MARITIME

A CRAZY IDEA ?

Retrofitting cruise ships to LNG by elongation

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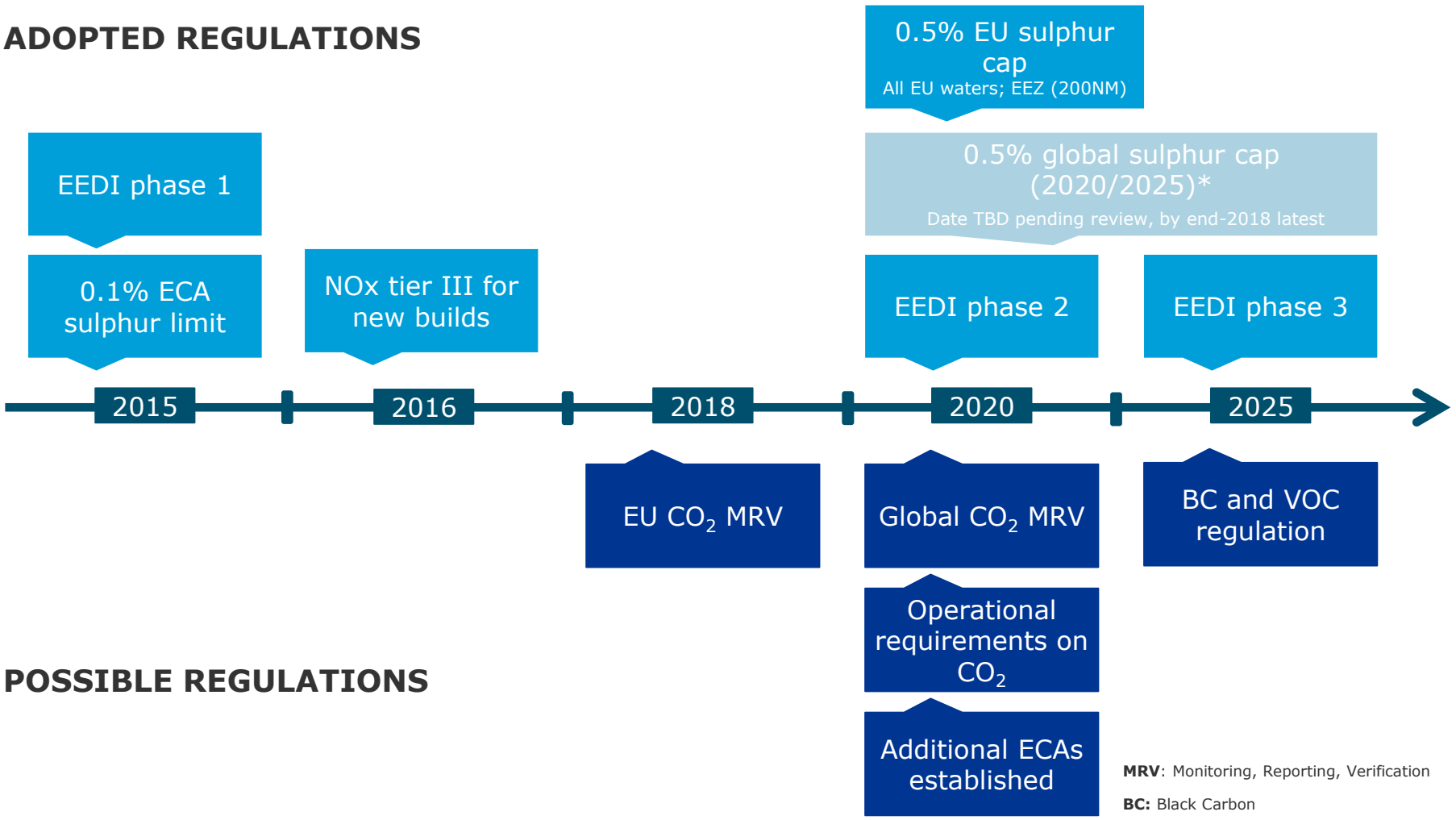
ADOPTED REGULATIONS



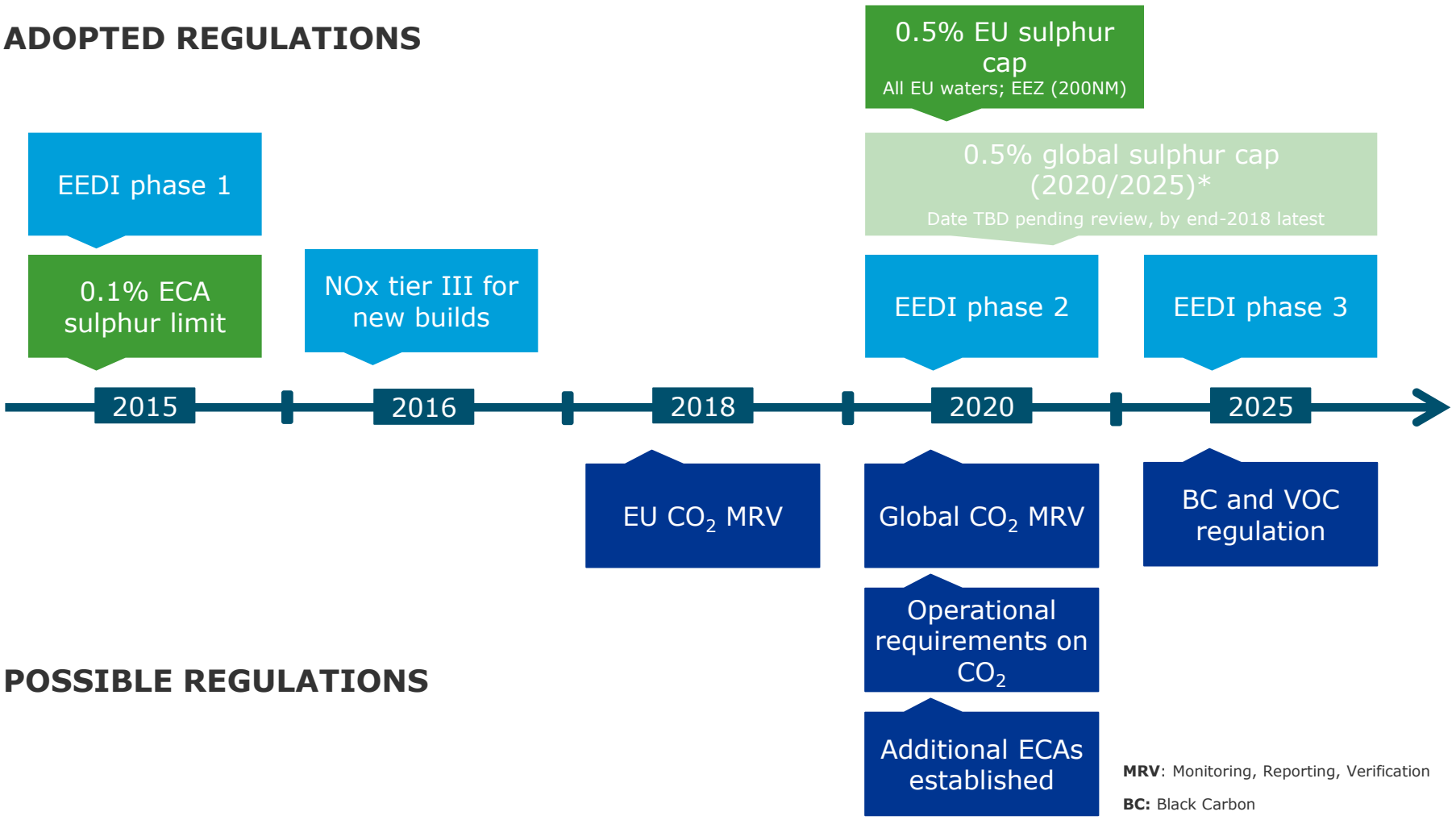
POSSIBLE REGULATIONS

MRV: Monitoring, Reporting, Verification

BC: Black Carbon

VOC: Volatile Organic Compound

1. A number of environmental regulations are on the horizon



MRV: Monitoring, Reporting, Verification

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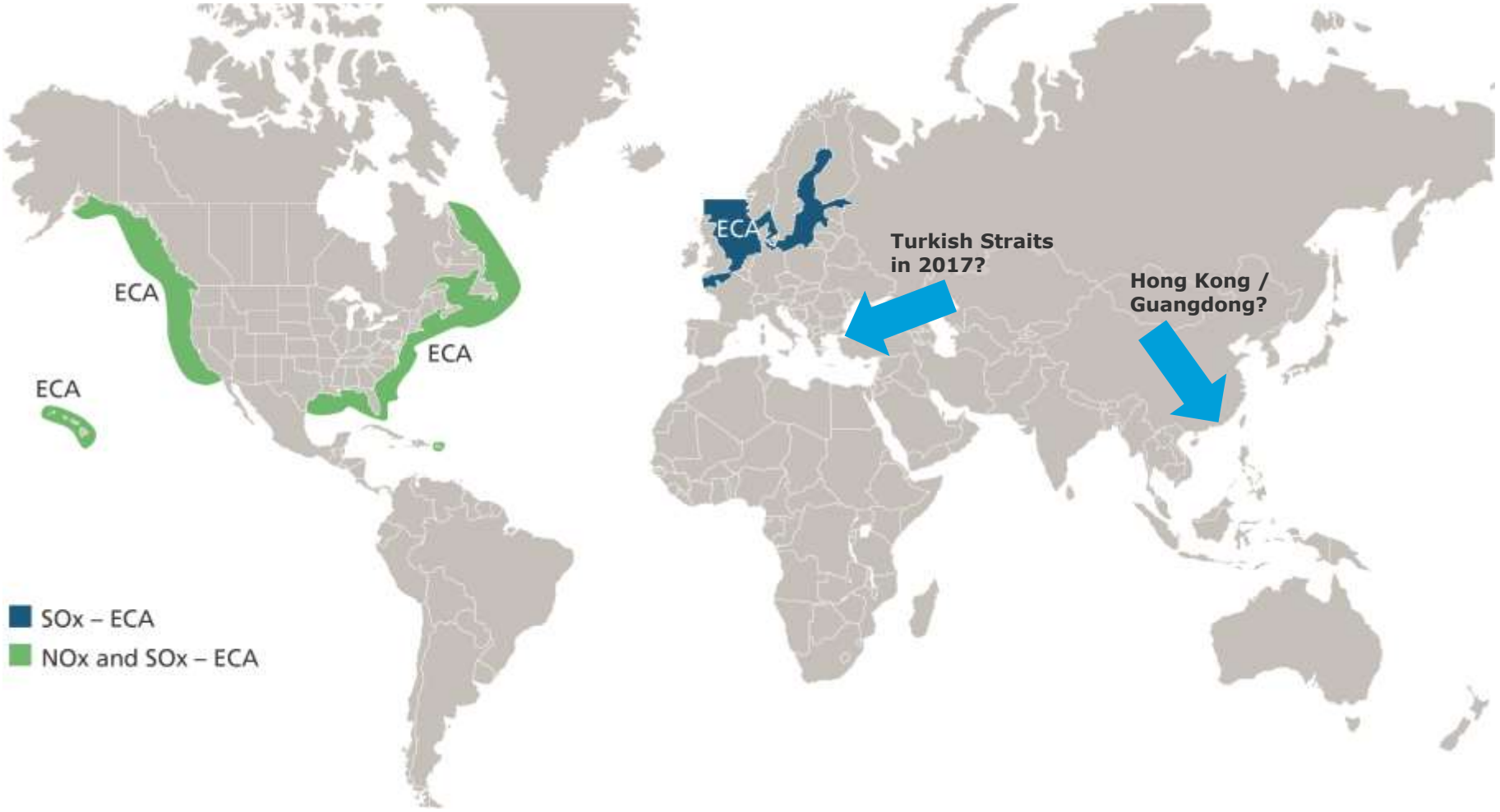
More stringent regulations on emissions to air



Benefits of using LNG against the upcoming environmental regulations

Emission component	Emission reduction with LNG as fuel	Comments
SOx	100%	Complies with ECA and global sulphur cap
NOx, Low pressure engines (Otto cycle)	85%	Complies ECA 2016 Tier III regulations
NOx, High pressure engines (Diesel cycle)	40%	Need EGR/SCR to comply with ECA 2016 Tier III regulations
CO2	25-30%	Benefit for the EEDI requirement No other regulations (yet)
Particulate matter	95-100%	No regulations (yet)

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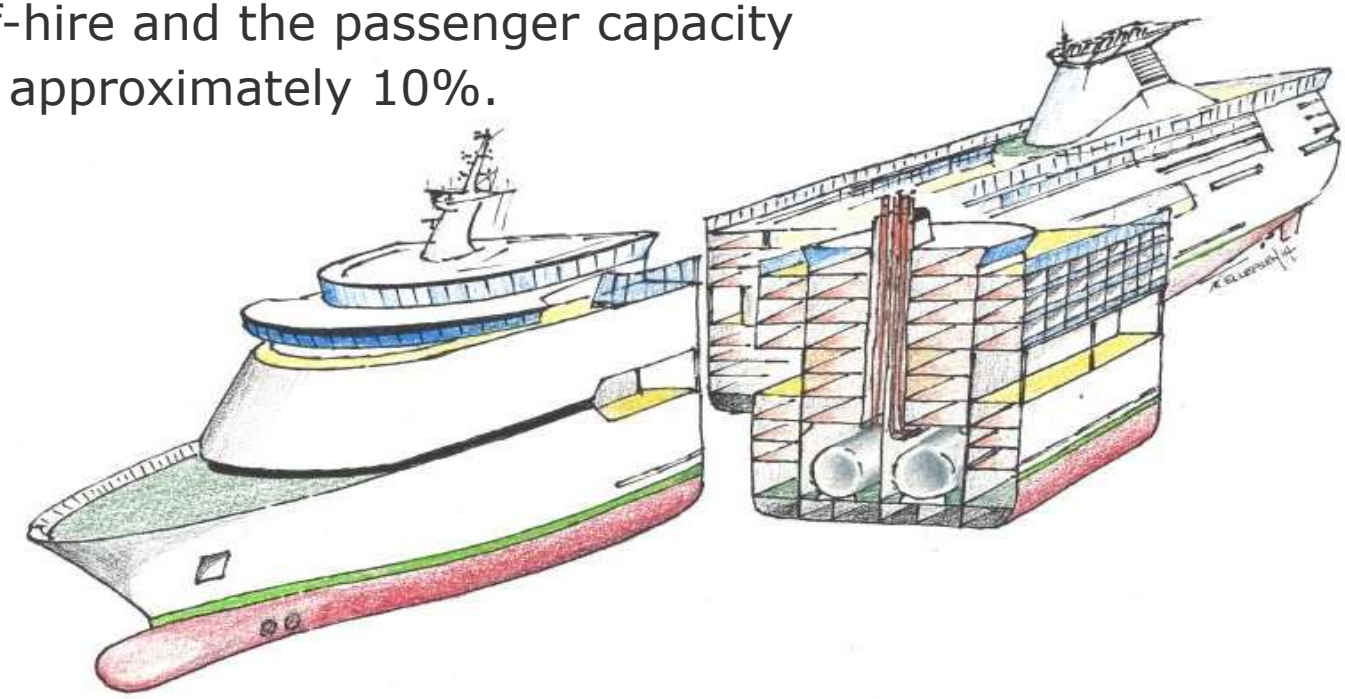
- A Crazy idea?

The concept – Convert a cruise ship to run on LNG by lengthening

- Inserting a new "LNG-ready" prefabricated mid-body section containing all the LNG systems, additional cabins and public spaces into the ship.

- Such a retrofit can be done in a few weeks, the ship does not need to go on a lengthy off-hire and the passenger capacity will increase by approximately 10%.



The idea - ENCHANTMENT OF THE SEAS, a real life example

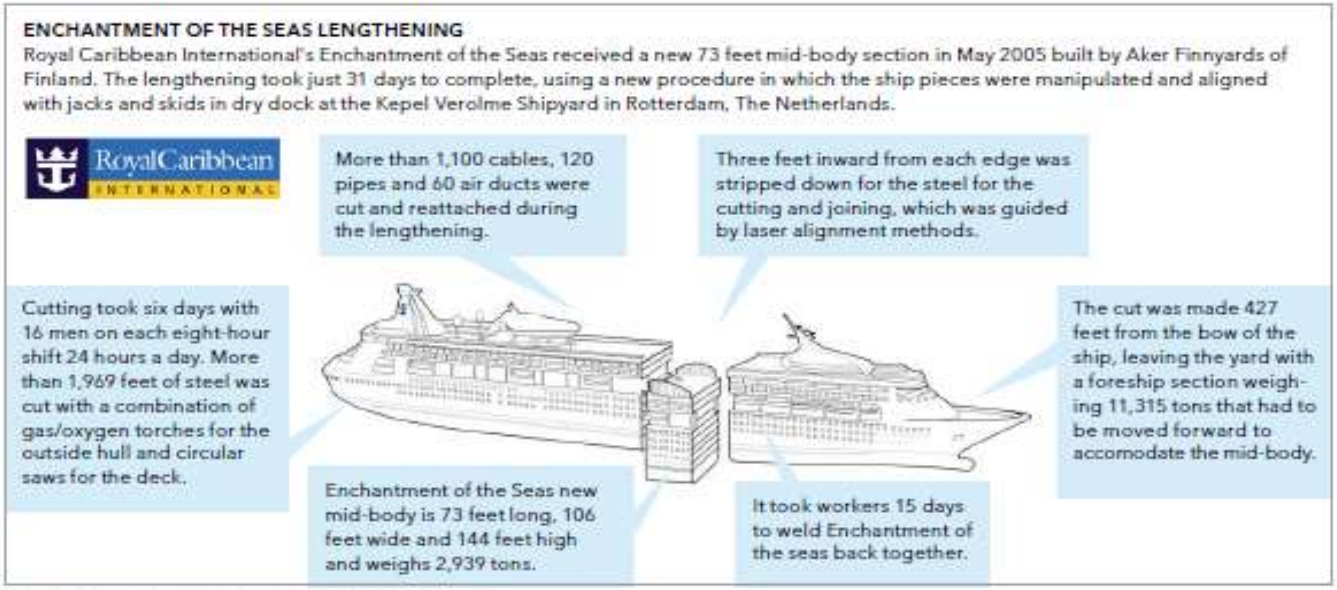


Figure 5: Enchantment of the Seas concept

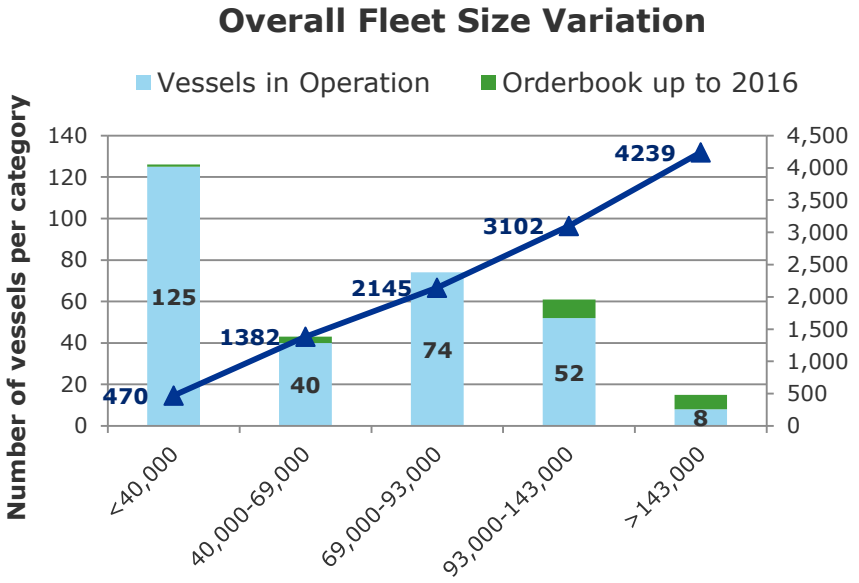
- A real life example is the ENCHANTMENT OF THE SEAS, lengthened in 2005 by adding a 22m-long mid-body section in order to increase the number of cabins.
- The conversion itself was completed in one month.

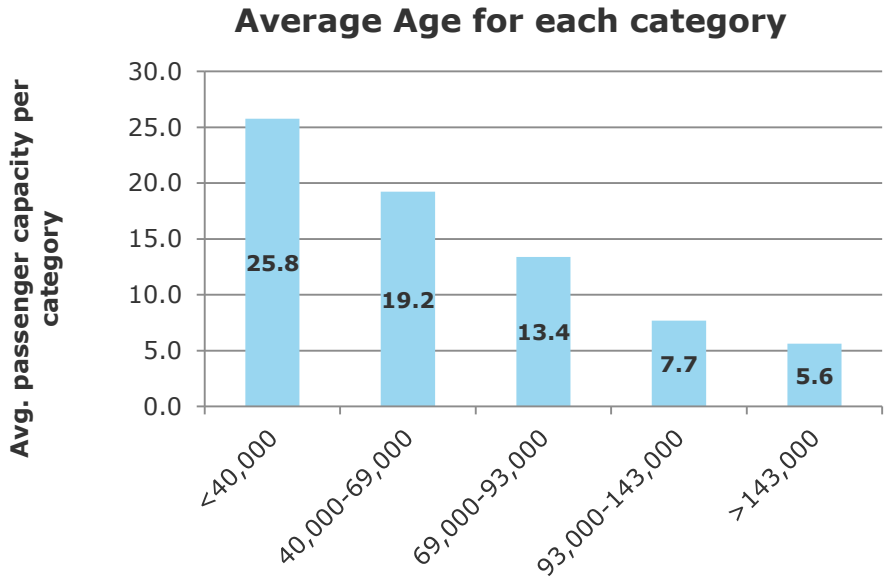
But why to consider retrofitting the vessel and using LNG ?

- A large number of cruise ships currently sailing to popular destinations will soon need to comply with stricter environmental regulations
- Compliance will require the installation of scrubbers, the use of LNG as fuel, or a changeover from heavy fuel oil (HFO) to marine gas oil (MGO)
- The difference in price between MGO and the HFO currently used can increase operational expenses by up to 40%

- Making ships more energy efficient and using distillate is an option, but the financial attractiveness needs to be investigated for every ship
- A conversion to LNG might, under certain circumstances, be an attractive alternative solution that eliminates the complexities of fitting scrubbers and the high cost of burning distillate fuel.

Potential retrofit market – Vessels of 8-19 year old & 40,000 - 143,000 GT which represent almost 55% of the fleet



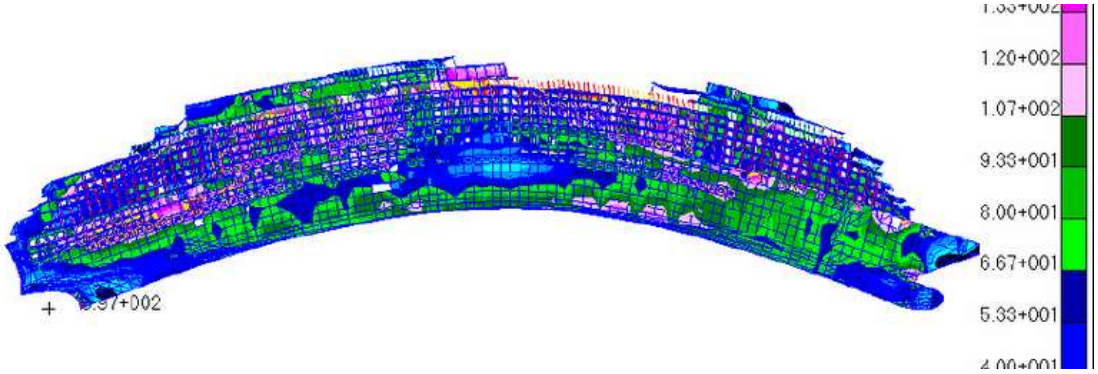


- Statistics show that the cruise industry is expected to continue to experience annual passenger growth of 7% (statistics from 1990 up to 2017)

- The future of cruising continues to look promising and the industry has a large growth potential, provided it continues to compete price-wise with the alternative options.

Case Study using the well tested 'LNG Ready' service offered by DNV GL - Technical highlights

- As mentioned earlier, every ship is different – so whether or not it can be converted must be extensively assessed.
- The minimum elongation limit is half a main vertical fire zone (approximately 22m); and the maximum could be a complete fire zone (approximately 43m).
- The longitudinal strength of the candidate ship has to be evaluated. The maximum allowable bending moment can become a showstopper if the hull is already designed to its optimum and cannot sustain any additional length.
- The increase in the longitudinal bending moment will require a corresponding amount of additional steel in order to maintain the required section modulus



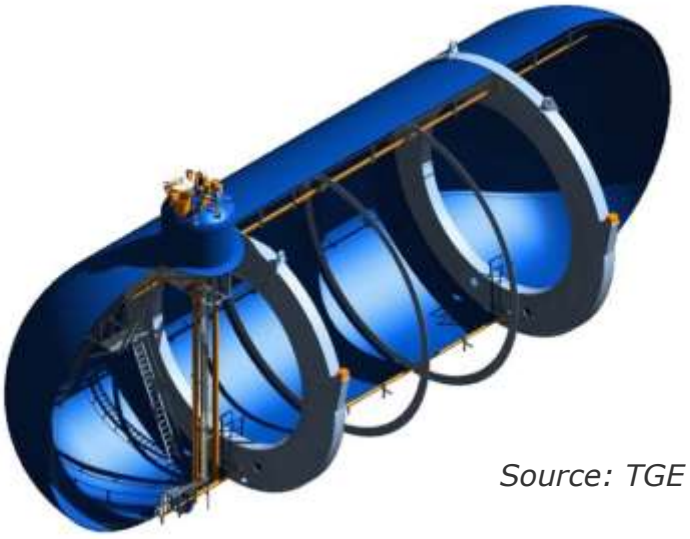
Not real example - For illustration purposes only

Technical highlights (continue)

- In a 23m compartment, the maximum possible volume of LNG is approximately 1,500m^3 due to design and structural constraints
- LNG type C tanks were used as these are currently considered to be the most feasible option
- With 1,500m^3 of LNG (~ 2,500nm – 6 days), approximately 70%-80% of all existing cruise itineraries can be operated.

- Involvement of the Flag is important as ship elongation operation is considered to be a major conversion

- The location of the bunker station need to to be considered
- Check if the engines can be converted to dual fuel

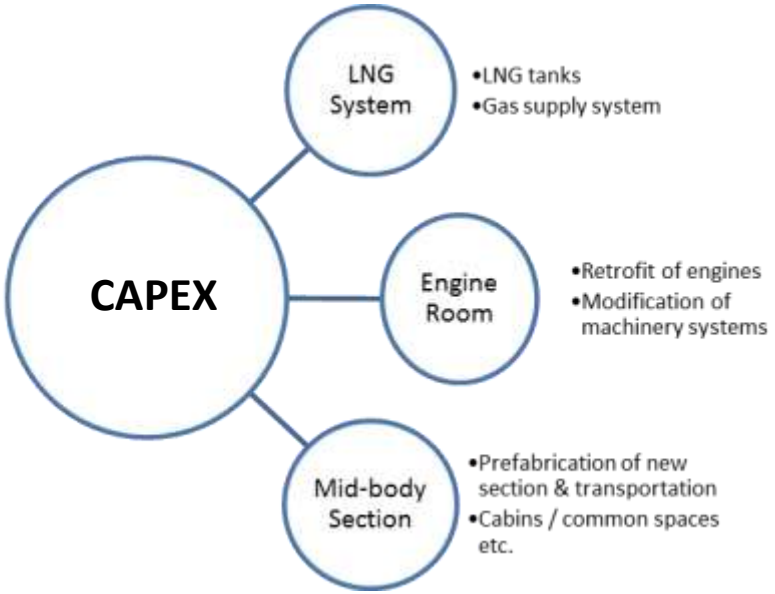


Source: TGE

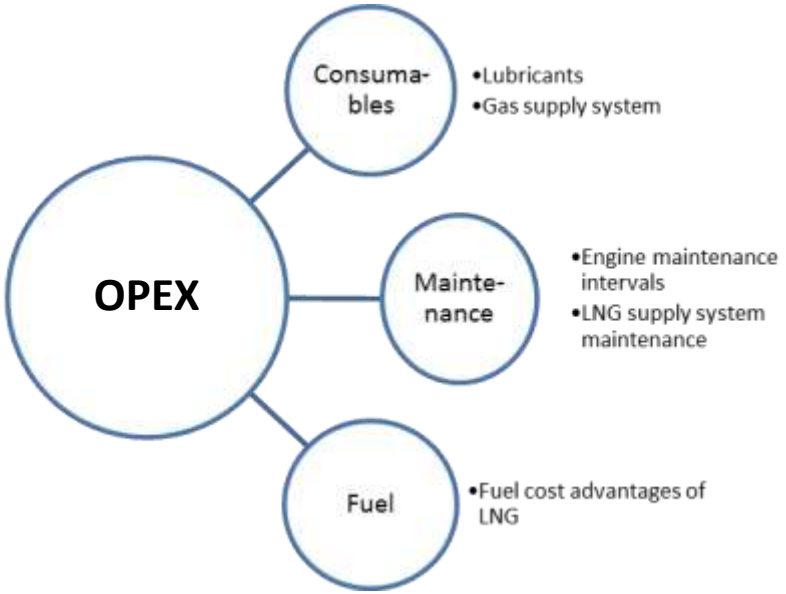
Financial Highlights

- In order to examine the financial attractiveness of our "crazy idea", we performed a high-level study and mapped the required investment for the LNG system

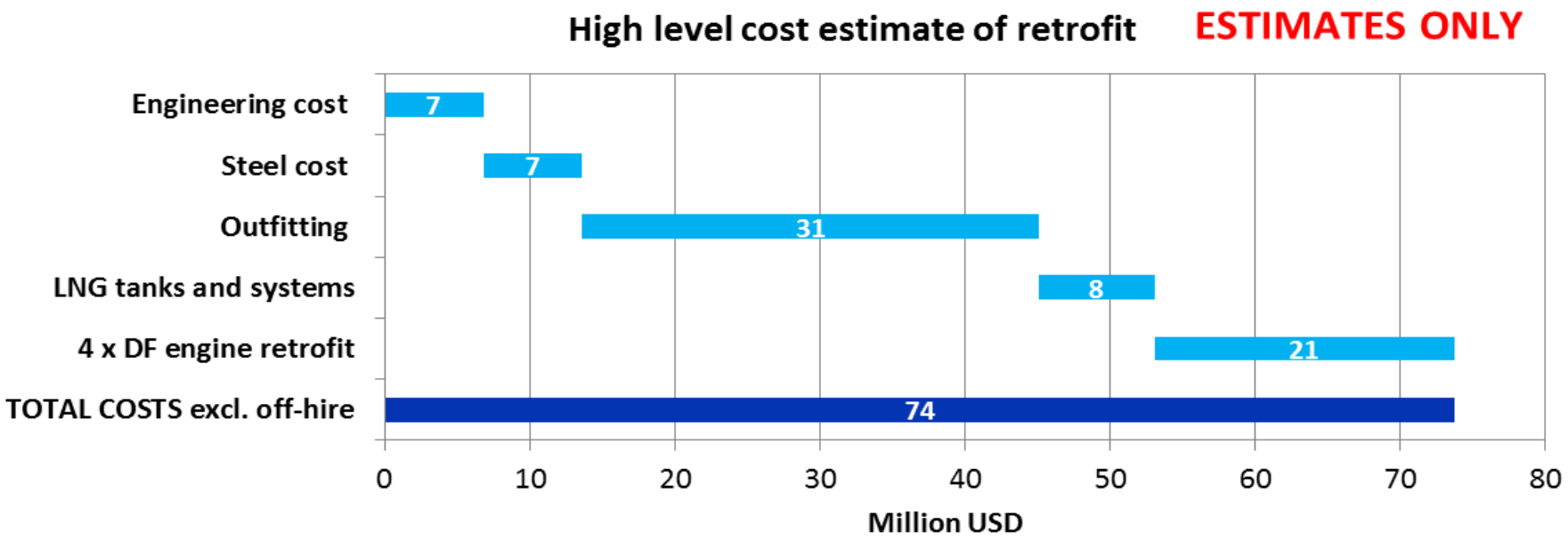
- In addition to the cost of the systems outlined below, the cost of having the ship off-hire needs to be taken into consideration.



- There is a reduction in the yearly operational expenses outlined below and an additional increase in revenue and profit from the larger number of cabins.



Required investment cost for the vessel elongation and use of LNG



- The LNG system includes all the necessary equipment from the bunker station to the engine.

- Not Included: Off-hire cost and transportation cost of systems

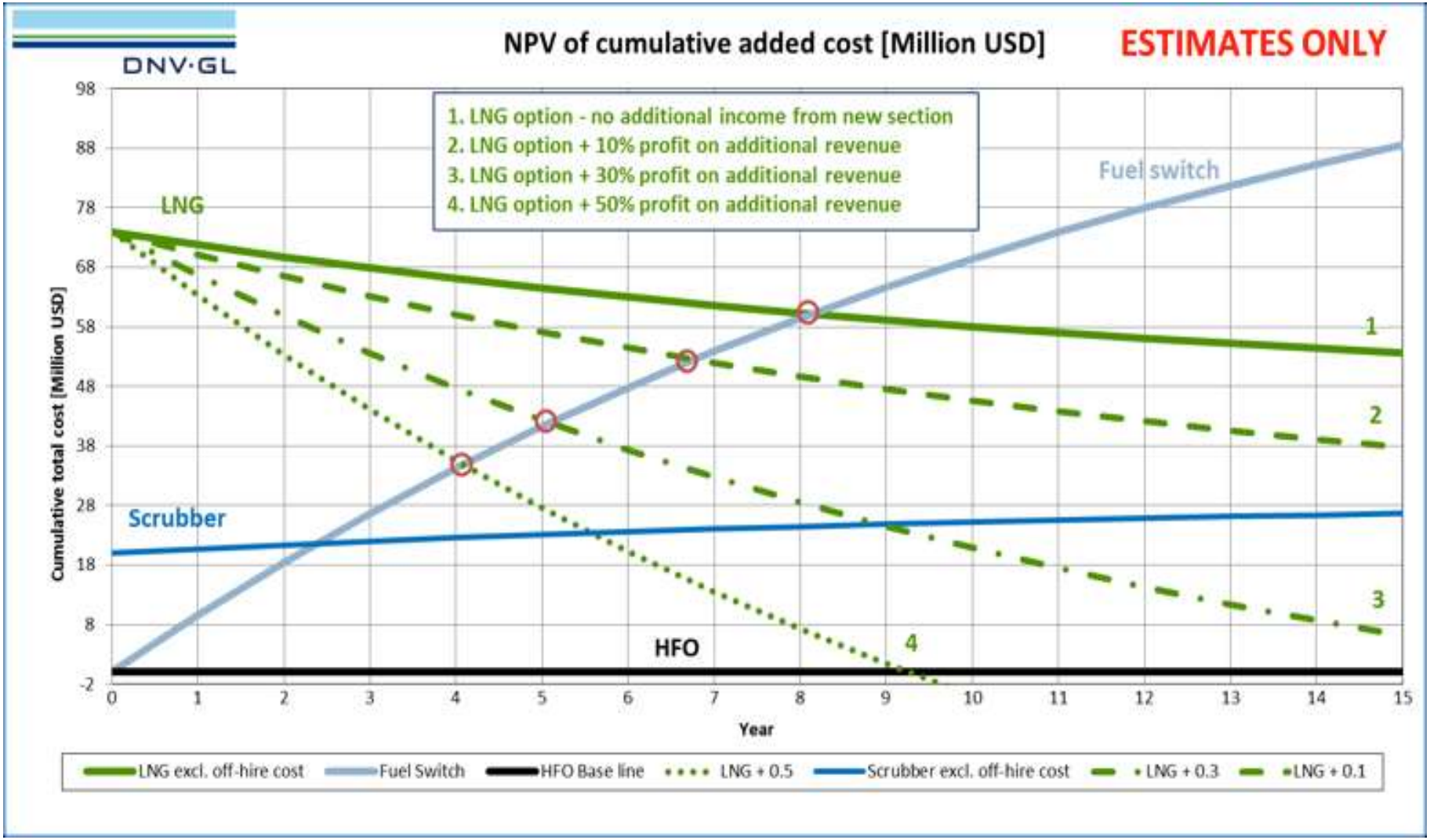
Assumptions used in the financial model

- The additional income generated from the new cabins for the LNG case has been taken into consideration when calculating the payback time based on the following assumptions:

Added staterooms with new mid-body section:	120
Number of passengers in the new section:	240
Daily revenue per passenger:	$ 220
Operating days of ship:	350 days

- LNG Price: $ 14/MMBtu (12.5% below HFO price)
- MDO Price: $ 25/MMBtu ($1,000/tonne)
- HFO Price: $ 16/MMBtu ($614/tonne)
- Discount rate applied: 8%
- No price increase over time is assumed
- 100% gas mode operation when operating on LNG
- The thermal efficiencies of diesel and gas engines are assumed to be identical

The financial attractiveness of the investment including the yearly revenue generated from the new section and the extra cabins

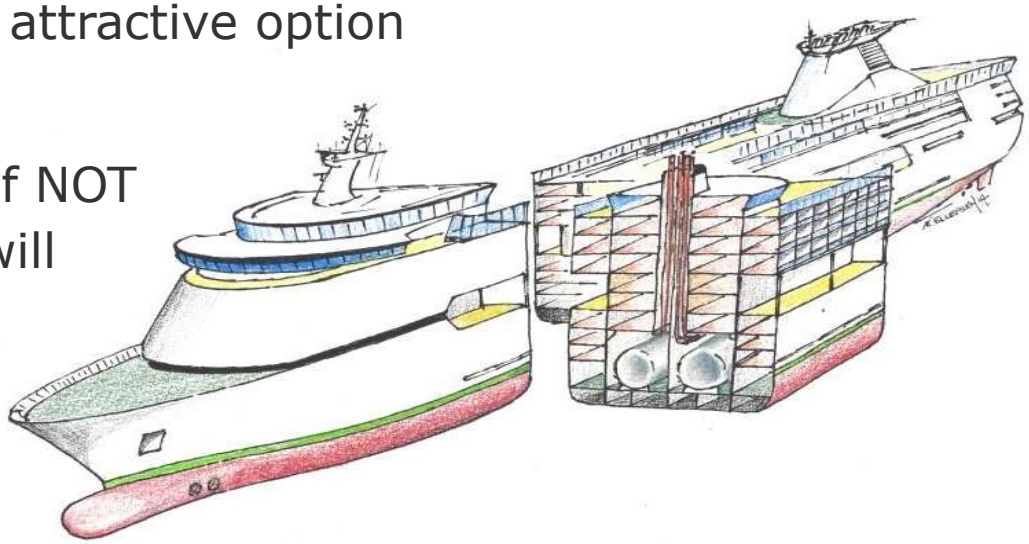


Summarizing

- Crazy idea or not ? – definitely an option worth of investigating
- Technically feasible ? – case-by-case dependent
- Financially attractive ? – depends on your investment strategy

- In DNV GL we believe that every newbuild discussion as well as retrofit should have the LNG as a fuel option in the agenda as under circumstances can be a very attractive option

- In the near future, the risk of NOT considering the LNG option will be higher than considering it NOW.



Thank you very much for your attention.

You are welcome to download the complete study from the following link:

http://www.dnv.com/binaries/LNG_RetrofitCruise_2014-03-L03_tcm4-596302.pdf

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