Breakthrough LNG Deployment in Inland Waterway Transport

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

Quantitative analysis LNG potential West-European IWT fleet

A sub-report of:
Stakeholder consultation report
Scenarios for the deployment of LNG in Inland Waterway Transport

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Disclaimer

Objective of the study

This study is a sub-report of the main study titled as "Scenarios for the deployment of LNG in Inland Waterway Transport." The scenarios presented in this study are merely meant to illustrate the effects of the price spread between LNG and diesel on the potential LNG fleet, whereas the scenarios in the main study take multiple factors into account. The scenarios presented in this sub-report are therefore complementing rather than competing.

Obtain insight into the:

Bandwidth of the price difference between diesel and LNG in the long term (spread).

Additional investment for LNG in relation to payback time.

Quantitative potential for LNG as fuel in the inland shipping in Western Europe, considering different scenarios in terms of:

- The number of barges that have potential for LNG.
- The share of LNG in total fuel mix of inland shipping.

Environmental effects of the estimated LNG potential, emissions of:

- NOx
- Particulate matter
- CO2

Approach

Desk research:

- Numerous studies on market developments of LNG, natural gas and oil.
- Studies on greening of the fleet: PLATINA 2, PROMINENT, LNG Masterplan.

Market Consultation:

- LNG suppliers: trends in pricing of gasoil and LNG for the Inland Waterway Transport sector.
- Banks and accountants: payback periods.
- Suppliers of equipment, ship wharfs: additional investments for LNG.

Defining exploratory scenarios:

- Parameters for an Optimistic scenario: large average spread LNG-diesel for the period 2016-2040, positive scale effects in LNG investments.
- Parameters for a Pessimistic scenario: small average spread LNG-diesel for the period 2016-2040, no scale effects in LNG investments.

Approach

Model calculations for providing the autonomous business case.
If within the payback period, the additional investment in LNG retrofit / installation is earned by due to savings in fuel costs, the vessel will be considered to have potential for application of LNG.

The model takes into account:
- The composition of the West European Inland fleet.
- Vessel types: large/small, push boats / cargo vessels / tankers / coupled convoys.
- Distribution (bandwidth) of fuel consumption (PROMINENT data).
- Lifetime (aging) of engines and replacement rate (PROMINENT data).
- Emission regulations (Stage V NRMM and access regime Port of Rotterdam) and compliance costs (PLATINA2 and PROMINENT data).
- Various levels of the average price difference between diesel and LNG for the period 2016-2050.

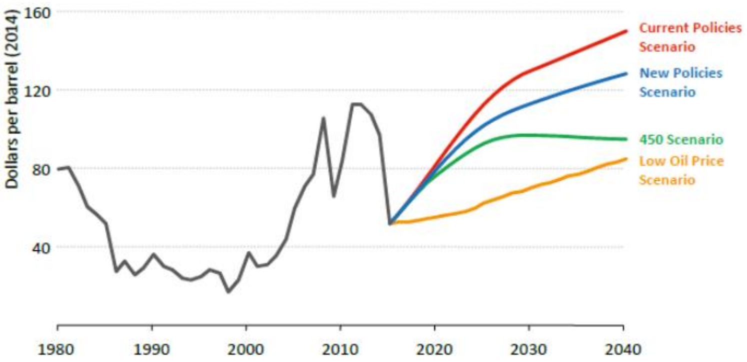
The model does not take into account:
- New (incentive) policies for greening of the existing inland fleet, like imposing standards or creating subsidies.
- Amendments to the no. of vessels, the fleet is considered to remain constant over time.

Scenario parameters

Return of investment (payback time): 12 years.

LNG and Oil price scenarios are based on “World Energy Outlook 2015”, considering a situation where LNG has always a limited price advantage relative to diesel. Some suppliers provide a fixed discount for LNG relative to the price of diesel. Spread of price advantage relative to a liter of diesel fuel:

- **Minimum of 5 Euro cents.**
- **Maximum of 35 Euro cents.**



Investment costs: a maximum cost advantage of 15% due to scale effects, mainly instigated by cheaper LNG fuel tanks.

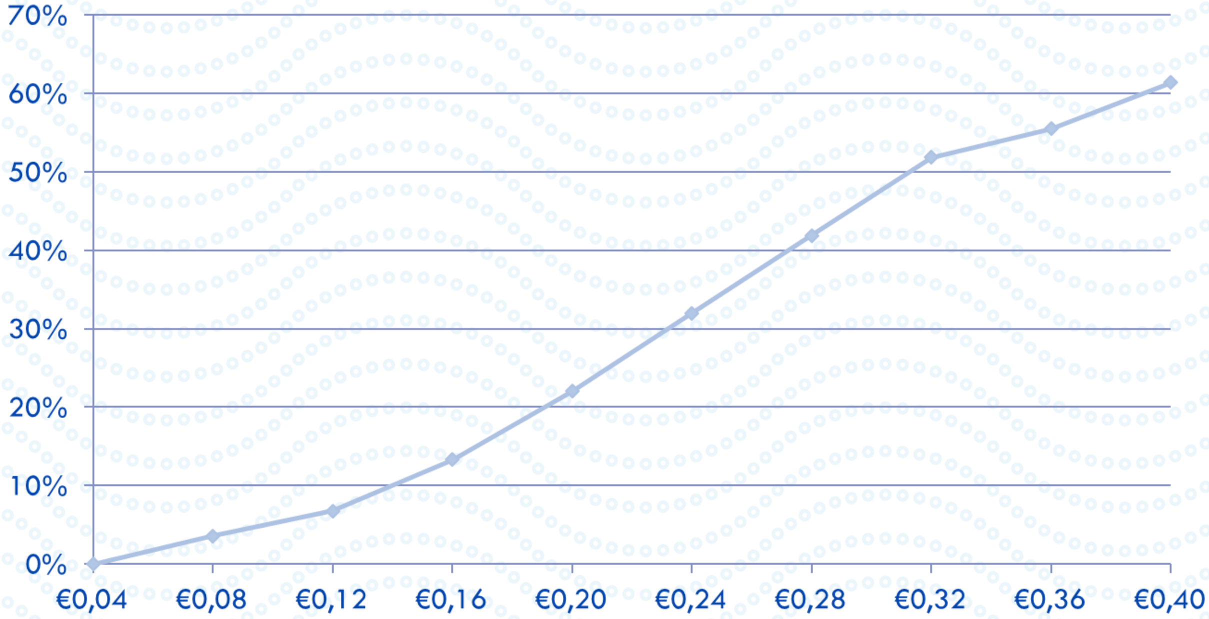
Results exploratory study

Scenario		1	2	3	4
World Energy Outlook scenario:		Low oil price	450 scenario	New policies	Current policies
Investment costs (factor)		1	0.95	0.9	0.85
Return of Investment bank (years)		12	12	12	12
Price difference LNG-Diesel (€)		**€ 0.05**	€ 0.17	€ 0.27	**€ 0.35**
	No. of vessels				
’80-84 m.'	782	0	3	66	108
'85-86 m.'	841	0	37	197	299
'87-109 m.'	438	0	34	260	453
'110-134 m.'	838	0	112	591	738
'135 m. or larger'.	278	0	22	115	201
Coupled convoys	138	0	49	75	85
500-999 kW Pushboats	218	0	2	5	19
1000-2000 Kw Pushboats	69	0	2	7	10
>2000 Kw Pushboats	25	6	20	22	22
Potential no. of vessels on LNG		6	281	1338	1935
Fuel consumption m3		21774	221271	592731	739914
% of fleet		0%	4%	19%	27%
% Fuel consumption		2%	18%	50%	62%

Sensitivity – price advantage

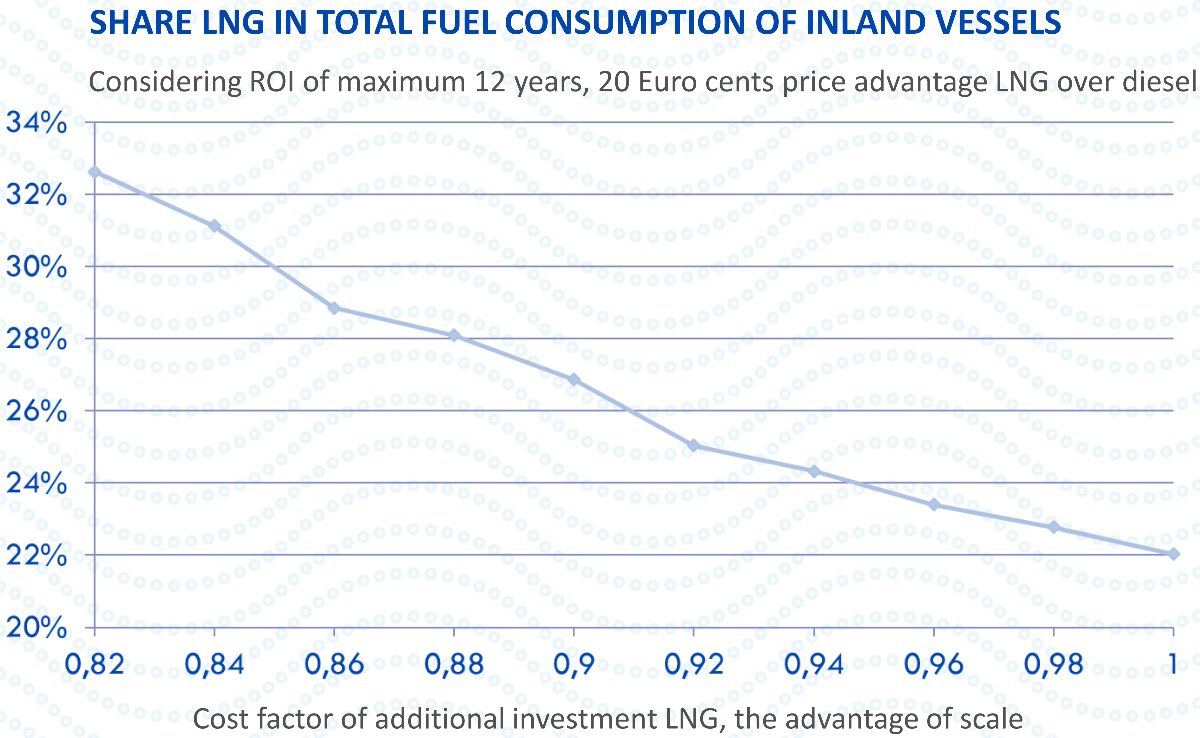
SHARE LNG IN TOTAL FUEL CONSUMPTION OF INLAND VESSELS

Considering a ROI of maximum 12 years, no scale advantage on investments

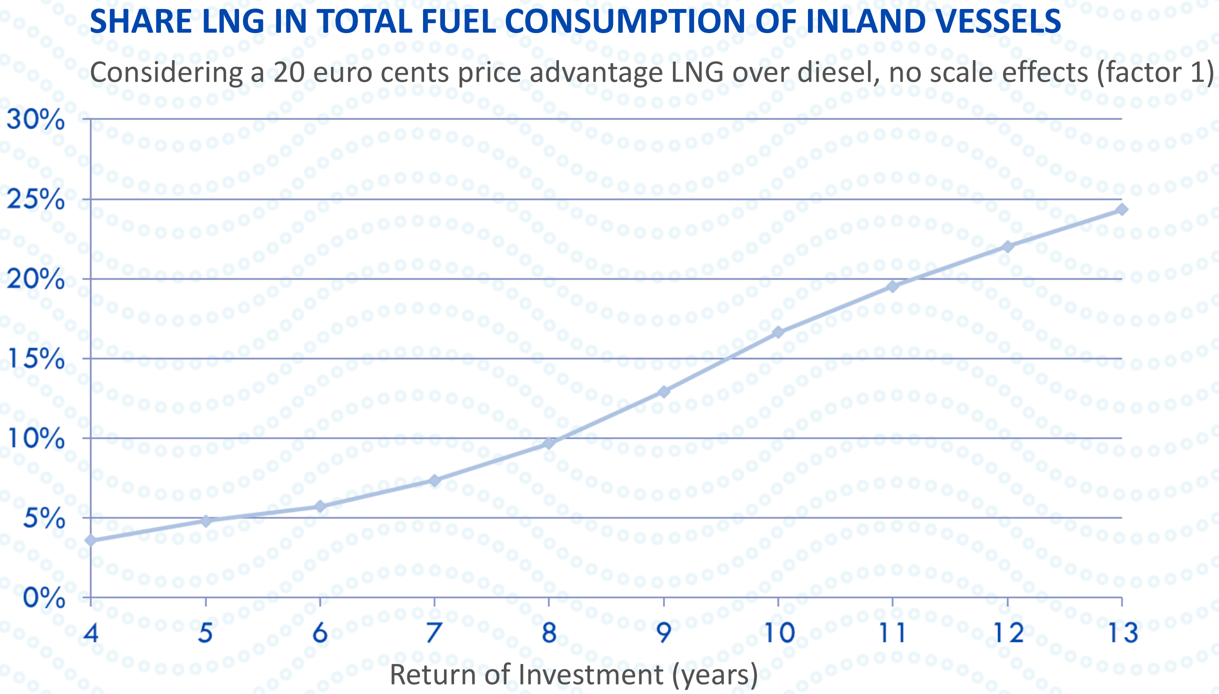


Price advantage of LNG relative to one liter of diesel fuel

Sensitivity – Investment costs



Sensitivity - ROI



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Contribution LNG to air quality

- Propulsion on LNG has a large contribution in reducing air pollutant emission, and thereby contributes to improving the air quality.
  Assumed emission profile for an LNG engine:
  - **1.8 grams NOx per kWh.**
  - **0.01 grams Particulate Matter (PM) per kWh.**

- Reduction of an LNG engine relative to a CCR2 diesel engine:
  - **6.0 -> 1.8 grams = -70% emission of NOx per kWh.**
  - **0.200 -> 0.01 grams = -99.5% emission of PM per kWh.**

Autonomous scenario

Study of end 2015 commissioned by the Dutch Ministry of Infrastructure and Environment. What is the impact on the environmental performance of inland shipping considering:

- **Stage V NRMM standard from 2019/2020.**
- **Access regime Port of Rotterdam from 2025, at least CCR 2 engines.**

Results:

- **The majority of the vessel owners are expected to replace existing engines with CCR2 engines before 2020 to avoid more expensive Stage V engines while simultaneously they satisfy the conditions to access the Port of Rotterdam in 2025.**
- **Existing vessel are expected to extensive using their CCR2 engines, multiple recondition cycles**

For more information, hereby the link to the report (in Dutch, summary in English):
https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2016/06/24/bijlage-3a-inventarisatie-milieuprestaties-bestaande-binnenvaartvloot-west-europa/bijlage-3a-inventarisatie-milieuprestaties-bestaande-binnenvaartvloot-west-europa.pdf

Optimistic LNG scenario

Positive business case for 1935 inland vessels on LNG, due to:

- **Large price advantage of LNG relative to diesel, 35 Euro cents per liter.**
- **15% reduction of investments costs for LNG.**

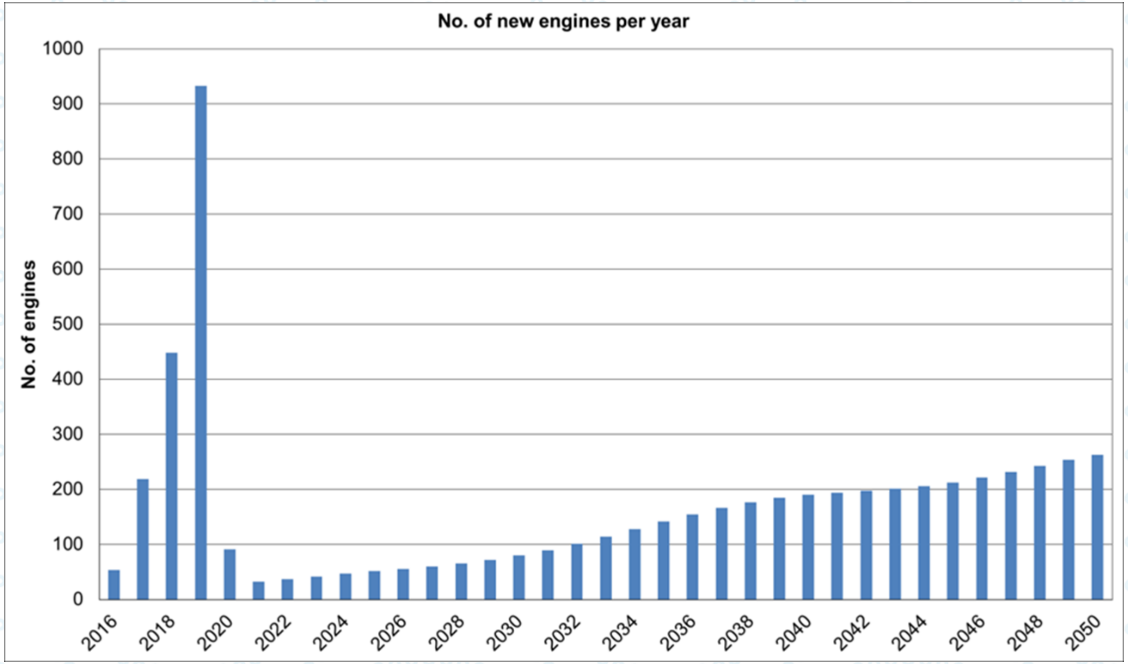
Effect: vessel owners shall replace their conventional engines with LNG engines to remain competitive in the IWT market and reduce (operational) costs. Consequently, this can be considered as direct potential from the market perspective. Note that possible incentive schemes like subsidies to enhance the deployment of LNG have not been take into consideration.

The LNG engine has a better environmental performance which results in a strong decrease of emissions.

The share of LNG in the total fuel consumption of IWT increases towards 62%.

Engine renewals – autonomous scenario

No. of engines replaced per year, only considering the enactment of Stage V standards and CCR2 Port of Rotterdam



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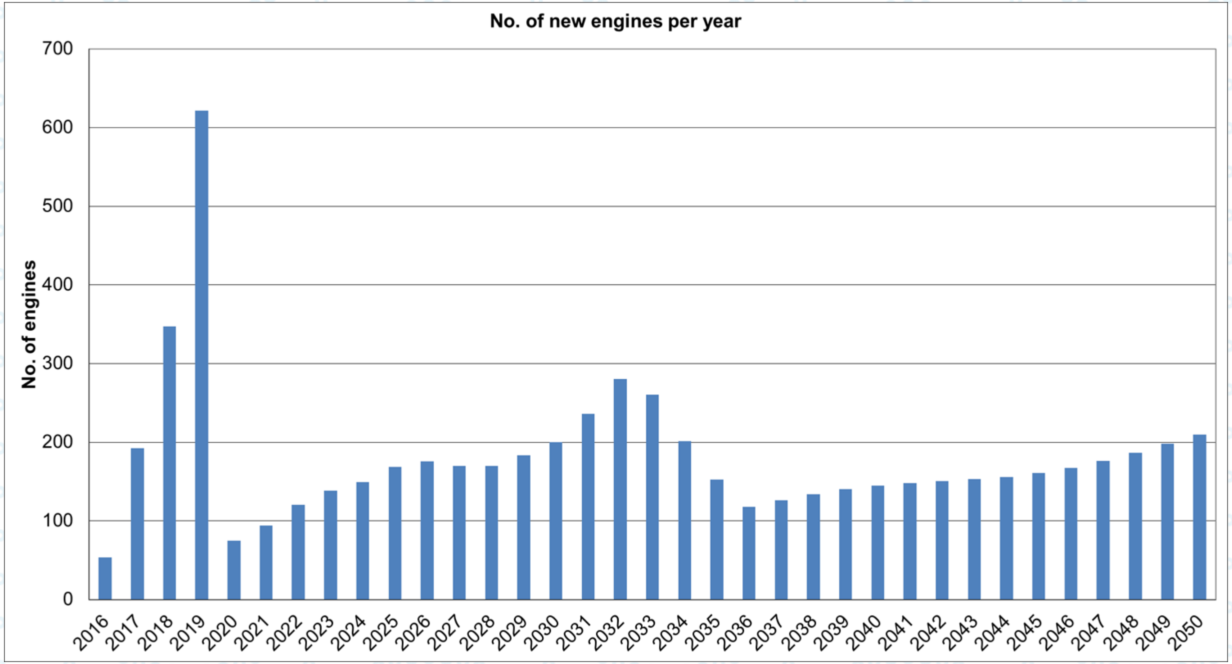
Engine renewals – optimistic LNG scenario

Engine renewals per year according to the "optimistic" LNG scenario, in addition to Stage V 2020 and CCR2 requirement in Rotterdam from 2025



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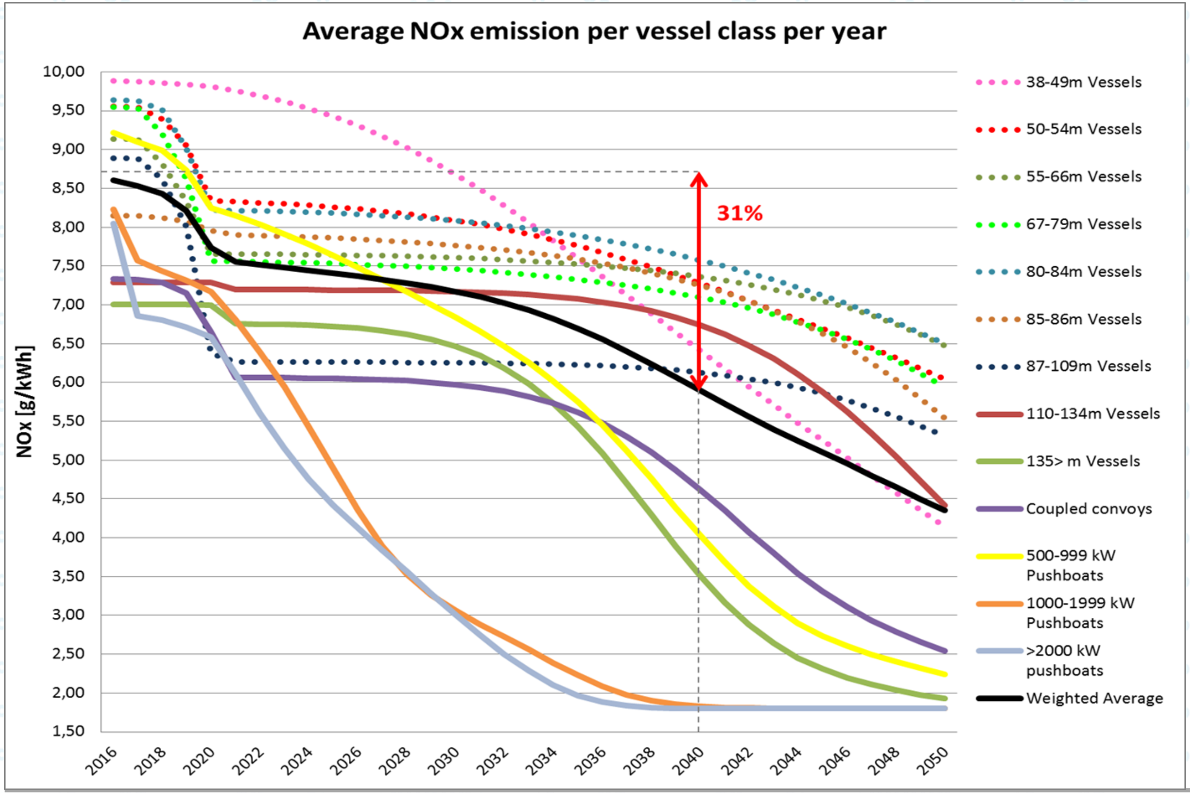
NOx emission – autonomous scenario



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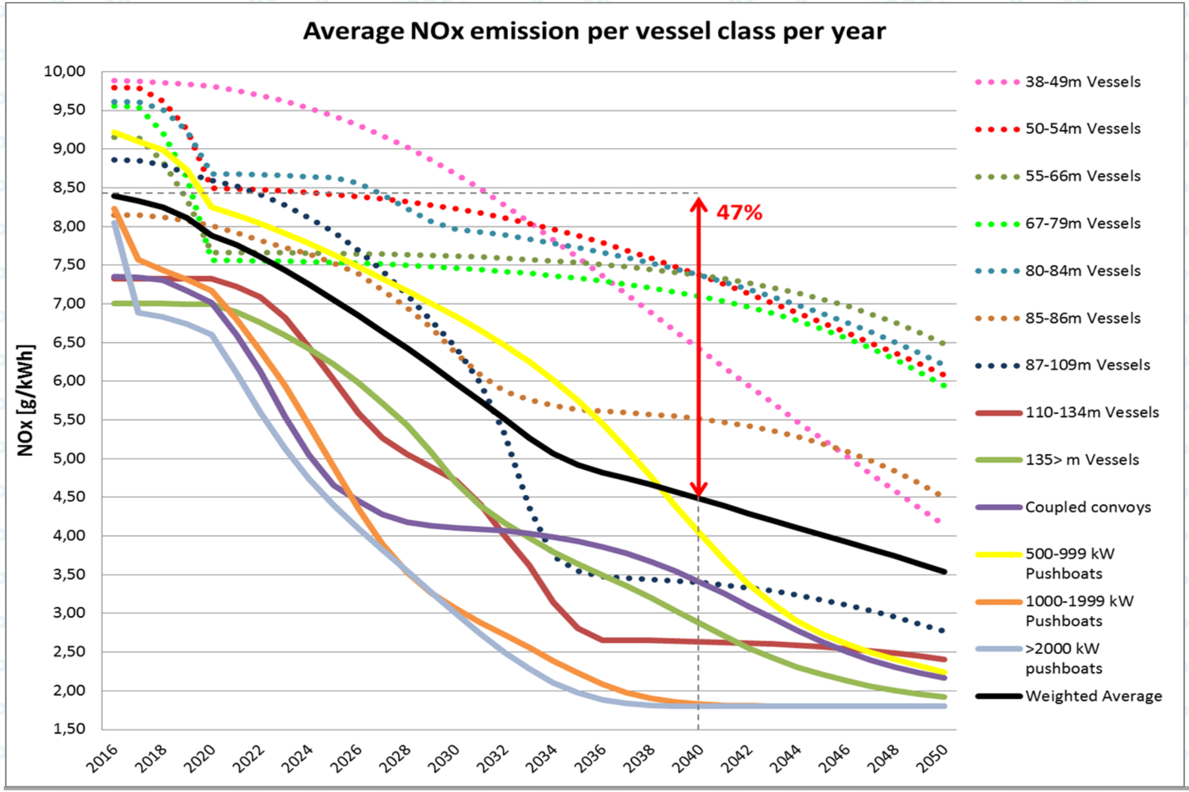
NOx emission – Optimistic LNG scenario



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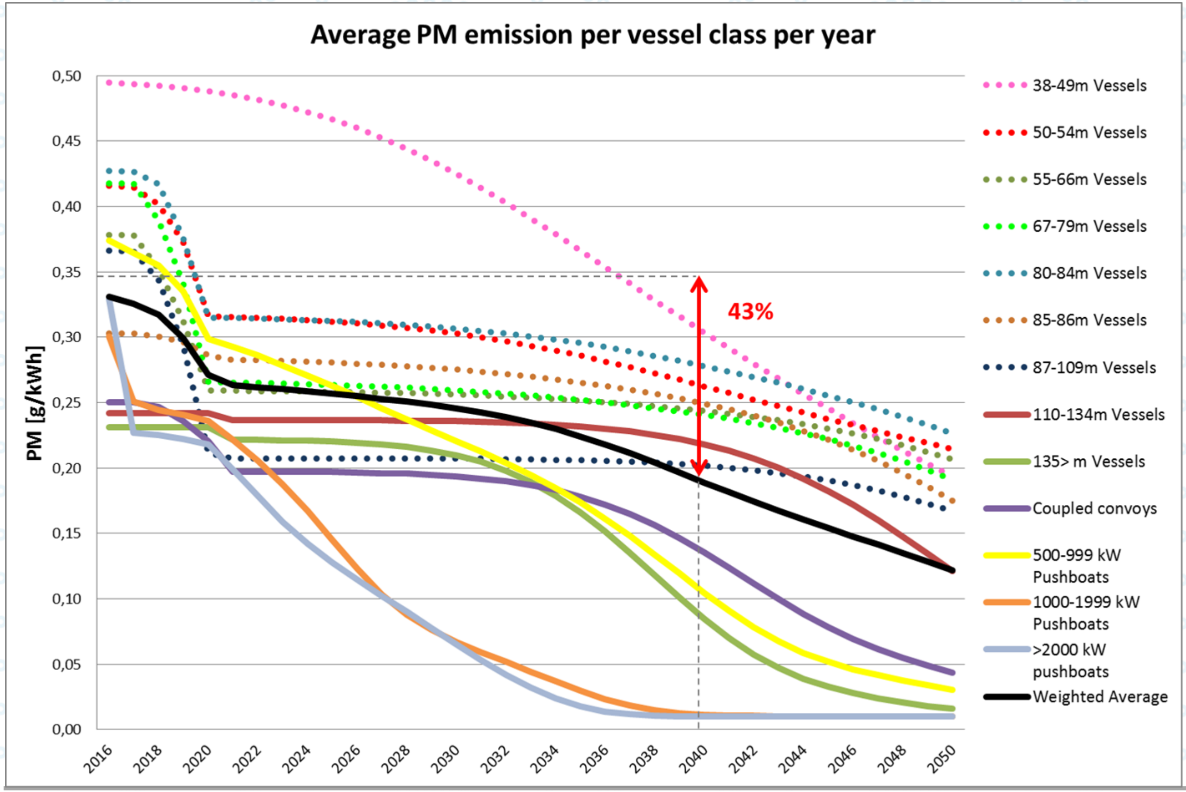
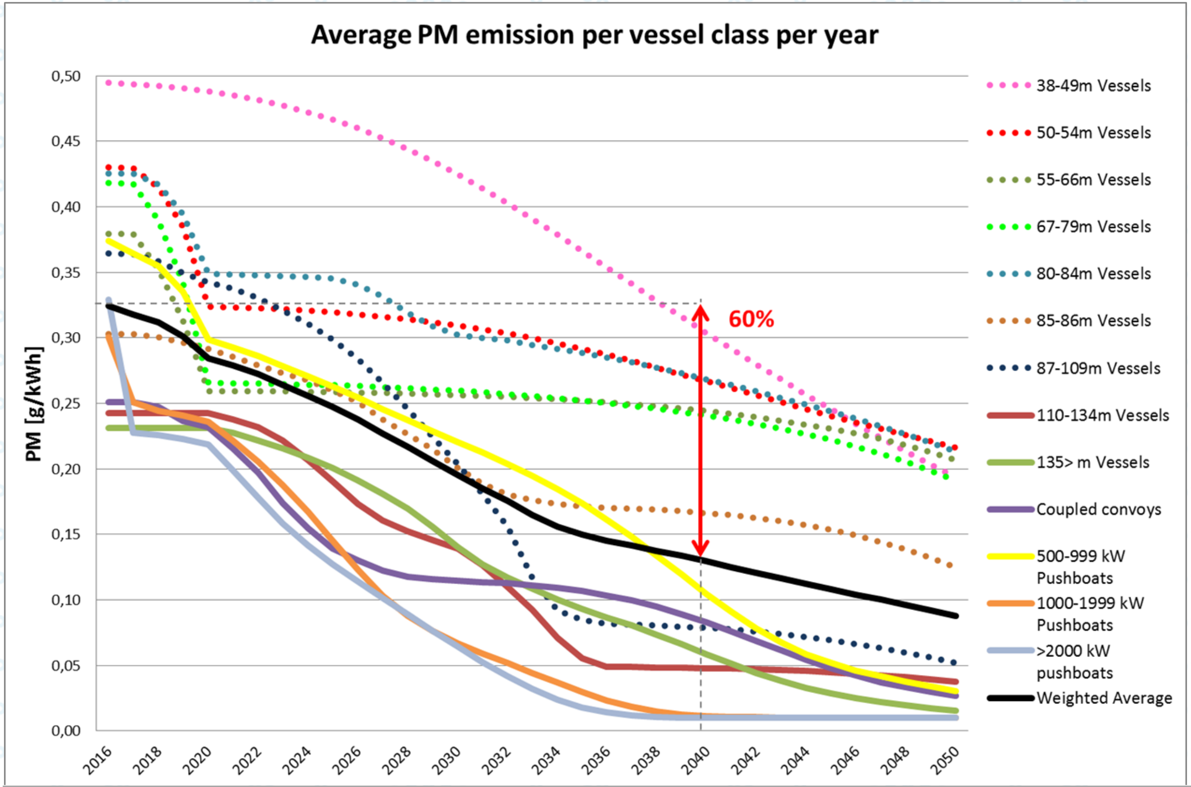
PM emission – autonomous scenario



PM emission – optimistic LNG scenario



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Contribution LNG to Air Quality

Reduction NOx emission from 31% to 46% in 2040, compared to 2016,

=> Factor 1.5 additional reduction of NOx in case of the optimistic LNG scenario.

Particulate Matter (PM) emission reduction from 43% to 60% in 2040, compared to 2016,

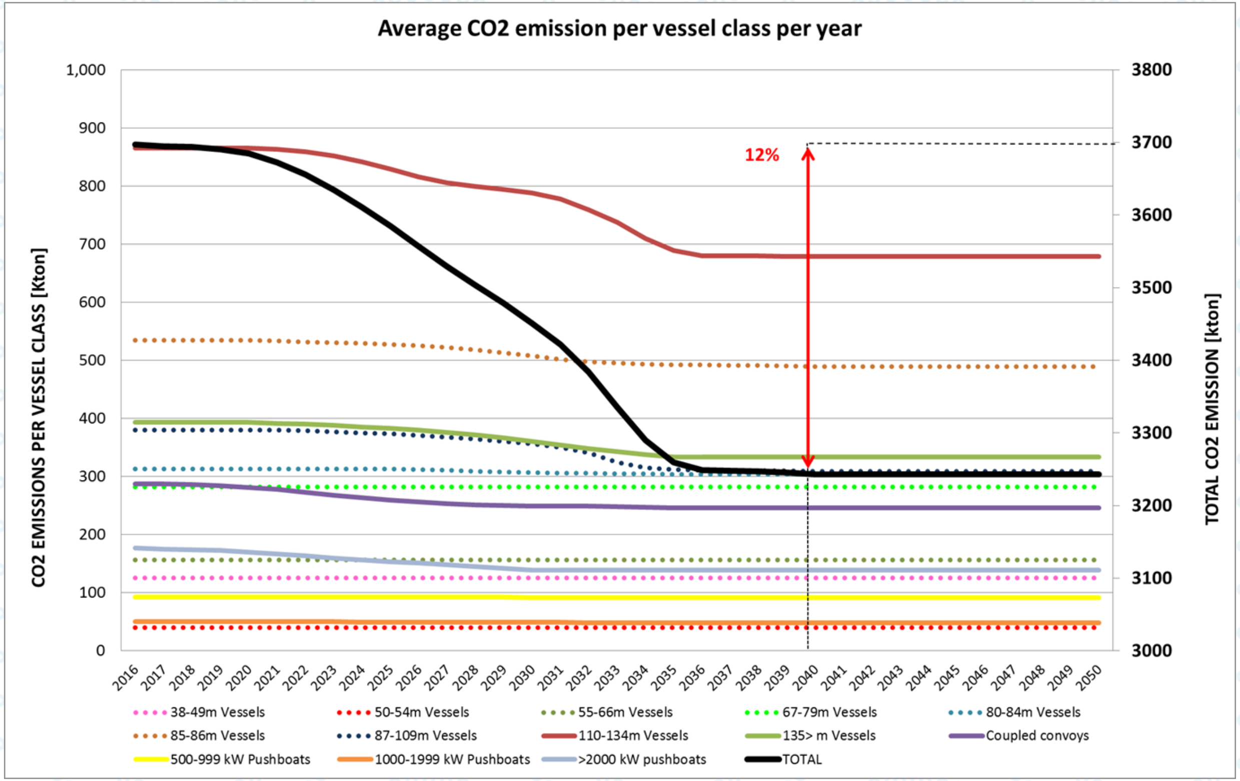
=> Factor 1.4 additional reduction of PM in case of optimistic LNG scenario.

Contribution LNG to reduction carbon footprint

Every engine renewal towards (conventional/fossil) LNG contributes roughly 20% to the reduction of CO2 emissions, under the pre-condition that the emission of methane slip will extensively reduce. Engine manufacturers indicate that the problem of methane slip will be solved by 2025 due to improved engine techniques.

This leads to a reduction of 12% in CO2 emissions between 2015 and 2040 in the optimistic LNG scenario (from 3700 toward 3250 Kton per year, see graph next page), under the pre-condition that the emission of methane slip will extensively reduce.

Contribution LNG to reduction carbon footprint*, optimistic LNG scenario



* The graph above considers the emission of methane slip to be extensively reduced

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Summarising conclusions

The price advantage for LNG relative to 1 liter of diesel fuel is expected to be in a range between 5 and 35 Euro cents.

A limited advantage of scale is considered on the additional costs for a transition to LNG: 15% cost advantage due to large scale production of LNG propulsion systems and LNG tanks.

There is a large spread in the potential of LNG vessels and share of LNG in the total fuel consumption of inland vessels :

- **Lower limit: 6 vessels and 2% of the fuel consumption.**
- **Upper limit: 1935 vessels and 62% of the fuel consumption.**

The potential is mainly sensitive for the spread in price advantage of LNG relative to diesel.

Summarising conclusions

The potential contribution of LNG on reduction of air pollutant emissions is relatively large. Greening the fleet will potentially go 50% faster considering the optimistic LNG scenario:

- **Reduction NOx emission from 31% to 46% in 2040 compared to 2016.**
- **Reduction PM emission from 43% to 60% in 2040 compared to 2016.**

LNG as transition fuel contributes directly to a reduction of the carbon footprint (CO2) and therefore to the objectives of the Climate Agreement of Paris from December 2015 (COP21), under the pre-condition that the emission of methane slip will reduce extensively.

Considering the large spread and unpredictability of the price difference between LNG and Diesel, the actual development of LNG in the Inland Waterway Transport sector is uncertain, yet the potential is significant.

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