SESSION ONE

ONSHORE POWER SUPPLY (COLD IRONING) OR LNG?

ESPO Conference 2015

Next year, Piraeus will be the ultimate capital of the maritime industry, as it will host in that same week the European Sea Ports Organisation (ESPO) Conference 2015 and the European Maritime Day!

The 12th edition of the ESPO Conference will take place on 20 and 21 May 2015 and will have as theme "Energy".

It will be a unique event combined with the famous Greek hospitality.

With European Commission Officials, Ministers, Top Managers of European ports and representatives of all major players of the maritime business, the conference will offer unprecedented opportunities for networking and for the exchange of information and ideas.

More information about the programme and registrations will soon be made available on: www.espo.be.

PORTOPIA is a 4-year collaborative research project under the Seventh Framework Program (FP7) of the European Commission now known as the "Horizon 2020" program. The project, which was launched in September 2013, monitors and reports key performance data for European ports and thus assists the industry in moving towards a more sustainable and competitive port system. Port authorities are involved in the project through ESPO, which is one of the 12 partners involved.

PORTOPIA will provide facts and figures on different perspectives of performance: market trends, socio-economic impact of ports, port environmental management, occupational health, safety and security, logistic chain and operational efficiency, port governance and investment and user perceptions of port services. Port stakeholders interested in the project can contact espo@portopia.be for more information or visit www.PORTOPIA.eu .

Tiziana Murgia
ASSOPORTI

BIOGRAPHY

1st September 2009 – PRESENT
Head of Communication and administration in the Italian Ports Association in Rome

FIELD
Port management and territorial development, lobbying in the EU and promotion of Italian ports on an international level

FUNCTION
Communication and International Affairs executive

MAIN DUTIES
Organization of International events regarding the promotion of Italian Ports
Working directly with public and private stakeholders develops events that regard Industrial Relations in Ports and the surrounding area.
Contributes in the preparation of Agreements/Memorandums of Understanding between Ports, Associations and Governmental bodies.
Develops new communication icons and participates daily in the implementation of the official website.
Maintains institutional relations both in Italy and the EU regarding upcoming legislation
International Relations and communication activity
Press officer
Law proposal writer for Secretary General
European Union documentation
Contracts and other documents
HR consultant for Secretary General having been Personnel executive in the Port Authority of Gioia Tauro for over 10 years.
Member for the Italian Ports Association in the Passenger and Labour Committee of the European Ports organization and also participant in the AIVP (worldwide network of ports and cities).

Air emission regulations & retrofitting cruise ships to run on LNG?

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BIOGRAPHIES

Jorge Pinto is MSc in Naval Architecture by the Universidad Politécnica de Madrid (1978).He has been playing as surveyor in all Maritime activities for Legacy DNV (now DNVGL): plan approval and surveys, both for ships and maritime equipment, and in different places (Lisbon, Oslo, Bergen, Harstad, Valencia, Tarragona, Vigo, Athens and Madrid). Since end 1978, being now Senior Principal Surveyor.He is responsible for the business development of the Oil & Gas activity in Spain for DNVGL, having played an active role on the LNG Bunkering services in this country.He is presently member of the Management Team of DNVGL in Portugal, Spain and France.

Alexandros Chiotopoulos is a consultant in the Shipping Advisory group in Norway. Alexandros holds a Masters in Mechanical Engineering from University College London (UCL). After his graduation he joined DNV GL and before he moves permanently in Oslo he worked in London, Singapore and Shanghai offices where he participated in a newbuilding project.
In his current role in Shipping Advisory, his main focus is on Energy Efficiency and LNG as a fuel. He has been involved in the development of the LNG Ready service and has participated in more than 20 commercial projects helping shipowners and charterers realise if LNG is an attractive solution for their vessels or not. In addition he has performed several market studies for different regions, examining the potential LNG fuel demand and LNG availability.

The cruise industry is facing new and stricter IMO air emission regulations. Considering the cost of investments and fuel prices, LNG may, in the authors' view, be a cost-beneficial solution that meets this challenge. In this report, the authors evaluate the possibility of retrofitting existing cruise ships to run on LNG as fuel, with the pros and cons attached.

PAPER

INTRODUCTION

A large number of cruise ships currently sailing to popular destinations will soon need to comply with stricter environmental regulations - requiring the installation of scrubbers, the use of LNG as fuel, or a changeover from heavy fuel oil (HFO) to marine gas oil (MGO) or a combination of these two. Compliance with regulations and the strongly fluctuating fuel prices

have made cruise operators sceptical about the success of their future business.
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 fuels in order to comply with the forthcoming regulations is an option, but the financial attractiveness needs to be investigated for every ship on a case-by- case basis. 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.

CONVERTING AN EXISTING SHIP

Converting an existing ship to run on LNG can in principle be done by:

1. Taking the ship out of operation and installing the LNG tanks and fuel handling systems in the existing hull. Such a retrofit will reduce the number of cabins and will involve technical complications as the LNG tanks require more space than HFO or MGO fuel tanks and such free space is not available on the ship. In addition, this is time-consuming and thus represents a loss of revenue due to the lengthy off-hire.

2. 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 investment is limited to approx. 10% to 12% of newbuilding costs.

In this study, we focus on the second option, which is proven to be the most feasible solution from a technical and financial perspective.

The potentially strongest candidates for conversion comprise 8-19-year-old ships between 40,000 GT and 143,000 GT which represent almost 55% of the fleet. Ships over 143,000 GT have been excluded as their length is already at the limit of present port capacities.

Ships below 40,000 GT are not considered favourable for lengthening due to the limitations of the ports they visit. Cruise ships of this size are usually in the luxury segment, typically visiting smaller and less busy ports without the infrastructure and ability to receive the bigger ships. Another reason is the lack of financial attractiveness; the payback time of the investment is increased due to the lower passenger capacity. However, because these are high-end ships, the investment cost could be absorbed by the higher premiums.

Generally, every ship has unique characteristics and whether or not it is a good candidate for conversion needs to be investigated on a case-by–case basis and in close cooperation with the respective flag state administrations.

Technical considerations

The ‘crazy idea’ outlined in the title involves the conversion of a cruise ship to run on LNG by lengthening it (Figure 1). A new prefabricated part, containing LNG tanks and all the required LNG systems, is added to the ship.

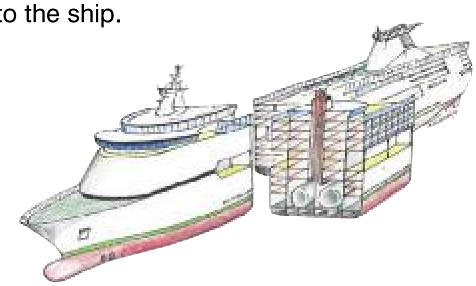


Figure 1: Elongation concept with prefabricated LNG tanks

A real life example is the ENCHANTMENT OF THE SEAS (figures below), 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.

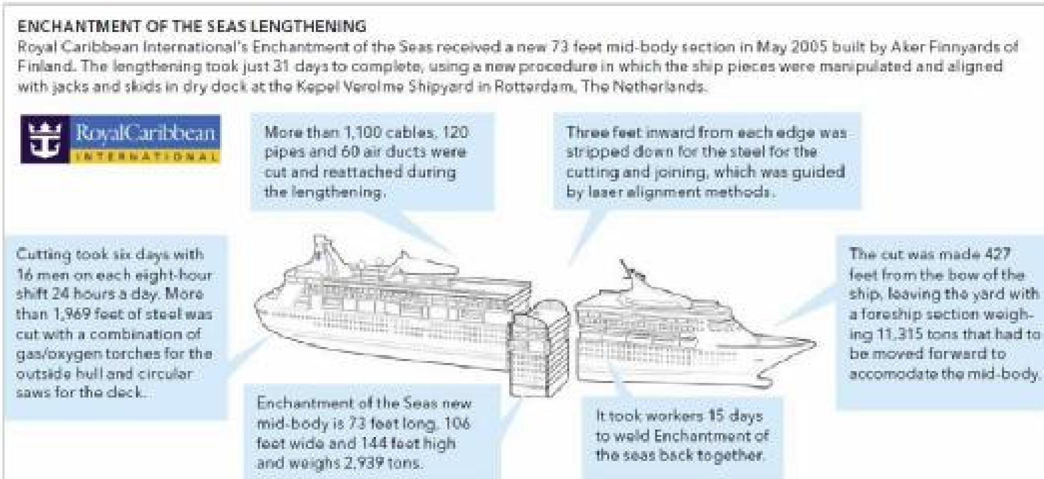


Figure 2: Enchantment of the Seas concept

Figure 3: Enchantment of the Seas

Figure 4: Enchantment of the Seas completed

As mentioned earlier, every ship is different – so whether or not it can be converted must be extensively assessed. In the following part, all the required technical modifications are outlined and presented from a hull and structural perspective, the machinery point of view and finally the operational side.

Benefits and current challenges of elongation and use of LNG as a fuel

Benefits

- Most likely improved revenue
- Increased number of passenger and crew cabins
- Improved environmental footprint
- Energy efficiency may be increased by installing flow-improving appendages during dry-docking
- Additional public space and retail capacity
- Additional open deck spaces
- Reduction of main engine maintenance hours
- Less engine crew required

- Cheaper lubricants
- Cleaner engine room
- No soot on decks – less cleaning and wash water needed
- No need for exhaust cleaning devices or catalytic reactors
- Slightly lower noise level in engine room

Current Challenges

- Design & retrofit cost compared to switching to distillates
- Time required for ship to be taken out of service for the retrofit operations
- Elongation may reduce the range of ports of call
- Bunkering challenges
- Statutory challenges
- LNG fuel cost pricing challenges
- LNG infrastructure challenges
- More tank space required to accommodate enough LNG to cover all the itineraries
- Onshore bunkering logistics are still under development
- Rules still under development
- More sophisticated fuel equipment is required
- Public perception not fully known

Lengthening characteristics

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 limits of the hull girder determine the elongation size. The increase in the longitudinal bending moment will require a corresponding amount of additional steel in order to maintain the required section modulus - deemed too costly to be seriously considered. Thus, the most feasible option for a potential candidate ship will be a new part that is half a fire zone in length.

Our technical feasibility study has shown that, in a 23m compartment, the maximum possible volume of LNG is approximately 1500m^3 due to design and structural constraints. The addition of new cabins will increase the total number of cabins by approximately 10%.

For this study, cylindrical pressure type C tanks were used as these are currently considered to be the most feasible option. A prismatic low-pressure tank, type B, is an alternative, increasing the LNG capacity by about 30%. However, for a type B tank, it has to be assumed that a controllable fatigue crack may occur as the worst-case leakage scenario. The leak rate is defined and the released LNG has to be controlled in a safe manner - which would be a challenge, especially on a cruise ship. In addition, the low max tank pressure of 0.7 bars for a type B tank results in limited flexibility for the tank operation and bunkering.

A high-level study showed that, with 1,500m^3 of LNG, approximately 70%-80% of all existing cruise itineraries can be operated. In order to cover the remaining routes, which are longer and require more fuel, the operator can either use the ship's dual fuel capabilities and burn MGO/HFO, depending on the location, or perform a second bunkering operation to fill up with LNG half way through the voyage. A potential new mid-body section of 43m will be able to accommodate approximately 3,000m^3 of LNG in total and this will enable the ship to carry out all the current itineraries.

Flag Engagement

Before deciding on a conversion, it is of the utmost importance to involve the Flag State Administration at an early stage, since a lengthening is defined as a major conversion. The new part of the ship must comply with the SOLAS regulation that is applicable when the conversion starts. According to SOLAS II-2/1.3.2, "Repairs, alterations and modifications which substantially alter the dimensions of a ship …shall meet the requirements for ships constructed on or after 1 July 2012 in so far as the Administration deems reasonable and practicable".

Although the term 'substantially' is not defined, a ship elongation operation is considered to be a major con- version as it alters the ship's initial dimensions. Therefore, the involvement of the Flag is even more important. Finally, the damage stability regulations to be applied need to be clarified at an early stage.

Current SOLAS requirements include the Safe Return to Port (SRtP) requirements, which should be complied with as well. However, as SRtP is a design requirement and applies to the whole ship, achieving compliance with a pre- 2012 ship is a significant challenge. The Flag should therefore be contacted in order to obtain an exemption from the SRtP requirements.

Hull and Structure

The following steps are required for the hull and structural part of the conversion:

- 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.
- A damage stability study needs to be performed in order to determine the location of the new part.
- Fire boundaries and the evacuation arrangements need to be sorted out when planning the inserted arrangement.
- Machinery spaces need to be appraised and re-arranged as necessary.
- The location of the bunker station might create some challenges as balconies, openings and lifeboats cannot be within a safety distance of the bunker station.
- The location of the vent mast needs to be considered in order to avoid disruptions on the upper decks.

Operational Requirements

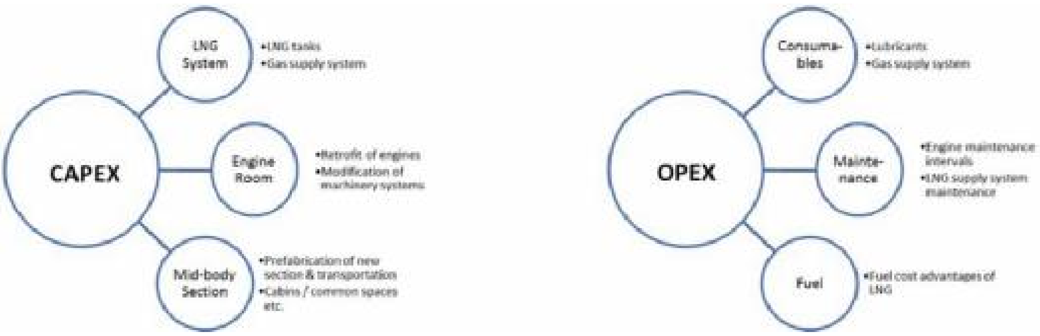
- A major nautical aspect that needs to be investigated is the slow speed maneuvering capability in port of the now longer ship.
- The addition of new cabins requires an increase in potable, black and grey water capacity.

Machinery Requirements

- The possibility of converting the main engines to dual fuel needs to be investigated. Engine suppliers are continuously developing retrofit packages for different engine types.
- A longer ship will also require an increased thruster capacity. New bow and stern thrusters might be necessary.
- The ship's power supply will need to be recalculated due to the increased hotel load. On the plus-side, exploiting the properties of LNG such as utilising LNG cold recovery for cooling and a higher waste heat recovery potential, both of which make the engine room more energy efficient, might balance out the need for additional hotel power.
- Removing the ship's entire HFO capability, including fuel treatment systems and tanks, could also be investigated. This will free up space in the engine rooms for new LNG tanks. However, this will leave the ship with MGO as its second fuel and thus have a slight effect on the fuel cost if MGO is consumed instead of HFO.
- Cutting the ship in half involves severing and splicing all the coordination systems, including cables, pipes and ducts. This is a job not to be underestimated

FINANCIAL ASSESSMENT

The investment cost required for such a conversion can be broken down into different categories. In addition to the cost of the systems outlined below, the cost of having the ship off-hire needs to be taken into consideration. On the other hand, 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.



High-level cost-estimate exercise

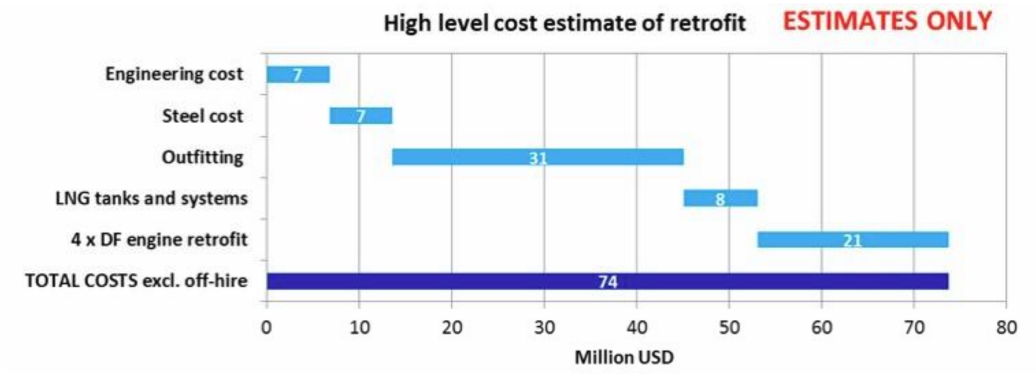
In order to examine the financial attractiveness of our “crazy idea”, we performed a high-level study and mapped the required investment for the LNG system. We then compared the LNG system to MGO propulsion and to HFO with a scrubber, which is considered to be the next best alternative. A complete, in detail study can be per- formed by DNV GL within the scope of our LNG Ready service.

For the high-level simulation exercise, a ship with the following characteristics was assumed:

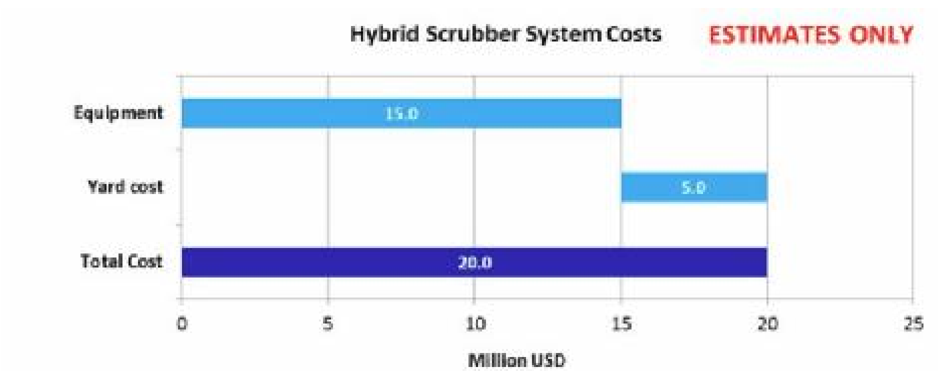
New mid-body section length:	23 m
New LOA of ship:	300 m
Beam of ship:	32 m
Ship GT:	75,000
Added staterooms with new mid-body section:	120
Total staterooms after elongation:	1,120
Engines before retrofit:	4 x MAN 12V48/60 at 12,600 kW
Engines after retrofit:	4 x MAN 12V51/60 DF at 11,700 kW

The high-level cost estimate was based on the following assumptions:

- The total weight was assumed to be 5,000 mt and the required steel was assumed to be 3,000 mt, which includes the outfitting, hull structure and required reinforcement.
- The LNG system includes all the necessary equipment from the bunker station to the engine.



For the scrubber system cost estimate, a hybrid system with 4 scrubbers, one per engine, has been used.



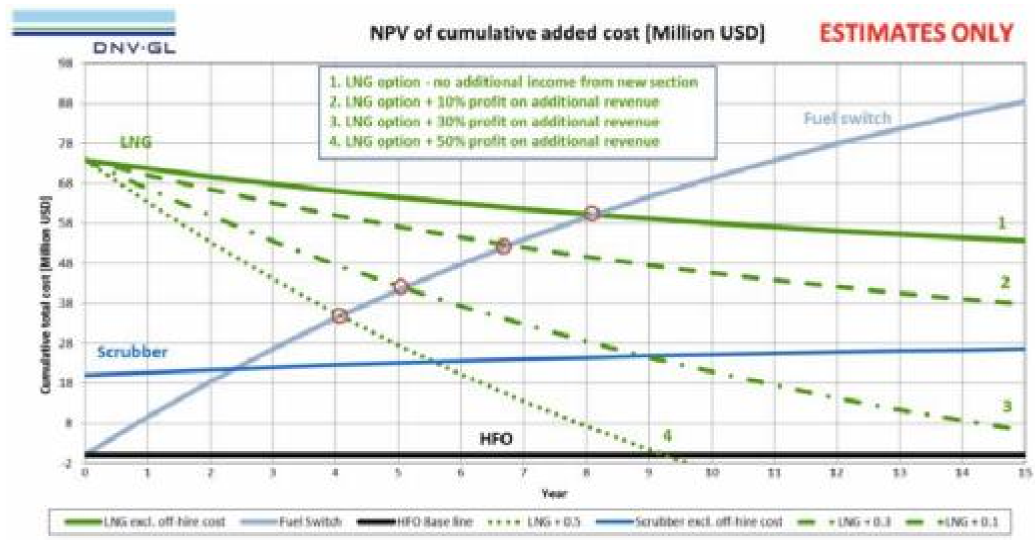
The parameters that have not been included in the cost estimate above are:

- The cost of having the ship off-hire as the daily income per passenger is a very case-specific parameter and depends upon each company's business strategy.
- For simplicity, the operational cost of the LNG system has been assumed to be equal to that of the diesel equivalent version of the ship.
- The transportation cost of the equipment (LNG tanks and systems and scrubber system).
- It is assumed that refit is used for energy optimisation. Therefore the energy consumption is reduced to a level which can be covered by the DF engines.

The financial result for the business case is presented below. 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

The scrubber and fuel switch case do not provide additional cabins and therefore no additional revenue from increased number of passengers. Four scenarios have been developed to calculate the payback time for the LNG option. The difference in the scenarios is the percentage of profit on the yearly revenue generated from the new mid-body section. A spread of 0% - 50% profit on the revenue has been applied to represent the potential economic gains of the elongation. The additional running costs generated by the passengers on-board the new mid-body section are covered by the extra revenue. By switching to MGO or installing a scrubber system there are no additional cabins and therefore no additional income.



When calculating the financial attractiveness of the LNG option, the following assumptions were used:

- 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
- The thermal efficiencies of diesel and gas engines are assumed to be identical
- All engines running at the same load point (assumed average load of 50% MCR)

The pricing of the LNG used above is based on the following rationale:

US Henry Hub price:	$ 3-4/MMBtu
US liquefaction cost:	$ 5/MMBtu
Distribution cost:	$ 3-6/MMBtu
Total final price spread of LNG:	$ 11-15/MMBtu

As is illustrated in the graph, the payback time of LNG compared to MGO is between 4 and 8 years, depending on the profit percentage of the revenue, as outlined above. For the upper profit margins of 30% and 50%, LNG is favourable compared to the scrubber option after 5.5 and 9 years, respectively.

DNV GL LNG READY SERVICE

The high-level analysis performed and presented above is part of the DNV GL LNG Ready service. The LNG Ready service has been developed in order to assist ship-owners, operators, yards and designers in identifying the most attractive compliance option for their ships. Through a detailed technical and financial feasibility study, the LNG Ready service investigates all the potential options for compliance and fuel cost reduction, uncovering any technical showstoppers as well as calculating the financial attractiveness of each option. The base case includes a comparison between fuel switch, scrubber with HFO and LNG as fuel. Other fuel alternatives like methanol, DME etc. can be included on request. For more information regarding the service, please contact the authors.

CONCLUSION

In the authors' view, retrofitting an existing cruise ship so that it can use LNG fuel is a feasible option for a number of existing cruise ships. The study presented above shows that every ship needs to be considered separately as each ship has unique design characteristics and limitations for the integration of a new section. The retrofit potential depends on the design and structural characteristics of each cruise ship and, based on that, technical showstoppers might arise. Another challenge the industry is facing at the moment is the size and location of the LNG tank due to the ship's structural limitations and the rules and regulations currently governing the specific topic. The IMO rules have not yet been confirmed. The strictest set of rules currently under discussion limits the maximum allowable tanks size. The fuel that can be stored in the new mid-body section of a typical cruise ship is approximately 1,500 m3 which is equal to the energy of about 800 m^3 of MGO.

This study has shown that retrofitting cruise ships to run on LNG – our crazy idea – is not only technically but also financially feasible if an attractive LNG price can be achieved. The calculated payback time is 4-8 years compared to MGO. LNG propulsion is a unique solution in that the ship achieves compliance, saves money on fuel, and generates extra revenue from additional passenger capacity. Certain ships now have a window of opportunity to take advantage of the potential financial benefits of LNG propulsion.

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