LNG in transportation: what is its potential for the sector?

With low emissions and competitive pricing, liquefied natural gas (LNG) appears to have significant advantages to emerge as an alternative or supplement to traditional fossil fuels. Although LNG has significant potential for growth over the long term, it will have to eliminate some uncertainties, especially those related to supply infrastructure.

Given its advantages, liquefied natural gas (LNG) has recently emerged as a possible alternative to petroleum products consumed by merchant vessels, on-road heavy-duty vehicles and diesel locomotives in certain countries. Its combustion produces 80% less sulphur oxide (SOx) than diesel fuel and 90%[1] less than the most common bunker fuel oils. LNG also permits a 10% to 20% reduction in CO_2 emissions, produces a miniscule amount of nitrogen oxide (NOx), and costs 30% to 60% less than traditional fuels. Routed by LNG carrier from production sites to an ever increasing number of consumer regions, its market is expected to grow significantly over the coming years (+6.5% in 2016[2]), along with its use in transportation. Though still in its infancy, this sector must address major challenges, primarily related to a lack of supply infrastructure. Despite the scope of investments to be made and the need to convince stakeholders that this change is beneficial, LNG as fuel has certain advantages and enjoys strong potential demand, which should reach 179 Mt in 2035[3].

A currently limited market with a wide range of sectoral dynamics

Presented as a substitute fuel for petroleum products in the maritime, road and rail transport sectors, LNG is marginally consumed at the present time. In maritime transport, the strengthening of antipollution standards since the early 2000s has led shipbuilding companies and engine manufacturers to develop technologies permitting the use of LNG as an alternative or supplemental fuel. For the past ten years, the fleet of LNG-powered merchant ships has grown significantly, reaching 73 units in 2015 (compared with only three in 2005), primarily ferries and platform supply vessels operating mainly in Northern Europe[4]. The reinforcement of ship emissions standards in 2015 for Emission Control Areas (ECA) and in 2020 for the rest of the world offers LNG significant potential for development, given its environmental benefits. By 2022, 80 other new vessels will be commissioned, primarily ferries, container ships and gas carriers, mainly in the United States and Northern Europe (Fig. 1). Added to these short-distance vessels are LNG carriers, with an increasing proportion of the fleet equipped with boil-off gas recovery systems which allow it to be used as fuel.

In road transport, the suitability of LNG as an alternative fuel has been confirmed for heavy vehicles (trucks and buses), although its use remains limited and geographically focused in three areas. In China, which is largest market worldwide, the number of LNG-powered vehicles reached 170,000 units in 2014[5], while refueling stations exceeded 2,500 sites compared with 241 in 2011[6]. In the United States, where the growth of LNG in road transport has been slowed by the

(1) Le Fevre, Christopher; Madden, Mike; White, Nick (2014) LNG in Transportation. A report published by Cedigaz
(2) Cedigaz, December 2015
(3) Le Fevre, Madden et al. (2014). Ibid
(4) DNV-GL, LNG fueled vessels, October 23, 2015
(5) Tsukimori, Osamu (18/06/2015) Japan pushes LNG for transport to help climate, energy security. Tokyo. Reuters. On-line: www.reuters.com/article/japan-lng-transport-idUSL3N0YQ1NI20150618#HfQ5tqZURhgPBdSl.97
(6) ResearchInChina (April 2015) China Filling Station and Gas Station Industry Report, 2015-2018

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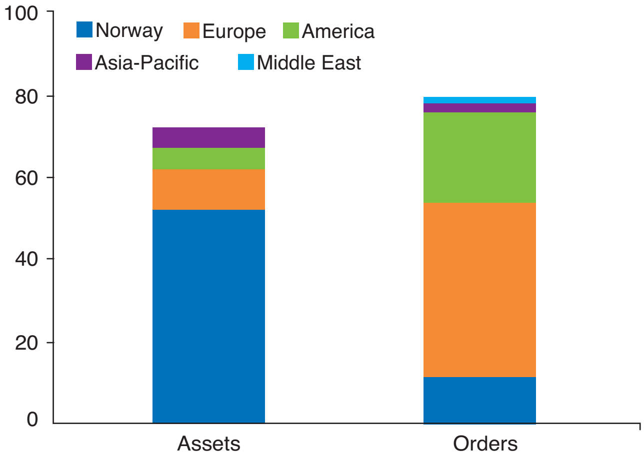
Fig. 1 – Number of LNG fueled ships (excluding LNG carriers)



Source: DNV-GL, Oct. 2015

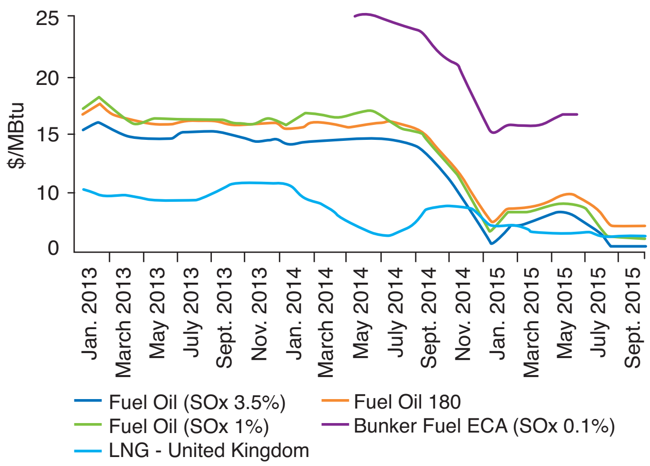
wider use of compressed natural gas (CNG) and traditional fuels, the number of refueling stations remained limited to 74 sites in 2015[7]. In the European Union, regulations in some countries have long limited the use of LNG as a road fuel, and as of 2014 there were only 45 refueling stations in operation[8]. The *Blue Corridors* project supported by the European Union will nevertheless permit significant roll-out of infrastructure along major freight routes, though.

In the rail sector, new LNG engines could replace diesel engines for locomotives on high-volume non-electrified freight lines, but this market is presently nonexistent. To date, no commercial lines have been commissioned, but pilot projects are currently underway in North America.

Environment and price: two drivers of growth

Consuming approximately 7.5% of petroleum products worldwide[9], mainly bunker fuels, the maritime sector is the source of a significant proportion of NOx and SOx emissions. Governed by the 1973 International Convention for the Prevention of Pollution from Ships (MARPOL) signed by 153 countries (98.5%[10] of the global fleet in tonnage), NOx and SOx emissions have been capped since the effective date of Appendix VI on May 19, 2005, signed by 86 countries (95.3% of global tonnage)[11]. The sulphur content of bunker fuels, initially set at 4.5%, fell to 3.5% in January 2012 worldwide, while in ECA areas, which covers the North Sea, the Baltic Sea, a 200 km band along the US, Canadian and French coasts in North America, as well as the waters along Puerto Rico and the US Virgin Islands, the threshold of 1.5% was lowered to 1% in July 2010, then to 0.1% in January 2015. Between 2020 and 2025, the global cap will be lowered to 0.5% which will force ship owners and operators to use cleaner but more expensive fuels, implement new emissions treatment technologies or turn to new types of propulsion, such as LNG. Disadvantaged by a lower energy density than traditional fuels, more complicated handling, infrastructures and currently limited availability, LNG nonetheless appears to be an attractive solution from both an environmental and economic point of view (Fig. 2). Despite the significant investments and operational costs related to storage and supply, if oil prices again rise, the price of LNG should significantly contribute to the sector's growth.

Fig. 2 – Comparison of LNG and bunker fuel oil prices in Europe (2013-2015)



Sources: Argus, IFPEN

In the road transport sector, regulations on sulphur oxides and nitrogen oxides implemented at the national and regional levels in the United States and Europe will only contribute to the margin for developing the sector to the extent the fuels, conventional engines and exhaust gas treatment technologies are adequate from this viewpoint. This does not prevent public authorities from encouraging the development of this new fuel, as in China, where emissions limits on trucks are consistent with European standards with a few years of delay, and where local and national authorities, in keeping with the 2012 Policy on the use of natural gas, are encouraged to take measures to support development of infrastructure and the sector. In June 2015[12], the Japanese government declared its intent

(7) US Department of Energy, Alternative Fuels Data Center. On-line: www.afdc.energy.gov/fuels/natural_gas_locations.html, consulted on December 14, 2015

(8) Sia Partners (2014) LNG in road fuel, what is the potential for France. On-line: www.energie.sia-partners.com/20140924/le-gnl-comme-carburant-routier-quel-potentiel-pour-la-france, consulted on December 14, 2015

(9) Le Fevre, Madden et al. (2014). Ibid. according to the International Energy Agency

(10) International Maritime Organization, Summary of status of conventions, On-line: www.imo.org/About/Conventions/StatusOfConventions/Documents/Summary%20of%20Status%20of%20Conventions.xls, consulted on December 14, 2015

(11) International Maritime Organization, Ibid

(12) Tsukimori, Osamu (06/18/2015) Japan pushes LNG for transport to help climate, energy security. Tokyo. Reuters. On-line: www.reuters.com/article/japan-lng-transport-idUSL3N0YQ1NI20150618#HfQ5tqZURhgPBdSl.97

to promote the use of LNG in road transport, though there are currently no LNG-powered trucks on the roads in this country, which absorbs nearly 38% of the liquefied natural gas consumed globally each year[13]. Beyond regulations, economic advantages are the main benefit to using LNG as fuel. Though investment and maintenance costs per vehicle are higher than for diesel-powered trucks (approximately €50,000 in additional investment and €5,000 in additional operational costs yearly per truck[14]) (Fig. 3), they are quickly offset by savings on fuel (Fig. 4). Although subject to significant regional variations tied to local market conditions, taxation and distribution costs, the price gap in favor of LNG (€0.15/km in Europe in 2014) would allow the additional cost to be recovered in just three to five years, according to a recent Cedigaz study.

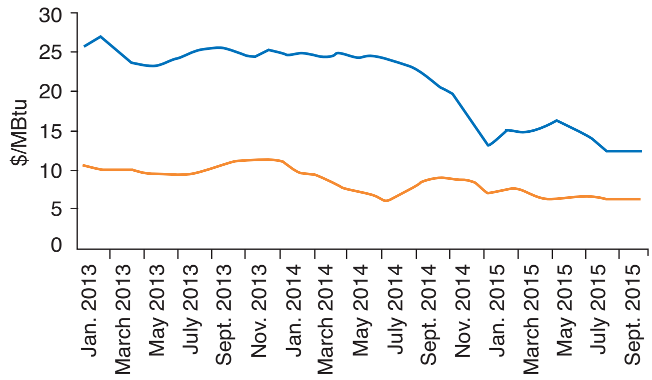
Because the use of LNG in rail transport is limited to countries with a developed, non-electrified network and since this sector contributes significantly less to pollution emissions (0.9% of greenhouse gases arising from transportation in Europe[15]), its development depends on LNG's competitiveness as compared with petroleum products. A 2014[16] study by the Energy Information Agency (EIA, US Department of Energy) assessed savings per gallon at $1.34 to $1.77 with recovery of additional costs in seven years.

Logistical, financial and regulatory obstacles to be eliminated

With its significant benefits, the development of LNG in transport is currently hindered by obstacles and uncertainties, that accompany the launch of a new industrial sector, which must be overcome.

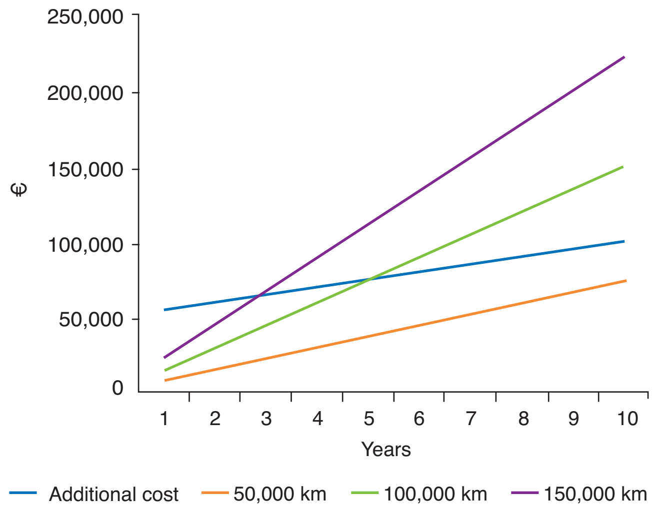
With these challenges, promoters of LNG in transportation must address this new fuel's logistical and operational deficiencies. In maritime transport, this involves convincing the operators that supply will increase and that prices will be favorable over the long term. Substantial investments will be needed to develop storage sites and fueling stations within the ports. Likewise, the development of LNG in road transport faces a paradox whereby distributors, noting the limited investments made by builders and engine manufacturers, have little inclination to deploy new infrastructure while the builders and manufactures, observing the weak supply network, restrict the development of new vehicles to

Fig. 3 – Comparison of LNG and diesel fuel prices in Europe (2013-2015)



Sources: Cedigaz, IFPEN

Fig. 4 – Cost recovery of LNG propulsion in European road transport



Sources: Cedigaz, MJM Energy

adapting existing models. Thus, one of the sector's major challenges is to develop infrastructure to make the fuel fully available and approach the level of flexibility required by certain carriers and ship owners. Gradual growth in the use of LNG should also increase the amount of information available to maritime and inland operators, thereby reducing risk aversion which holds back investors.

In both the maritime and inland sectors, significant investment and operational costs could limit the growth of the sector. In the maritime sector, although costs can be offset by fuel savings and extra costs are quickly recovered, the construction of LNG-powered ships entails extra cost and the conversion of existing ships is expensive, given the need to adapt engines, install cryogenic

(13) Cedigaz (November 2014), Natural Gas in the World 2014
(14) Le Fevre, Madden et al. (2014). Ibid
(15) Le Fevre, Madden et al. (2014). Ibid
(16) EIA (April 2014), Annual Energy Outlook with projection to 2040, On-line: www.eia.gov/forecasts/aeo/index.cfm#liq_nat_gas, consulted on December 14, 2015

storage tanks on-board and possibly construct land-based storage sites. These additional costs may constitute barriers to entry, even if economies of scale would be achieved as the sector develops, as also expected in the road transport sector. In this sector, higher costs could in fact restrict investment decisions to truck fleet renewal periods, which indicates a long-term roll-out. Road carriers could also need to bear the cost of refueling stations in view of the limited number of users, even though LNG suppliers would support them under long-term contracts. Likewise, in the rail sector, transport companies face similar risks when deploying stations along railways. It is also necessary to establish whether locomotive fleets, which can operate over vast networks, are of adequate size to achieve economies of scale and make the necessary investments profitable.

Deployment of LNG in the transport sector presumes the introduction of standards and regulatory frameworks to ensure safety around this potentially dangerous energy source. Although LNG has a positive safety record, the relative lack of experience handling it in various ports around the world and the lack of recognized international regulations mean that the authorities are cautious when granting construction and operating permits. While some standards have been adopted at the local level, the globalization needed for safety standards is increasing, particularly thanks to the January 2015 publication of ISO guidelines for systems and installations for supply of LNG as fuel to ships[17]. Even before future international antipollution standards take effect, it is important to clarify the division of responsibilities between the ship owner, the operator and the country of registration to ensure they are carried out. Likewise, the adoption of international standards will contribute to the growth of the road transportation market. ISO guidelines are currently being developed, and principles concerning LNG stations for fueling vehicles should be published in April 2016[18]. Application of these new standards could help stations to convince local authorities, who sometimes have difficulties in understanding this new technology but whose authorization is required.

A potential worldwide market of 179 Mt in 2035

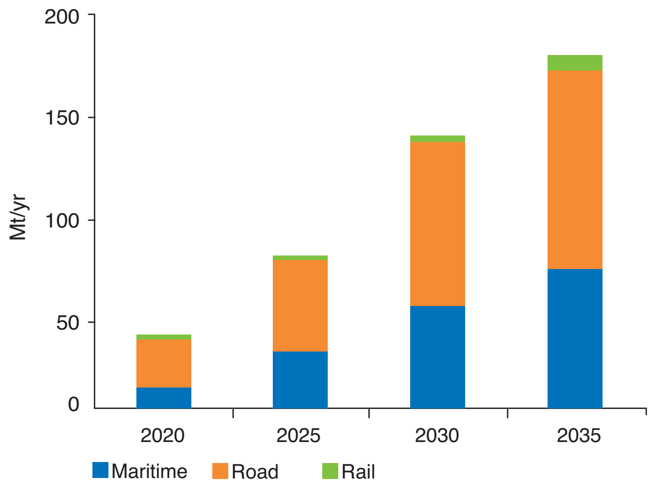
Though the use of LNG in maritime transport is discretely expanding at this time, its market share of maritime fuels remains extremely low due to a very limited fleet.

(17) ISO/TS 18683: 2015 Guidelines for systems and installations for supply of LNG as fuel to ships. On-line: www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=63190, consulted on December 14, 2015

(18) ISO/DIS 16924.2 Natural gas fueling stations - LNG stations for fueling vehicles. On-line: www.iso.org/iso/catalogue_detail.htm?csnumber=57960, consulted on December 14, 2015

A variety of scenarios for the development of LNG, taking into account growth in the maritime sector, price differences between LNG and traditional fuels, implementation of the obligations set forth in Appendix VI of the MARPOL treaty and the creation of new Emission Control Areas, have been proposed to establish prospects for growth in this market. By 2035, the spectrum of possible outlooks varies widely between 3.5 Mt/yr to 224 Mt/yr, though most scenarios predict a potential of 20 to 80 Mt. In its base scenario, established in 2014, Cedigaz expects significant growth, with potential demand for LNG in maritime transport which could reach 18 Mt by 2020, then 36 Mt by 2025 and 77 Mt by 2035[19] (Fig. 5).

Fig. 5 – Potential LNG demand in transport



Sources: Cedigaz, MJM Energy

In the road transport sector, the absence of binding international environmental standards, technological advancements in exhaust gas treatment for diesel engines and the importance of local factors (distribution network, taxation, etc.) support the assumption in which development of LNG as an alternate to diesel is a function of differences among fuel prices and occur at various rates across the regions. Seeking to establish the sector's potential worldwide, Cedigaz assumed in its base scenario that the global truck market would rise by 30% between 2015 and 2035, that the wholesale price of gas would remain below $5 to 8/MBtu compared with ultra-low sulphur diesel, that the supply network would be 75% completed in 2035 and that economies of scale will be achieved. The results of the study show potential for strong growth, as annual worldwide demand for LNG in road transport could reach 23 Mt by 2020 and 96 Mt by

(19) Le Fevre, Madden et al. (2014). Ibid

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2035[20]. Europe could therefore consume approximately 5 Mt by 2020 and 17 Mt by 2035, while Chinese demand could represent 10 Mt in 2020 and nearly 40 Mt by 2035. These projections, in line with the results of studies published by the Oxford Institute for Energy Studies[21] and the International Energy Agency[22], above all represent potential whose achievement is highly dependent on developing infrastructure and on the competitiveness of LNG prices.

In the rail sector, the potential growth of LNG appears more limited, due to the size of the market and its consumption of petroleum products, equal to 15%[23] of demand in the maritime sector. Currently at zero, the use of LNG presumes the development of infrastructure that does not currently exist, significant investments and relies on a clear choice by companies to decide whether to opt for a fleet of LNG-powered locomotives. Demand in this sector should not emerge before the mid-2020s and will only involve a limited number of countries. The EIA estimates that rail transport could consume 0.6 Mt of LNG in 2025 and 2.3 Mt in 2035[24] in the United States, while Cedigaz projects potential demand of 0.9 Mt in 2025 and 6.2 Mt in 2035 worldwide.

(20) Le Fevre, Madden et al. (2014). Ibid
(21) Le Fevre, Chris (2014), The Prospects for Natural Gas as a Transport Fuel in Europe. The Oxford Institute for Energy Studies, (March 2014). On-line: www.oxfordenergy.org/wpcms/wp-content/uploads/2014/03/NG-84.pdf
(22) IEA (November 2013), World Energy Outlook 2013
(23) Le Fevre, Madden et al. (2014). Ibid
(24) EIA (April 2014), Annual Energy Outlook with projection to 2040, On-line: www.eia.gov/forecasts/aeo/index.cfm#liq_nat_gas, consulted on December 14, 2015

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