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LNG as a fuel, a solution to the tightening of environmental rules & regulations in the transport sector

*A 16% decrease of CO2 emissions, up to 90% of pollutants avoided, 3% cheaper**

Topic : Oil & Gas
November 2017

siapartners

*For a diesel road tractor (Iveco Stralis) covering over 100 000 km / year compared to an equivalent Euro 5 vehicle. The price is calculated for the life span of the vehicle (7 years) for a current French fuel price (January 2016).



Executive summary



The use of LNG as a fuel



LNG as a road fuel



LNG as a marine fuel



Conclusion and perspectives



For more information



Executive Summary



Executive summary

The tightening rules & regulations on emissions (**particulate matter, SOx, NOx...**), have propelled the use of **natural gas as a fuel** to the forefront. This fossil resource, essentially composed of **methane**, allows a reduction of **CO₂** emissions up to **24 %** compared with gasoline and emits almost **no local pollutants**. While the use of gas as a fuel has existed for several decades for cars, the use of Liquefied Natural Gas (LNG) as a fuel has reached today a satisfying level of technological maturity for heavy duty vehicles (trucks and buses) and large sea vessels allowing **large-scale distribution** of this fuel.

For **road transport**, LNG is seen as an interesting solution for vehicles conceived for **long distances** such as trucks and buses. The sector is mainly led by **China** which still counts more than **90%** of **LNG refuelling stations** worldwide. However, the pace of this market's growth slowed down lately, especially due to less subsidies and governmental incentives, yielding place to the development of new markets. Europe is committed to the development of LNG as a road fuel especially through the project **Blue Corridors**. In this study, Sia Partners forecasts an increased demand in the sector : the global GNL as a road fuel consumption would rise from 2 Mtpa* to **26 Mtpa** in 2030, representing 5% of global LNG demand worldwide.

In **maritime transport**, the activity is mainly concentrated in **Northern Europe**. However, the **IMO's** decision taken on the 27th October 2016 to apply a 0.5% Global Sulphur cap from January 1st 2020 will reinforce the already ongoing development of **LNG bunkering projects** in **Europe, Asia** and the **US**. Despite the recent shipping crisis, the demand for LNG as a fuel in this sector could still reach **more than 29 Mtpa** by **2040**, which would represent **13%** of global fuel demand in shipping. Sia Partners projects an increase in demand for LNG marine fuel from less than 0.5 Mtpa today to more than **22 Mtpa** in 2030, representing between 9% and 11% of global marine fuel demand.

In spite of the recent **fall in oil prices** which weakened the position of LNG as a cheap fuel for road and maritime transportation since our [latest publication](#) **on this topic was released, the supercool fuel's development perspectives remain positive. Total demand for LNG fuel is estimated to be around **50 Mtpa by 2030** according to Sia Partners.

Global environmental policies aiming at reducing CO₂ emissions and cutting SOx, NOx and particulate matter from transportation put LNG in a favourable position. Some players of oil sector see in this market **the opportunity to reorient or diversify** its activities in times of low barrel prices (read [Sia Partner's study](#) *on this topic). This trend was manifested in the recent talks between Total and the French gas player ENGIE about acquiring part of LNG business portfolio from ENGIE. Ultimately, the environmental benefits of the fuel are even more reinforced with the possibility of **biomethane liquefaction**.

Please find out below the entire Sia Partners analysis on LNG as a fuel and its development prospects globally.

* Million tons per annum

** Only available in French



Analysis of the natural gas as a fuel global market

A global context suitable to LNG development for road and maritime transport



1 General context: Global stakes of the transport sector

A key sector generating significant amounts of Greenhouse Gases (GHG) and local pollutants emissions in the world

Transport is a very energy intensive sector. It is thus one of **the main sources of global GHG emissions**. For diesel and petrol which represent 93% of fuels used in this sector, up to 84% of GHG emissions come from combustion (Tank-to-Wheel) while the remaining 16% represents indirect emissions related to the production, transport and refining (Well-to-Tank).

Emissions of local pollutants (including **NO_x**, **SO_x** and fine particles) which experienced very little change since 2000 continue to represent a real public health problem. A problem of which the transport sector is mainly responsible.

The strong dependence of the sector on petroleum products makes it very sensitive to the volatility of prices and significantly **weakens the energy security** of the non oil producing countries.

Key figures

[Source : Sia Partners consolidation from IEA/OECD 2015]

27.6% of global energy consumption in 2013 is **2563.52 Mtoe**

23% of global CO₂ emissions in 2013

7.4 Gtonnes of CO₂ emitted **by the transport sector** in 2013, mainly in the United States (23%), Russia (4%), and China (9%)


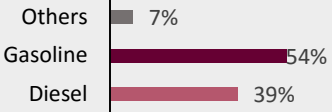

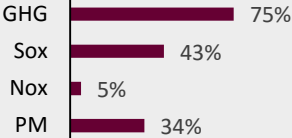

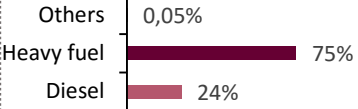

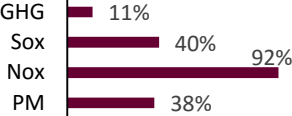




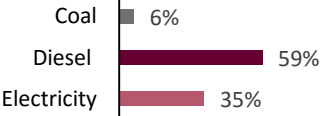


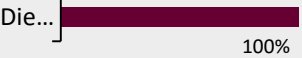

47% of NO_x global emissions in 2010

92.5% of the consumption of fuels in this sector coming from petroleum products

These challenges are now requiring from manufacturers and states the development of new sources of mobility that are adapted to each and every transportation mode. These innovations should be more efficient, more sustainable and less greenhouse gas-emitting.

1 General context : Different transportation modes

85% of the GHG emissions and local pollutants related to transportation are generated by road and sea vehicles

	Main fuels*	Total consumption*	Main emissions**	Alternative engines development
 Road transport FOCUS		 1939.4 Mtoe		++ Even if they represent only a small share of the market, the number of alternative engines (gas, hydrogen, electricity) is increasing and most of them are marketable products.
 Maritime transport FOCUS		 271.7 Mtoe		++ Due to the tightening of rules & regulations, heavy fuel has to face intense competition from LNG and diesel and the use of additional particulate filters.
 Aviation		 299.8 Mtoe		- Alternative fuels (LNG, GTL) are being tested but no industrialization is foreseen in the short term.
 Railway		 65.58 Mtoe		+ Less GHG producing locomotives, using LNG, are being developed but are still at the experimental stage.
 Inland navigation		 < 160 Mtoe		+ New LNG waterway vehicles are being currently developed, however the trend is still very localized for the moment.

* Figures of 2013

** In relative share of the total emissions in the transport sector

Regarding their size and technological maturity, the road and sea vehicles market are the most favorable to the emergence of new oil-free engines.

[Source : Sia Partners consolidation according to IEA 2015]

Mtoe : million tons of oil equivalent

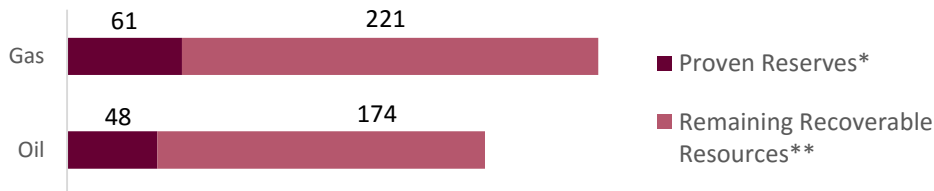


1 General context: Environmental assets of natural gas

Natural gas can reduce GHG emissions by up to 24%

World reserves of Oil & Gas (in current consumption years)

[Source : Sia Partners consolidation according to IEA 2016]



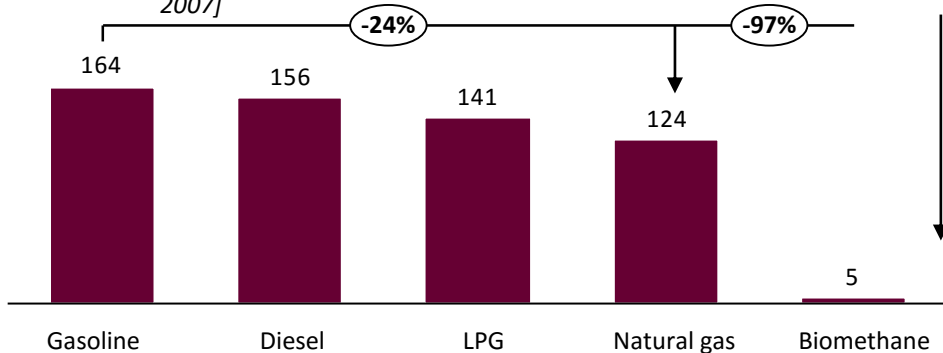
*Discovered volumes having a 90% probability that they can be extracted profitably
 **Proven reserves, reserves growth, and yet undiscovered resources that are judged likely to be ultimately producible using current technology

Natural gas reserves, mainly concentrated in Eurasia and the United States, **could be substantial** depending on future discoveries and the improvement of extraction technologies.

Gas can also be produced by **anaerobic digestion of organic waste**. It is then called **biomethane** which is mainly produced in **Europe** today. It represented a global volume of **1 Mtoe** in the world in **2013**. (WBA,2016)

Well-to-wheel** GHG emissions of main fuels (gCO2eq/km)

[Source : Sia Partners consolidation according to JRC 2007]



Reference vehicle with a gasoline engine consuming 7 liters per 100 km

Since it is mainly composed of methane, **natural gas emits almost no local pollutants** (SOx, NOx, fine particles...).

Natural gas emits up to 24% less greenhouse gases than oil. **Since biomethane has an almost neutral carbon footprint**, its addition to the gas energetic mix allows a significant decrease in the carbon impact of gas as a fuel.

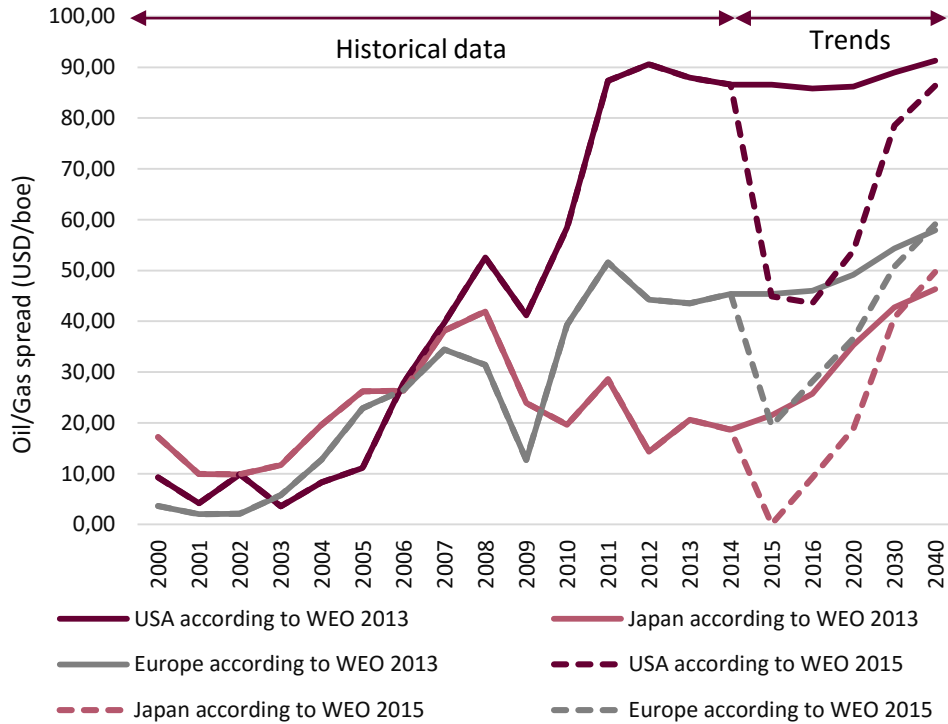
Natural gas has significant reserves and important environmental advantages over other fossil resources. These assets are not at the expense of its price which makes it a very interesting fuel.

1 General context: Economic assets of natural gas

The spread between natural gas and oil prices decreased due to the fall of oil prices, a tendency that should be reversed in the upcoming years

**Past and forecasted evolution of Oil-Natural Gas spread* (\$/boe)
A comparison between the 2013 and 2015 scenarios**

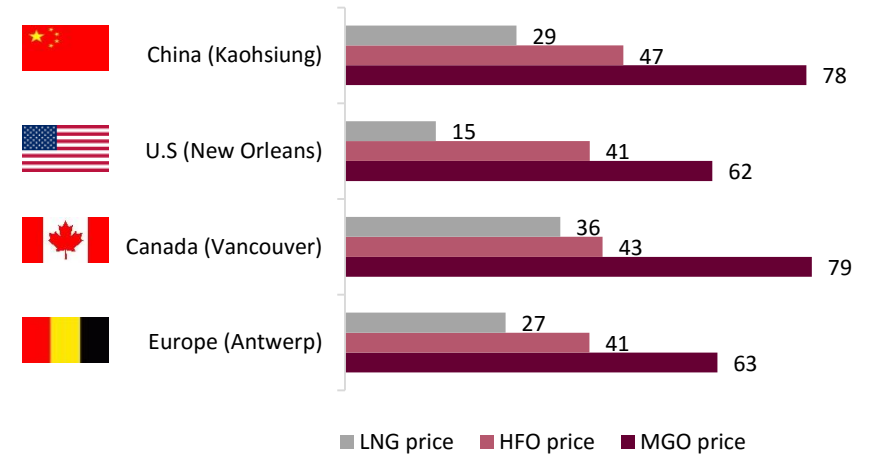
[Source : Sia Partners consolidation according to WEO 2013 & 2015]



*A positive spread means that gas is cheaper than oil

Comparison of fuel prices in a selection of ports in July 2017 (\$/boe)

[Source : Sia Partners consolidation according to Ferc and ShipandBunker]

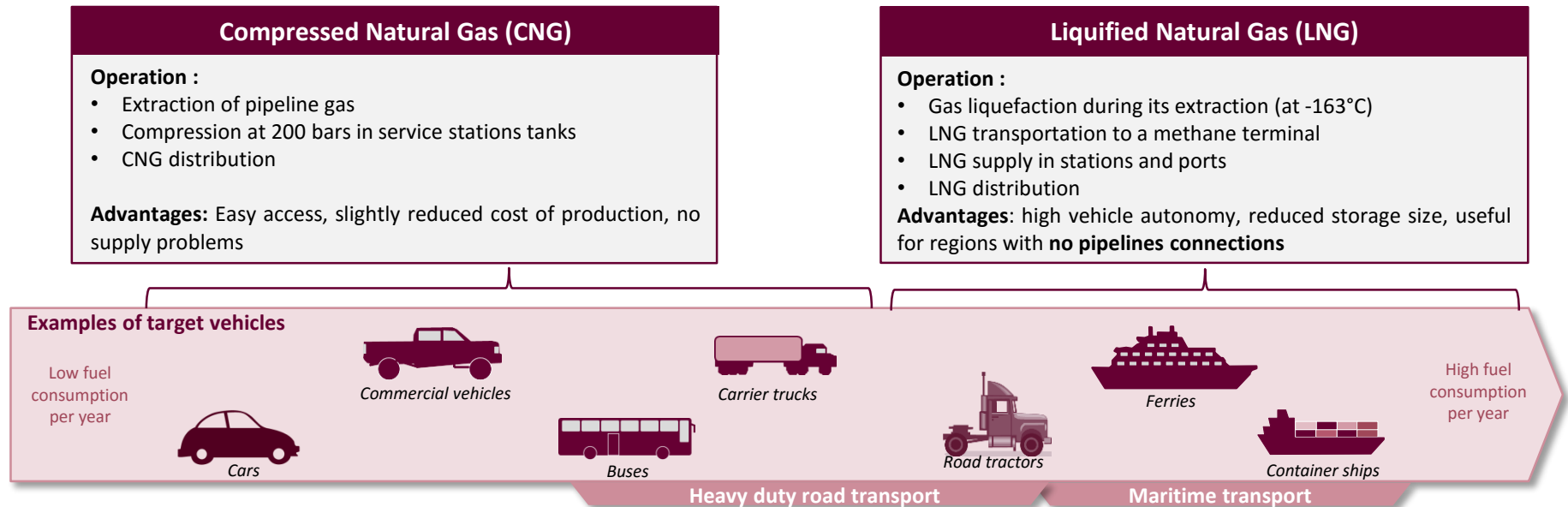


In spite of the 2014 drop in oil prices, LNG conserves a significant financial and environmental advantage over conventional fuels especially with the increasingly strong regulatory constraints. Furthermore, with the predicted recovery of oil prices in the upcoming years, LNG should be still playing an increasingly important role as a transportation fuel.

1

General context: Natural gas as a fuel

Regarding its flexibility of use, natural gas can be used as a fuel for almost all types of vehicles



- The Natural Gas for Vehicles (NGV) sector gathering CNG and LNG as a road fuel, consumed in 2013 almost **65,5 Mtoe** (2,9% of world demand in the transport sector), **half** of this demand coming from **light-duty vehicles**. This corresponds to 2% of the world gas production in the same year. [WEO 2015]
- LNG, with a better energy density than CNG is preferred for vehicles requiring a greater autonomy and having a large annual consumption. These are mainly **long distance** trucks and seagoing commercial vessels.
- The still emerging LNG as a road fuel industry only represents for the moment **a small share of global natural gas consumption for transport**. However, this share will significantly grow on mid and long-term with the expansion of LNG for long distance heavy-duty vehicles.

The use of natural gas as a fuel should experience a strong growth in the upcoming years driven by increasingly mature technologies and a tighter environmental regulatory framework. In the case of LNG, this growth should be mainly observed in both road and maritime transportation sectors.



LNG as a road fuel

An efficient alternative for heavy duty vehicles diesel

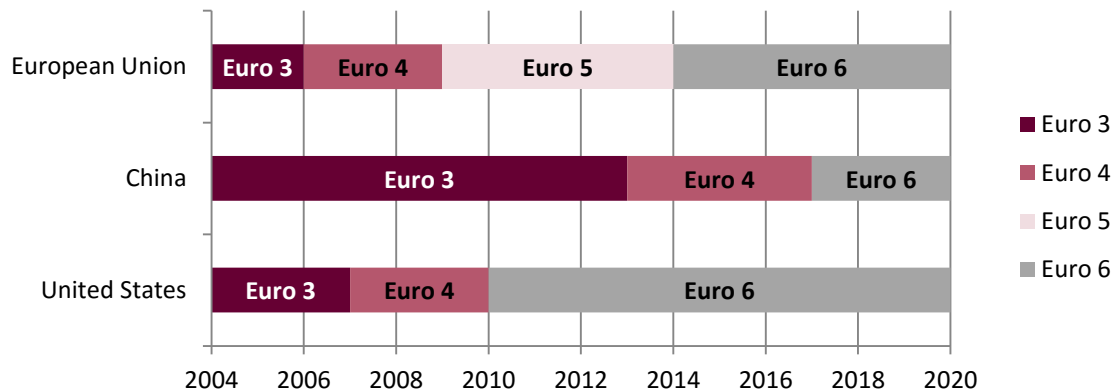


Road transport: Context and stakes

The tightening global standards of pollutants emissions in road transport are serving the interest of LNG

A comparison of pollutants emissions standards implementation schedules* in several countries

[Source : Sia Partners consolidation according to ICCT]

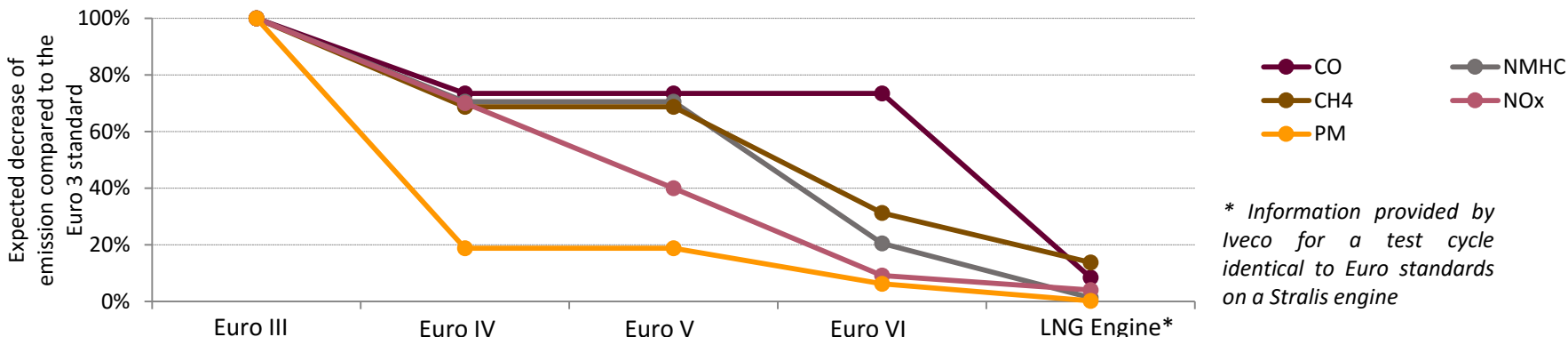


*Indicative comparison, test cycles may be different depending on the country

China has already implemented tighter restrictions in some provinces and cities

Comparison of Euro standards with an LNG vehicle emissions (The Euro 3 standard is taken as a reference)

[Source : Sia Partners consolidation according to Iveco, European Union]



* Information provided by Iveco for a test cycle identical to Euro standards on a Stralis engine

Euro 6 standards require vessels to abide by stricter emissions limits. Diesel fuelled vehicles must thus be equipped with scrubbers (EGR, SCR) that tend to be rather heavy and expensive. Alternative fuels such as LNG are, for their part, in total compliance with Euro 6 requirements.

2 Road transport: The interest of using LNG as a fuel

LNG enables to reduce emissions of pollutants and CO2 with a payback of less than 3 years

Performance of a LNG Tractor truck

(a standard Euro 5 tractor truck is taken as reference)

[Source : Sia Partners consolidation according to Ivéco, Mercedes, Fuelswitch, Transports Mendy]

	Euro 5 diesel tractor truck	LNG tractor truck
Environmental criteria	CO2	+ 0 – 8%
	Fine particles	- 66%
	NOx	- 77%
	Noise	=
Economic criteria	Purchase price	+ 12 000 €
	Operating costs*	=
	Cost of a service station	Already existing infrastructure
Others	Autonomy	~ 1 500 km
	Others	Adding EGR and SCR filters increasing the PTAC
		Lighter vehicles (no filters) Enhanced driving comfort



In addition to largely meeting the Euro 6 standard, LNG reduces CO2 emissions of the vehicle while the diesel filters tend to increase these emissions.



The low cost of the LNG allows in the case of trucks (travelling about 100 000 km/year) to reach paybacks of less than 3 years.



The development of LNG requires the establishment of a network of dedicated fueling stations that are still not enough spread today.

Influence of the criterion on the technical solution

favorable

little influence

adverse

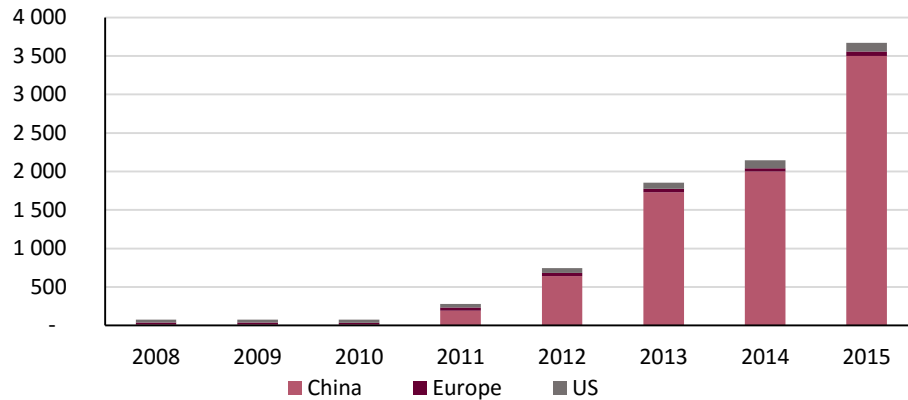
LNG as a road fuel has rather low paybacks and substantial environmental benefits compared to diesel. These factors have recently enhanced the development of its use for heavy duty vehicles in several countries.

2 Road transport: Situational analysis of the LNG sector

The number of LNG refilling stations have been multiplied by more than 8 in 4 years and 90% of this growth comes from China

Development of LNG service stations in the world

[Source : Sia Partners consolidation according to NGVA, US department of Energy]



The sector of LNG as a road fuel has experienced a very fast development in the last few years with an average growth rate above 100% during this period.

China is the leader of this growth (cf. focus), followed by **the US** and **Europe**. These three players represent almost 99% of the market today.

Manufacturers are today **highly geographically segmented**. Even though some are trying to take their chance in foreign markets (Volvo, Daimler...), there is **no international leader for now**.

The Chinese ENN showed **interest in the American market** by integrating the joint venture BluLNG, the number 2 LNG constructor in the US. The group also invests in **Europe** and has two offices in the **Netherlands** and the **UK**.

Main players of the LNG as a road fuel sector

[Source : Sia Partners consolidation]

	China	US	Europe
Vehicle constructors 	CAMC	Freightliner	Volvo
	Sinotruck	Peterbilt	Scania
	Dongfeng	Kenworth	Daimler
Station builders 	ENN		LNG24
	Sinopec	BluLNG	
	CNOOC		Axégaz
	PetroChina	Clean Energy	Rolande LNG
			Renault Trucks
			Mercedes-Benz
			Ivéco
			GNVert
			Gas Natural
			Fenosa

The extremely rapid growth of the LNG as a road fuel sector in China in recent years heralds a significant potential of development for the rest of the world, the United States and Europe topping the list. For the latter, a true dynamic was unleashed to push the development of the sector.

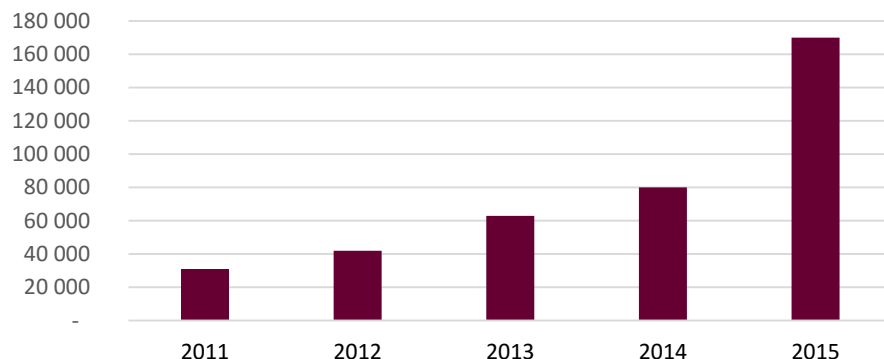
2 Road Transport: Focus, LNG as a road fuel in China



China is the global leader of the sector, especially thanks to strong governmental incentives

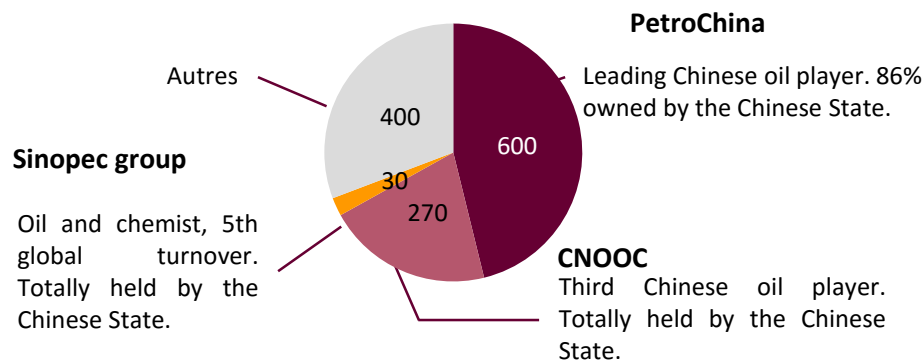
Evolution of the number of LNG vehicles in China

[Source : Sia Partners consolidation according to Reuters, Gasfund, Nomura Holdings Inc.]



Distribution of LNG service stations manufacturers in China in 2014 (by number of stations built)

[Source : Sia Partners consolidation according to Zeus int 2014]



The surprisingly fast development of the LNG as a road fuel industry in China is due to several factors:



A less important role of the Chinese Government in the LNG market, since subsidies to LNG as a road fuel significantly decreased since 2015.



Low cost trucks and fuelling stations due to cheap labour and an important scale effect.



In spite the recent fall in oil prices and the decrease in governmental incentives, **natural gas** remains a **cheaper clean fuel** compared to other alternatives

After strongly encouraging LNG as a road fuel development these recent years, the Chinese Government seems to start moderating this growth by increasing the gas price and reducing subsidies to LNG projects. Nevertheless, China should remain the leader of the sector long and mid-term.

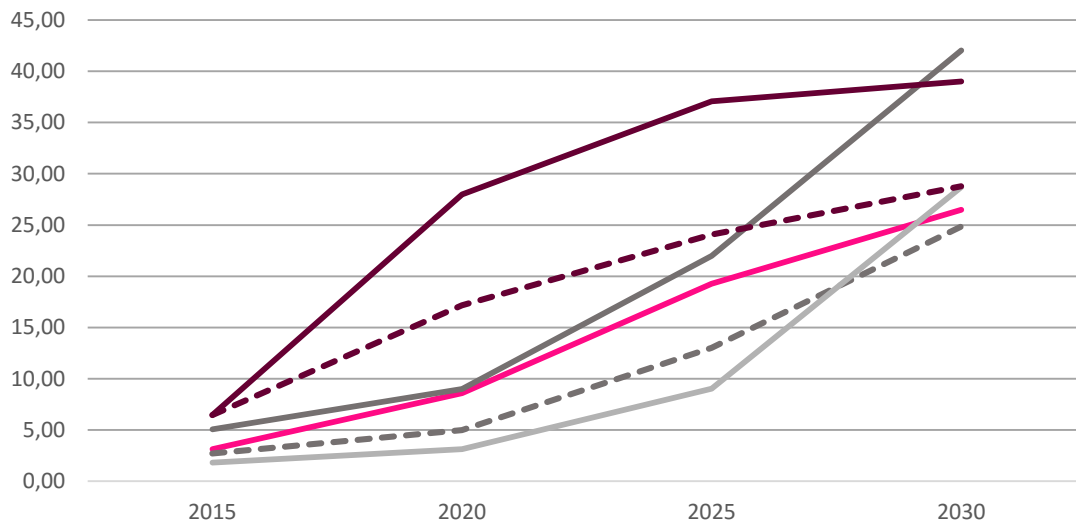


Road transport: Development perspectives of the LNG sector

The LNG as a road fuel sector could exceed 26 mtpa by 2030, representing 5,3% of world demand for LNG

Evolution of the expected growth of LNG as a road fuel under different scenarios

[Source : Sia Partners consolidation according to Shell 2014, Gazprom 2011, WEO 2016 & Navigant research]



Pre and post 2014 oil price drop Sia Partners scenarii

- Sia Partners, **New Realistic Scenario**
- Sia Partners, High Scenario published in **November 2014**
- Sia Partners, Low Scenario published in **November 2014**

Other comparative pre-2014 oil price drop scenarii

- Shell, High Scenario published in **November 2014**
- Shell, Low Scenario published in **November 2014**
- Pace Global, (European Union only) Scenario published in **November 2014**



The development of the sector will go through **the financing of infrastructure**.

The European Union, by the Blue Corridor project, aims to create a station every 400km along key axes.



The regulatory framework is taking shape with the adoption in 2014 by the UNECE* of the 110 regulation which defines vehicles certification and LNG as a road fuel facilities.



The low life expectancy of trucks (6 to 10 years) allows a **rapid renewal of the world fleet** (approximately 7% per year), encouraging the development of the sector.

The development of LNG as a road fuel seems promising in the short and medium term for the three current leaders: China, United States and Europe. This growth will take place simultaneously with that of marine LNG since the two sectors can take advantage of multimodal facilities.



LNG as a maritime fuel

A market concentrated in Europe and that is going global

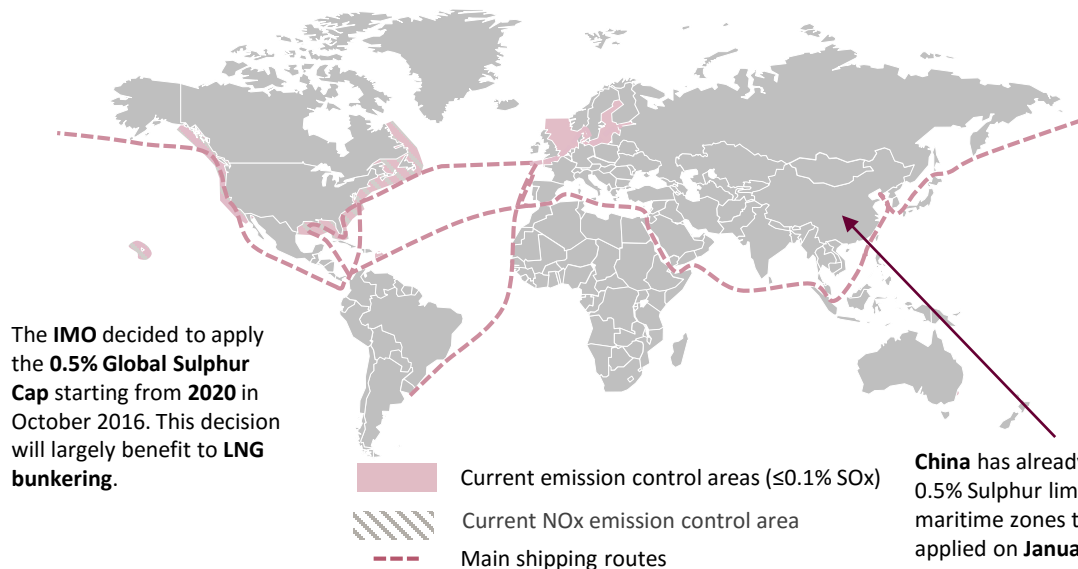
3

Maritime transport: Context and stakes

Tougher regulations on Sulphur emissions will compel some ship-owners to a conversion of their vessels

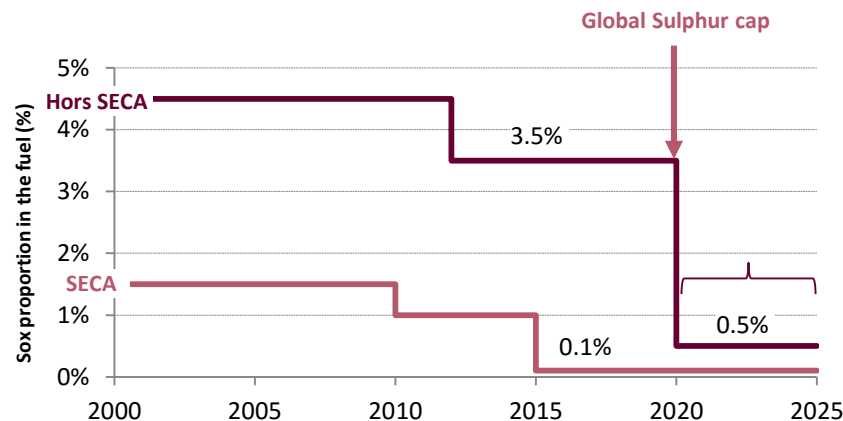
Sulphur emissions from ships are framed by the IMO * in some specific SECA zones **

[Source : Sia Partners consolidation according to IMO, Wärtsilä, WorldMaritimeNews, DNVGL]



In and out of these zones, the regulation will harden in the upcoming years

[Source : Sia Partners consolidation according to Wärtsilä 2016, Ship & Bunker]



Ship-owners have four technical solutions to deal with these restrictions:

Scrubbers

Allowing for strong investment and a more important fuel consumption to avoid SOx emissions.

Marine gasoline use (MGO)

Less emitting fuel but much more expensive than HFO. It is possible to install two tanks to use this fuel in SECA areas.

Shift to an LNG-powered motor

Less emitting fuel cheaper than MGO and HFO but requiring heavy investment for the conversion of the ship.

Hybrid fuels (ULSFO)

Several suppliers have released new hybrid fuel products containing a maximum of 0.10% m/m Sulphur

Due to the tightening regulations on Sulphur emissions, ship-owners are now hesitant on the technical solution to adopt. LNG seems to be an attractive solution both technically and economically.

3

Maritime transport: The interest of using LNG as a fuel

With an operation cost reduced by half, the incremental cost of LNG can be compensated between 1.5 and 4 years

Comparative analysis of the different technological alternatives

(a ship using heavy fuel oil without filters is taken as a reference)

[Source : Sia Partners consolidation according to DNVGL 2012, DMA 2013]

	Filters	Marine gasoline	LNG
Environmental criteria	CO2	+ 2%	- 20%
	Fine particles	- 40%	- 100%
	NOx	- 5%	0 %
	SOx	- 90%	- 90%
Economic criteria	Incremental purchase cost	+ 3 – 13 M€	+ 4 – 17 M€
	Existing ships modification	2 – 9 M€	0,5 – 1,5 M€
	Operating costs*	+ 2%	+ 52%
Others	Port investments	0	15 – 140 M€ /port
	Others	Reducing the loading volume	Possibility to use oil as a fuel outside the SECA zones



LNG is **the least polluting** existing solution regarding both greenhouse gases and local pollutants.



The **low cost** of LNG allows to offset **substantial incremental** costs in particular for new vessels.



The deployment of LNG will require the installation of **specific infrastructures** in most ports.

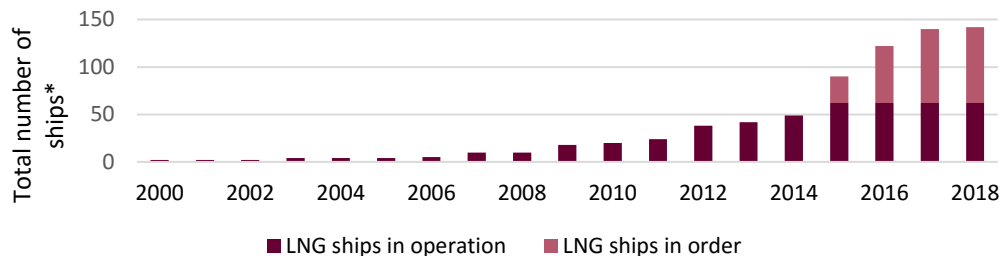
LNG has a central position as an alternative fuel thanks to its low operating cost, despite the latest fall in oil prices, and its ability to meet the strictest requirements on emissions. Some players are thus already committed in the LNG sector in order to prepare the upcoming regulations, especially the Global Sulphur Cap in 2020.

3 Maritime transport: Situational analysis of the LNG sector

Mainly used in Europe, LNG represents less than 1% of global consumption of marine fuels

Existing LNG ships and those under construction in the world

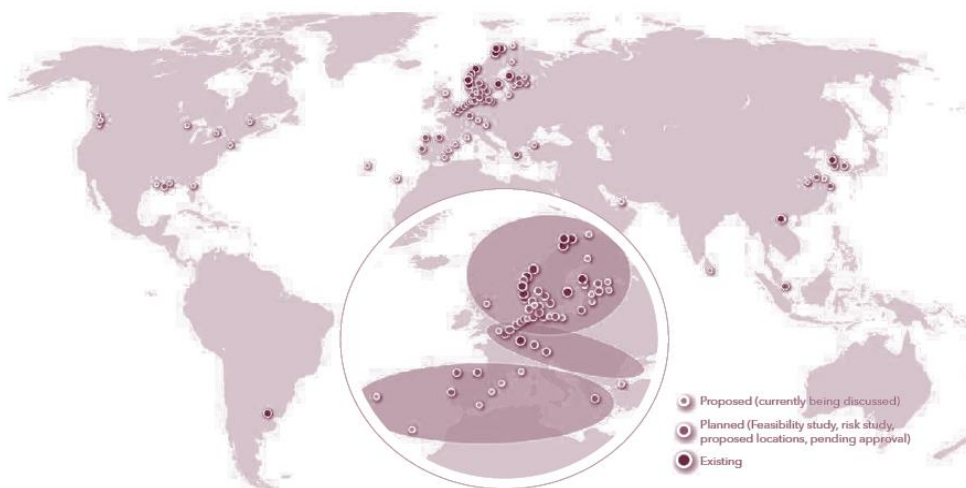
[Source : Sia Partners consolidation according to DNVGL 2015]



The development of LNG ships **has recently accelerated**, surpassing the 100 level of existing or under construction vessels.

Existing LNG supply infrastructures and those under construction

[Source : Sia Partners consolidation according to DNVGL 2015]



The main part of the existing supply infrastructures are situated in **Northern Europe** today. Many projects start being planned around the world.

This concentration of infrastructures encourages mainly **'short-sea' shipbuilding** (ferry or ro-ro type) in the SECA zone.

The market is mainly concentrated today in the Baltic sea with more than 75% of existing supply. This model could be exported to the rest of the world with the extension of the SECA regulations in 2020.

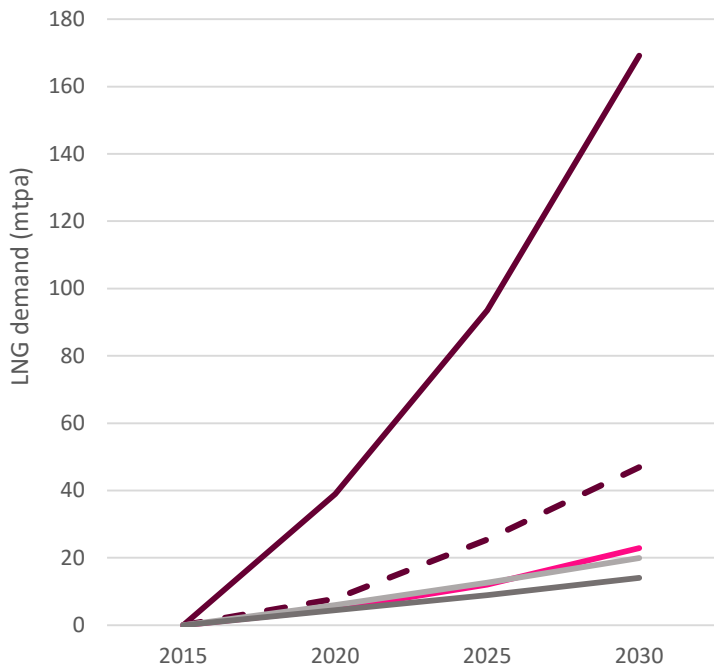
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Maritime transport: Development perspectives of the LNG sector

Marine LNG chain could represent between 9% and 11% of the world marine fuel demand by 2030

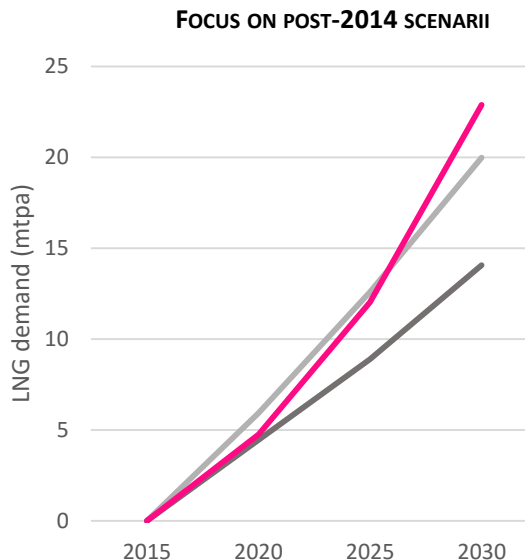
Growth forecasts of the marine LNG sector under different scenarii

[Source : Sia Partners consolidation according to Cedigaz, Llyods, IEA]



Pre and Post-2014 oil price drop Sia Partners scenarii

- Sia Partners, **New Realistic Scenario**
- - - Sia Partners, Realistic Scenario published in November 2014
- Sia Partners, High Scenario published in November 2014



Other comparative scenarii

- WEO, Scenario 2015
- WEO, Scenario 2016



In Europe, **national and European projects** multiply to participate to the funding of the sector, particularly via the RTE-T program.



The adoption by the **IMO*** of the **Global Sulphur Cap** starting from **2020** will enable a faster development of LNG as a marine fuel.



On the basis of these regulatory developments, the industry could have a promising future on **the short and deep-sea** at the global level.

Despite the 2014 oil price drop, LNG is still considered as an alternative fuel that could enter the market. The driver of the surge in LNG use as a marine fuel is the compliance with low-sulphur emission standards. Yet the slow stock turnover, as average lifetime of a ship is between 25 and 40 years, hinders the transition towards LNG or biofuels engine.



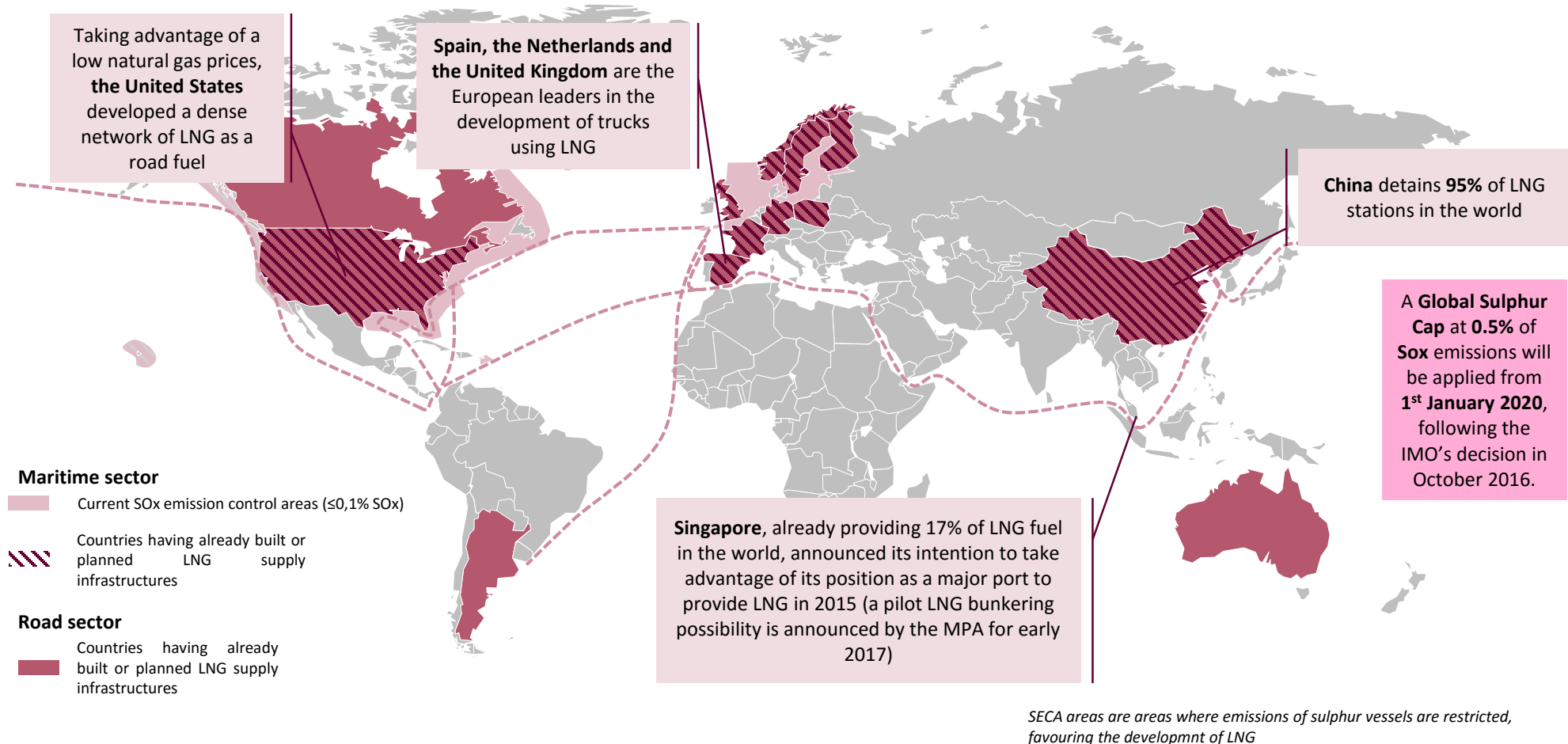
Conclusion and perspectives

LNG as a fuel is destined to grow around the world and could become a major player in the transport sector

4

Conclusion and perspectives: The development of LNG as a fuel in the world

China, the United States and Europe stand as the key players in the LNG as a fuel sector



While China leads the race on LNG as a road fuel development, Northern Europe is a referent player in marine LNG. The United States are also developing important road and marine LNG infrastructures. Other players such as Singapore and other European countries are starting to explore LNG bunkering and develop LNG fuelling stations.

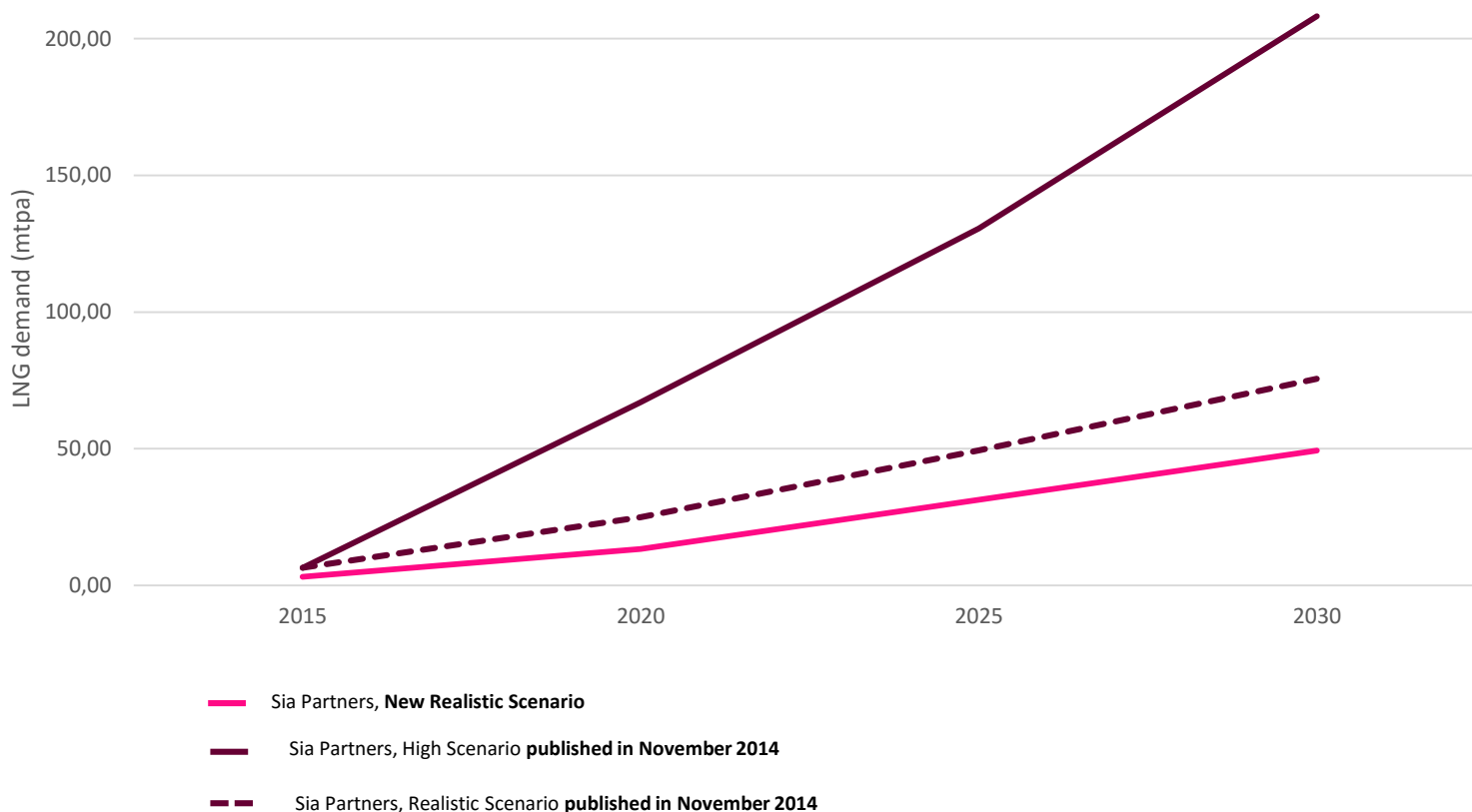


4 Conclusion and perspectives: The development of LNG as a fuel in the world

LNG as a fuel may represent almost 50 mtpa in 2030 according to Sia Partners realistic scenarios

Forecasts of growth in the sector of LNG fuel under different scenarios

[Source : Sia Partners consolidation according to Shell, Pace Global]



Even though growth perspectives have been hindered since the oil prices collapse in 2014, they now represent 9% of the world demand for LNG, and they are still favorable given the evolution of the regulatory framework. Oil & Gas players are showing growing interest towards this alternative, and the race between stakeholders is on to reach a still unoccupied status of world leader.



4 Conclusion and perspectives: The development of LNG as a fuel in the world

Main evolutions in the sector since November 2014, the publication date of the latest Sia Partner's analysis on this topic

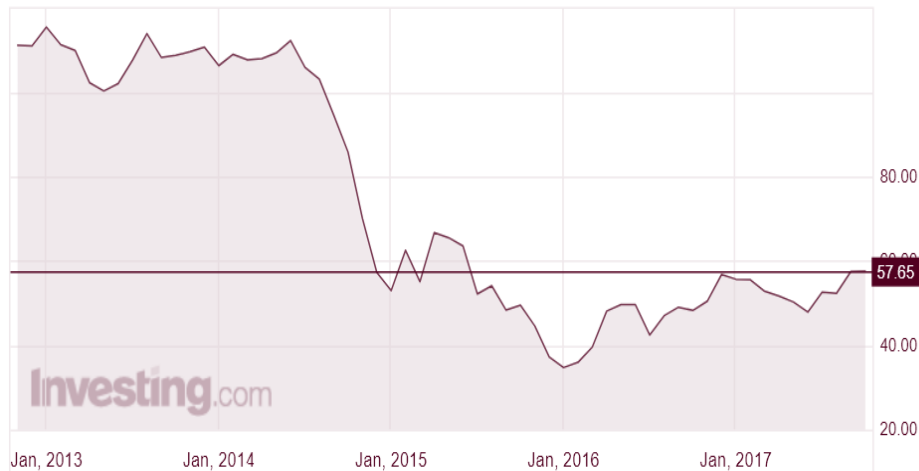
Many evolutions took place since the latest Sia Partners study on LNG as a fuel was published in November 2014. Overall, the fall in oil prices that occurred at the end of 2014, slowed down the growth of LNG as a fuel giving it less optimistic perspectives on the mid-term. However, the recent restrictions on emissions from maritime transportation and the COP 21 and 22 goals to reduce emissions from road transportation, place LNG as a clean fuel with bullish growth perspectives.

A sharp fall in oil prices since 2014, slows down LNG growth ...

- The fall in oil prices from **100 \$/barrel mid-2014** to over **50 \$** currently, slowed down the development of LNG as fuel.
- Almost **80%** of **LNG** in the world is traded on long-term contracts with prices **indexed** on or at least related to oil prices.

Brent crude oil price evolution according to Investing.com, October 2017

Brent Oil Futures * **57.65** +0.28 (+0.49%)



... but, stricter restrictions on emissions maintain bright perspectives for LNG as a road and maritime fuel

Road transportation



- The UN's **COP 21** defined more ambitious goals to reduce emissions coming from road transportation.
- LNG is seen as a viable road fuel to meet these targets.
- Although **China** and the **US** remain world leaders, the **EU** is developing important infrastructure for LNG as a road fuel through the project **Blue Corridors**.

Maritime transportation



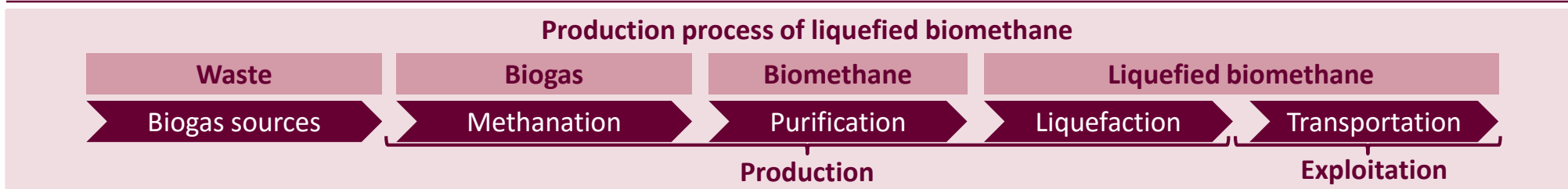
- In October 2016, the IMO adopted a 0.5% Global Sulphur Cap starting from **January 1st 2020**.
- The **NOx** restriction areas were also extended by the IMO.
- **China** started applying **SOx** and **NOx** restrictions onshore in many ports since **2017**.

Although the economic situation seems to be slowing down the growth of LNG as a fuel, many LNG projects are being developed and the fuel is gaining ground in governmental policies worldwide. The increasing use of biomethane also reinforces the positive environmental impact of LNG.

4

Conclusion and perspectives: The development of LNG as a fuel in the world

Biomethane offers interesting development perspectives of bioLNG, a renewable alternative for gas-fuelled vehicles and ships



Comparative analysis between LNG and bio LNG on strategic factors

	LNG	Bio LNG
GHG emission reduction	24% Well to wheel emissions avoided compared to diesel	80% Well to wheel emissions avoided compared to diesel
E.U. incentives	Financial and legal support for the deployment of alternative fuels infrastructures	10% share of fuels produced from renewable sources in the transport fuel mix by 2020
Filling stations in Europe in 2016	107 distributed in 11 countries	Few distributed in UK, Sweden, the Netherlands
Energy independence	- Extraction from natural gas deposit	+ Local production from agricultural and industrial waste and sewage sludge



Bio LNG is an **emerging fuel** produced thanks to liquefaction of biomethane.



Bio LNG allows vehicles autonomy **over 1000 km**, which makes it a suitable fuel for long distance transportation.



The use of BioLNG prevents reduces by 50% Nox emissions and by 95% fines particles compared to Diesel.

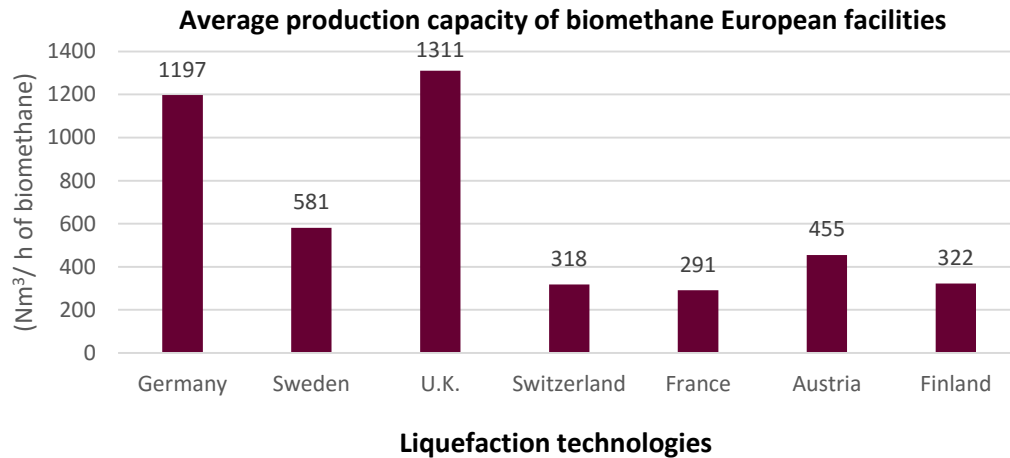
[Source : Sia Partners analysis according to ADEME, European Commission, EAFO]

Small scale bioLNG represents a real development axe for greener LNG as a fuel. Despite a slightly higher cost, bioLNG has advantages other than reducing the environmental impact. Due to its local production, it guarantees a security of supply, and an independence from the international gas market price.

4

Conclusion and perspectives: The development of LNG as a fuel in the world

Biomethane liquefaction is a vehicle for flexibility for the disposal of production surplus among producers



Progress has still to be made in small scale liquefaction technology to make it less expensive. Liquefaction does not benefit from **economies of scale** yet with the amount of biogas provided. Furthermore, in France it is still more profitable to inject biomethane in the network due to **preferential injection prices** and rather low production volumes.



BioLNG as a fuel can be seen as a **complementary use** for biomethane producers offering higher **flexibility**. The production surplus can be liquefied and supply filling stations with an eco-friendly fuel produced from local renewable sources.



Despite the remaining hindrances such as the **lack of maturity** in liquefaction technologies, European biomethane production and existing **refuelling infrastructures** are favourable to the development of bioLNG as a fuel. Thus, numerous Oil & Gas players such as **Air Liquide** are investing in the market and smaller players are also developing their own technologies such as **Cryopur**.

	Nitrogen refrigerant	Single cycle mixed refrigerant	ERIEE cryogenics	Stirling cycle
Associated flows	+	+	+	-
Electric consumption	0.24 kWh/Nm ³	0.47 kWh/Nm ³ (Wärtsilä)	0.5 kWh/Nm ³ (Purification + liquefaction)	N.A.
Associated flows	>310 Nm ³ /h	>620 Nm ³ /h	70 < Flow < 2000 Nm ³ /h	6 < Flow < 930 Nm ³ /h
Actors				

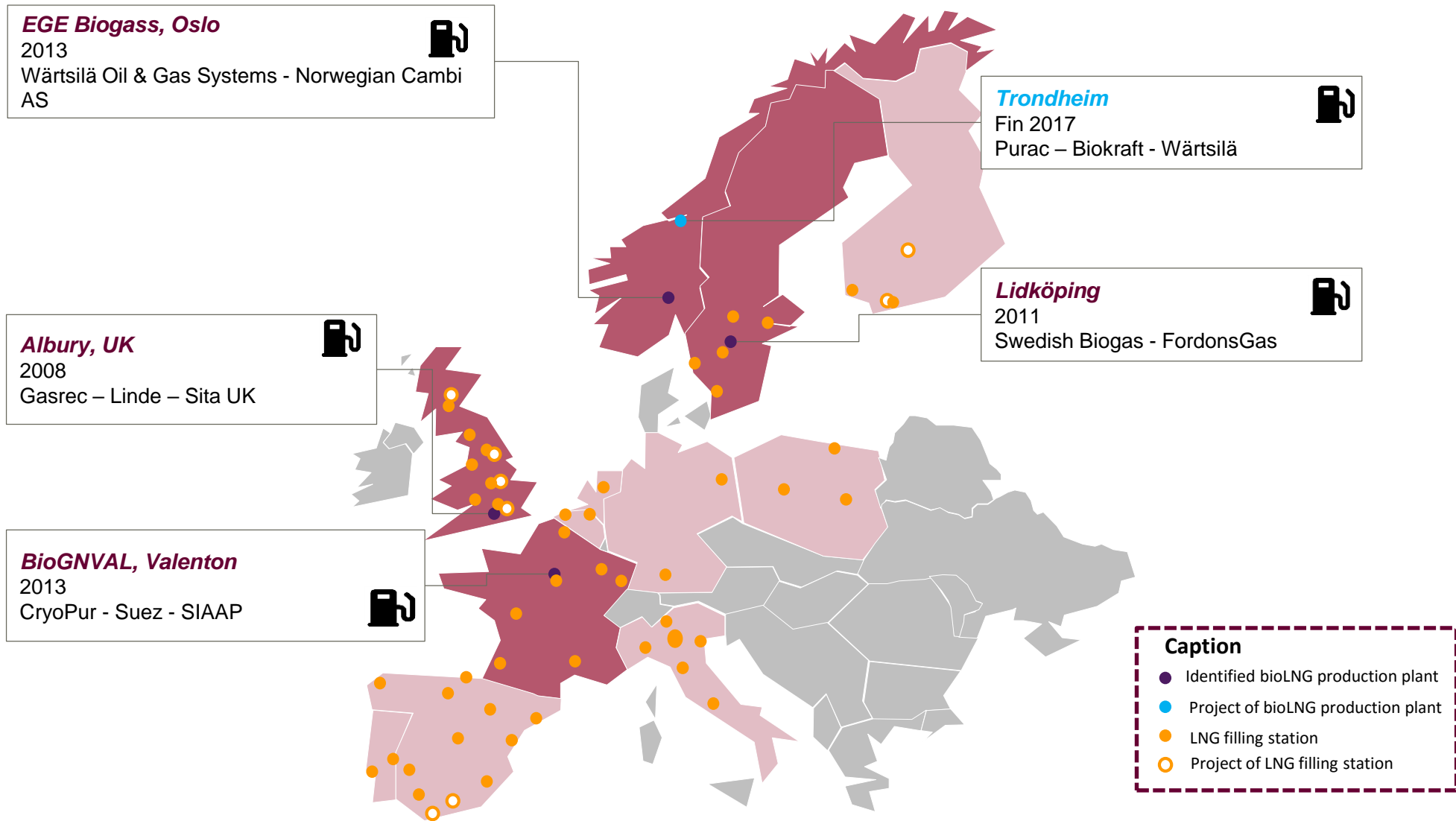
BioLNG as a fuel is a complementary business model for biomethane producers, but liquefaction activity experiences fast change and growth.

4

Conclusion and perspectives: The development of LNG as a fuel in the world

BioLNG as a road fuel is a recent and flourishing market that may take advantage of the already existing LNG infrastructure

Identified bioLNG as a road fuel production plants in Europe





Conclusion and perspectives: The development of LNG as a fuel in the world

BioLNG is a promising fuel with almost no environmental impact but its development is shadowed by rather costly technologies

STRENGTHS

Bio LNG is a fuel made from **renewable sources**, and does not belong to the biofuel category, whose development is hindered by E.U.

Bio LNG is an alternative solution to **sell biomethane production** and enables producers to yield benefits from production surplus.

WEAKNESSES

Low volume of production may slow down the full scale deployment of this fuel.

THREATS

BioLNG as a transport fuel is an **emerging market** and its deployment require **investments** in production facilities and filling infrastructures.

OPPORTUNITIES

The French « Plan Climat » foresees the creation of a « clean mobility fund » to sustain the development of filling infrastructures for alternative fuels, and tax benefits to be given for the purchase of trucks fuelled by natural gas.

Still, **Third and Fourth Generations** of bioGNL, resulting from microalgae recovery, allow production of biogas **in larger amount** than former generations.

Development prospects for marine transport

Investment in LNG infrastructure is an opportunity for the later deployment of bioLNG

The Rotterdam Port started a study in collaboration with the National LNG Platform and several firms to assess the opportunities to develop LNG as a marine fuel in the port of Rotterdam. This study is expected to be released by the end of 2017 ([more information](#)).

Development of LNG and bio LNG as a marine fuel is increasingly being considered.

German government acts for the development of LNG as a marine fuel : they announced earlier in September 2017 the launch of a funding plan to support investments in LNG ship conversion. Hamburg will also host soon a LNG terminal ([more information](#)).

BioLNG as a fuel allows transport sector to meet higher standards regarding GHG emissions reduction and may benefit from regulatory drivers.



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