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CHINA – THE 'MOVE' TO LNG

Examining the Primary Drivers for Uptake of LNG as a Transport fuel in China

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Liquefied Natural Gas (LNG) as transportation fuel takes up over a quarter of the domestic market for LNG in China. In 2017, road and marine, with majority being road transportation, consumed about 5.45 million metric tonnes of LNG sourced either from domestic LNG plants or imported LNG. LNG fuelled vehicles increased 41% to about 310,700 units, with LNG heavy duty truck sales growth hitting a record high of over 500%, adding 91,100 more to total 210,000 units by the end of 2017. This was incentivized mostly by the diesel-LNG price differential, government policy support and improved logistics industry driven by stronger economic growth. Conversely, the growth rate of LNG refilling stations in China continued to slow down since 2013, reaching 2528 stations nationwide by the end of 2017. Gas shortage during winter 2017/18, coupled with government's request to prioritize supply to the residential sector, also created some pressure on supply availability/security of LNG fuel, although this has been much less severe in winter 2018/19.

This paper will take a closer look at driving factors of the strong growth of LNG consumption in the transportation sector, analysing their influence on the development and challenges of this particular market from the perspectives of alternative fuels, infrastructure development and policy/regulation impact. It will explore how LNG can play a greater role in building a cleaner transportation system.

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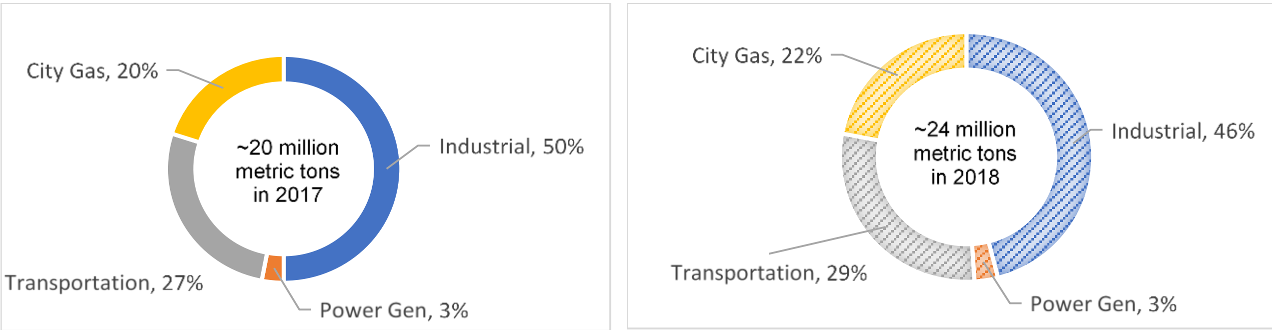
Introduction

China has no doubt the largest market for LNG in transportation sector in the world. It takes up over a quarter of the huge downstream LNG market in China (see Figure 1 and 2). LNG as transportation fuel has gone through a long journey in China since the first experimental research on LNG vehicle in Sichuan in 1961 (Li, Yongchang). Looking back, the market experienced a continuous growth driven by varied factors each year but not without some bump and grind. LNG consumed in the transportation sector reached 5.45 million metric tonnes in 2017 and is estimated to continue to grow to 6.72 million metric tonnes in 2018 according to Sublime China Information (SCI). Its growth rate recovered from the dip of 9% in 2016, when the fuel price differential against diesel dramatically narrowed amidst a USD 40/bbl crude oil world, back to over 20% in two consecutive years in 2017 and 2018 (28% and 23% respectively). Road transportation is the main contributor of the LNG uptake. LNG for marine bunkering in China is still in its infant stage, with only 0.06 million metric tonnes consumed in 2018.

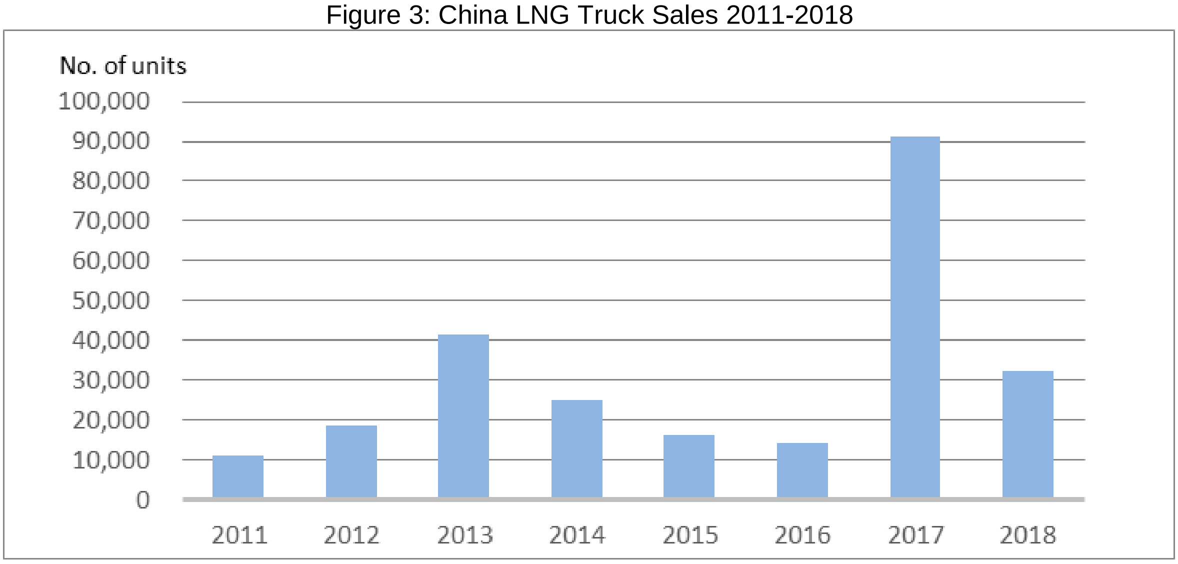
Figure 1 & 2: China Downstream LNG Consumption by Sector in 2017 and 2018



Source: Sublime China Information (SCI) (2018, 2019)

In terms of LNG vehicles, the impact of the record high sales growth in 2017, which was mainly driven by LNG heavy duty trucks (HDT) (500% growth), finally absorbed in the market, leading to a lot more moderate sales performance in 2018. The high LNG price in the winter of 2017-2018 due to gas shortage also brought some hesitation to the market. By end of 2018, there are 343,933 LNG fuelled vehicles running on the roads in China according to SCI's latest statistics, 33,233 units increment from 2017. 236,265 are LNG HDTs, maintaining its share about two thirds of the total LNG vehicle population. The remaining one third are LNG buses and coaches (107,668). On the supply infrastructure side, there are 2552 LNG refuelling stations across the country by end of 2018 (2528 by end of 2017), drawing LNG from either domestic mini-liquefaction plants or coastal LNG import terminals. Just for comparison's sake, there are only 4650 LNG trucks in Europe and 153 LNG refuelling stations in total by end of September 2018.

Figure 3: China LNG Truck Sales 2011-2018



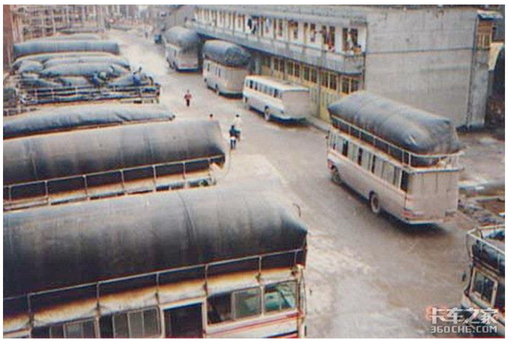
Source: SCI (2015, 2019)

This paper will mainly focus on the road transportation sector, starting with exploring how everything started. And then take a closer look at the driving factors that have been influencing the up and downs of LNG use in the transportation market. Finally, we will also touch on marine bunkering in the last section of the outlook to provide insights on how LNG can help China build an overall cleaner transportation sector.

How it Started…

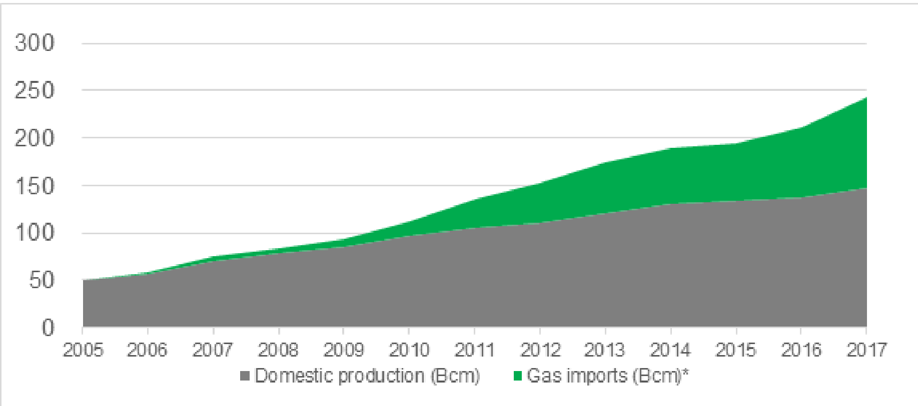
This market obviously didn't come to exist out of nothing. Several industry players along the value chain may claim they initiated it and they may each have some share of the truth. Because it was by collaboration among gas/LNG producers and suppliers, OEMs and investors who developed and made available LNG supply, LNG engines and vehicles, and refuelling facilities available to enable and gradually cultivate the market. However, the story did not start with natural gas in liquid form.

Back in the 1950s, the lack of oil encouraged investigation into all possible alternatives for vehicle fuel. The discovery of large natural gas reserve in Sichuan in 1958 and associated gas in oil fields across the country inspired people to trial with natural gas (Jiang, Dai, 2017). For instance, provinces like Sichuan and Henan (associated gas from Zhongyuan oil field) used bagged natural gas to fuel buses. Huge gas bags sat on top of buses running around in cities. Natural gas was not only available but also cheap. Gas price in Henan was only RMB 0.30 /m3 even in the later years, say 1987 (Li, Yongchang), or about USD 0.98/MMBtu[1]. However, there were challenges using gas directly: the extremely low volumetric energy density constrained the mileage in a single fill; about 30% efficiency loss using petroleum engine; and not to mention the safety concerns, inconvenience as well as the not so fashionable appearance.



Soon people started to explore a more condensed form of gas as transportation fuel i.e. Compressed Natural Gas (CNG) and Liquified Natural Gas (LNG), first dual fuel with petroleum products and ultimately solely on CNG/LNG. The technical research on LNG vehicles in China can be traced back to as early as 1961 (Li, Yongchang). However, it was not until 2008, when LNG utilization in the transportation sector was recommended and accepted in the National High-Tech R&D Program of China (the 863 Program, 2008-2010) in the 11th Five-Year-Plan, that LNG vehicles were able to fully commercialize and then entered the first fast development phase. The main gas producers and suppliers (i.e. the National Oil Companies (NOCs)) played an important role to gather industry participants to push this through. They were keen to create new gas demand beyond the conventional city gas and power generation for the incremental supply from LNG import and Central Asia pipeline gas import starting in 2006 and 2010 respectively.

Figure 4: China Natural Gas Supply (bcm)



Source: IHS

Availability of LNG supply and good fuel economics, with low natural gas price in comparison to petroleum products, provided an attractive case for the government as well as industry participants to invest in tackling relevant

[1] This paper uses annual average of the CNY and USD exchange rate (8.7 for the time before 2000).

technology such as LNG engines, cylinders for cryogenic fuel and refuelling facilities, establishing necessary industry standards, as well as investing in infrastructures such as mini liquefaction plant and LNG refuelling stations. Take LNG HDT as an example, the latest 13L LNG engine manufactured locally in China can generate 430 horse power which is sufficient to manage the majority of road conditions in China. Equipped with single 995L LNG tank instead of multiple smaller tanks which add more weight to the truck, LNG HDT's cruising radius is over 1000 km with a single fill now. And the LNG for transportation network is further enhanced with thousands of LNG refuelling stations built along logistic routes to provide fuel.

Drivers for Uptake of LNG as Transportation Fuel

Once it was off the ground, the development of LNG utilization in the transportation sector in China has been driven by several factors. In general, they can be categorized into internal factors i.e. cost competitiveness against alternative fuel (mainly diesel), and external factors such as LNG supply availability, infrastructure i.e. LNG refuelling stations, and economy growth etc. Some of the factors are to some extent interlinked such as the cost competitiveness and LNG supply availability. Above all these factors are policies and regulations which have an essential influence on almost everything. Most of these policies and regulations are developed to address air quality issues and environmental concerns. This paper does not attempt to exhaust all the factors but to study the key ones that have had the most substantial impact and illustrate how they worked together to shape the market.

Cost Competitiveness of LNG

Cost competitiveness in terms of LNG vs. diesel price differential is the core driver of LNG uptake in the transportation sector and sales of LNG vehicles. LNG HDTs which serve industrial and commercial B2B customers are most sensitive to this factor. The paper will use LNG HDTs as a case study to examine the impact of this economic factor. In the case of China, even though downstream LNG price has significantly increased since the beginning of the century due to natural gas price reform and deregulation of market, LNG still maintains a robust price advantage compared to diesel in general. In the closing meeting of Sino-Euro International Logistic Foyer Natural Gas Vehicle Rallies in October 2018, Mr. Cui, Limin, Deputy General Manager of Kunlun Energy Strategy and Planning department and Natural Gas Integrated Utilization Project shared that if a LNG HDT runs a 100,000 km a year, about RMB 120,000 (or USD 18,154) in fuel savings can be achieved compared to a diesel HDT clocking the same mileage (www.lngche.com, 2018).

The price differential fluctuates as the domestic LNG price reacts to supply & demand balance while China's regulated diesel price is indexed to a basket of international crude oil prices, creating incentives or hesitation for people to switch to LNG truck. The period 2014-2017 experienced the most phenomenal price cycle. Just when LNG vehicle sales embraced a boom in 2013 and 2014, supported by fast development of the refuelling station network expansion during 2012-2014 (see Figure 8), it was hit by the dramatic oil price drop (and corresponding diesel price drop) in the end of 2014 and a surge of domestic LNG price caused by increased feed-in pipeline gas price during China's natural gas price reform during 2013 to 2015. New LNG HDT sales dropped drastically in two consecutive years in 2015 and 2016 (see Figure 3). LNG consumption was also largely influenced by this factor. Despite the absolute volume continued increasing since the establishment of the market, the growth rate fluctuated with the change of fuel price differential. In 2015, it was still able to maintain at double digits growth assisted by the new trucks released to the market in the previous year, reaching 2.57 million metric tonnes in annual consumption. The effect of the narrowed fuel price differential was greatly felt in 2016, pulling the consumption growth rate down to only 5%, adding merely 0.14 million metric tonnes. In 2017 the consumption resumed a strong growth rate to 36% with recovered fuel price differential, landing at 3.68 million metric tonnes by SCI's estimate (SCI, 2016, 2017, 2018).

There are several angles to look at the cost competitiveness. Taking Zhejiang province as an example, a coastal province where LNG refuelling stations are supplied with imported LNG. From simple fuel pump price comparison (heating value equivalent), apart from 2015 and 2016 when international crude price was at around USD 40~50/bbl, LNG pump price demonstrated close to 40% advantage on average to diesel (see Figure 5). Truck driver or logistic companies often compare the fuel cost of covering same mileage e.g. 100 km[2] (see Figure 6). From investor's perspective, they will also take the payback period on the additional capital cost of a LNG HDT compared to a diesel HDT (see Figure 7) into account. In China, a payback period of equal or less than 1.5 years is often deemed acceptable.

[2] Fuel consumption varies depending on the model of truck. Here assumes it requires 32kg of LNG or 35L of diesel to cover 100km distance for a heavy-duty truck with 430ps horsepower.

Figure 5: Zhejiang Pump Prices Comparison

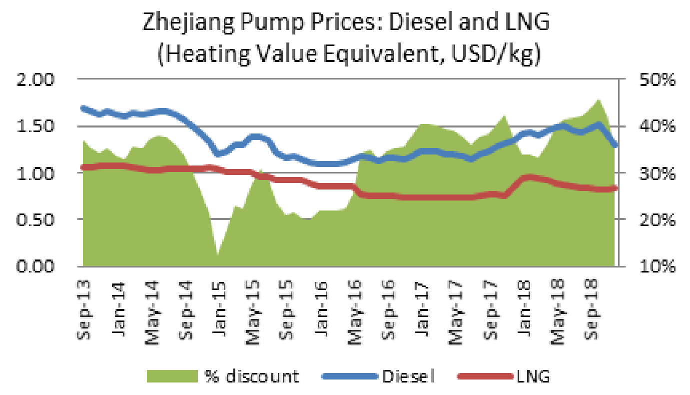
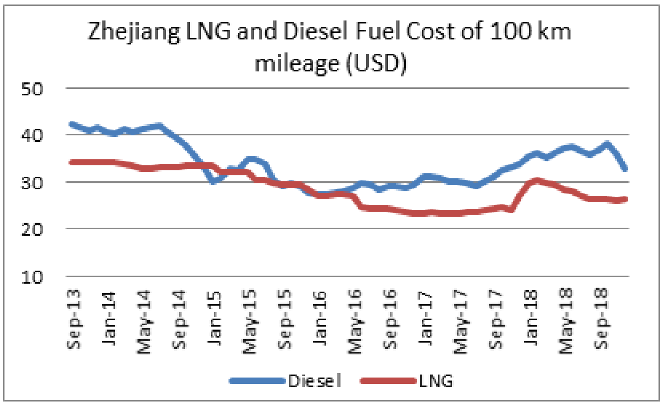


Figure 6: Zhejiang LNG and Diesel Fuel Cost Comparison



Source: SCI, ICIS and local Pricing Bureaus

Table 1: LNG HDT Payback Analysis under Different Crude Prices and LNG DES Prices Scenarios

Brent \ LNG DES	5	6	7	8	9	10	11	12
40	**1.62**	2.12	3.04	5.43	25.16	-9.56	-4.02	-2.54
50	1.37	**1.71**	2.26	3.36	6.53	112.55	-7.38	-3.57
60	1.18	1.43	**1.80**	2.43	3.75	8.17	-45.50	-6.01
70	1.04	1.23	1.50	**1.91**	2.63	4.24	10.93	-18.93
80	0.93	1.08	1.28	1.57	**2.03**	2.86	4.88	16.49
90	0.84	0.96	1.12	1.33	1.65	**2.16**	3.14	5.74
100	0.77	0.87	0.99	1.16	1.39	1.74	**2.32**	3.48

Brent: USD/bbl, LNG DES: USD/MMBtu

Key assumptions:

General	
Driving range	80000km/year
Tank volume	950 litre
Range	800 km
Capex	
SI engine	45000rmb
LNG tanks	45,000rmb
Total incremental fixed cost	70,000rmb
Opex	
Diesel consumption for 100km	35 L
LNG consumption for 100km	32 kg

Source: SCI, local Development and Reform Commission, own analysis

Policy & Incentives

Cost competitiveness appears to have the strongest influence on the LNG uptake in the commercial road transportation business. LNG buses/coaches and their associated LNG consumption, on the other hand, are usually driven by another factor-government policy and incentives. Recognizing the pressing environmental challenges, the Chinese government issued a series of policies since the 12th Five-Year-Plan to build a lower carbon and lower emission transportation system including both roads and waterways. The environmental benefits of natural gas and LNG are well accepted and have been deemed an important alternative fuel to achieve the target. Some of the policies were dedicated to promoting use of CNG and LNG vehicles in the urban areas to tackle the local air quality issue in densely populated areas. One example is the promotion of using CNG and LNG vehicles for city bus, taxi, city logistics and short distance inter-city buses in the 12th Five-Year-Plan of Energy Conservation and Emission Reduction in Road and Waterway Transportation issued by the Ministry of Transportation in Apr 2011.

Following the guidelines outlined by the central government, municipal and provincial governments prescribed more specific policies and fiscal incentives. Sichuan offered fuel subsidy to both CNG and LNG city buses, taxies and passenger coaches in rural areas. Chongqing encouraged local LNG vehicle and vessel market via government procurement and invited state-owned enterprises acting as role models. It also encouraged acceleration of infrastructure network establishment, allowing “moderate over construction of LNG refuelling facilities”. Shandong government offered RMB 30,000 (about USD 4,518) vehicle purchase subsidy to public transportation companies and entities when they purchase natural gas vehicles worth RMB 200,000 (about USD 30,120) and above by 31st Dec 2016. LNG vehicles in the public transportation segment, given its public service nature, are more often driven by environmental related government policies and less sensitive to fuel cost differential. Nevertheless, it has its own unique challenge, which is the competition from electric vehicles that generate no local emissions at all.

Besides policies, particular regulations are also important in shaping the LNG for transportation market. The enforcement of truck oversize and overload control under the national standard of GB1589-2016 issued in late 2016 together with a strong economic growth in 2017 made truck owners rush to buy new on-spec trucks to avoid losing business opportunities. With the upcoming enforced emission upgrade to National VI (equivalent to Euro VI) in 2019, the prospect of diesel truck ban in certain area such as the main ports in Beijing-Tianjin-Hebei area since Oct 2017 (another regulation driver), and the improved price advantage of LNG, many of them chose LNG trucks which already met the more stringent emission requirement and eventually led to a record high LNG truck sales growth of 500% year-on-year in 2017.

Gas/LNG Availability

The strong sales performance, however, was dramatically weakened towards the end of 2017 and in 2018 when a gas supply shortage occurred in winter, another external influence factor mentioned earlier. In the case of gas shortage, the Chinese government requires gas supply to be prioritized to residential and heating uses, limiting the supply to almost all other consumption sectors including transportation. This affected both domestic liquefaction (hit by restrictions in availability of pipeline gas for liquefaction) and imported LNG supply (preferentially regasified into the pipeline network). The tightened supply also pushed up the domestic LNG prices, seriously (if temporarily) deteriorating the cost competitiveness of LNG, causing some hesitation in the LNG HDT market when entering into 2018.

Infrastructure

Infrastructure and vehicles are the main characters in the famous 'chicken and egg' story when a new fuel market is developed. Historical data on LNG refuelling stations and sales of LNG HDTs illustrate a clear trend that the availability of refuelling facilities is an impetus for the acceleration of LNG vehicle growth. Number of LNG HDTs rose moderately in the first a few years when there were only hundreds of refuelling stations. But the strong fuel price advantage and a decent margin by the refuelling stations under a supportive government policy during 2012~2014 ignited the enthusiasm of investors. Number of refuelling sites tripled from 2012 to 2014 to almost 2000 sites and enabled the fast development of LNG vehicles and LNG uptake in the following years. Some refuelling station's daily throughput volume can be as high as 100 metric tonnes serving hundreds of trucks each day. However, in general the fast increase in number of sites also led to somewhat reduced LNG consumption per site. The drop of pump prices of alternative petroleum products in a low oil price period since the end of 2014 also created some downward pressure on LNG pump prices as well as LNG consumption (see table 2 for the changes in LNG refuelling station payback period). SCI believed these are the main contributors to the squeezed profitability of LNG refuelling stations and resulted in a longer payback period especially during 2014 to 2016 (SCI, 2017).

Table 2: China LNG Refuelling Station Investment Payback Periods

Year	**Annual Profit (million RMB)**	**Capex (million RMB[3])**	**Investment Payback (year)**
2011	2.80	8.78	3.14
2012	2.50	8.78	3.51
2013	1.50	8.78	5.85
2014	1.20	8.58	7.15
2015	1.00	8.06	8.06
2016	0.74	8.06	10.89
2017	2.36	8.06	3.42

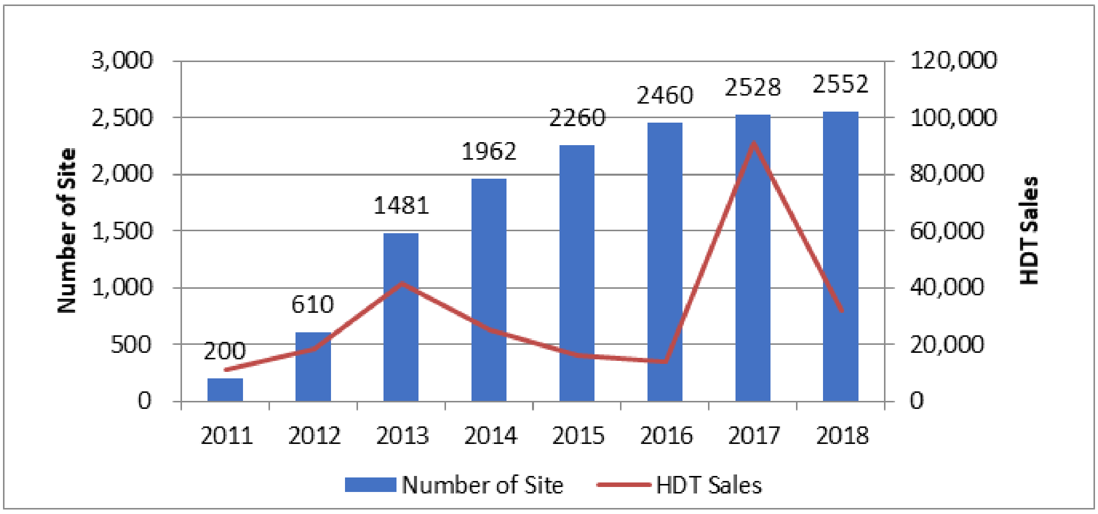
Source: SCI, 2018

LNG refuelling station investment return recovered in 2017 enabled by a large increase in LNG consumption volume due to reasons that has explained in the earlier section on Cost Competitiveness. However, the 2017-2018 winter gas shortage created another uncertainty on LNG availability during winter, which further slowed down investment for new sites. Also, the elaborate project approval procedures would discourage new entries when

[3] Capital investment of LNG refuelling station does not change frequently but exchange rate does. To avoid confusion caused by the different exchange rate applied to the same amount of capital investment in Chinese currency, this table

economic attractiveness was not strong enough. Growth of refuelling sites has been low at about 2~3% in the recent years (SCI, 2018). If situation unchanged, this may slow down the expansion of LNG for transportation market, especially to new regions, in the next couple of years.

Figure 8: Number of LNG Refuelling Sites and LNG HDT Sales



Source: SCI (2015,2019)

LNG: Building a Cleaner Transportation System in China

To fulfil China's environmental commitment and in improving air quality, the Chinese government is determined to build a green transportation system. The latest Three-Year Action Plan for Blue Sky Battle (hereafter, the "Action Plan") issued in 2018 described several methods, including enhancing railway use for cargo logistics, encouraging means to increase transportation efficiency, eliminating diesel trucks that do not meet emission requirements (1 million units by 2020 in key areas), bringing forward the roll-out of national VI emission standards for petroleum fuels, promoting the use of new energy vehicles, advocating the use of vessels with cleaner fuels (electric or LNG) in coastal and inland waterways, and tightening emission supervision along the transportation value chain etc. Apart from continuing to tighten the emission standards of petroleum products, there are not too many cleaner alternatives of transportation fuel. Thus, different segments of the transportation industry have adopted different solutions. LNG, being the cleanest burning hydrocarbon and given its higher energy density, is best suited for larger and/or heavier load of transportation with fixed routes and long mileages.

In the heavy duty logistic sector, LNG-fuelled trucks are expected to be the most plausible cleaner and affordable alternative to diesel trucks in the next one to two decades. With current taxation regimes of fuels and energy pricing in China, unless there is another major oil price drop for a prolonged period of time, LNG is most likely to retain its fuel cost competitiveness. Also, along the development of LNG HDT market, there has been continual improvement in the technology and cost effectiveness of LNG engines. Mr. Wang, Huadong, Head of the Special Vehicle Research Department of Shaanxi Heavy Duty Automobile Co. Ltd Engineering Research Institute, shared that the difference in the purchase cost of LNG HDT and diesel HDT has been reduced from RMB 120,000 ~ 140,000 to RMB 80,000 ~ 100,000. The difference with diesel HDT that meets National VI is further reduced to RMB 60,000 to 80,000. He expected the gap to be further narrowed down to only about RMB 30,000 (USD 4,539) by 2020 (Automotive Observer, 2017). Other alternatives include electric powered heavy-duty trucks and hydrogen (fuel cell) trucks. However, both still need quite a bit of time to overcome technical challenges before they can be commercialised and reduce the cost of the vehicle as well as the fuel to be attractive.

In urban transportation where travel distances are shorter, electric powered buses, coaches and light commercial vehicles do have their advantage in terms of zero local emission. However, close to 70% of the electricity in China is still generated from coal. There is a high chance that the EVs running in the cities are powered by a coal fired power plant in the distance. Looking at the full well-to-wheel cycle, it doesn't necessarily reduce the overall carbon and other air pollutants emission. Therefore, LNG or CNG vehicles could still be a good compliment to reduce overall emissions until less carbon intensive power generation picks up in the entire power system.

Apart from heavy duty logistics, another area where LNG can make a huge difference for a cleaner transportation system is waterways transportation. LNG has potential to be used by cruise liners, ferries, barges and tug boats among others while generating very limited emissions. However, the development of this sector has been slow in China compared to road transportation. There are roughly 140 LNG fuelled (about 45% single LNG fuel) vessels by end of 2018 according to SCI's incomplete statistics, among which 133 are for inland waterway mainly in the Yangtze River, Jing-Hang Canal and Huangpu River. There are 19 LNG bunkering stations in China by the same time. Nevertheless, only less than half are in operation due to lack of demand.

Development of this segment has been slow since the demonstration started in 2009 and faces a few key challenges. While LNG's benefit in bunkering is well recognized by Chinese government which has issued several encouraging policy guidelines, the capital investment required for LNG fuelled vessels and related infrastructures are higher than road vehicles and hence require stronger economic incentive. In 2018, the spread between LNG and MGO can save on average around RMB 360,000 (USD 54,463) a year for a single LNG vessel, 1.9 times that in 2017 by SCI's calculation (SCI, 2019). However，it is still not attractive enough for large scale switching. Many of the subsidy policies by the government were ended in 2015 and 2017. New subsidy plans have not been announced, leaving the market in suspension.

Another reason is a lack of standards and specifications for the LNG bunkering industry, as well as quality control of bunkering fuels in general. On one hand, the safety requirements for LNG fuelled vessel are very high, resulting in higher maintenance and operational cost, for example, in China, LNG ship-to-ship bunkering is still not allowed so bunkering must be conducted via an anchored facility. On the other hand, supervision, especially on product quality, of the marine oil market is not as tight as road transport, allowing some room for lower quality but cheaper fuel oil.

The situation may change in 2019, after a few new policies and guidelines dedicated to reducing emissions in marine sector were issued in 2018. There are policies to tighten emission requirements in the Emission Control Area (ECA) and ban entry of high emission vessels to key regions such as the Yangtze delta. A stronger determination from government to improve the environment can be sensed from these documents. Furthermore, there is evidence that some of the issues faced by LNG for bunkering mentioned before are also being addressed. For example, the national engineering design standards for LNG bunker refuelling stations (GB/T 51312-2018) has been published. And more related standards and requirements are expected to be finalized by 2020. These will pave the way for LNG to release its potential in waterways transportation for China.

Conclusion

To summarize, LNG is cost-competitive, reduces sulphur emissions (virtually zero sulphur emissions), particulates and nitrogen oxides, and can help reduce well-to-wheel greenhouse gas emissions. Besides, it has other benefits such as burning LNG in spark-ignition engines is quieter than burning diesel in compression-ignition engines. Therefore, LNG-fuelled trucks and vehicles can help reduce noise levels in residential areas. Currently LNG fuelled vehicles and vessels are still only a fraction of the whole transportation sector. For instance, LNG HDT is only about 7~8% of the total HDT market, but it is aspired to reach about 30% in the future according to Mr. Wang, Huadong (Automotive Observer, 2017). With the increasing availability of LNG in China from both inland mini-LNG plants and increasingly from coastal LNG receiving terminals, improving engine and vehicle technologies that keep lowering vehicle purchase cost and enhancing fuel efficiency, clearer and simpler industry standards and regulatory procedures that can enable faster expansion of refuelling infrastructures networks, together with the continuous incentives and support from government, LNG fuels in transportation can play a greater role to help China realize a cleaner, affordable and sustainable transportation system in the foreseeable future.

Bibliography

李永昌,'中国液化天然气汽车的发展历程', 自贡市清洁能源产业协会论文精选, [Online]

Available: http://www.zgsqjny.com/View_37_41.html

Li, Yongchang, 'Development Course of China LNG Vehicle', Paper Selection by Zigong City Clean Energy Industry Association, [Online]

Available: http://www.zgsqjny.com/View_37_41.html

蒋岱 (14th May 2017), '50 年代就出现 扒一扒燃气车的前世今生', www.360che.com 卡车之家， [Online]

Available: http://www.360che.com/tech/170427/79196.html

Jiang, Dai (14th May 2017), 'Emerged since the 50s, Understand the History of Gas Vehicles', www.360che.com ，[Online]

Available: http://www.360che.com/tech/170427/79196.html

'行驶逾 1 万公里穿越欧亚大陆 LNG 车比柴油车强在哪儿' (11th Oct 2018), www.lngche.com, [Online]

Available: http://www.lngche.com/article-5880-1.html

'Travel over 100,000km across Eurasia, LNG Vehicle v.s. Diesel Vehicle' (11th Oct 2018), www.lngche.com, [Online]

Available: http://www.lngche.com/article-5880-1.html

'天然气重卡暴涨的背后',*汽车观察*, 11th Sep, 2017，

'Behind the Surge of Natural Gas Heavy Duty Truck', *Automotive Observer, 11th Sep 2017*

Available: http://www.sohu.com/a/191238057_190282

‘天然气价格上涨，重卡企业依旧乐观’，*中国证券报*, 15th Aug 2013

‘Natural Gas Price Increased, Heavy-Duty Truck Enterprises Still Optimistic’, *China Securities Journal*，15th Aug 2013

Available: https://www.cn357.com/a20166_20190101_1_1

中国 LNG 市场年度报告 (2014-2018), Sublime China Information, 2015,2016, 2017, 2018, 2019

中国 LNG 车船市场年度报告 (2014-2018), Sublime China Information, 2015,2016, 2017, 2018, 2019

中国 LNG 物流与加气站市场年度报告 (2014-2018), Sublime China Information, 2015,2016, 2017, 2018, 2019

China LNG Market Annual Report (2014-2018), Sublime China Information, 2015,2016, 2017, 2018, 2019

China LNG Vehicle/Vessel Market Annual Report (2014-2018), Sublime China Information, 2015,2016, 2017, 2018, 2019

China LNG Logistics and Refuelling Station Market Annual Report (2014-2018), Sublime China Information, 2015,2016, 2017, 2018, 2019

Policies

国务院关于印发打赢蓝天保卫战三年行动计划的通知（2018），State Council of P.R. China

Notice on Three-Year Action Plan to Win the BlueSky Battle (2018), State Council of P.R. China

关于深入推进水运行业应用液化天然气的意见（征求意见稿）（2018），交通运输部

The Instructions on Promoting the Use of Shore Power and LNG Vessels in Yangtze River Main Lines（2018），Ministry of Transport, P.R. China

加快长江干线推进靠港船舶使用岸电和推广液化天然气船舶应用的指导意见 （2018），交通运输部

Instruction on Accelerating Shore Power for Berthing Vessels and Promoting Application of LNG Vessels Along Main Lines of Yangtze River (2018), Ministry of Transportation, P.R. China

公路水路交通运输节能减排“十二五”规划（2011），交通运输部

12th Five-Year-Plan of Energy Conservation and Emission Reduction in Road and Waterway Transportation (2011), Ministry of Transport, P.R. China

交通运输节能减排专项资金管理暂行办法（2011），财政部，交通部

Temporary Management Measures of Dedicated Fund for Energy Conservation and Emission Reduction in Transportation (2011), Ministry of Finance, Ministry of Transportation, P.R. China

关于促进天然气汽车产业健康发展的意见 (2013)， 四川省发改委

Opinions on Facilitating the Healthy Development of Natural Gas Vehicle Industry (2013), Sichuan Development and Reform Committee, P.R. China

四川省“十二五”清洁汽车产业发展规划，四川省

Sichuan 12th Five-Year-Plan on Development of Clean Vehicle Industry (2013), Sichuan Province Development and Reform Committee, P.R. China

重庆市人民政府办公厅关于推广应用液化天然气车辆（船舶）的实施意见 (2015)，重庆市

Opinion on Implementation of Promoting Application of LNG Vehicle (Vessel) (2015), People’s Government of Chongqing, P.R. China

山东省节能与新能源城市公交车示范推广资金管理暂行办法 （2013），山东省财政厅

Temporary Management Measures of Demonstration and Promotion Funds of Energy Conservation and New Energy Urban Bus in Shandong Province (2013), Department of Finance, Shandong Province