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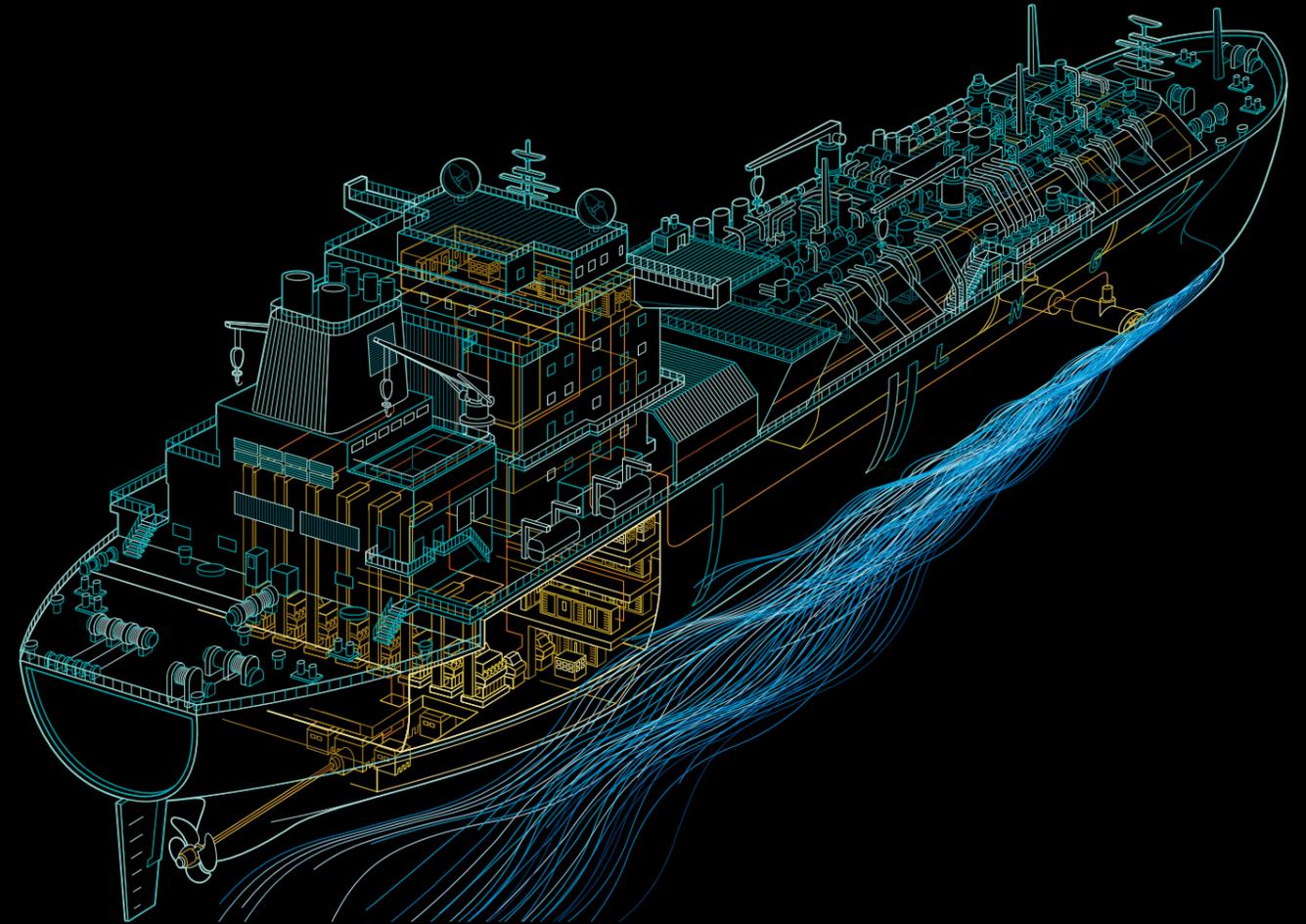
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Dual Fuel Electric Propulsion for large-size LNG Carriers The Green Solution

Dual Fuel Electric Propulsion

- good for the environment, good for the bottom line

The rapid development of LNG Carriers in recent years has led to the emergence of dual fuel engines used in combination with electric propulsion systems as a leading new technology in LNG Carrier propulsion. ABB has been the technology innovator in this arena and is today the leading supplier of electric propulsion solutions to large-size LNG Carriers.

The nature of LNG transport has evolved in the last few years, and so too has the operational requirements of LNG vessels. In addition to traditional 20- to 30-year LNG charter contracts, new ships are ordered and constructed for various trade routes and spot markets, which requires varying operational profiles. To stay profitable, modern LNG Carriers require a propulsion solution that provides fuel flexibility and high efficiency across the entire propeller speed range.

As a consequence of these new operational requirements, dual fuel engines combined with electric propulsion have become the technology of choice for new LNG Carriers. In 2006, the first large-size LNG Carrier equipped with electric propulsion, provided by ABB, was launched. Since then, numerous new LNG Carriers have been delivered with electric propulsion. The experience gained from these projects shows that system performance meets or exceeds the specification requirements for both efficiency and operational benefits.

Why electric propulsion?

Electric propulsion offers a clear competitive edge over other propulsion technologies for meeting today's LNG Carrier requirements for environmentally-friendly and cost-effective operations. Some of the main advantages of electric propulsion include:

- The most effective LNG propulsion – enables lower fuel consumption across the whole speed range
- Reduced installed power – the electric power plant is utilized both for propulsion and cargo handling
- Environmentally-friendly – produces the lowest emissions and provides full fuel flexibility
- Enhanced maneuverability and crash stop – the variable speed drives ensure full flexibility in torque, rpm and power output at the propulsion motor
- Reliability and availability – through high propulsion redundancy and standardized, well-proven technology



The K-Line LNG Carrier, *Tangguh Jaya*, is equipped with a state-of-the-art electric propulsion system from ABB.

Comparison Study Fuel Consumption

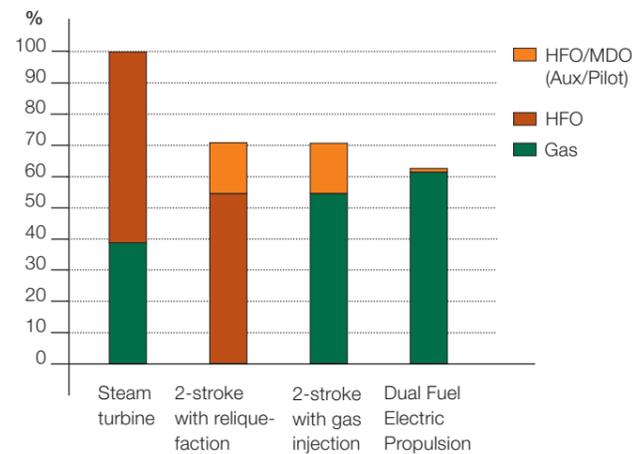


Fig. 1 Fuel consumption relative to steam turbine system (100%)

Comparison Study Emissions

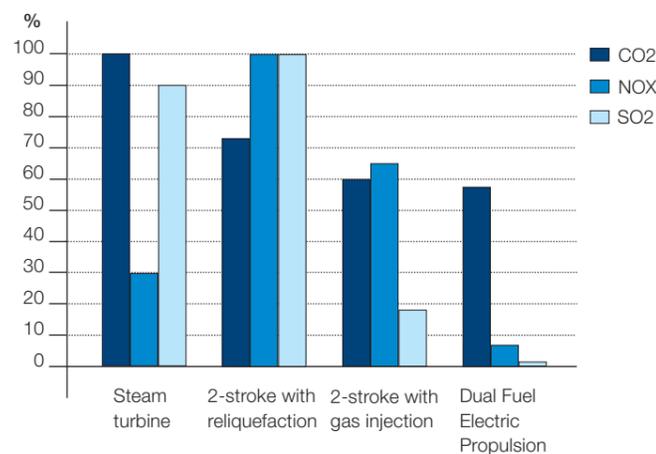


Fig. 2 Comparative emission levels from various LNG propulsion types

Electric propulsion has emerged as the technology of choice due to its superior fuel efficiency and low emissions.

Propulsion Efficiency

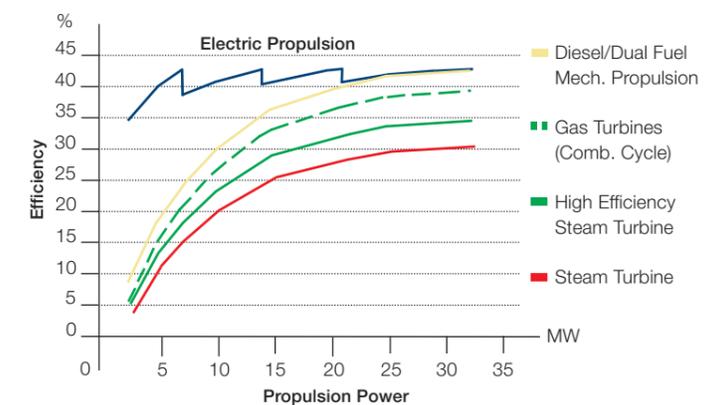


Fig. 3 Propulsion efficiency as a function of propeller loading

Electric propulsion concepts - flexible and configurable solutions

Dual Fuel Electric Propulsion (DFEP) has two main core technologies; dual fuel four-stroke engines and the electric propulsion system. In close cooperation with engine manufacturers, ABB provides electric propulsion system arrangements to meet individual customer requirements and redundancy concepts for both single- and twin-screw LNG ship designs.

Figure 4 below shows a typical configuration for a single screw carrier with a 2-split, 6.6 kV power plant and two medium-speed electric motors connected to a common gearbox. Figure 5 represents a configuration for a twin screw carrier with a 6 kV power plant and direct-coupled, slow-speed propulsion motors. Both examples feature 50% redundancy from top down to the propulsion motors, providing a speed capacity of around 75% after any single failure in the redundant system.

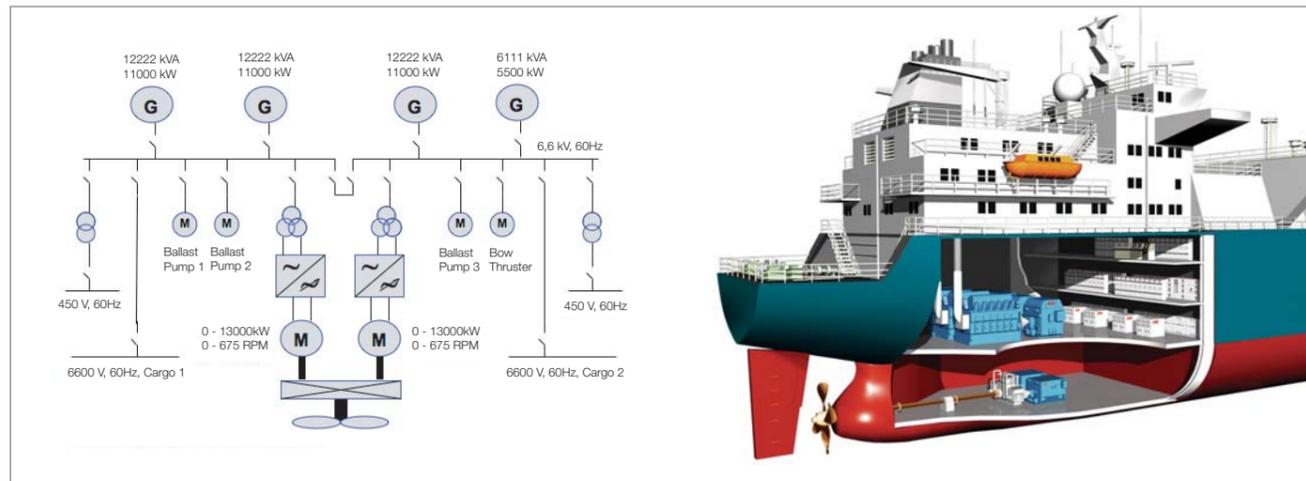


Fig. 4 Typical configuration for a single skeg LNG Carrier

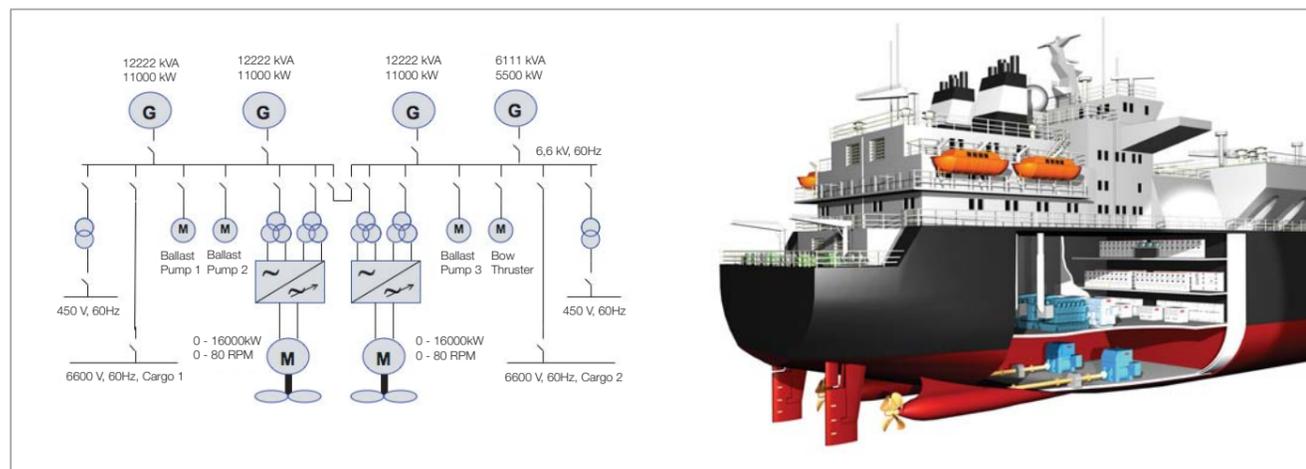


Fig. 5 Typical configuration for a twin skeg LNG Carrier

Solutions based on standard, well-proven equipment - all manufactured and engineered by ABB

ABB has long and proven track record in electric propulsion. To LNG Carriers, ABB typically supplies all High Voltage (HV) electrical equipment, from the generators to the propulsion motors and all related propulsion control systems.

ABB electrical propulsion products are manufactured in ABB factories with high competence in marine applications. To meet the high reliability demands of LNG Carriers, ABB draws on its long experience as the leading supplier of electric propulsion to cruise ships, which have similar electric propulsion and power plant requirements as LNG Carriers.

ABB electrical products for the maritime market are well-proven and specially designed for demanding marine applications. Our synchronous AMG generators and AMZ motors have efficiency levels among the highest available and offer rugged construction to withstand vibration and rough sea conditions. The robust ABB Medium Voltage (MV) Unigear switchgear and Unimotor motor control switchgear are used for HV distribution networks. The metal-clad, arc-proof switchgear housing provides high-level safety and protection for personnel.

Unique drive technology

Variable speed drives are critical for optimal performance of an electric propulsion system. Utilizing ABB's award winning DTC - Direct TorqueControl - motor control technology, our ACS 6000 Marine Drives offer the most accurate and smooth speed and torque control of any variable speed drive system. This means minimum torque ripple at the propeller shaft and low vibration and noise levels. Another major benefit of the ABB 24-pulse drive solution is that the harmonic distortion from the propulsion system is kept within classification limits without use of harmonic filters in the main switchboards.



Power generation - synchronous AMG generator



Power distribution - Medium Voltage switchboard



Variable speed marine drive - ACS 6000



Electric propulsion motor - AMZ synchronous motor

Marine Services

- for the life of your LNG vessel

ABB offers a unique Marine Services program, which is a framework of services designed to provide maximum equipment availability based on the operating profile of each vessel.

With an ABB Marine Service agreement, vessel operators in close cooperation with trained ABB service specialists choose precisely those services that best fit their particular vessel requirements. In this way, maintenance costs, scheduling and responsibilities can be determined in advance for the years to come.

A comprehensive range of Marine Services

To ensure safe operation and maintenance of the equipment throughout the lifetime of the vessel, the service concept addresses long-term availability requirements through specialized services such as preventive Maintenance Planning, Planned Repair and Drydocking, On-call Services, Commissioning, Spare Parts Management, Modernizations and Training.

ABB provides a number of equipment-specific training courses at the ABB Marine Academy. In addition, ABB supports the crew in their daily maintenance activities through the unique eMST electronic Maintenance Support Tool, which coaches them through each maintenance activity using video footage and pictures of the actual equipment, together with detailed step-by-step instructions.



The ABB Marine Service network includes more than 280 service professionals in 19 Marine Service Centers around the world, providing 24/7 service and support to the international LNG shipping community.

To help customers achieve more reliable operations and avoid off-hire, ABB has developed a comprehensive Marine Services program with preventive maintenance at its core.

Provalys was the world's first large-size LNG Carrier to be equipped with electric propulsion, supplied by ABB.



Maersk Methane is a new generation environmentally-friendly LNG Carrier equipped with electric propulsion from ABB.

Azipod® for icegoing LNG Carriers

The need for year-round LNG ship service in frozen, remote areas is increasing. Vessel operations in these sensitive arctic environments require propulsion technology that is specially designed for harsh ice conditions. The design and operational characteristics of the ABB Azipod® propulsion system make it uniquely qualified for this type of service.

Originally developed for ice operations almost 20 years ago, Azipod® is today the leading propulsion system for icegoing and icebreaking vessels and boasts a remarkable track record in more than 80 icebreaking vessel installations.

