The environmental impact of LNG as vehicle fuel and the potential of liquid biogas

http://www.poreen.eu/

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LNG – Environmental analysis and risk assessment

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Contents

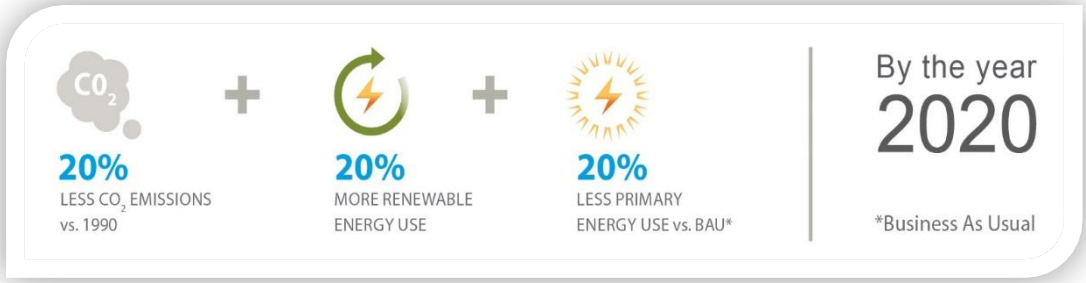
- Natural Gas and LNG as vehicle fuel;
- LNG risks and safety – existing laws and regulations;
- LNG environmental impact and evaluation (LCA);
- LNG infrastructure and supply.

The focus is on the transport sector

LNG as vehicle fuel

GHG emissions due to transport sector ~ 20% of total emissions

- ~ 93% of this are represented by road transport
- In this sector emissions have risen by ~ 26% in the period 1990-2006
- In this period passengers vehicles increased by 34%, 62% for heavy goods vehicles



2020 climate and energy package

LNG as vehicle fuel

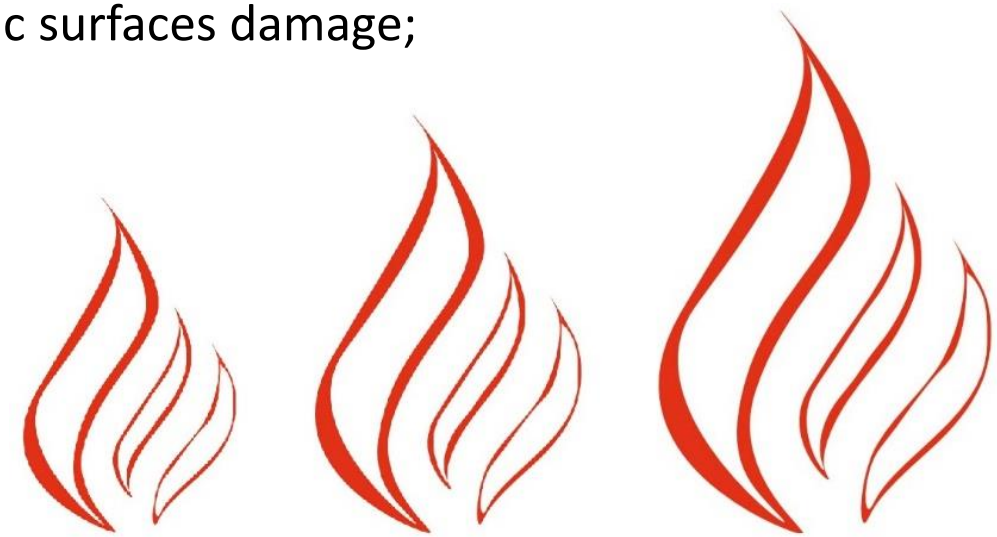
Advantages of Natural Gas:

- Environmental benefits with a reduction of CO_2 from combustion;
- Readily available at a competitive price using well known technologies;
- In can decrease the dipendency from importations ad usage of other conventional fuels.

LNG risks and safety

Risk aspects linked with LNG handling:

- Cryogenic temperature could cause burns and metallic surfaces damage;
- LNG can explode on contact with oxygen;
- LNG vapour is asphyxiate;
- Spill containment.



LNG risks and safety

Some international laws and regulations:

- ISO 12991 Liquefied natural gas (LNG) - Tanks for on-board storage as a fuel for automotive vehicles;
- ISO 12617 (Draft International Standard in 2012) LNG connector;
- ISO 12614 (Draft International Standard in 2012) LNG vehicle on-board equipment;
- ISO 16924 (Committee Draft in 2012) LNG station for fuelling vehicles;
- NFPA 59A Standard for the Production , Storage and Handling of LNG (2006).

LNG environmental impact

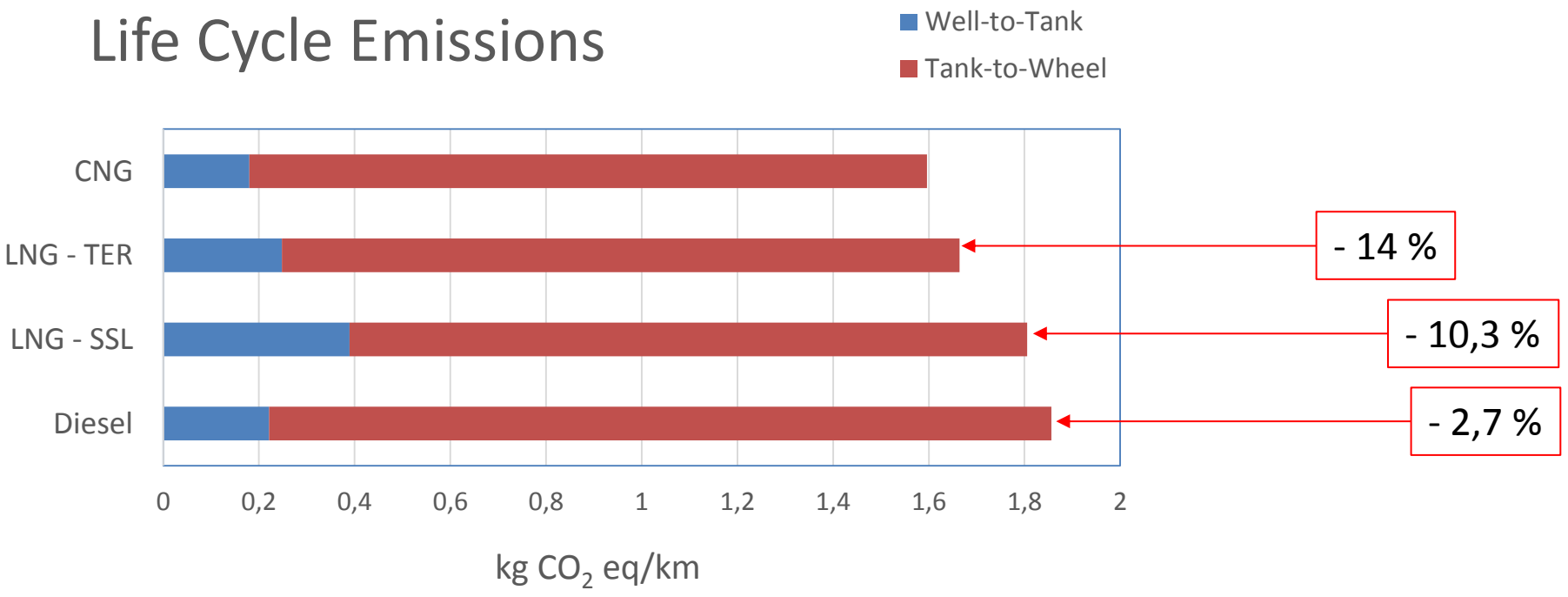
Less air pollution during combustion

- ~25% reduction in GHG emission in automotive vehicle sector;
- - 23% CO_2 / - 92% NO_x / - 100% SO_x / -98÷100% particulate in maritime sector.

However Methane is a potent GHG with a high GWP100 level

Species	Chemical formula	Lifetime (years)	Global Warming Potential (Time Horizon)		
			20 years	100 years	500 years
CO_2	CO_2	variable §	1	1	1
Methane *	CH_4	12±3	56	21	6.5
Nitrous oxide	N_2O	120	280	310	170

LNG environmental evaluation



LNG infrastructure

Critical aspects	
Optimum ratio between NG vehicles and refulling stations	No more than 1000 NG vehicles per refulling station
Refulling station distance	NG stations equal to 10-20% of conventional stations
Waiting time for refuelling	Technological improvement and L-CNG stations

European projects

- GasHighWay
- Blue Corridor Project

NG supply in Italy

Natural gas vehicle situation in Italy

- 880000 natural gas vehicles (~ 80% of Europe's entire car fleet on gas);
- 1060 NG refuelling stations (1010 are open to the public);
- 8 L-CNG filling stations (the last one as part of the Blue Corridor Project – April 2014);
- 3 import terminals for LNG (Panigaglia, Porto Viro, Livorno);
- Lacks truck-loading facilities.

Market penetration of LNG is very low

NG supply in Italy

Italian gas grid is well spread

- 8 entry points from abroad;
- 53 entry points from national production;
- more than 30000 km of pipelines.

Actually there are 2 possible ways to supply LNG refuelling stations

NG supply in Italy

Buy it at LNG terminals

Liquefy pipeline natural gas directly on site

Liquefy purified biogas from anaerobic digestion and landfills

From Biogas to Biomethane to Bio-LNG

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Contents

- Biomethane advantages and opportunities;
- Upgrading technologies;
- Incentive scheme for transport sector;
- Some possible scenario.

The focus is on biomethane as alternative fuel

Biomethane advantages

Obtained from biogas purification (upgrading)

- Alternative fuel with higher energy density;
- CO_2 emissions during combustion = CO_2 capture during biomass grouth;
- Less dependence on natural gas importations;
- It could be involved in Smart Grids;
- It could be injected into the national gas grid.

It represent an opportunity to fulfil the
UE 20-20-20 targets

Upgrading technologies

Upgrading process: removal of biogas impurities (mainly CO_2 and H_2S) to obtain biomethane

Biomethane composition compared with Natural gas

To be removed

Substance	Biogas from anaerobic fermentation	Natural gas (H-gas quality)
methane	50 – 85 %	83 – 98 %
carbon dioxide	15 – 50 %	0 – 1,4 %
nitrogen	0 – 1 %	0,6 – 2,7 %
oxygen	0,01 – 1 %	-
hydrogen	traces	-
hydrogen sulfide	up to 4,000 ppmv	-
ammonia	traces	-
ethane	-	up to 11 %
propane	-	up to 3 %
siloxane	0 – 5 mg/m^3	-
Wobbe Index	4.6 – 9.1	11.3 – 15.4

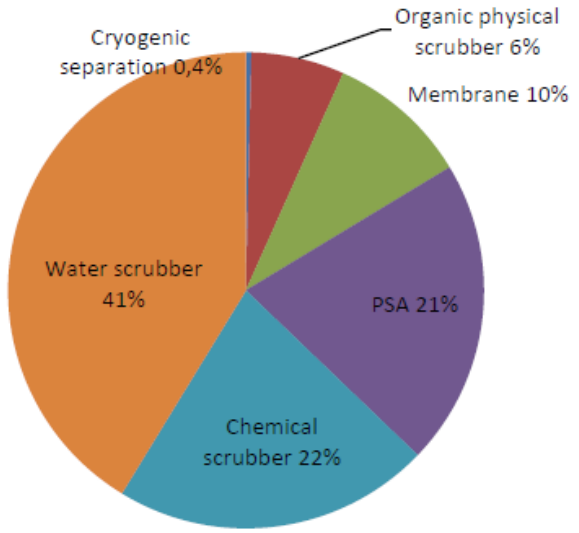
Source: IEA Bioenergy 2014

Upgrading technologies

Up to now there are several upgrading technologies available on market

Parameter	Water scrubber	PSA	Membrane (2-4 stages)	Chemical scrubber (amine)	Organic physical scrubber
CH_4 in product gas	96 – 98 %	96 – 98 %	96 – 98 %	96 - 99 %	96 – 98 %
Availability	95 - 98%	95 – 98 %	95 - 98%	95 - 98%	95 – 98 %
Annual maintenance cost (% of investment cost)	2 - 3%	2 – 3 %	3 – 4 %	2 – 3 %	2 – 3 %
H_2S removal	Yes	External	External	External/Yes	External
H_2O removal	External	Yes	Yes	External	External
N_2 and O_2 separation	No	No/partly	Partly (O_2)	No	No
Electricity consumption (product gas > 4 bar(g)) (kWh/Nm³ raw biogas)	0.2 – 0.3	0.2 – 0.3	0.2 – 0.3	0.10 – 0.15	0.2 – 0.3
Heat (kWh/Nm³ raw biogas)	None	None	None	0.5 – 0.6	Internal
Pure CO_2	No	Yes	Yes	Yes	No

Source: IEA Bioenergy 2014



Sourse: IEA Bioenergy 2014

Cryogenic separation is still in a developing phase

Incentives scheme (automotive)

D.M. December 5th, 2013

1 CIC (Certificati di Immissione in Consumo) measured in € x 10^{-1} Gcal of biomethane (10 Gcal = 11,63 MWh)

Feedstock	Number of CIC			
	New plant		Existing plant	
	Sold to a r.s.	Own r.s.	Sale in o.r.s.	Own r.s.
By – products < 70%	1	1 · 1,5 (1°÷10° year)	1 · 0,7	1 · 0,7 · 1,5 (1°÷10° year)
By – products ≥ 70%	1,7	1,7 · 1,5 (1°÷10° year)	1,7 · 0,7	1,7 · 0,7 · 1,5 (1°÷10° year)
By – products = 100%	2	2 · 1,5 (1°÷10° year)	2 · 0,7	2 · 0,7 · 1,5 (1°÷10° year)

Up to now, the CIC value is unknown, supposed to be in a range between 300 ÷ 800 €/CIC

Some possible scenario

First scenario

One owner for all the chain

A compression station is not required

- Characteristic biogas size: 500 $Nm^3 \cdot h^{-1} \approx 250\ Nm^3 \cdot h^{-1}$;
- Upgrading technology: PSW;
- Final price: 1 € · kg^{-1} of LBG (no tax).

Second scenario

One owner for Biogas, Upgrading and Compression plants and transportation

Different owner for LBG and L-CNG facilities

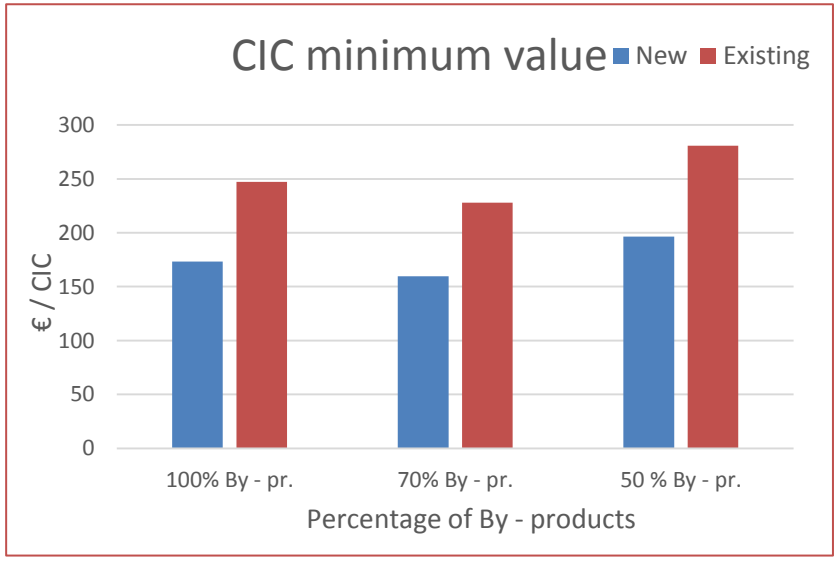
Third scenario

More biogas producers agree to build together a liquefaction facility

A compression station for each biogas plant, as well as CBG transportation, are required

First Scenario

One owner for all the chain



Biomethane production (biogas + upgrading)

Liquefaction plant

Refuelling station

The incentive obtained for this scenario is 3 times the base incentive value (2,1 times for existing plants)

Second Scenario

Biomethane producer

Biomethane production (biogas + upgrading)

CNG plant

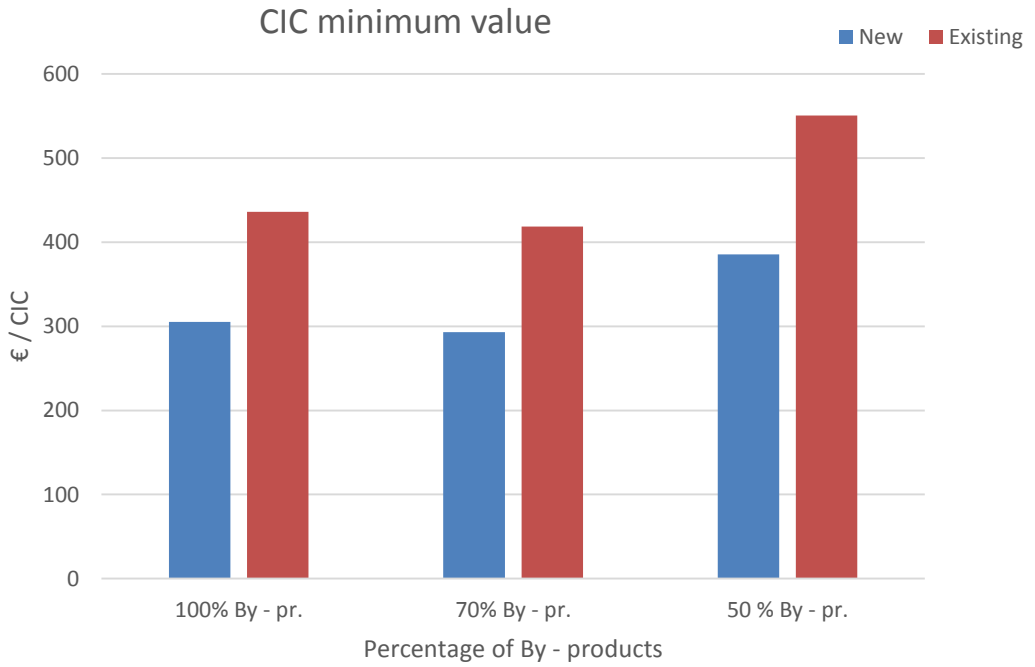
CNG transport by truck (50 km distance)

LBG producer

Liquefaction plant

Refuelling station

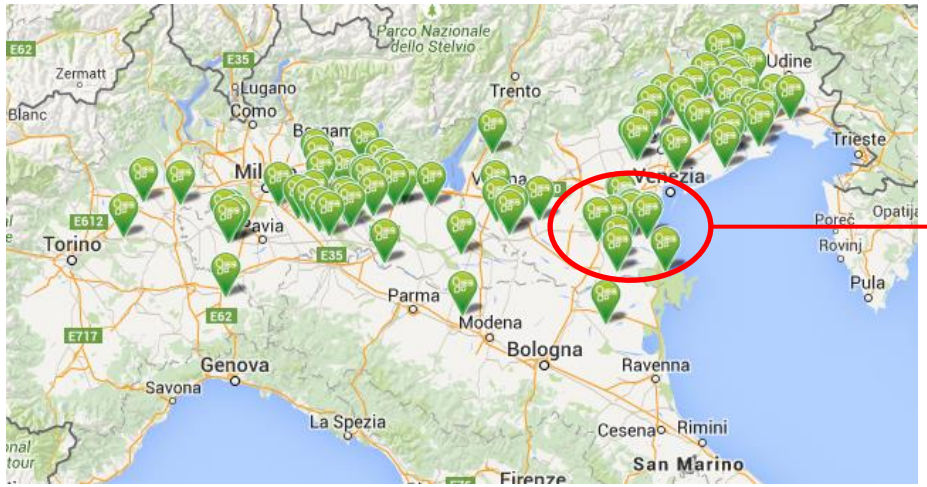
Second Scenario



The incentive obtained for this scenario is 2 times the base incentive value (1,4 times for existing plants)

Third Scenario

Partial map of existing biogas plants; source IESBiogas

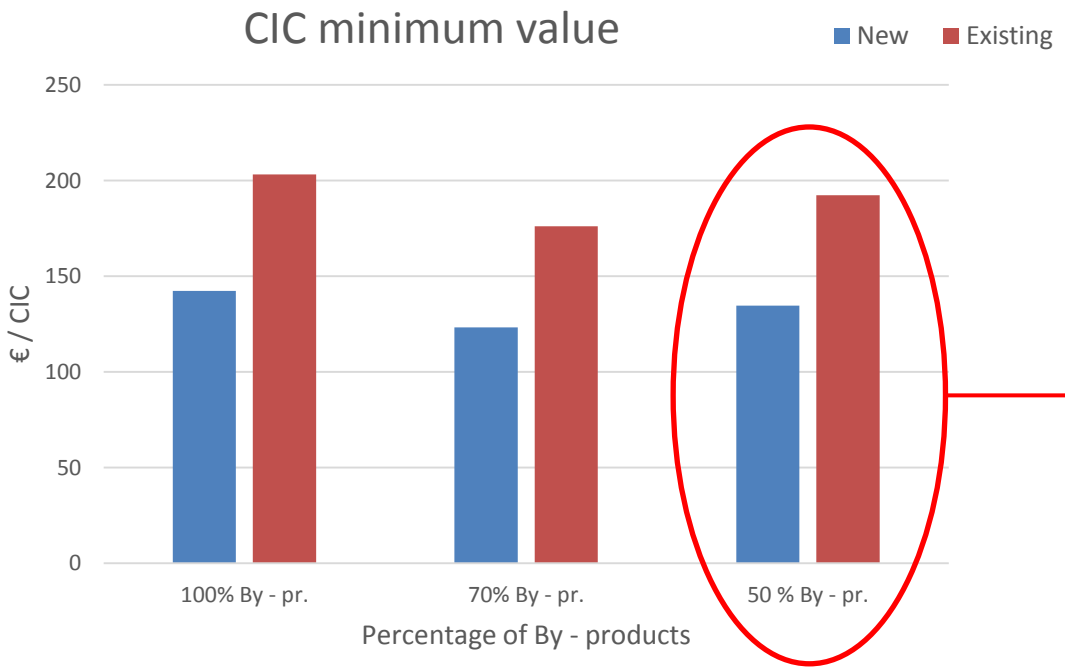


More biogas producers

In the northern regions a lot of biogas plants are present, also near the coast

- 5 real biogas plants taken into account;
- Equal size of 500 $Nm^3 \cdot h^{-1}$;
- Main distance from LBG facility ~ 26 km;

Third Scenario

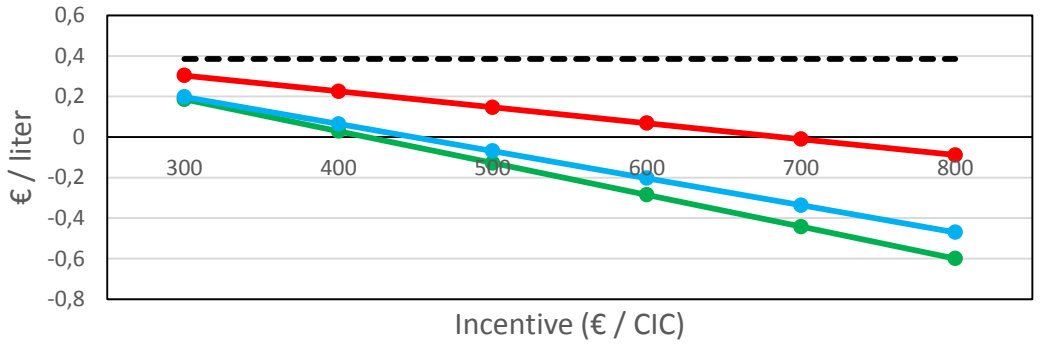


By means of economies of scale the reduction in feedstock price has a higher weight than in other scenarios

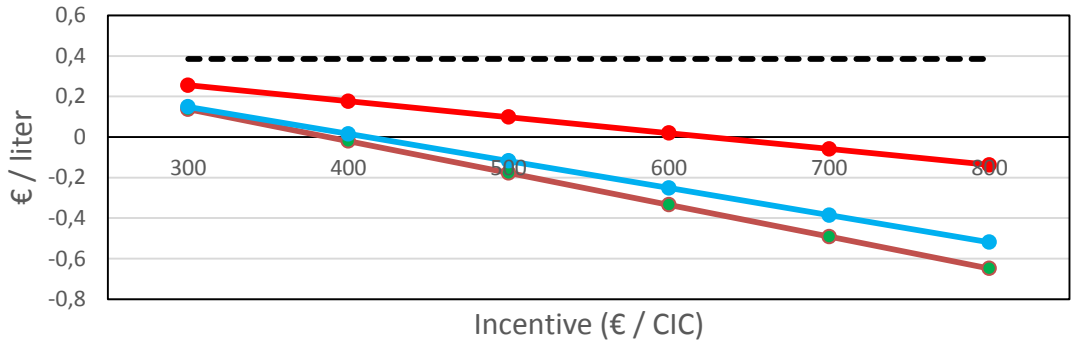
The incentive obtained for this scenario is 3 times the base incentive value (2,1 times for existing plants)

Sensitivity analysis

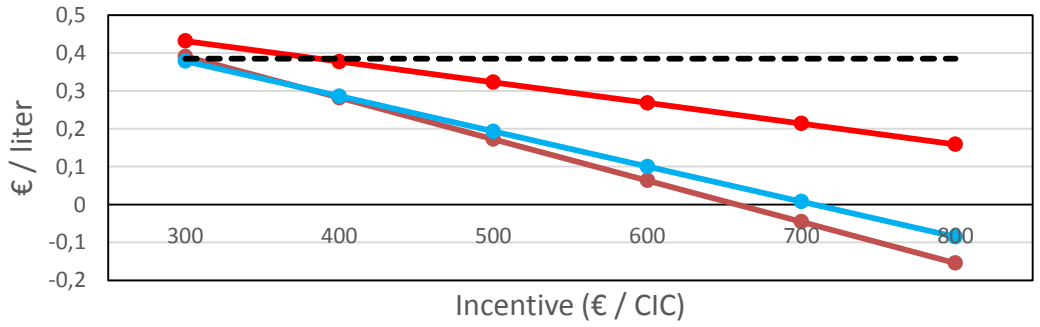
LNG production cost (first scenario)

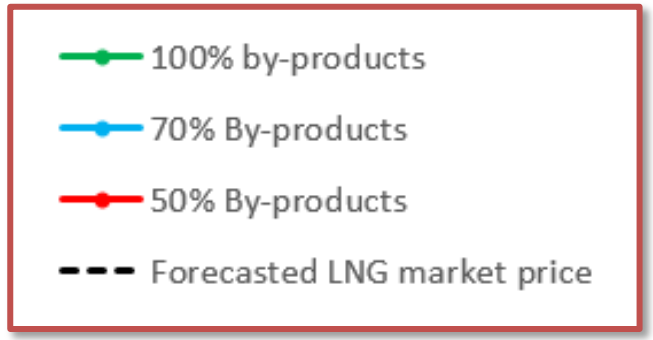


LNG production cost (third scenario)



LNG production cost (second scenario)





Conclusions

- Strategic role of NG and LNG;
- Italian incentive schemes for automotive;
- Biomethane opportunity to overcame the supply issue for LNG.