With regulatory compliance becoming more and more of a global issue, Wärtsilä is launching new propulsion systems for tugs emphasising environmental sustainability. The systems have been developed utilising the company’s strong competences in hybrid propulsion technology. Since tugs typically operate in or close to harbours, they are particularly affected by environmental considerations, and the need to reduce emissions is an increasing concern for tug owners and operators.

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Wärtsilä’s new designs are based on recently introduced Wärtsilä HY concept and on the company’s proven LNG technology. Among the benefits of the new designs are the flexibility and efficiency provided to the operation of the tug by the Wärtsilä HY technology. Furthermore, the total installed main engine power is less than with conventional hybrid tug designs, while maximum bollard pull is achieved via power boosting from the batteries. Using less engine power also decreases emission levels and, therefore, the vessel’s environmental impact. It also reduces the fuel bill and lessens the amount of engine maintenance needed, which again adds to the cost savings.
Tugs operate over a wide power range; running mostly on low load. The potential exists, therefore, for improvements through flexible power generation and energy storage, for example by running purely on batteries at low loads, or on a combination of batteries and gensets in other modes. However, when power is needed it is needed as close to instantaneously as possible, and this requirement is now made more flexible with the development of hybrid systems. A hybrid system in this context consists of both mechanical and electrical power sources, with batteries used as vital energy storage.

The simultaneous optimisation of performance at both low and high loads is now possible with hybrid configurations. The use of batteries also enables load peaks to be met when they exceed the running power available. This overcomes the typical dilemma for tug operations of keeping engines at or close to their design point, and then shutting them down when not needed.

The development of battery technology in recent years, together with innovations in hybrid drives, DC-grid solutions, shore charging, automation, and PTI motors has enabled exciting new possibilities. These technologies have all been tested and successfully utilised in other Wärtsilä projects and vessel segments. Above all, they make increased redundancy possible, which provides the most important operational security for operators, notably the vessel’s uptime.

The key to success is to find the optimum combination of engines, gensets, thrusters, distribution, and energy storage in accordance with the actual operational profile for the vessel, and with all the main requirements of the specific project.

In addition to selecting a concept that enables the optimum engine load for fuel consumption in all modes of operation, much can be gained by optimising the propeller’s rpm and pitch. Electrical motors and converters allow the propeller to operate at low rotation, thereby providing the flexibility to create hydrodynamic benefits, and reduce mechanical losses.

In this document we have evaluated nine alternative propulsion concepts for a 75TBP harbour tug as a case study, and have made comparisons with respect to fuel consumption, emissions and running hours.

The nine alternative systems evaluated are:
- 1a. Diesel-Mechanic – FPP, high speed engines
- 1b. Diesel-Mechanic - FPP
- 1c. Diesel-Mechanic - CPP
- 2a. Diesel-Mechanic – FPP - PTI
- 2b. Diesel-Mechanic – CPP – PTI
- 3a. Diesel-Mechanic – FPP – Battery
- 3b. Diesel-Mechanic – CPP – Battery
- 4. Diesel Electric – FPP
- 5. Diesel Electric – FPP – Battery

While this paper considers only a 75TBP harbour tug, the same comparisons are relevant and can be adjusted for the full range of tugs, and for specific operational profiles.
Typical operating profile

Since the results in this comparison depend on an understanding of the vessel’s operations and profile, the following typical profile is used as the basis for this exercise.

Although the exact operating profile will differ between harbours, this profile is found to be relevant for most operational areas.

This profile is based on 260 operational days (3120 hours) per year including harbour standby. The rest of the year is in cold standby and is not relevant for the comparison due to the minor power need and its supply from shore.
As there are several configurations possible, in this chapter we describe the most relevant, and in the following chapter we shall compare these nine concepts.

Since alternatives 3b and 5 appear to be the most interesting for future tug market needs, we have described the operational modes and energy flow for these.

**ALTERNATIVE 1A**  
**DIESEL MECHANIC WITH FP PROPELLERS, HIGH SPEED ENGINES**  
This alternative having two diesel mechanic main engines with direct drive to fixed pitch propellers forms the basis for comparison purposes. The two drive lines are independent. Typically, most tugs are built with this configuration and a separate auxiliary power system.

A slipping clutch is normally used in this configuration to avoid the fixed pitch propellers overloading the engines at low speeds.

![Alternative 1b; Diesel Mechanic with FP propellers, medium speed engines](image)

**ALTERNATIVE 1B**  
**DIESEL MECHANIC WITH FP PROPELLERS**  
Similar as alternative 1a but with medium speed engines.

**ALTERNATIVE 1C**  
**DIESEL MECHANIC WITH CP PROPELLERS**  
Similar as alternative 1b but with controllable pitch propellers.
**ALTERNATIVE 2A**

**PTI BOOST WITH FP PROPELLERS**

In addition to the diesel mechanic alternatives, with direct drive in this configuration there is also a PTI (Power Take In) with the electric motors being powered from the aux. genset.

---

**Fig. 3** Alternative 2a; PTI boost with FP propellers

---

The PTI can be used to run the thrusters independently in pure electric mode or to boost the main engine. The electric motors and converters allow operation at low rotation speeds, thereby enabling the flexibility to benefit the hydrodynamics, and to reduce mechanical losses.

When running in electric propulsion mode from the PTI, the main engine is disconnected by a clutch. When running in “boost” mode, the PTI power, as well as the engine power, is limited to dimensional power on the propeller.
LIMITATION

This configuration relies on power from the PTI as well as from the engine to provide the power needed for the fixed pitch propellers (FPP). The alternative is to oversize the main engines or install a slipping clutch capable of running up to nominal engine speed. This figure illustrates the power available and the power needed for the FPP, both in bollard pull and free-sailing condition:

Table 1. This table illustrates how the engines are operated in the different modes

<table>
<thead>
<tr>
<th>Operational Modes Analyses</th>
<th>Steaming Max</th>
<th>Transit High</th>
<th>Transit Eco 1 12kn</th>
<th>Transit Eco 2 8kn</th>
<th>Peak Load 75 TBP</th>
<th>Medium Assist</th>
<th>Low Assist</th>
<th>Loitering Stand by</th>
<th>Harbour Stand by</th>
<th>Harbour</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of Operational time:</td>
<td>0.1%</td>
<td>3.0%</td>
<td>11.0%</td>
<td>11.0%</td>
<td>2.0%</td>
<td>12.0%</td>
<td>25.0%</td>
<td>25.9%</td>
<td>10.0%</td>
<td>64.4%</td>
</tr>
<tr>
<td>Main Engine 1 - W8L20E</td>
<td>54%</td>
<td>36%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
<td>56%</td>
<td>24%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Main Engine 2 - W8L20E</td>
<td>54%</td>
<td>36%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
<td>56%</td>
<td>24%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Main Genset 1 - W8L20E</td>
<td>57%</td>
<td>39%</td>
<td>63%</td>
<td>28%</td>
<td>60%</td>
<td>56%</td>
<td>26%</td>
<td>20%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Aux Genset 1 - Highspeed</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Battery used as generator</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Harbour Power</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>38%</td>
</tr>
</tbody>
</table>

Fig. 5 75 tBP hybrid harbour tug with WST-24FP

ALTERNATIVE 2B
PTI BOOST WITH CP PROPELLERS
Similar as alternative 2a but with controllable pitch propellers.
ALTERNATIVE 3A
PTI BOOST, BATTERY SUPPORTED, FP PROPELLERS
In this configuration, the propulsion is supported from a battery pack. The contribution from the batteries is described in a separate chapter. The genset can operate with variable rpm. The batteries can be charged either from the PTOs, the genset, or from a shore connection.

Fig. 6 Alternative 3a; PTI boost, battery supported, FP propellers

Table 2. This table illustrates how the engines and batteries are operated in the different modes

<table>
<thead>
<tr>
<th>Operational Modes Analyses</th>
<th>% of Operational Time:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Steaming Max</td>
</tr>
<tr>
<td>Main Engine 1 - W8L20E     %</td>
<td>54%</td>
</tr>
<tr>
<td>Main Engine 2 - W8L20E     %</td>
<td>54%</td>
</tr>
<tr>
<td>Main Genset 1 - W8L20E     %</td>
<td>57%</td>
</tr>
<tr>
<td>Aux Genset 1 - Highspeed   %</td>
<td>0%</td>
</tr>
<tr>
<td>Battery used as generator  %</td>
<td>0%</td>
</tr>
<tr>
<td>Harbour Power               %</td>
<td>0%</td>
</tr>
</tbody>
</table>

LIMITATION
The limitation is the same as for 2a because of the fixed pitch propeller.
ALTERNATIVE 3B
PTI BOOST, BATTERY SUPPORTED, CP PROPELLERS
Similar as alternative 3a, but with controllable pitch propellers and the auxiliary genset being replaced by a battery pack. The battery will deliver power until the State of Charge (SOC) of the battery is within a certain limit.

The electrical motor will also act as generator/PTO (Power Take Off) in this configuration.

Table 3. This table illustrates how the engines and batteries are operated in the different modes
MODES OF OPERATION/ ENERGY FLOW
The main modes are described in this chapter.

ELECTRIC MODE
Both engines off, and all power is provided by the batteries. Batteries run the propellers through the PTIs and the aux supply.

This mode applies to waiting time, low power operations, and short duration “green” operations.

Max propulsion power is 920kW at 760rpm (max 21 min. with 600kWh battery capacity)

10 knots Eco speed with 70kW for the hotel load, will give a minimum of 26 minutes operating time on batteries.

HYBRID / ELECTRIC MODE
w/ Start & Stop control
The start & stop control is dependent upon the state of charge of the battery pack. At a low state of charge, the engine provides the power and recharges the batteries

This mode applies to waiting time, low power operations, and short duration “green” operations.
**HYBRID MODE**

One engine runs the propeller and the PTO on the same side. The other propeller is powered by the PTI.

Batteries support the engine with dynamic loads, such as peak shaving and short time boosts.

This mode can be applied for sailing up to 10 knots.

**POWER BOOST MODE**

The PTI and main engines provide the power simultaneously.

This mode can give 3420kW of continuous propulsion (allowing for 100kW aux power) and 4350kW peak propulsion power in bollard pull condition with battery support for max 22 min. (in this case with 600kW/h battery).
ALTERNATIVE 4
DIESEL ELECTRIC

This alternative features a pure diesel electric version with variable rpm on the main engines and DC-grid distribution. It is separated into two independent drive lines.

Fig. 12: Alternative 4; Diesel Electric

Main Gensets:
75TBP - 2x 9L20 - 1800kW – 1000rpm + 1x 8L20 – 1200kW – 1000rpm

Table 4. This table illustrates how the engines are operated in the different modes.
**ALTERNATIVE 5**

**DIESEL ELECTRIC, BATTERY SUPPORTED**

Same as alternative 4 but with less installed power through having fewer cylinders and one genset replaced by batteries.

Fig.13 Alternative 5; Diesel Electric, battery supported

This table illustrates how the engines are operated in the different modes:

<table>
<thead>
<tr>
<th>Mode</th>
<th>Steaming</th>
<th>Transit High</th>
<th>Transit Eco 1</th>
<th>Transit Eco 2</th>
<th>Peak Load</th>
<th>Medium Assist</th>
<th>Low Assist</th>
<th>Loitering Stand by</th>
<th>Loitering on Battery</th>
<th>Harbour Stand by</th>
<th>Harbour Stand by on battery</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of Operational time</td>
<td>0.1%</td>
<td>3.0%</td>
<td>6.7%</td>
<td>4.3%</td>
<td>3.3%</td>
<td>7.3%</td>
<td>2.0%</td>
<td>12.0%</td>
<td>25.0%</td>
<td>5.4%</td>
<td>20.5%</td>
</tr>
<tr>
<td>Main Genset 1 - W8L20E</td>
<td>86%</td>
<td>56%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
<td>85%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Main Genset 2 - W8L20E</td>
<td>86%</td>
<td>56%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
<td>85%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Battery as generator</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>24%</td>
<td>86%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Harbour Power</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Table 5. This table illustrates how the engines and batteries are operated in the different modes.

Even if the electrical losses are higher in steaming modes compared to the DM PTI alternatives, the flexibility and correct loading will deliver better overall fuel efficiency.
**MODES OF OPERATION/ ENERGY FLOW**

All of the modes for a diesel electric tug are flexible, and can be automatically selected based on the lever position and power demand. The main modes are described in this chapter.

**ELECTRIC MODE**

Both engines off, with all power produced by the batteries

This mode applies to waiting time, low power operations, and short duration “green” operations.

Max propulsion power is 1400kW allowing 100kW for aux power (max 15 minutes).

10 knots Eco speed with 70kW for the hotel load, will give a minimum of 29 minutes operating time on batteries.

**HYBRID / ELECTRIC MODE**

*with Start & Stop control*

The start & stop control is dependent upon the state of charge of the battery pack. At a low state of charge, the engine provides the power and recharges the batteries.

This mode applies to waiting time, low power operations, and short duration “green” operations.
**ONE GENERATOR MODE**
A single engine provides the power with batteries taking the boost from sudden load peaks. The maximum continuous propulsion power in this mode is 1400kW (100kW hotel load).

Batteries can assist with short time boosts of the propellers up to 2920kW for a max of 14 minutes.

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**TWO GENERATOR MODE**
Power boost mode. The batteries and engines provide the power simultaneously.

Batteries support the engines with dynamic loads, such as peak shaving and short duration boosting of the propellers.

This mode can give approximately 2940kW of continuous propulsion (100kW hotel load) and 4150kW peak propulsion (max 17 min continuous).
Comparison

We have based this comparison on the known performance data and losses for all components as derived from our test labs and sailing vessels with Wärtsilä solutions. Since we have all the needed elements and products in-house, and can offer all the concepts, the comparisons can be considered reliable and well-founded.

**FUEL CONSUMPTION**
The efficiency comparison has been performed based on fuel consumption per kWh of power delivered to the thrusters, and all losses (mechanical and electrical) in the different alternatives are taken into account.

---

**Fig. 18 Fuel consumption in relative comparison for the alternative concepts**
Fig. 19 Emissions comparison

![Emissions comparison graph](image)

- **Wärtsilä Conventional DM Config**
- **Wärtsilä HY DE Config**

<table>
<thead>
<tr>
<th>Emitter</th>
<th>Wärtsilä Conventional DM Config</th>
<th>Wärtsilä HY DE Config</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂</td>
<td>~23%</td>
<td>~19%</td>
</tr>
<tr>
<td>NOₓ</td>
<td>~40%</td>
<td>~35%</td>
</tr>
<tr>
<td>SOₓ</td>
<td>~22%</td>
<td>~18%</td>
</tr>
<tr>
<td>Particulates</td>
<td>~48%</td>
<td>~40%</td>
</tr>
</tbody>
</table>

Fig. 20 Engine running hours per year

![Engine running hours graph](image)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Engine Running Hours (hours per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM - FPP</td>
<td>Alt.1a: 5,616, Alt.2a: 5,435</td>
</tr>
<tr>
<td></td>
<td>Alt.3a: 4,933</td>
</tr>
<tr>
<td>DM - CPP</td>
<td>Alt.1b: 5,616</td>
</tr>
<tr>
<td></td>
<td>Alt.2b: 4,558</td>
</tr>
<tr>
<td></td>
<td>Alt.3b: 3,769</td>
</tr>
<tr>
<td></td>
<td>Alt.4: 4,558</td>
</tr>
<tr>
<td>DE</td>
<td>Alt.5: 2,344</td>
</tr>
</tbody>
</table>

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Wärtsilä Marine Solutions business white paper | Wärtsilä HY Tug propulsion systems
## Hybrid features

The battery will provide the following functionality, regardless of the selected concept.

Battery charging/ discharging is controlled by a DC-DC converter to provide the correct current and state of charge (SOC), thereby prolonging the life of the battery.

The use of Frequency Converters and a modern Power Management Systems (PMS) for the complete system is essential in order to control the dynamics, optimise performance, and eliminate blackouts.

### PEAK SHAVING

Since the electrical motor controlled by the frequency converter has instant power availability from the batteries, a rapid response to the variations in loads will be absorbed by this electrical drive line, in order to maintain a constant loading of the main engines. This reduces fuel consumption, as well as wear and tear (maintenance costs). For example, if there is a rapid increase in the load on the propulsion converters, the battery will decrease its charging or increase its discharge before the load change has any effect on the gensets. If the load change is consistent, the load will be transferred to the gensets after a given period of time.

![Fig.21 Peak shaving](image)

The blue curve represents the variation in load, and the lower curve is the variation taken by the batteries. The middle curve is the stable load for the engines.

During peak-shaving, the SOC of the battery system can fluctuate to some degree, but will in the long run move towards the charge SOC set-point.

In case of a generator, battery, or bus-link trip, peak-shaving will be disabled until the system stabilizes again following the blackout prevention situation.
AVOID RUNNING ADDITIONAL GENSETS
As the battery will absorb all major load variations and peaks, the engines will operate on a stable load, and can as such be used at a higher loading without any risk of starting up new gensets during transients or normal load variations.

As regards the charging, it is beneficial wherever possible to charge the batteries during harbour mode. If onshore power supply is available.

BATTERY OPERATION
This mode can apply when the tug is entering or leaving harbour at slow speed or while on stand-by. The capacity of the batteries will be dependent upon the power needed and the period of time for which battery operation is required. This is something that has to be calculated for each particular vessel. The capacity of the batteries can, in theory, be unlimited but is dimensioned according to cost and space.
Energy Management System (EMS)

The Energy Management System (EMS) controls the vessel’s power systems. It contains the functionality normally covered in a Power Management System (PMS) by starting, stopping, and controlling the configuration of the diesel generators. In addition, it controls the vessel’s energy flow, and the utilisation and charging of the batteries. It optimises the diesel engines’ fuel consumption, while ensuring a stable and secure supply of power to the vessel’s consumers, using the batteries to smooth fluctuations in power demand.

The EMS can be tuned over time to adapt to changing operating profiles, new requirements, or to improve performance based on collected operational data.

Safety

Overloads/ blackouts are avoided by monitoring the total energy consumption in relation to the available power generation. Loads are quickly reduced, controlled by the EMS to avoid overloads or, in a worst case scenario blackouts, for sudden engine/generator trips.

In the battery system, each battery cell is protected against high currents. Exposure to high temperatures could result in the initiation of a thermal runaway event for the battery pack. The battery room is, therefore, insulated to prevent external heat sources radiating heat into the room. There is also a water mist system to prevent the batteries being exposed to temperatures high enough to initiate a thermal runaway event.

One of the key safety features is the ventilation system. The ventilation system’s sizing and design is important in order to secure thermal exposure prevention and the life cycle of the batteries.

System responsibility

By integrating the products into a total concept, it has been possible to develop the functionality needed to optimise the overall performance of the vessel.

The steadily decreasing cost of flexible power generation, distribution and storage, indicates that a system approach is needed for several vessel segments.

Since many clients are requesting these benefits, Wärtsilä can take the responsibility for providing complete packages with fewer interfaces. Wärtsilä’s integration and system supply eases and improves the construction, performance and operational efficiency, for both the yard and the owner.
Conclusion

If we compare the most relevant configurations, the alternative 3b (Diesel-Mechanic, CPP, Battery) will give an increased efficiency of 27% compared to a traditional system with high speed engines, and 11% compared to a traditional system with medium speed engines.

Alternative 5 (Diesel-Electric, FPP, Battery) will give an increased efficiency of 38% compared to a traditional system with high speed engines, and 22% compared to a traditional system with medium speed engines.

Running hours are reduced by 58% on the main engines and in addition no need for utility gensets. Furthermore, if we take the other main benefits as shown on page 22 into consideration, this would appear to offer interesting configurations for future new builds.
Benefits

These benefits are achievable with the Wärtsilä HY propulsion system:

**LESS INSTALLED POWER**
This configuration will be able to keep the max bollard pull (BP) with less installed power over a certain time period based on the design requirement. Using less engine power will also decrease the amount of maintenance needed. The battery can be charged from the PTOs, the genset, or from a shore connection.

**LOW FUEL CONSUMPTION > EMISSIONS**
A significant reduction in fuel consumption is achieved by operating the engines and propellers as close as possible to their design curve. It is supported by the battery system to handle variations and low load modes.

**LOW LOAD OPERATIONS ON BATTERY**
Transit ECO and Loitering modes can be operated purely on the battery pack.

**OPTIMUM ENGINE LOADING**
It is possible to run the engines at optimum load in all modes, and with the batteries handling the peaks, the engines will operate more efficiently thus reducing the maintenance requirement. The converters allow the main engines to run at variable rpm to follow the propeller curve.

**SMOKELESS OPERATION**
With battery instant power available, load peaks will be handled by the PTI drive line thereby avoiding the main engines from handling these peaks.

**COLD SYSTEM START-UP**
The necessity to wait for the engines to warm-up is overcome by the energy storage system, leading to instant ship readiness.

**AUTOMATIC POWER BACK-UP**
An increased level of safety is reached through emergency back-up algorithms and the built-in redundancy of the power sources.

**FLEXIBILITY IN POWER GENERATION**
For the Diesel Electric Hybrid configuration, the operator is provided with flexibility to run the vessel in the most efficient way using the gensets and batteries. The variable rpm on the gensets and propellers will automatically select the optimum point in all modes.

**REDUCED RUNNING HOURS**
Ref. comparison the engines’ running hours are reduced by up to 58% due to this flexibility in enabling the correct engine loading and because of the energy storage with the batteries.

**CONNECTION FOR FUTURE POWER SOURCES**
By introducing the DC-bus and batteries, the system is prepared for possible future upgrades and power sources, e.g. fuel cells.
INCREASED RELIABILITY WITH LOW COMPLEXITY
In case of failure on a generator, DC-bus or propulsion motor the vessel will still be able to operate with reduced BP. This means for an operator that the vessel is still in operation and will be able to get out of the sailing course for the assisted vessel in case of a failure.

EASY AND SAFE TO OPERATE
The control system (Power & Energy Management System) and operator interface will ensure intuitive operation of the complete system. To enable the crew to maintain its full focus on the tug’s operation, the system has been developed to simply select mode of operation, with the control system ensuring that the needed power for this mode is provided. The control system will also ensure that any sudden load step cannot overload the system.

INSTANT LOAD TAKING
Due to the instant power available from the batteries, the response from the system improves the manoeuvrability of the vessel.

DESIGN HIGHLIGHTS
With Wärtsilä ship design following benefits will in addition be relevant:

• Optimised hull for low resistance and high towing/escort performance, with good seakeeping, high manoeuvrability, safety and comfort for the crew
• Distinctive design outlook
• Designed for building & maintenance friendliness
• Flexible engine and hybrid propulsion concept
• Easy and safe to operate
• Approval in Principle from BV, ABS & LR

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