moment is the Port of Rotterdam authority, which strongly stimulates the further roll-out of LNG in the IWT sector. This appears from the projects and activities, such as the joint initiative for the creation of an LNG break-bulk terminal on the Maasvlakte, the establishment of a bunkering infrastructure for IWT, the participation in the LNG Masterplan and LNG Platform, and cooperation with the port authorities of Antwerp, Mannheim, Strasbourg and Switzerland in the fields of research, promotion, knowledge transfer, regulation and bunkering infrastructure. The Port of Rotterdam authority is, due to its relatively independent role, in a better position to perform abovementioned activities as compared to a party like Shell, which has very clear commercial interests.

3. Promoting COOPERATION

Improving cooperation between the involved stakeholders is a third success factor. A key to improve cooperation is the development of trust between the various stakeholders and to prevent the development resulting in a disproportionate dominance of some stakeholders over other ones.

4. Understanding for the CHALLENGES faced by various stakeholders

It is essential to understand the technical, financial, commercial and operational challenges faced by various stakeholders and to have a deep understanding of the position the various stakeholders take. There could arise major barriers in case of a lack of understanding, for example when there is no sufficient insight into the economic background of the various types of IWT companies. It appeared from this research that the consulted stakeholders have a very realistic view on the challenges faced by the various stakeholders. Also the industry organizations in the IWT sector have much understanding for each other's positions, for example for the position of Shell and in particular regarding their investment in 30 LNG driven vessels. However, understanding is one thing, 'appreciation' for the investment choice is another.

5. CONCEPTUALIZE the solutions
In order to develop a fuel market the final concept of the market, developed in cooperation with the various stakeholders, should be illustrated so the role for the different parties can become clear. Especially with developments that have a complex interrelationships, like abovementioned, it is very essential to have a very clear conceptual image. This image is also an important basis for the further development and deployment of for example the LNG supply chain along the major rivers, and there should be a clear view of customers that will be served. Various previously mentioned initiators played an important role in developing a conceptual image of possible solutions along the Rhine, Maas/Meuse and the Danube.

6. Developing the COMMERCIAL case
When there is a clear image of the concept with which LNG can be deployed and of the associated challenges, and when all stakeholders are aware of their role and challenges, then all various parties can focus on their individual business cases for entering the market. Thereby there should be sufficient degrees of freedom in order to be able to react on LNG price developments and changes in other factors.

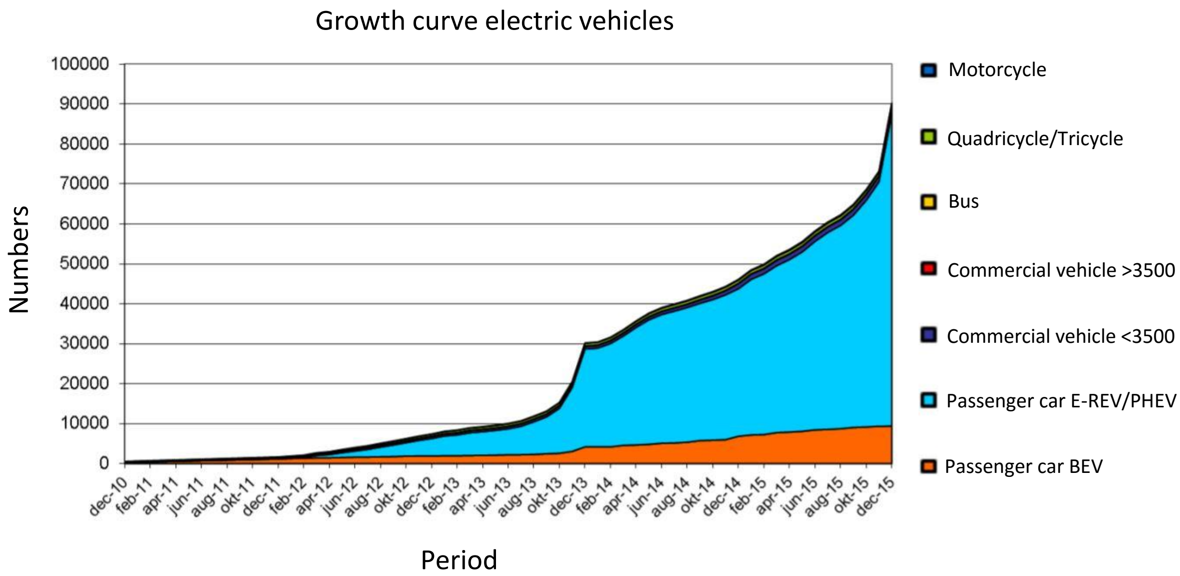
The Port of Rotterdam authority, the powerful party that raised in phase 2 to bring all various stakeholders together, can play a facilitating role regarding this point.

It is exactly this point where Allen's model becomes tangled with the current situation in the IWT market. While it is exactly the economic problems related to a large share of the market forming a barrier for the development of the LNG market. The basic market conditions are simply not yet in place, preventing a gradual transition of the/part of the existing fleet towards LNG. The individual business forms a severe bottleneck for many companies in the sector and only a large player will be able to force a breakthrough in the market by means of a large-scaled initiative. As also pointed out in chapter 4 the current situation requires an unorthodox measure to finance the existing fleet. An example is the European co-funded project under lead of the EICB, which forces a breakthrough by putting the focus on both the supply side (LNG bunkering stations), demand side (LNG driven vessels), and related studies. The many tax benefits and subsidies for hybrid cars shows what the impact of external financing possibilities can be. The Netherlands is an example of a country which provided significant stimulus for hybrid cars. By the end of January 2016 there were in the Netherlands approximately 18 thousand charging points and more than 400 fast charging stations. The figures below illustrate how rapidly a vehicle fleet and related infrastructure can develop when the right fiscal incentives are present, which have significant positive effects on the business case for users of these vehicles.

7. CONDUCTING the Orchestra

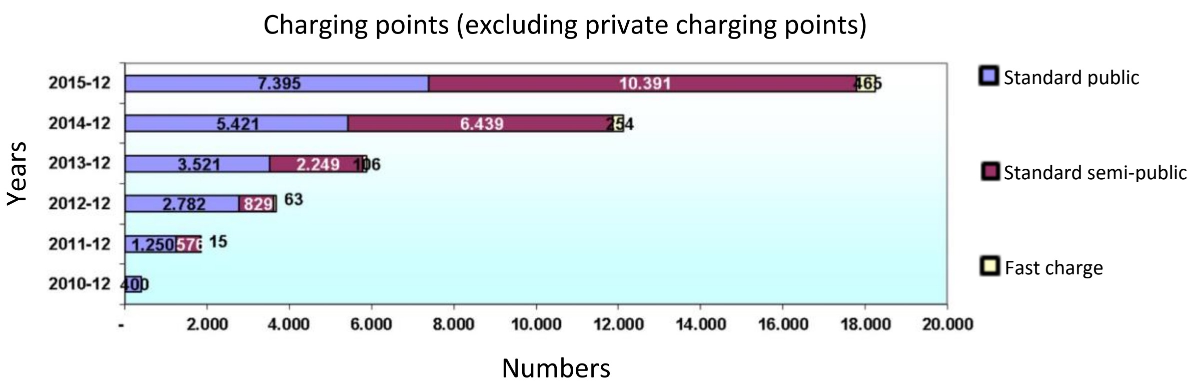
A last and final success factor is guiding the transition process: conducting the orchestra. Allen (2015) sees again a role for this success factor by a powerful party who is able to bring stakeholders together – for example the Port of Rotterdam authority.

Figure 4: Development of registered electric vehicles in the Netherlands



Source: http://www.rvo.nl/onderwerpen/duurzaam-ondernemen/energie-en-milieu-innovaties/elektrisch-rijden/stand-van-zaken/cijfers

Figure 5: Development of charging points in the Netherlands



Source: http://www.rvo.nl/onderwerpen/duurzaam-ondernemen/energie-en-milieu-innovaties/elektrisch-rijden/stand-van-zaken/cijfers

LNG BINNENVAART
Deployment in Inland Waterway Transport

8 Epilogue

The framework of Allen (2015) presented in the previous chapter illustrates the various necessary elements which play a role in the deployment of LNG. It appears that many thing are going well for the introduction of LNG, but the basic market conditions are not in place yet due to the lack of a positive business case.

Four scenarios are handled in this report whereby the necessary investments in LNG driven vessels, either newbuild and/or refit, varies with a volume of 20 up to 60 vessels per year. The development at the moment is still significantly below the scenario with the most modest LNG deployment: scenario based on the expectations as described in the Energy report. It is expected that Shell's impulse will result in a yearly commission of some 10 vessels for three years long (2016-2018) – half of the number of vessels required in the scenario based on the Energy report. In addition to the Shell initiative it is known to have only one other example of a newbuild and one of a refit.

Given the abovementioned situation it can be expected for now that the scenario based on the Energy report, in which 20 LNG driven vessels will be commissioned each year resulting in an LNG fleet with a 5 percent stake in the total fleet by 2030 – and a 18% stake in the transport performance, will be an upper limit. Achieving this upper limit requires an additional number of large customers/shippers or ship owners who will invest in the LNG capacity by either newbuild or refit operations. It will be necessary to pull out all the stops to realize the latter case – first – to search to innovative and unusual financial measures whereby some suggestions have been made in this report and also – second – to search to funding possibilities in the EU. During interviews with EU stakeholders it was implicitly expressed that there are opportunities for funding in the EU.

In addition, it is necessary to implement a stimulating policy for the imposition of port dues in seaports and inland ports. 'Environmental Port Charging' should be introduced convincingly.

The sector will not be able to prevent newbuilding due to the additional economic benefits of newbuilding over refitting. However, this does not mean that refitting has no priority

An offensive and sector wide action plan is absolutely required for the further greening of the sector. Next to efficiency measures related to among others the sailing behavior, monitoring and adjusted design of vessels, it is also a must to realize a transition towards LNG due to three reasons. First, in order to improve air quality in cities with relatively high IWT intensity like the city of Rotterdam. Second, due to far reaching requirements of customers regarding sustainability in logistics. Third, LNG is a first step towards a more sustainable sector and contribution to climate targets as forerunner of bio-LNG.

LNG is not a panacea while it is only feasible for relatively large vessels with a high fuel consumption. It should therefore always be combines with other measures as described in this report.

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10 Interview partners

Alain Bourgeois	Vice President, Gas & LNG, Bergen Energi AS
Peter Colon	Buck Consultants International
Dan Veen	TNO Senior Business Developer Maritime & Offshore
Lauran Wetemans	Shell - General Manager D-LNG | LNG Fuel
Guido de Wilt	European Commission, DG Environment, Unit C3 Air
Helmut Morsi	European Commission DG MOVE, Conseiller to the Director MOVE B “European Mobility Networks” Focus on Innovation & New Technologies (technical advice only)

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