Hybrid Propulsion

Flexibility and maximum efficiency optimally combined

Engineering the Future – since 1758.

MAN Diesel & Turbo

MAN Diesel & Turbo

The responsible way in leading technology

MAN Diesel & Turbo is the world's leading designer and manufacturer of low and medium speed engines – engines from MAN Diesel & Turbo cover an estimated 50% of the power needed for all world trade. We develop two-stroke and four-stroke engines, auxiliary engines, turbochargers and complete propulsion trains that are manufactured both within the MAN Diesel & Turbo Group and at our licencees.

More than ever before, MAN Diesel & Turbo's development focus is the environmental performance of our engines. Using our unrivalled grasp of large engine technology, we aim to make our engines progressively cleaner, more powerful and more efficient.

We are firmly committed to reducing emissions while increasing fuel efficiency and power density. This includes an active partnership with environmental institutions and development banks. For our customers, it means engines and propulsion systems that result in powerful yet clean prime movers.

MAN Diesel & Turbo: Hybrid Propulsion

Reliability and reduced emissions

Superb plant flexibility with hybrid ship propulsion

In times when the need for more intelligent fuel use in marine applications and flexible propulsion systems is great, MAN Diesel & Turbo faces the challenge of meeting environmental standards without sacrificing propulsion efficiency and ship performance. Emissions regulations are getting stricter and in the future, when higher fuel prices become more likely, we need to offer smart solutions, which provide ship owners and operators with a well-balanced and tailor-made propulsion plant regarding flexibility and performance. Hybrid propulsion trains designed by MAN Diesel & Turbo are ready to facilitate the best system solution for your project.

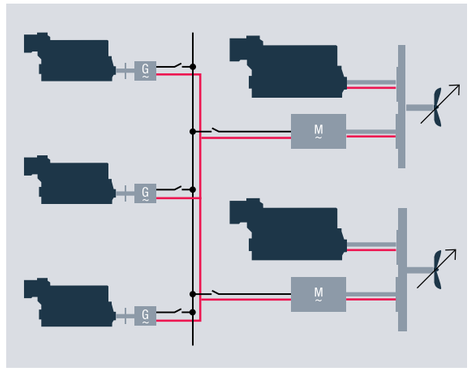
How does a hybrid propulsion system work?

Mechanic and electric power work together in the propulsion train, optimising the propulsion efficiency for ships with a flexible power demand. The combination of mechanical power, delivered by diesel engines, and electrical power, provided by electrical motors, delivers propulsion power, which assures the ship a broad operational capability, providing the right amount of power and torque to the propeller in each operation mode.

Whereas a diesel-mechanic propulsion system is often designed according to its maximum power demand, which, for example, is fitted for a tanker or cargo vessel according to the most hours of the operation profile, a hybrid propulsion plant is better prepared for changes in operation during the vessel's trip or even the vessel's lifetime.

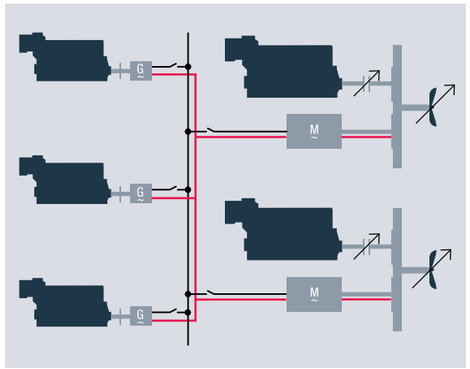
Hybrid propulsion systems can be differentiated between configurations, where the diesel engines and the E-motors work in parallel on the propeller (CODLAD), or where either the diesel engine or the E-machines are used (CODLOD).

CODLAD (Combined Diesel-Electric **and** Diesel Engine)

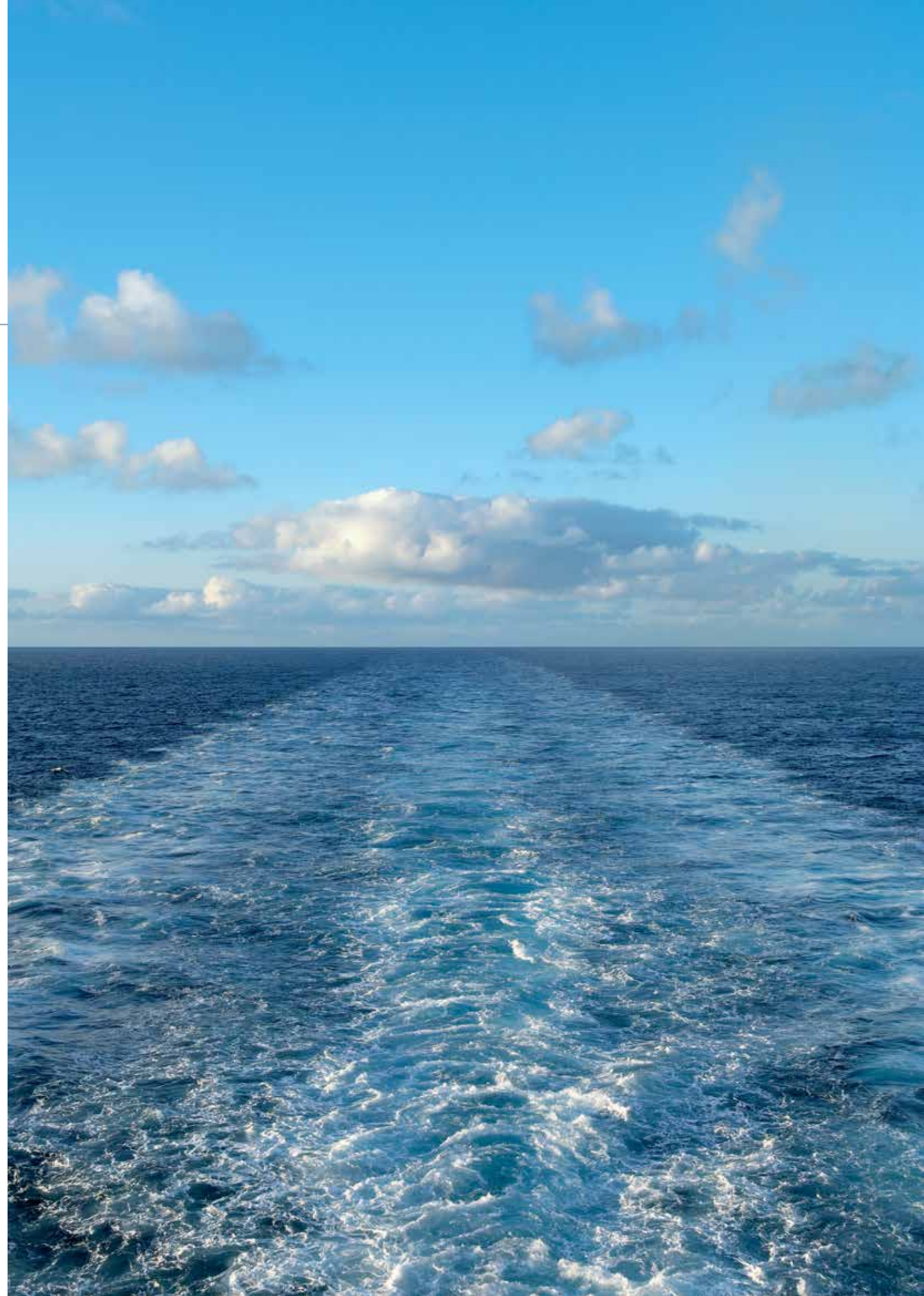


Example: Passenger ferry using a PTI-booster in case of the need for additional power

CODLOD (Combined Diesel-Electric **or** Diesel Engine)

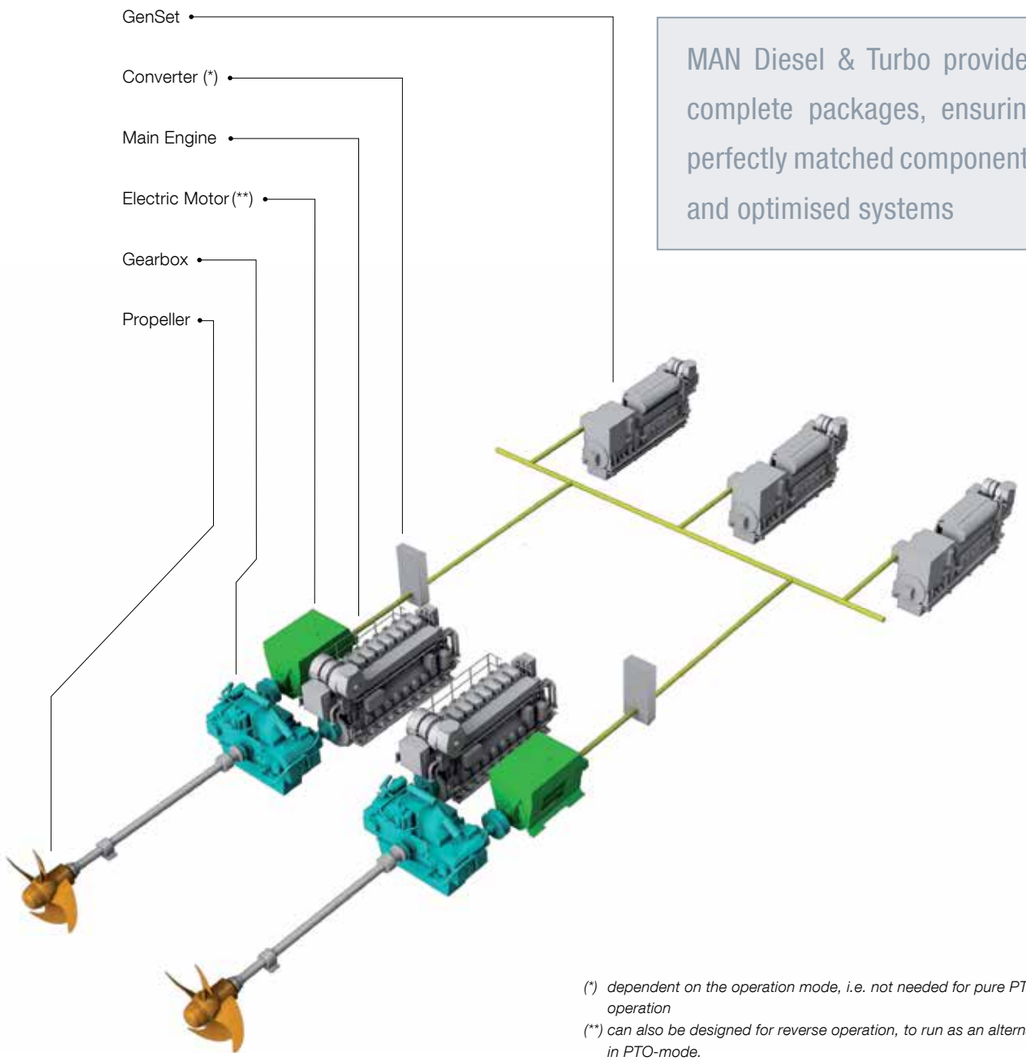


Example: Navy vessel using electric propulsion for slow sailing speeds



Sample Hybrid Propulsion Plant

The major components of a hybrid propulsion plant are shown in the picture below:



MAN Diesel & Turbo provides complete packages, ensuring perfectly matched components and optimised systems

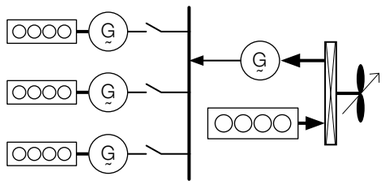
(*) dependent on the operation mode, i.e. not needed for pure PTO operation

(**) can also be designed for reverse operation, to run as an alternator in PTO-mode.

Hybrid Operation Modes

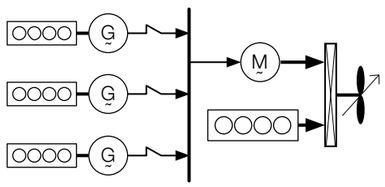
1. Generator mode (PTO-mode)

The main engine provides not only the power for ship propulsion, it also supplies the electric power needed for the ship's consumers. This mode is i.e. selected for transit sailing. It allows a high loading of the main engine, running with low specific fuel oil consumption and therefore with minimal emissions. This often prolongs the maintenance period of the gensets as they can be switched off when not needed.



2. PTI booster mode

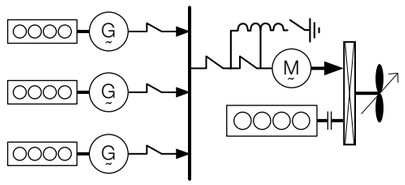
The PTI booster mode is mainly selected for maximum speed. Together with the main engine the electric machine works as an auxiliary motor, which delivers support to the propeller. The gensets deliver the electric power, both for propulsion and the vessel's consumers. The PTI booster mode increases mainly the flexibility of the propulsion system for peak loads.



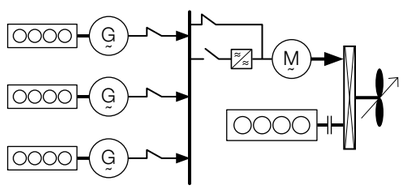
3. PTO/PTH mode

For some types of vessels, like for chemical tankers, a redundant alternative propulsion system is recommended for emergency operation. In case of the main engine is not operating the electric machine is used as a motor, which delivers the power for the propeller. The gensets supply the propulsion power as well as the electric power for the vessel's consumers. To start the electric machine independently as a motor a starting device is needed.

a) Installed genset capacity is much higher than the PTH-motor power rating ("Strong mains")
An autotransformer unit is a common solution to start the PTH-motor from zero speed.

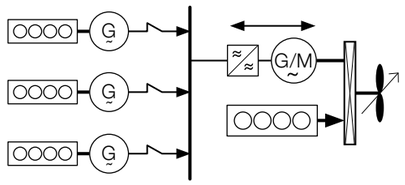


b) Installed genset capacity is in the same range like the PTH-motor power rating ("Weak mains")
A smart solution for starting the PTH-motor is a small frequency converter, which can also be used to operate the propeller with variable speed at slow sailing. In parallel a circuit breaker is installed, which is closed for continuous PTH-operation with constant propeller speed or in PTO-mode.



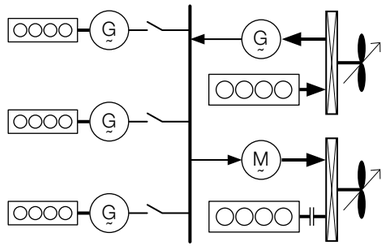
4. Hybrid mode

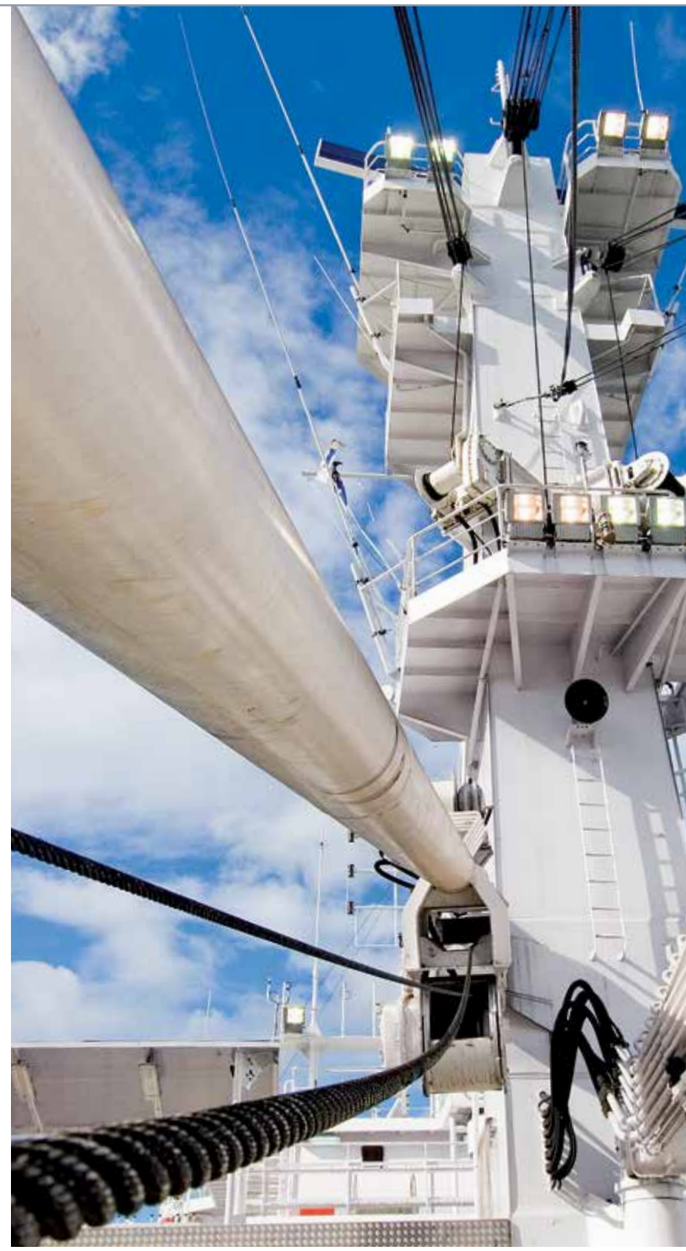
The electric machine is used as alternator as well as propulsion motor (PTO/PTI). This opens the way for flexible use of the main engine and the gensets. In electric/PTI-mode the propeller is driven with variable speed by a frequency converter. In PTO-mode the converter supplies a fixed voltage and frequency to the mains. The main engine and the shaft generator can operate in a range of 70% to 100% rpm. Doing so maximizes both propeller and engine efficiencies and also helps to reduce exhaust emissions.



5. Electrical cross-connection mode (Electric Shaft)

In case of a twin propeller application there is a possibility of driving both propellers with the power of one main engine supplying one shaft machine (PTO) and run the other shaft machine as "take-in-device (PTI)". This mode ensures a high loading of the running main engine as well as extra redundancy and flexibility to the complete propulsion system.





The advantages of a Hybrid Propulsion System

Flexible use and highest efficiency

MAN Diesel & Turbo provides fully tailor-made hybrid propulsion solutions. All components such as the main engines, gensets, switchboards, converters, electric motors, gearboxes and propellers are individually designed. Our packages include many benefits:

- Large variation of operation modes appropriate for a flexible power demand, for slow speed operation up to boosting. This results in an optimal overall plant operational capability with fast system responses and a high plant flexibility.
- The propeller can be driven by the diesel engine, and/or by the electric motor, resulting in a highly redundant and reliable propulsion system.
- In hybrid mode the diesel engine and the propeller can operate with variable rpm (combination mode) and the network frequency and voltage is fixed and stable.
- Reduced plant operating costs due to the possibility to operate the main engines and auxiliary gensets in a range where the required amount of power is provided by a combination of engines which run near or at their optimal loading with their minimal specific fuel oil consumption.
- As a result of high plant efficiency over a wide range of operation modes, not only fuel oil consumption is lower, but fuel related emissons like SO_x and CO_2 are also reduced. Further pollutants are reduced as there is less incomplete combustion that intensively occurs in the low-loaded engines.
- While mechanical optimisation is often determined by one or a few operational modes, the electrical drive capability tremendously increases flexibility. “Off-designs” for hybrid propulsion systems are fewer compared to pure mechanical system designs.
- In E-mode with variable-speed E-motors less noise is caused and pressure side cavitation on the propeller is reduced, as it can be operated at an optimal speed/pitch ratio. Propeller speed and pitch can be controlled independently. Additionally, the underwater noise signature can be reduced. This especially offers benefits at slow speed sailing.
- Depending on the operational modes of the vessel the main engines and the auxiliary engines run less hours per year and, when in operation, on higher loads. Both lead to less required maintenance.

Hybrid Propulsion Applications

Offshore vessels

Offshore Support Vessels (OSV) or Anchor Handling Tug Supply (AHTS) vessels are good examples of offshore ships with high flexible power demand and, per consequence, different operation modes and sailing speeds. The operation profile is often split into two parts: one with a high propulsion power demand for transit and free sailing and another with a significantly lower power demand when operating the vessel in dynamic positioning mode and station keeping. A typical installation may have two main propulsors and separate engine rooms to ensure system redundancy and flexibility.

In addition, if extra power is needed, for bollard pull operation for example, this can be provided by the electric motor, using it for PTI boosting. The booster PTI can also be well-applied in ice operations. In transit the extra power from the engine can be used to supply the PTO. For ships with a wide range of activities, a hybrid system offers significantly lower fuel consumption, improved maneuverability and lower emissions compared to the other existing systems. Noise and vibration levels are also reduced, providing comfort to the crew.

Navy applications

Navy vessels must be able to accelerate to top speed in a short period of time. Thus flexibility and a propulsion system’s boost ability are very critical. These ships often have limited engine room space, but a high power demand. The use of a hybrid system in such cases provides the necessary surplus power needed in the full-power mode.

Offshore patrol ships are good examples of ships which the hybrid system can be well-applied to. Patrol ships can be operated at low speeds by the electric motor and at a high power demand by the main engine and the PTI booster.

Propeller noise emissions can be reduced dramatically when the propeller is operating in hydrodynamically good conditions with no cavitation at the propeller. As noise is a key factor in navy projects, a well-designed propulsion system will emit lower noise levels, preserving mission success with a quiet ship response.

Example of a Hybrid Propulsion Package

Offshore fishing vessel (78m):

- 1 x 6L32/44CR: 3600 kW
- 1 x CPP VBS 1020: 5300 kW, Ø 4,2m with AHT nozzle and rudder bulb
- 1 x Shaft machine for PTO/PTI/PTH operation
- 2 x 9L16/24 + 1 x 6L16/24 aux. gensets: 2 x 941 kWe + 1 x 627 kWe

Operation modes:

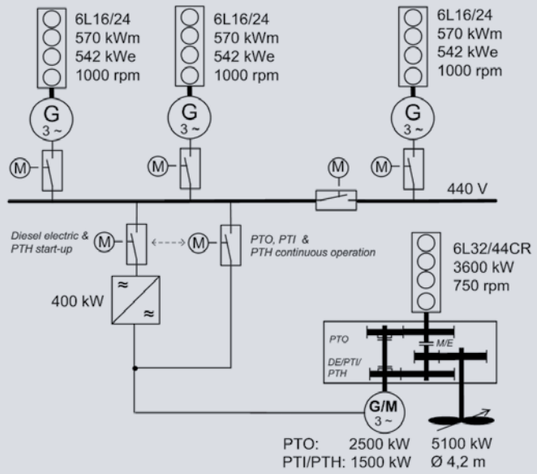
1. Diesel-mechanic propulsion: M/E and propeller are operated in combinator mode. SG breakers are open. Gensets supply power for the vessel's consumers.

2. Diesel-mechanic propulsion with PTO: M/E is running and PTO is engaged. The gensets are stopped. Constant speed mode and combinator mode are available, delivering a constant net frequency or a variable net frequency in a rage of 50 to 60 Hz.

3. Diesel-mechanical propulsion with boost: Both M/E and gensets are running at constant speed. The shaft machine is operated as a PTI-motor which is boosting the propeller.

4. Diesel-electric propulsion (PTH): M/E is stopped. Gensets are running. The propeller can operate either with constant speed or with variable speed. In constant mode the PTH-motor is directly connected to the gensets. In variable speed mode the PTH-motor is connected via a frequency converter, which is also used as starting device for the PTH-motor and for slow speed and sailing in Diesel-electric mode.

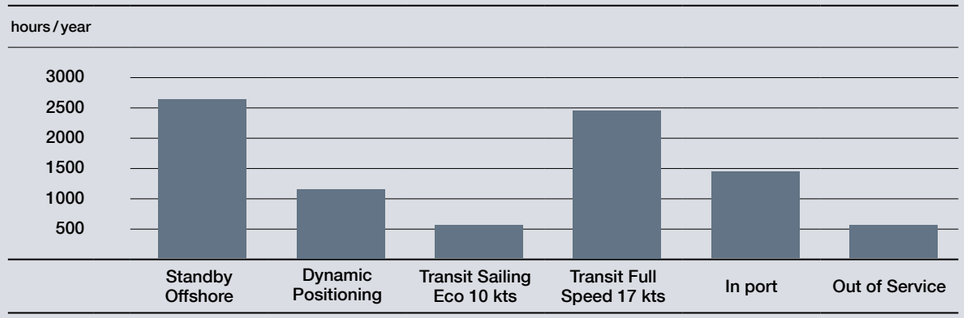
Single line diagram



Multi purpose supply vessel (95m):

- 2 x 6L32/40: 2 x 3000 kW
- 2 x 8L21/31: 2 x 1760 kW
- 1 x CPP 6000 kW
- 2 x Shaft machines for PTO/PTI operation

Operational profile



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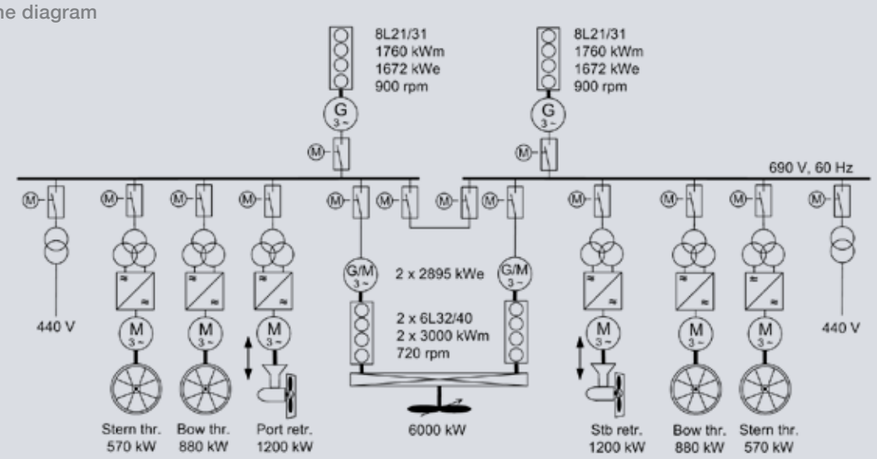

World-Class Service

Marine propulsion, gensets and stationary plants

The PrimeServ offering

The MAN Diesel & Turbo Group offers worldwide, round-the-clock service, 365 days a year. In addition to MAN Diesel & Turbo's service headquarters in Augsburg, Copenhagen, Frederikshavn, Saint-Nazaire, Hamburg and Stockport, service centers on all continents provide comprehensive and continuous support.

MAN Diesel & Turbo engines are renowned for their quality and durability. We are a global organization with a strong local presence, delivering exceptional field service management, tailor-made solutions, and first-class technical support.

PrimeServ provides advice and assistance to customers throughout the product lifecycle, from delivery to resale. With our far-reaching network of Service centers, we respond rapidly to customer needs. What's more, we offer outstanding service and unrivalled technical expertise. Plus, we only use genuine spare parts – safeguarding the longevity of your engine.

PrimeServ's aim is to provide:

- Prompt delivery of high demand OEM spare parts within 24 hours
- Fast, reliable and competent customer support
- Individually tailored O&M contracts
- Ongoing training and qualification of operators and maintainers
- Global service, open 24 hours-a-day, 365 days-a-year
- Diagnosis and troubleshooting with our high performance Online Service

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