Alternative Energy Systems for LNG Carriers

There is a sufficient number of proposals for the propulsion and energy generation of a LNG carrier, ranging from the conservative and tested steam turbine solution until more innovative ideas such as fuel cells hybrid systems, although not tested yet. Each one of the proposed solutions has both advantages and disadvantages which are related to economic savings, environmental impact and safety issues.

Since 2004 many LNG carrier projects with propulsion other than steam turbine have been under construction. The preferred solutions so far include medium speed dual-fuel Diesel-electric installations and direct drive slow speed Diesel and reliquefaction plant installations.

The information presented here is part of a study that was based on a selected LNG carrier size (150,000 m³) and limited to the following five propulsion alternatives:

- Steam Turbine (Single Screw)
- Dual-fuel-electric (Single Screw)
- Two-stroke Diesel + Reliquefaction (Twin Screw)
- Simple-cycle Gas Turbine-electric (Single Screw)
- Combined-cycle Gas and Steam Turbine-electric (Single Screw)

The steam turbine plant is the most reliable and tested solution for the propulsion of liquefied natural gas carriers. It offers a very easy method to utilize the boil-off gas (BOG) and has the ability to burn low-grade fuel as well as cargo boil-off. Also the steam turbine vessel has the lowest initial cost.

Steam engines both medium speed dual-fuel and two-stroke with reliquefaction have broken already the steam turbine domination in the LNG carrier sector, but they have an additional initial cost between 1 and 2 million US$ (all numerical values mentioned in this newsletter concern the specific project studied). In the case of 2-stroke Diesel engine the advantages are the high efficiency and the lower operating cost. The medium speed dual-fuel engine provides fuel flexibility and more flexible machinery arrangement which enables the vessel to carry more cargo compared to the steam and 2-stroke Diesel alternatives.

Furthermore, for the Diesel propulsion systems there is higher availability of experienced crew compared to steam propulsion systems. Gas turbine propulsion systems for LNG carriers have an advantage over steam turbine and Diesel based systems in terms of increased cargo volume, because of their lightweight and flexible machinery arrangement, which leads to increased revenues.

Also their low emissions comply with the IMO’s MARPOL Annex VI and EU’s regulations for emission control in coastal areas without further modifications and additional equipment for emission reduction.

On the other hand the high fuel consumption of a steam turbine plant leads directly to high CO₂ emissions. Although NOx emissions of traditional LNG carriers are very low owing to the combustion characteristics of boilers, their SOx emissions are considerable because of the heavy fuel used to top up the energy requirement.

Therefore steam turbine systems and 2-stroke diesel engines will have to switch from HFO to a fuel with low sulphur content (low sulphur HFO or MDO) for the SOx reduction when the vessel approaches coastal areas.

Dual-fuel medium speed Diesel engines will not have a difficult in complying with the IMO limits for NOx emissions (without the need of Selective Catalytic Reduction) and SOx emissions as well, for as long as MDO is used as add-on fuel when BOG is not available.

Considering the aforementioned, gas turbine units can be more beneficial to ship owners due to the recent strides toward limitation of emissions. In addition, the gas turbine combined cycle plant offers a substantial increase in profits, if the added complication in the machinery arrangement is acceptable.

The increased cargo carrying capacity in conjunction with the higher thermal efficiency compared to the steam turbine, compensates for the higher investment cost required for these alternative installations (gas turbines in a

Main technical and economic considerations that affect the selection of a propulsion plant for LNG Carriers

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<td>Handling simplicity / Uninterrupted crew availability</td>
<td>Environmental footprints</td>
</tr>
<tr>
<td>Fuel choice flexibility: Boil-off, gas burning of reliquefaction</td>
<td>Environmental footprints</td>
<td>Extra-energy available / Safe operation: Separate engine room, double-well gas piping, control of high pressure gas in the engine room</td>
<td>An environmentally-friendly propulsion system improves the company’s social image</td>
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The increased cargo carrying capacity in conjunction with the higher thermal efficiency compared to the steam turbine, compensates for the higher investment cost required for these alternative installations (gas turbines in a
simple or combined cycle have an additional initial cost between 6 and 7 million US$).

The installation cost (for the main engine and the auxiliaries, the shaft line, the propeller, the rudder, etc.) can vary a lot from project to project, depending on when, where, how many and of course which type of engine will be installed. An indicative cost is between 400,000 and 600,000 US$, assuming that the heavier and less compact solutions such as the two-stroke Diesel and the steam turbine require the higher installation cost.

The operating cost consists of the fuel and lubricating oil cost, the maintenance cost and the crew salaries. Regarding the operating cost, all the alternatives, except the gas turbine, offer significant improvements in terms of fuel economy although the maintenance cost is higher than the steam turbine plant. The two-stroke Diesel has the lowest operating cost and the gas turbine combined cycle plant follows with a small difference (of about 140,000 US$/year). The medium speed dual fuel Diesel has also lower operating cost than the steam turbine (but 1.75-1.89 million US$/year higher than the two previous alternatives). The gas turbine has the highest operating cost mainly because it requires a high quality petroleum fuel (MGO has been considered as back up fuel for gas turbines) with a relative high price. This represents a significant added cost of 2.8 million US$/year compared to the steam turbine vessel and 5 million US$/year approximately, compared to the two-stroke Diesel and COGES solutions.

In conclusion, there is not a unique optimum solution for the propulsion of liquefied natural gas carriers. Each alternative has its advantages and disadvantages that must be evaluated before the selection of the propulsion plant for a specific project. Therefore, the decision for the propulsion plant to be installed, must be examined separately for each case, based on the specific size of the vessel, the operating profile (speed, trade distance, use of boil off gas and forced boil off gas or boil off gas and fuel oil as add-on, or fuel oil only and boil off gas reliquefaction, etc.), the fuel oil and LNG price trends and the availability of bunkers of the correct grade in the vicinity, the initial cost for each propulsion system, the maintenance cost, the spare parts availability and the crew availability and so on.

CS & Associates Involvement

CS & Associates Ltd. can proceed with a thorough evaluation of the vessel’s energy requirements and the possible power plant scenarios in order to facilitate the important techno-economical decision involved in the vessel’s propulsion/energy plant selection. Also CS & Associates Ltd., has developed a close co-operation with the department of Marine Engineering of the School of Naval Architecture and Marine Engineering of the National Technical University of Athens. The focus of the co-operation is the optimization of state of the art marine power plants for use on board various ship types including LNG carriers and also a study, analysis and modeling of fuel cell systems for utilization onboard LNG carriers.

Useful Links

- International Labor Organization
- Society of Naval Architects and Marine Engineers (SNAME)
- Royal Institute of Naval Architects
- Institute of Marine Engineering Science & Technology
- International Maritime Organization
- International Association of Classification Societies
- Oil Companies International Marine Forum
- Intertanko
- Hellenic Marine Environment Protection Association
- Marine Technology Society
- United States Coast Guard

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About Us

CS & Associates Ltd. was founded by former Vice President of ABS Mr. Chryson Sariyanidis on March 1994.

Since then the Company has been successfully involved in a large number and variety of technical, managerial and consulting projects by efficiently utilising the know-how, long experience and worldwide acceptance of its founders and associates.

CS & Associates Ltd. are aiming to provide professional services in almost all marine related technical issues in the most efficient and cost effective way on a worldwide basis. As a result of the large number and variety of the projects we have been involved, the areas of our expertise consist in but are not limited to:

- New Building: Reviews, negotiations, plan approval, construction follow up, etc.
- 24h Emergency Response: Stress and stability assessments, advisory services, damage surveys, legal support in possible claims, etc.
- Safety and quality management systems (ISM/ISO): Studies and implementation

IACS and IMO regulations: Studies and implementation
CAS surveys, Conversions, etc.