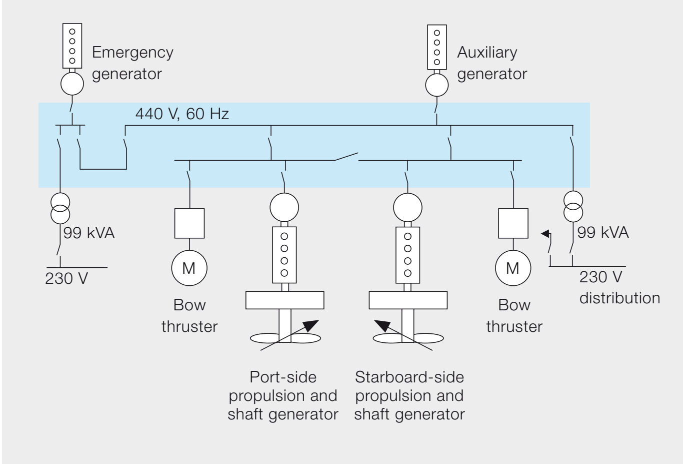
Laying the course

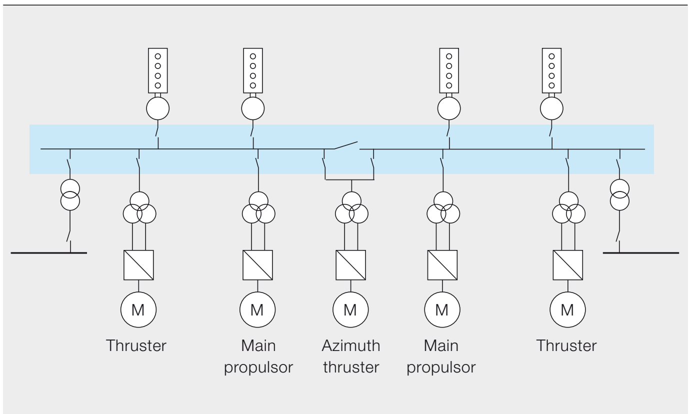
Achieving fuel savings for anchor handling tug supply vessels through electric propulsion

TOR ARNE MYKLEBUST – Electric propulsion in platform or offshore supply vessels has been used since the early 1990s. The technologies have advanced over time, and today there are several optimal propulsion systems that reduce fuel consumption and environmental impact, simplify design and construction and better utilize onboard space, and create an improved working environment for the crew. The need to reduce fuel consumption and operational costs have been the driving forces behind the advancement of electric propulsion technology, and the economic benefits have been significant. Until recently, offshore supply vessels have been the focus. But now, the use of electric propulsion in anchor handling tug supply vessels is gaining more attention and is extending savings to another shipping segment.

1 Propulsion systems for offshore supply vessels (OSVs)



1a Conventional direct mechanical propulsion



1b Electric propulsion

Electric propulsion has demonstrated substantial fuel reduction compared with direct mechanical propulsion for offshore support vessels. The fuel savings can reach 15 to 25 percent in typical operation profiles, and as much as 40 to 50 percent in pure DP (dynamic positioning) operations ➔ 1.

Although most electric power and propulsion plants utilize the same fundamental concepts, there is nevertheless a range of different configurations on the market. To achieve optimum savings, ship owners, ship yards and designers must evaluate all available options and examine a number of criteria when considering products, systems and services ➔ 2.

Achieving fuel savings

The introduction of electric propulsion requires the replacement of the shaft between the main engine and the propeller with a system comprised of generators, switchboards, transformers, drives and motors. The system has an efficiency of approximately 90 percent, which means that there are additional losses in the system that must be accounted for in some way. The variation of losses between the different electric topologies is small. However, electric losses are always minor compared with the hydrodynamic losses of the propellers and the combustion efficiency in the main engines. So although electric losses are introduced, the reduced hydrodynamic and combustion losses nevertheless lead to a reduction in the system's total losses.

Reduced fuel consumption in an electric propulsion system can be attributed to two key elements. The first is the variable-speed control of the propeller, which reduces the no-load losses of the propellers to a minimum compared with classical fixed-speed controllable-pitch propellers. The second element is the automatic start and stop of the diesel engines, which ensures that the engine load is kept as close to its optimum operating point as possible, within the limits of operation.

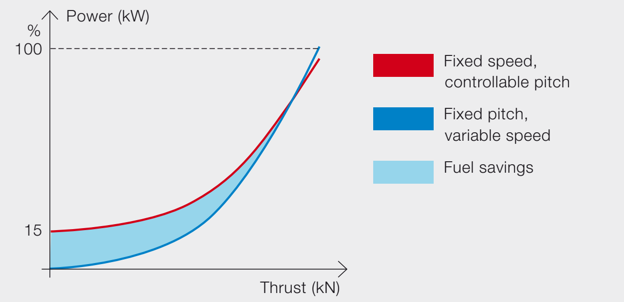
The classical design of an offshore support vessel, including the AHTS (anchor handling tug supply) vessel, is to use fixed-speed propellers with controllable pitch. Compared with variable-speed control of the propeller, this is a very inefficient way of controlling the thrust, due to the high no-load losses of the fixed-speed propellers ➔ 3. This alone contributes to most of the savings in electric propulsion when applied to offshore vessels. In addition, the utilization of the thruster capacity in DP operations is very low for most of the operational days in, eg, the North Sea, even though this is regarded as a harsh environment.

The other major impact of electric propulsion comes from its potential for optimal loading of the diesel engines by using a number of smaller engines, as compared with using a small number of larger units. Depending on the load, the automatic start and stop of the engines

2 Criteria for evaluating electric propulsion configurations

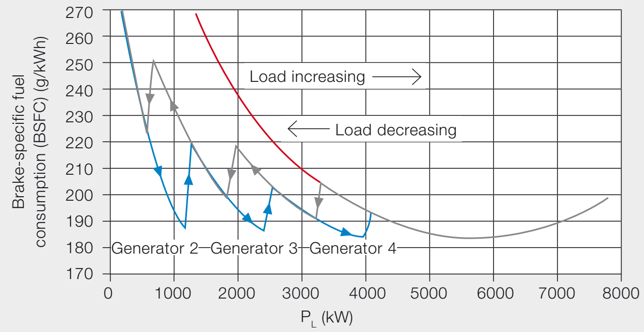
- Cost-efficient building and installation
- Flexible design that improves ship utilization
- Increased safety
- Availability of propulsion and station keeping systems used for DP (dynamic positioning)
- Reduced fuel consumption
- Reduced environmental footprint (ie, lower emissions)
- Improved working environment for the crew
- Low maintenance costs
- Ease of maintenance during the life cycle of the ship
- Ease of maintenance in the region of operation, often worldwide
- Spare parts availability
- Remote and onboard support
- Minimization of the constraints that lead to suboptimal performance
- Minimization of adverse effects on other equipment
- High ice-breaking and ice-management performance for icebreakers

3 The benefit of variable speed



Comparison of shaft power versus provided thrust from a fixed-speed controllable pitch propeller (CPP) and a variable-speed fixed-pitch propeller (FPP)

4 Fuel consumption per kWh of produced energy

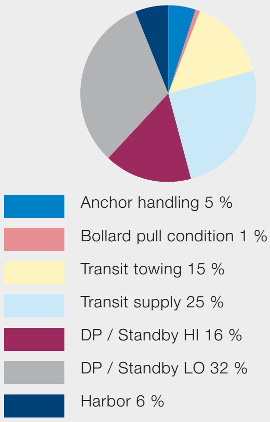


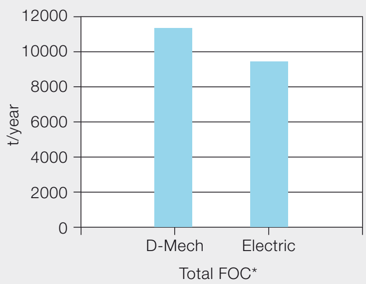
Four equally sized diesel engines running in parallel, with automatic start and stop functionality of the power management system, compared with one large diesel engine providing the same total power (red line)

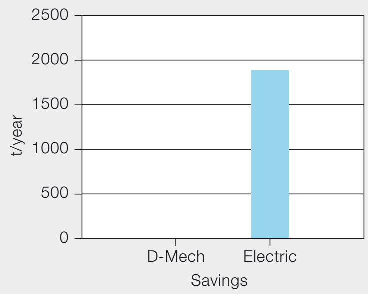
5 Electric propulsion and direct mechanical propulsion for a 200+ metric ton bollard pull AHTS

	Fuel oil consumption		
Operation mode	Base case D-mech (kg/h)	Electric propulsion (kg/h)	Operation profile (h/year)
Anchor handling	2,280	2,295	438
Bollard pull condition	2,451	2,795	88
Transit towing	1,898	2,053	1,314
Transit supply	1,276	1,036	2,190
DP/standby HI	1,377	1,020	1,402
DP/standby LO	1,015	620	2,803
Harbor	26	25	526

Total FOC* (kg/year)	11,293,005	9,396,661	
Total FOC* (t/year)	11,293	9,397	
Difference (t/year)	0	**1,896**	







* Full operational capability

The variable-speed control of the propeller and the automatic start and stop of the diesel engines in an electric propulsion system can reduce fuel consumption.

yields better loading and thus reduces fuel consumption ➔ 4.

For a 200+ metric ton bollard pull AHTS, fuel consumption has been calculated at close to 1,900 metric tons lower when electric propulsion is used ➔ 5.

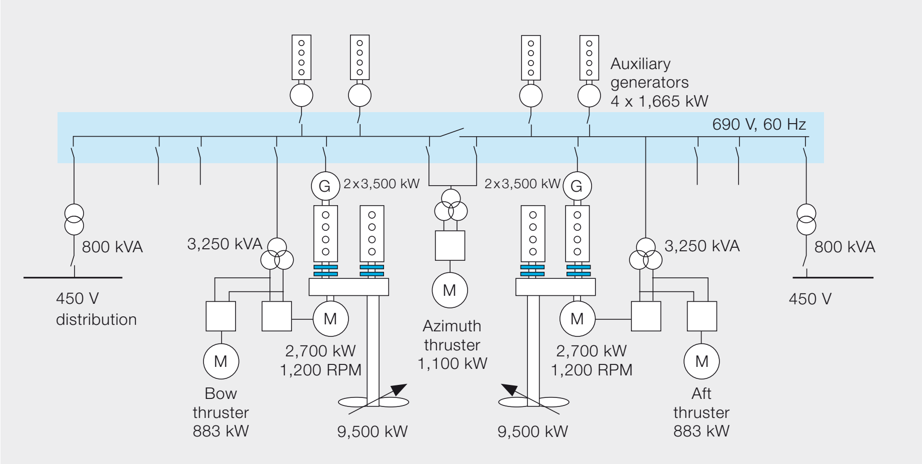
The required installed propulsive power for an AHTS is greater than that of a typical offshore supply vessel, and as a result, the cost of the propulsion systems and installation is also higher. In traditional AHTS systems, the design is optimized for the building costs and for obtaining the guaranteed bollard pull. In the past, less emphasis was placed on operational costs when designing and selecting propulsion concepts. With today's unpredictable fuel prices and mounting environmental concerns, this is subject to change. Now there are several vessel designs in which the operational costs and in particular the fuel consumption are the primary areas of focus.

Hybrid propulsion

An alternative to the full electric solution is the combination of mechanical and electric propulsion systems – the so-called hybrid propulsion system ➔ 6. Here, the vessel can be operated in one of three ways.

- Full electric propulsion for low-speed maneuvering, transit and DP
- Full mechanic propulsion for tugging and high-speed transit
- Hybrid electric and mechanical propulsion, where electrical equipment can be used as a booster for

6 Hybrid electric and mechanical propulsion for a 200+ metric ton AHTS



the mechanical propulsion system to maximize bollard pull

In terms of installation costs, hybrid solutions are more economical than pure electric solutions, and are quite comparable in terms of fuel consumption. For these reasons, several new AHTS designs have been based on such hybrid solutions, especially those with high bollard pull.

However, the increased mechanical complexity of such hybrid systems – where the crew must be more active and manually select the optimum operational modes for the prevailing conditions – should not be disregarded. In pure electric propulsion systems, it is much easier to optimize the configuration of the power and propulsion plant automatically, ensuring that the system will always operate as closely as possible to optimal conditions, with or without minimal manual interaction.

Propelling ahead

For AHTS vessels, traditional propulsion systems had been optimized to obtain guaranteed bollard pull and minimize building costs, but at a price – higher fuel consumption and substantial environmental emissions, especially CO_2, when compared with electric propulsion. With the adoption of electric propulsion by OSVs (offshore supply vessels) and now too by AHTS vessels, fuel consumption, emissions and operational costs are being drastically reduced.

Much of the same savings may be achieved by using hybrid electric and mechanical propulsion at a lower building cost than is the case with pure electric propulsion, but with the caveat that the crew must be actively involved in selecting the optimal configuration for varying operations.

Electric propulsion systems make fuel savings possible through the flexible operation of the vessel, even though the system itself introduces new losses in the energy chain. Efforts can of course be made to reduce these new losses, but in order to maximize the benefits of electric propulsion, the focus should primarily be on designing a simple, reliable and flexible system.

ABB's electric propulsion offerings

ABB is the world leader in electric propulsion and offers a full range of systems – from variable-speed electric machinery for shaftline propulsion and mechanical thrusters to a unique family of podded propulsion systems, most notably the Azipod®. ABB has delivered hybrid electric propulsion systems to a number of OSV/AHTS vessels, including those from DOF ASA, Farstad Shipping ASA, Island Offshore AS, REM Offshore AS, Solstad Offshore ASA, Ezra Marine Services and China Oilfield Services Ltd., providing low-voltage generators, transformers, drives and electric motors for main propulsion and maneuvering.

For a 200+ metric ton bollard pull AHTS, fuel consumption has been calculated at close to 1,900 metric tons lower when electric propulsion is used.

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