Hybrid marine technology for wind farm service vessels

Words: John Haynes, associate fellow of the Nautical Institute, associate member of RINA, Yachtmaster Ocean and Advanced Powerboat Instructor

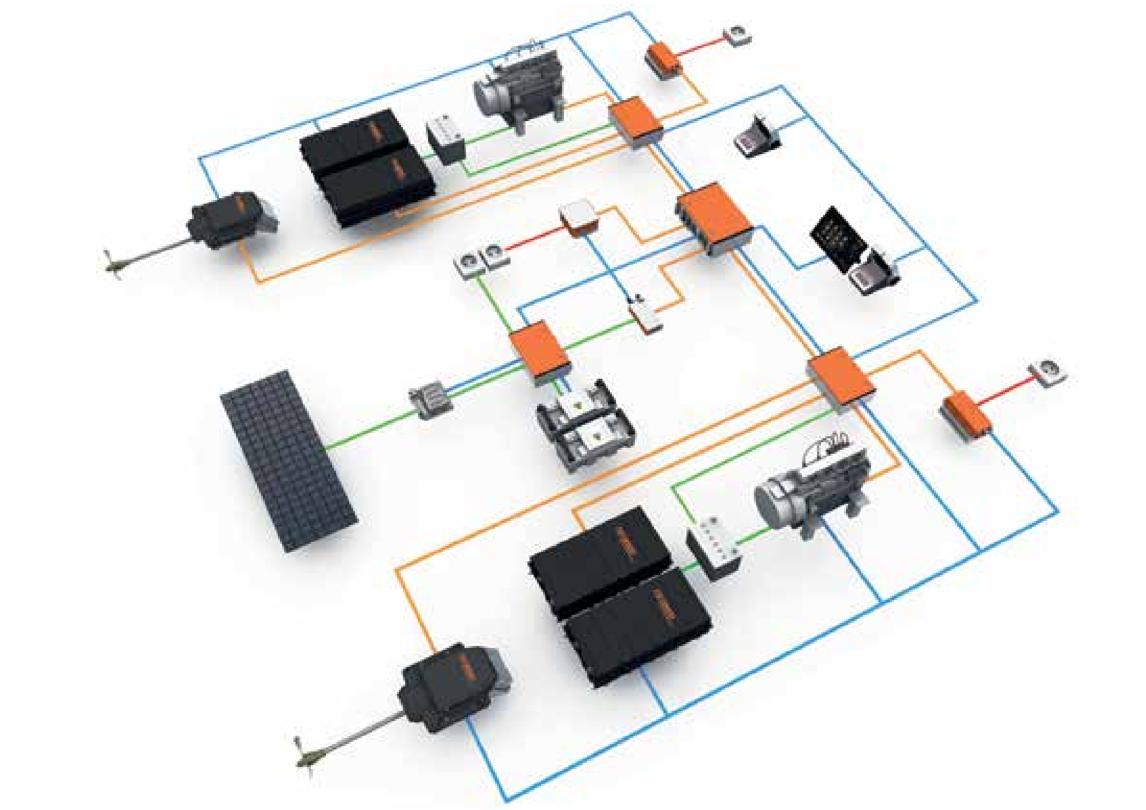
If wind, wave and tidal energy installations are striving for genuine 'green' credentials it is logical to reduce consumption of fossil fuels wherever possible. Hybrid technology is being utilised by many transport sectors and industries around the world. The marine industry is now recognising the potential of utilising hybrid power and innovative propulsion systems.

The coastal countries of northern Europe are all experienced maritime nations with access to innovative design, high technology and construction expertise that has helped to develop the vessels that support offshore wind. The latest vessels have been optimised for high speed passage, turbine access and loitering at sea in harsher conditions. These designs are intended to have the capability to be utilised in sea areas such as the German North Sea and UK Round 3 wind farm developments that are further offshore. The last ten years has seen the wind farm service vessel market expand significantly with a steady evolution in design as operators aim to become more competitive and meet changing requirements. Key drivers for new designs are the ability to access wind farms in higher sea states and improved fuel efficiency.

WFSV and hybrid power systems

In 2015 two significant developments caused many operators, owners and builders of professional vessels to consider hybrid marine power. Firstly the new emissions laws in ports and secondly there is now an incentive for high technology manufacturers to invest in developing alternative energy solutions, including high performance batteries. For the wind farm support industry to move forward in a genuinely sustainable manner it needs to utilise expertise from land transportation, aviation and other critical infrastructure sectors to drive innovation and support relevant safety standards.

A serial hybrid is where the engine in the system only powers a generator and is not mechanically connected to the propeller shaft. A parallel hybrid is where the engine is mechanically connected along with an electric 'machine' that can operate as both



propulsion motor and a generator. The reduced electric propulsion, generator and battery demands of a parallel system reduce the costs compared to a serial system. Parallel systems are more likely to win initial market acceptance because of a perceived greater reliability, as the 'trusted' diesel engine is still connected to the propeller shaft with the electric propulsion adding a redundant system.

Selecting hybrid for efficiency

When studying work cycles of workboats it is relatively straightforward to make a decision for new builds on whether to go for a diesel/electric hybrid system. Other issues, such as the cost of downtime and structural alterations affect the cost-benefit calculations for retrofit of in-service craft. With vessel life cycles of 20 years, naval architects and builders of new craft will start to offer designs that have space and access routes to enable retrofit of hybrid installations later in the vessels life.

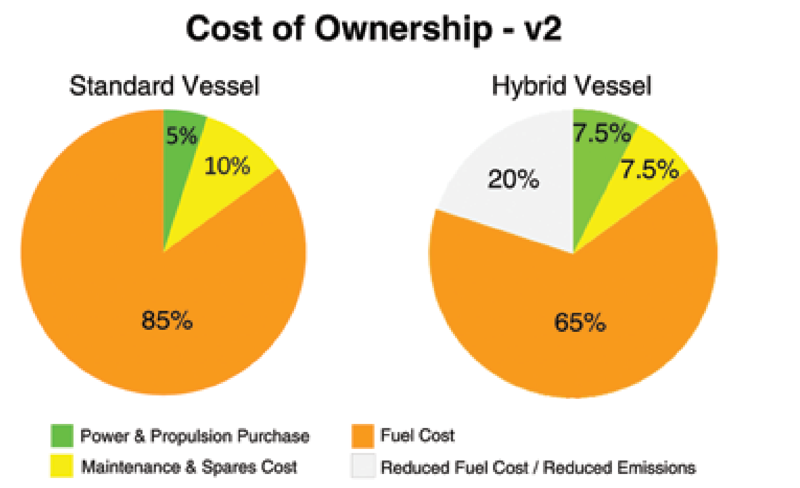
The professional marine sector is entering a period of rapid change and commercial opportunity. Boat builders, engine manufacturers, designers and naval architects are now developing hybrid systems for WFSV, survey vessels, patrol vessels, superyacht tenders and unmanned craft. Benefits include improvements in energy reliability, increased fuel efficiency; lifecycle cost reductions and reduced emissions. Not all vessels are suitable for hybridization. It is import to use a consistent process that identifies which sectors and vessels hybrid is most relevant for.

Quantifying and classifying:

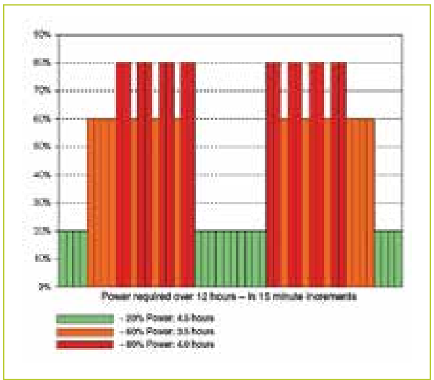
- Quantify operating conditions
- Quantify the vessels duty cycle
- Quantify the engines load cycle
- Classify types of suitable vessels
- Classify types of hybrid systems
- Combinations of boats and 'hybrid' systems

The hour of power

The Hour of Power is a hybrid concept using a combination of diesel/electric/ battery, that enables a vessel to use conventional diesel engines and propulsion system, charge batteries when running diesels, charge batteries from shore power, run on battery/electric for up to one hour or loiter on battery for significantly longer. The concept enables vessels to run in and out of port for an hour on electric with battery power and then carry out their open sea work on diesel power. The Hour of Power concept lends itself to WFSVs operating in



A 'Hybrid' power system will cost more than a standard system.
The 'White Space' objective is to reduce emissions and overall costs.



the ongoing wind farm maintenance phase. The aim of this hybrid solution is to enhance conventional power and propulsion systems. Vessels can reduce emissions and improve fuel consumption, whilst extending engine maintenance periods and overall engine life.

The Hour of Power focuses on hybrid solutions linked to viable business cases. This is not just green energy for the sake of it. Many commercial harbours around the world have 10 knot speed limits for low wash or safety reasons and are within 1 hour of sea. For commercial and professional organisations the simple concept of running vessels with zero emissions around ports will shape decisions that lead to improvements of in-service systems and procurement of next generation vessels. The overall objective is fuel saving and improved efficiency by all means.

WFSV and the hour of power

Certain maritime sectors are potentially well suited to hybrid diesel/electric systems. These include wind farm support vessels undertaking maintenance work and pilot boats. Both have relatively consistent duty cycles, often running seven days a week, to drop off or collect technicians and pilots. Focus is now on identifying the engineering and systems integration required to bring together viable and sustainable solutions for these vessels.

A typical working day starts with the WFSV crew preparing the vessel for departure at around 06.00. The hybrid vessel would be disconnected from shore power which has been used for overnight battery charging. The vessel can leave the dock and harbour on battery/electric power, which also means zero emissions. At the outer sea buoys diesel power takes over for the high speed transit out to the wind farm and to deliver the technicians onto the wind turbines, during this period the batteries are re-charging.

12 hour working day for WFSV:

06.00 to 07.00
1 hour depart dock/harbour

07.00 to 08.00
1 hour open sea transit out

08.00 to 16.00
8 hours in wind farm

16.00 to 17.00
1 hour open sea transit back

17.00 to 18.00
1 hour return harbour/dock

18.00 to 06.00
12 hours alongside

Many vessels have hours of waiting in the wind farms and as they are on standby they cannot anchor. Loitering at low speed and low revs is not an efficient load cycle for diesel engines, which leads to increased maintenance and reduced engine life. This loitering period could be carried out on battery power. Later in the day diesel power is used for the high speed transit back to port, the batteries are re-charging. At the outer sea buoys battery electric power takes over to enter the harbour, with zero emissions. Around 18.00 the vessel returns to the dock where shore power is re-connected for overnight charging.

12 Hour duty cycle for diesel/battery/electric WFSV:

Depart harbour:
Battery/electric with zero emissions

At outer sea buoys:
Diesels ON

Running at speed:
Use diesels (charging battery)

Push on to turbines:
Use diesels (charging battery)

Loitering:
Battery power for slow speed or stopped

At outer sea buoys:
Diesels OFF

Return harbour:
Battery/electric with zero emissions

Overnight:
Charge battery with shore power

Metrics and the hour of power

There are various methods to determine the most efficient speed for a vessel to travel at on Battery/Electric power. Naval architects can model this specifically vessel by vessel, but to enable operators to identify approximately how many kilowatts of alternative energy they may need to bring onboard there are simple methods. One of the main criteria that enables battery/electric power to work efficiently is to operate the vessel below both ‘hump’ speed and ‘hull’ speed. The start of the hump is beyond the point where the boat exceeds its displacement hull speed.

The hump is clearly defined on the speed/resistance curve for any size of vessel. As speed increases a fuel meter shows fuel consumed, which will significantly increase at the hump. Another source of information is to generate a speed/power curve from the engine management system that shows how many Kilowatts of energy are consumed at a particular speed. For the sake of simple calculation this should be done in zero current and zero wind conditions. Separate allowances can be made for favourable or opposing current and or wind. The main objective is identifying how many Kilowatts of battery energy are required to replace Kilowatts of diesel energy.

Next generation batteries

US battery manufacturer XALT Energy has the experience of taking high voltage battery projects from concept through cell production into the finished system for maritime applications. The company are working with boat builders, naval architects and marine operators to analyse different workboat duty cycles. Robert Young, Technical Lead for Marine Applications at XALT Energy said, ‘Engine management data can be matched to battery characteristics to develop the most efficient solutions. Onboard energy management systems are designed to ensure that battery systems operate at optimum performance. The objective is hybridizing and electrifying marine vessels to produce financial benefits and reduced emissions. The design objective is specifying complete systems with power discharge/charge

capabilities that are most efficient for their expected use.'

Using The Hour of Power concept as a baseline the company are designing Lithium-ion battery systems that consider the footprint, weight, cost benefits and safety case for marine applications such as WFSV. Systems are modular and can be scaled to suit energy levels required.

Installing batteries can add redundancy

Banks of batteries can be permanently installed in each hull on WFSV catamarans. As WFSV have surplus deck space and are designed to carry ISO containers an alternative would be to create portable energy units that could be carried on deck. As many WFSVs are designed to have modular payloads this would enable containers to be moved between vessels as changing duty cycles, or contracts with green credentials, require alternative energy onboard.

Professional boat operators around the world have learned that power and performance are relevant, but reliability and durability are important factors for all types of engine and propulsion. A WFSV with battery/electric capability linked to x2 main engines, x1 generator and battery bank has various power options.

Hybrid diesel/battery/electric systems offer redundancy:

x2 Main Engines:
Directly powering propulsion

x1 Main Engine:
Directly powering propulsion

x1 Generator:
Running electric powered propulsion

Battery Bank:
Running electric powered propulsion

WFSV using renewable energy

The IMO Energy Efficiency Design Index (EEDI) aims to reduce emissions from large ships by 30% between 2014 and 2025. Countries developing new green energy policies may want to enter the offshore wind, tidal and wave energy sectors by specifying vessels that harmonise with the global reduction in use of fossil fuels.

Identifying the viability of hybrid diesel/electric power for offshore wind farm support vessels is an interesting project that links green energy onboard with renewable energy from the environment. Hooking up to offshore wind farm turbines may even provide charging options. Many wind farms are 'overplanted', this means there is more energy generated by wind than is required for the grid on land. This surplus allows for downtime and maintenance of turbines. For offshore wind farms in sea areas such as the Dogger Bank in the North Sea, which is over 80 miles from land, wind generated electricity could be utilised at source from the local offshore grid to power hybrid battery/electric vessels working in the sea area.

Looking to the hybrid future

For naval architects working in the WFSV sector class rules, safety, performance and cost are relevant when considering innovative battery power and diesel electric propulsion systems. The challenge for designers is to engineer solutions utilising hybrid technology which are affordable plus manageable in terms of physical size, weight and maintenance.

As new sources of energy become available it is important to identify which energy source best fits the vessel, duty cycle and environment to give efficient power when it is needed. Since no two vessels, routes or captains are alike, decisions can be improved with data logging and analysis. Commercial off the Shelf (COTS) power management systems will bring together diesel/electric/battery and smart data to create optimised whole vessel hybrid systems.

As ocean going shipping, automotive, transport and aviation move rapidly towards hybrid solutions it will be interesting to see how Wind Farm Service Vessels decide to utilise the numerous opportunities. ■

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