Technical Meeting — 2 February 2022

Ashar Khan, Manager New Build Projects Australia-Pacific, Wärtsilä, gave a presentation on *Wärtsilä Products and Solutions—Powering a Sustainable Maritime Future* as a webinar hosted by RINA using the Zoom software platform with the Secretary of the ACT & NSW Branch of the IMarEST, Geoffrey Fawcett, as MC on 2 February. This presentation attracted 20 participating on the evening.

Introduction

Ashar began his presentation with on overview of Wärtsilä's operations. Founded in 1834, Wärtsilä is a global leader in innovative technologies and lifecycle solutions for the marine and energy markets. The company emphasises innovation in sustainable technology and services to help customers continuously improve their environmental and economic performance. Their dedicated and passionate team of 17 500 professionals in 200 locations in more than 70 countries shape the decarbonisation transformation of their industries across the globe. In 2021 Wärtsilä's net sales totalled EUR 4.8 billion. Wärtsilä is listed on Nasdaq Helsinki

Wärtsilä's operations around the world
(Map courtesy Wärtsilä)

Wärtsilä offers new-build engines, propulsions systems, hybrid technology and integrated powertrain systems. In the services arena they have a global network of maritime expertise, performance-based agreements, planned and unplanned maintenance services, and upgrading and optimising installations.
The marine product portfolio provides upgradable solutions for customers' future challenges, including

- core stand-alone engines and propulsion systems
- key complementary technologies for catalytic NOx reduction, fuel-gas supply systems, and electrical and power-management systems; and
- an upgrade path towards decarbonisation via fuel flexibility, hybrids and IMO target compliance.

They serve most marine segments including passenger vessels (cruise, ferries and yachts) offshore (oil-and-gas and wind); merchant (bulk carriers and tankers, cargo vessels, container vessels, LNG carriers, ro-ro and PCTC vessels), and special-purpose vessels (including fishing, navy and tugs).

Engines and Gensets

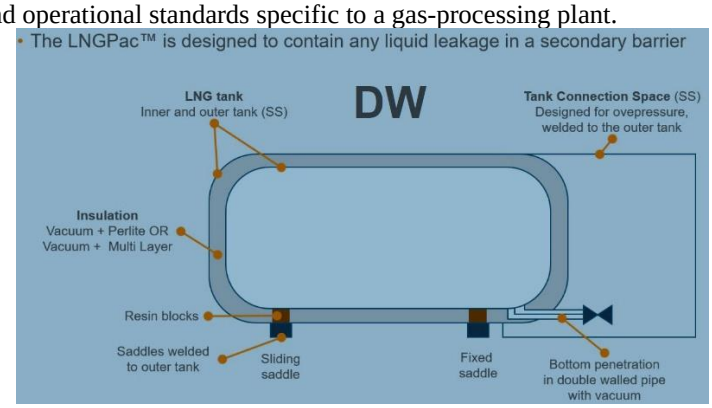
Wärtsilä is continuously developing its portfolio of gas and multi-fuel engines to suit different marine applications. As well as medium-speed engines, they now have high-speed engines.

Wärtsilä High Speed
Lighter, smarter, greener, launched in 2018, for main propulsion and genset applications
12V (27 L) and 16V (36 L), mechanical output 749–1340 kW, electrical output 675–1155 kW at 1500–1900 rpm.

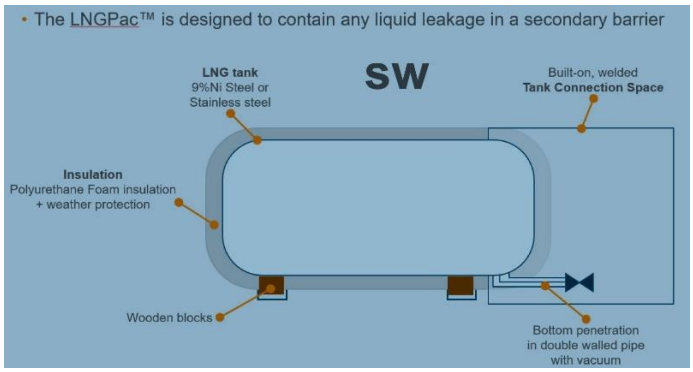
Wärtsilä Medium Speed
Main propulsion and genset applications; available in diesel, dual fuel or pure gas.
Propulsion Engines: output 800–19400 kW
Dual fuel output 1110–18320 kW at 600–1200 RPM
Gensets (50 and 60 Hz): electrical output 700–9370 kW at 1200–750 RPM
Dual fuel: electrical output 920–9220 kW at 1200–750 RPM
Pure gas: electrical output 4225–8450 kW at 720–750 RPM

Fuel Gas System

The Wärtsilä LNGPac™ system is based on an IMO C-type LNG storage tank with either double-walled vacuum or single-walled polyurethane (PUR) insulation. All LNG pipelines, e.g. from the bunker station to the tank, are insulated. All necessary process equipment is installed in a separate unit, which can be either mounted directly to the LNG tank or placed remotely. The LNGPac™ system has been designed in compliance with international safety requirements and operational standards specific to a gas-processing plant.



Wärtsilä's LNGPac™ double-wall tank
(Diagram courtesy Wärtsilä)



Wärtsilä's LNGPac™ single-wall tank
(Diagram courtesy Wärtsilä)

Details of Wärtsilä's LNGPac™ tank
(Table courtesy Wärtsilä)

IMO C-Type LNG-Tank	Double-wall tank	Single-Walk tank	
LNG Volume	25 – 500 cbm	300 – 5000 cbm	500 – 5000 cbm
Dmax (2 < L/D < 7)	6.5 m	10 m	10m
Design pressure	4 – 9 barg	4 – 7 barg	4 – 7 barg
Insulation	Vacuum	PUR	PUR
Tank type	Single-lobe	Single-/Bi-lobe	Multi-lobe
Positioning	Horizontal or Vertical, Top- or Below-deck		
Secondary barrier	Not required		
Bunkering capacity (DN 50-200)	40 – 1000 cbm/h		

Propulsors and Gears

Wärtsilä Propulsion solutions and services are built on unique experience, technical and engineering expertise, all focused on delivering the highest efficiency, safety and manoeuvrability to enable the future of vessel propulsion. Offerings include gears and transmissions, propellers, thrusters, waterjets, and propulsion control systems.

Controllable-pitch Propellers

Wärtsilä Controllable Pitch (WCP) propeller systems provide excellent performance and manoeuvrability, and are recommended for vessels with frequent sailing routes that involve multiple operating conditions. It is an ideal choice for diesel-mechanical propulsion with both medium-speed and low-speed diesel engines. The WCP comprises a boss, propeller blades, shafting, hydraulics, control system and any further accessories required.

Technical Data

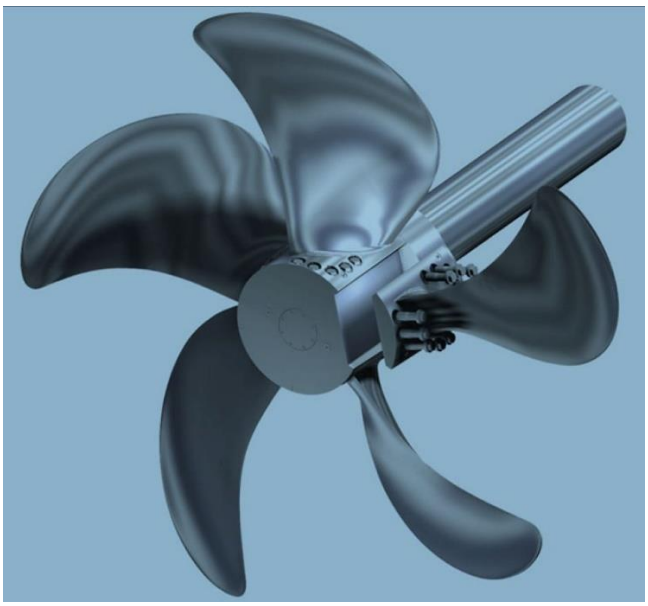
- Power range starting from 500 kW, no upper limit.
- 4- or 5-bladed propellers starting at a diameter of 1200 mm.
- Bronze or stainless-steel propellers.
- Various boss types, depending on the application.
- Compliant with all ice classes.

Options/Add-ons

- US EPA Vessel General Permit 2013 compliance.
- Zero-pollution sterntube.
- Underwater replacement of propeller blades.
- Trailing propellers or full blade feathering.
- Navy/research/fishing requirements for low noise signature.
- EnergoPac rudder or EnergoProFin boss cap for increased efficiency.
- Continuous oil monitoring for increased reliability.
- Wärtsilä high-performance (HP) nozzle.
- Shaft withdrawal interval reduction.
- Cruise control and fuel savings with EcoControl functionality.

Fixed-pitch Propellers

Wärtsilä fixed-pitch propellers range from 1 to 12 m in diameter, and up to 95 t mass can be produced.
In addition, the Wärtsilä Built-up Propeller (BUP) is an attractive alternative to a monobloc propeller. The easily (de)mountable blades and the possibility of under water (de)mounting enable the propeller blades to be replaced or repaired with minimum interruption to the normal operating service. The BUPs are supplied in stainless steel or bronze. Connections to the propeller shaft are made using a flange and fit bolts. Most BUPs are delivered with 4- and 5-blade propellers, but 6-bladed propellers can also be delivered on request. There are no propeller diameter or mass limits.



Wärtsilä's Built-up propeller
(Image courtesy Wärtsilä)

Steerable and Transverse Thrusters

Wärtsilä Thrusters are available in different series covering a wide range of customer needs.

Wärtsilä Steerable Thrusters (900–3300 kW)

The Wärtsilä Steerable Thruster (WST) series is intended for tug or offshore/wind-farm support vessel applications, and for river/inland waterway vessels.

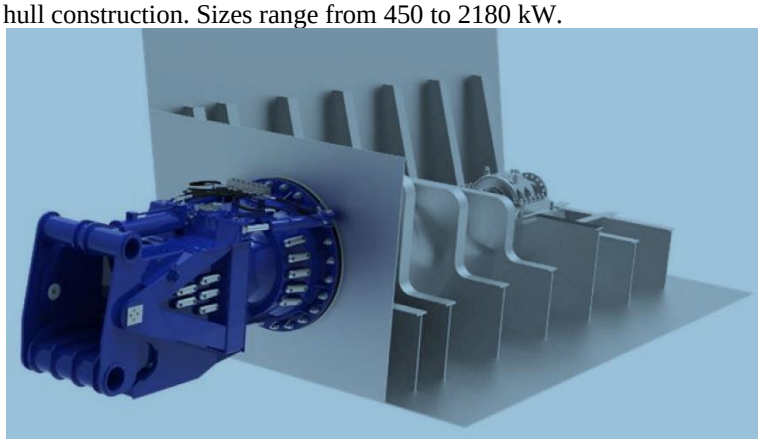
Wärtsilä Retractable Thrusters (1000–6500 kW)
Retractable thrusters provide additional manoeuvring and station-keeping capabilities. The thruster can be fully retracted inside the hull for transit or shallow-draught operations. Retractable thrusters up to 4500 kW are available in L- and Z-drive configuration. All WSTR feature an 8° tilted propeller gearbox design to minimise thruster-hull and thruster-thruster interactions. LMT types are equipped with a 3° tilted nozzle.

Wärtsilä Underwater Mountable Thrusters (2435–6500 kW)
The Wärtsilä WST-U designated underwater mountable thrusters belong to a series with several added features, such as an increased power range, an 8° tilted propeller gearbox, and the Wärtsilä Thruster Nozzle to provide superior and reliable DP performance. The underwater mountable thrusters from the LMT series are available for the lower end of the power range.

Wärtsilä Transverse Thrusters (603–550 kW)
CP and FP options are available.

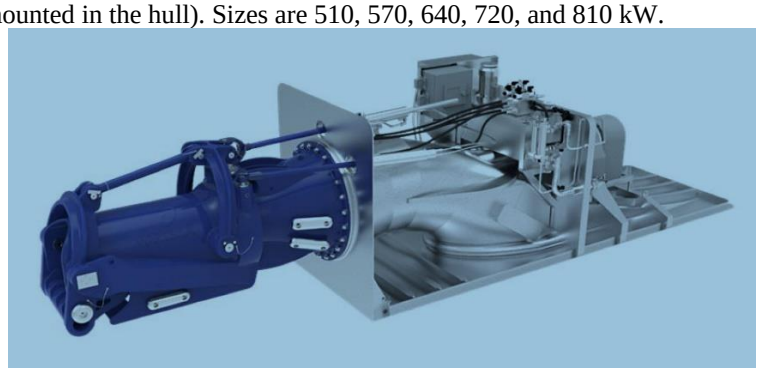
Waterjets
Wärtsilä waterjets have been developed in line with the latest efficiency, performance and operating demands for fast ferries, crew-transfer vessels, patrol vessels, workboats, and luxury yachts. They are available in full duplex stainless steel and aluminium, and range from 500 kW to 50 MW.

Modular WJX Series
This waterjet series is a modular design, and comes with loose outboard parts, thrust bearing, hydraulic power pack, machinery controls (LMCS) and PTO (gearbox mounted). Options include inboard or outboard hydraulics. Material is duplex stainless steel. Excluding the inlet, design is by Wärtsilä with fabrication at the building yard and becomes part of hull construction. Sizes range from 450 to 2180 kW.

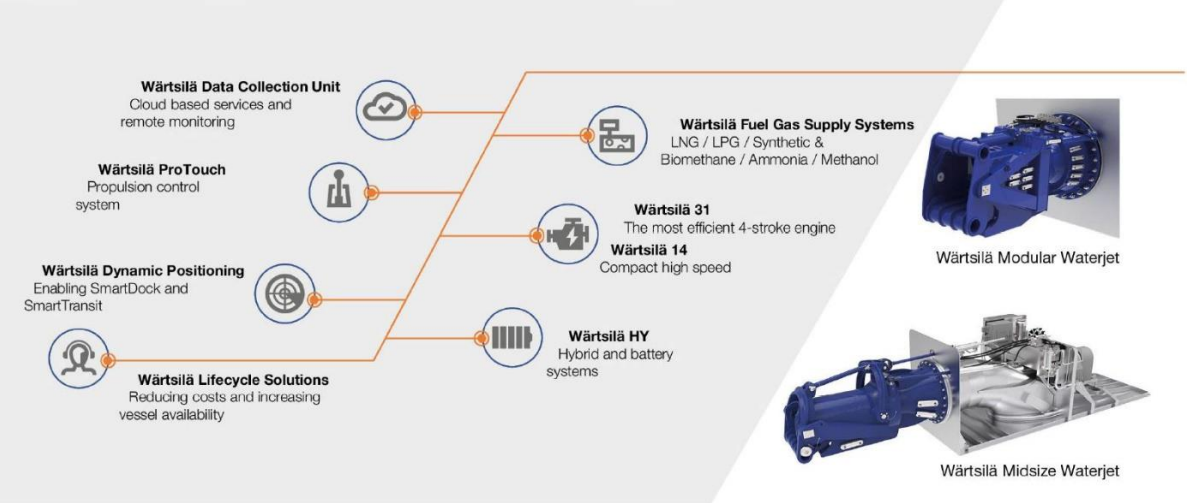


Wärtsilä's modular WJX series
(Image courtesy Wärtsilä)

Midsize LJX Series
This waterjet series is a package design, with all components mounted on a skid including outboard parts, thrust bearing, hydraulic powerpack, machinery controls (LMCS), and PTO. The hydraulics are always inboard (skid mounted). Materials are aluminium for the inlet and outboard parts (jetavator and reversing plate) and duplex stainless steel for the stator bowl, impeller and shaft. Including the inlet, design and fabrication is by Wärtsilä (the skid is completely mounted in the hull). Sizes are 510, 570, 640, 720, and 810 kW.



Wärtsilä's midsize LJX series
(Image courtesy Wärtsilä)



Wärtsilä's integrated waterjet solutions
(Image courtesy Wärtsilä)

Gearboxes and Transmissions

Wärtsilä gears have been designed to meet the highest standards of operational efficiency, reliability and low noise and vibration.

Gear Configurations

- 1-speed gearboxes, for installations with a single engine and propeller operating at a constant propeller speed. The Wärtsilä SCV designation indicates a vertical offset, while SCH represents a horizontal offset.
- 2-speed gearboxes, for installations with a single engine and propeller able to operate at two selectable propeller speeds. The Wärtsilä SCV/2 designation indicates a vertical offset, while SCH/2 represents a horizontal offset.
- Double gearboxes, for installations with two engines and one propeller operating at a constant rotational speed. "Twin-in single-out" gears have Wärtsilä designation TCH.
- Special gearboxes, e.g. gearboxes with both horizontal and vertical offsets, are available upon request and are customised for the specific application.
- All Wärtsilä gears can be supplied with built-in multi-disc clutches for engaging the propeller.

Decarbonisation and Future Fuels

Shipping contributes to 2.6% of the global emissions (based on 2018 figures). CO_2 is the largest of the greenhouse gases (GHGs), while other important ones are methane (CH_4) and nitrous oxide (N_2O).

In 2015 the United Nations signed the Paris Agreement which set an ambition to limit global warming to well below 2°C above pre-industrial levels and pursue efforts to limit it to 1.5°C — in part by pursuing net carbon neutrality by 2050.

Following the Paris Agreement, the International Maritime Organisation (IMO) had set mid- and long-term targets for shipping to reduce its total annual GHG emissions by at least 50% by 2050 compared to 2008, whilst pursuing efforts towards phasing them out entirely. It is further preparing short- and mid-term regulations which will step-by-step increase the reduction of carbon emissions. This is covered in Marpol Annex VI.

The Poseidon Principles

The Poseidon Principles are the world's first sector-specific, self-governing climate alignment agreement amongst financial institutions. The principles establish a global framework for assessing and disclosing the climate alignment of ship finance portfolios. They are consistent with the policies and ambitions of the International Maritime Organization, including its ambition for greenhouse gas emissions to peak as soon as possible and to reduce shipping's total annual GHG emissions by at least 50% by 2050.

The Sea Cargo Charter
The Sea Cargo Charter establishes a framework for assessing and disclosing the climate alignment of ship chartering activities around the globe. It sets a benchmark for what it means to be a responsible charterer in the maritime sector and provides actionable guidance on how to achieve this.
The Sea Cargo Charter is consistent with the policies and ambitions of the International Maritime Organization (IMO), including its ambition for greenhouse gas emissions to peak as soon as possible and to reduce shipping's total annual GHG emissions by at least 50% by 2050.
As a result, the Sea Cargo Charter will enable cargo owners and shipowners to align their chartering activities with responsible environmental behaviour and incentivise international shipping's decarbonisation, to shape a better future for maritime shipping and society.
The Sea Cargo Charter is applicable to bulk ship charterers.

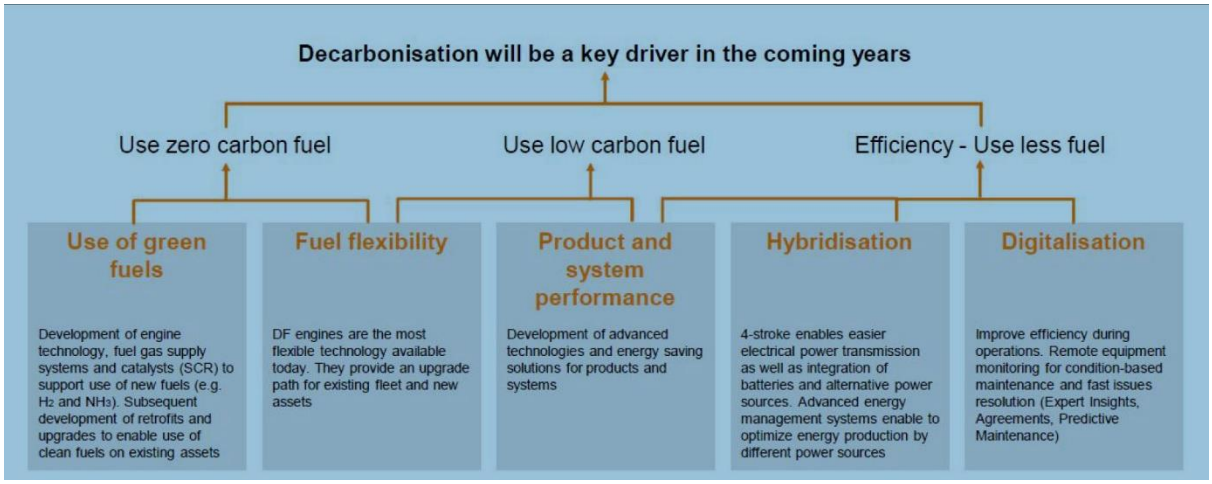
The EU Fit for 55 Package
The European Union's legislative proposals cover a wide range of policy areas including climate, energy, transport and taxation, setting out the ways in which the Commission will reach its updated 2030 target in real terms.
In the maritime area, ships will get a rating with respect to their energy efficiency (A, B, C, D or E, where A is the best). Administrations, port authorities and other stakeholders as appropriate, are encouraged to provide incentives to ships rated as A or B, thus sending out a strong signal to the market and the financial sector. A ship rated D or E for three consecutive years is required to submit a corrective action plan, to show how the required index (C or above) would be achieved. Such category shall also be exposed to financial risk, charter risk and regulatory risk.

Developments and Initiatives by Wärtsilä
Wärtsilä expects to launch a ground-breaking two-stroke future fuels conversion solution, and has joined forces with MSC for a technology demonstration in the first quarter of 2022.
Wärtsilä and Simon Møkster Shipping Norway are to study the feasibility of ammonia and LNG dual-fuel operations.
Wärtsilä and SHI South Korea have agreed to collaborate on ammonia-fuelled engines for future newbuilds.
Wärtsilä and Eidesvik Offshore Norway are to cooperate in the world's first ammonia conversion project.
Wärtsilä and Grieg Edge are collaborating to develop a ground-breaking new tanker, MS *Green Ammonia*. The vessel, which will both transport and run on green ammonia, is expected to be in operation as early as 2024. The development project is part of the Zero Emissions Energy Distribution at Sea (ZEEDS) initiative.
Knutsen OAS Shipping AS and Repsol, with the Sustainable Energy Catapult Centre, will commence the world's first long-term full-scale testing of ammonia as a fuel in a marine four-stroke combustion engine using a NOK20 million grant from the Norwegian Research Council through the DEMO 2000 programme.
Wärtsilä gas engines to burn 100% hydrogen are on the way; engines with blends of up to 60% hydrogen and 40% natural gas have already been successfully tested.
Wärtsilä expects that the first ammonia-fuelled engine would be ready by 2023, and the first hydrogen-fuelled engine by 2025.

Bio- and Hydrogen-based fuels
Bio- and hydrogen-based fuels are needed to decarbonise the shipping industry. However, there are business risks which must be considered.

- Fuel Availability: Variations due to local regulations and feedstock, production capacities and existing infrastructure.
- Increased CapEx and OpEx: Carbon-neutral fuels typically require existing equipment to be replaced and are likely to be more expensive than fossil fuels, at least initially.
- Impact on Vessel Structure: Many carbon-neutral fuels will have lower volumetric energy density compared to HFO and LNG, and require larger tanks to maintain vessel endurance.
- Increased Complexity: Managing some cryogenic or toxic fuels will require more complex solutions to comply with rules and regulations.
- Shipyard Capacity: There is a mismatch between the number of shipyards capable of handling the fuel conversion work and the size of the international commercial fleet.

Wärtsilä's Technology Developments
Wärtsilä's technology developments are aligned with long-term industry needs and technology trends.



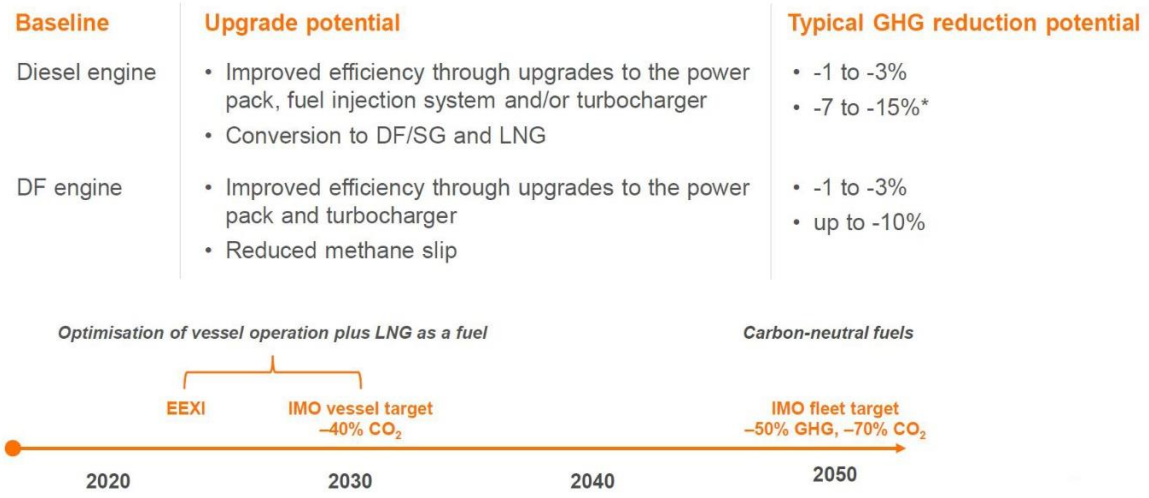
Wärtsilä's technology developments
(Diagram courtesy Wärtsilä)

Engine Technology Development

The development of engine technology is ongoing. The time schedule and cost impacts for engine performance are as follows:

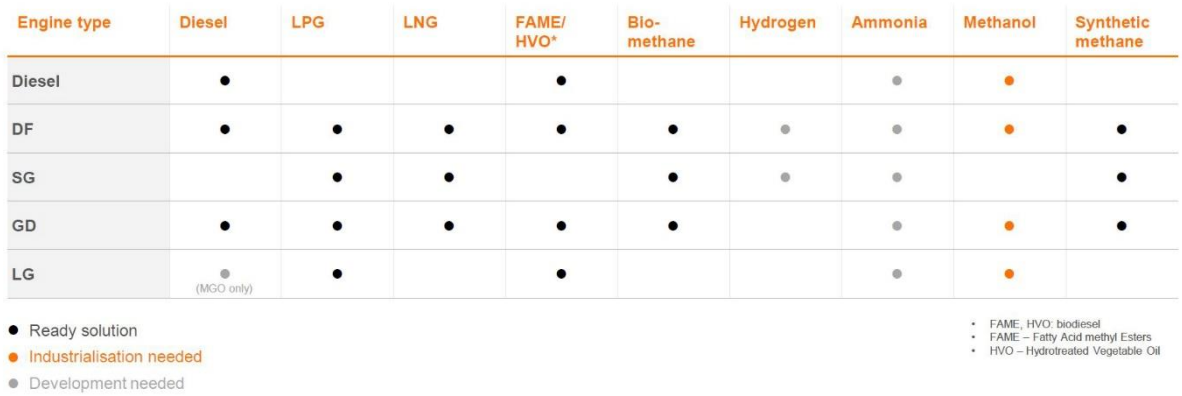
- Bio or synthetic methane (CH4): Verified in 2003; contains about 99% methane and can readily be used in liquid form with equipment made for LNG.
- Methanol (MeOH): Verified in 2015; A methanol conversion package is available for the ZA40 engine and Wärtsilä has the technology to burn methanol. The next step is to industrialise this technology on the relevant portfolio engines according to market needs.
- Ammonia (NH_3): Expected to be verified in 2023; Wärtsilä has technologies which are capable of using ammonia.
- The needed combustion concepts to maximise engine performance and related safety technologies are currently being investigated.
- Hydrogen (H2): Expected to be verified in 2025; Wärtsilä's gas engines are already able to blend LNG with up to 20% hydrogen, and combustion concepts have been made for 100% hydrogen. Future efforts will be directed towards maximising engine performance.

Total greenhouse gas emissions can already be reduced on existing engines.



Reduction potential of GHG emissions on existing engines
(Diagram courtesy Wärtsilä)

We have the knowledge and technologies to burn most the future fuels; development is on-going for the rest.



Fuel technology for future fuels
(Diagram courtesy Wärtsilä)

We will have fuel storage and supply systems for most future fuels.

Fuel storage and supply systems for future fuels
(Diagram courtesy Wärtsilä)

The dual-fuel engine is an excellent fuel-flexible choice for the future, operating on diesel and Otto cycles, with three separate fuel-injection systems. As a matter of interest, Wärtsilä DF engines have been chosen for the new Spirit of Tasmania vessels, and for the new SeaRoad ro-ro vessel.

Wärtsilä Solutions and Concepts for Decarbonisation
Wärtsilä solutions and concepts for decarbonisation include energy-saving devices, engine power limitation, fuel conversions, batteries and shore connections.

Energy-saving Technologies
To meet the requirements for 2030 and beyond, Wärtsilä has been proactive in developing existing solutions and innovating and partnering to ensure that there are options available to suit all vessel types and operating profiles. Solutions include

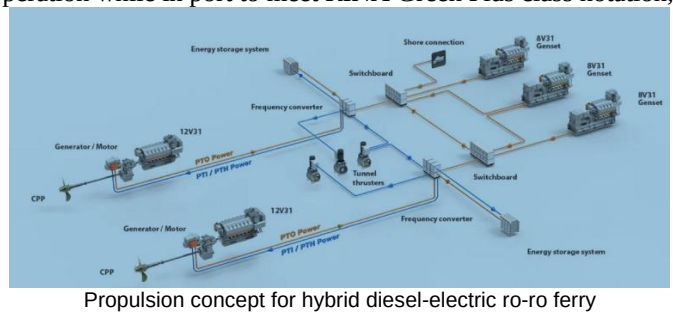
- Air-lubrication systems with microbubbles generated by a compressor blown under the hull; these have been approved by classification societies.
- Gate rudders (with a rudder either side of the propeller) which improves the turning efficiency and manoeuvrability.
- EnergoProfin, i.e. propeller-boss cap fins, which reduce the propeller boss vortex resulting in fuel savings and a reduction of underwater noise and vibration.
- EnergoFlow, i.e. a pre-swirl stator (consisting of multiple curved fins and a ring) which creates optimal inflow for the propeller by guiding one side of the stern flow in the

opposite direction to the propeller rotation, improving fuel efficiency and reducing NOx and CO_2 emissions.

- EnergoPac, i.e. an integrated propeller and rudder design with the aftmost shaft bearing integrated with the rudder, reducing flow separation behind the propeller boss and thus reducing fuel consumption.
- High-performance nozzle to increase thrust a reduce fuel consumption.
- Rotor sails, i.e. using the principle of the Magnus effect whereby useful thrust is created by rotation of a rotor in an air flow, resulting in a difference in pressure on the different sides of the rotor; the thrust depends on the wind angle and speed, with the maximum thrust being created when the wind direction is just aft of the beam. The rotor sail is named after the German aviation engineer and inventor, Anton Flettner, who started developing the rotor sail in the 1920s.
- Wärtsilä's OPTI Design methodology is the result of highly experienced design engineers having access to the very latest and most sophisticated software and analysis tools, and aims to achieve a perfect match between the propeller, engine and hull.

Wärtsilä Propulsion Designs and Concepts
Here Ashar showed diagrams of a number of Wärtsilä solutions for various types of vessels.

Ro-ro Diesel-electric PTO/PTI and Hybrid
The hybrid solution of shaft generators, converters and transformers includes a 5000 kWh energy-storage system, enables zero emissions operation while in port to meet RINA Green Plus class notation, and deliver fuel savings.

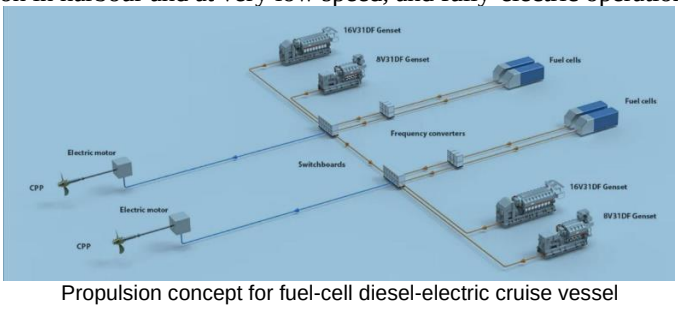


Propulsion concept for hybrid diesel-electric ro-ro ferry
(Diagram courtesy Wärtsilä)

Ferry with Zero Emissions
This battery solution enables ferry operations using an all-electric propulsion solution with shore charging at the destination. This offers zero-emissions transportation and faster response time to thrusters, which allows better manoeuvrability and efficiency.

Ferry Diesel-electric and Hybrid
The flexible hybrid solution allows the vessel to operate the engines at their optimal load by providing peak shaving which removes variable loads and also acts as spinning reserve. This reduces fuel consumption and associated emissions, increases engine maintenance intervals and reduces noise levels when needed.

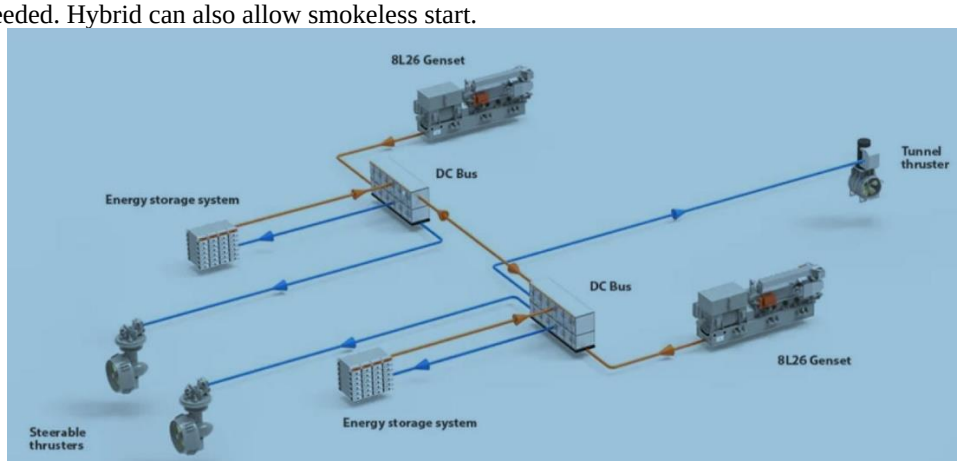
Cruise Vessel Fuel-cell Diesel-electric
The fuel cell supplies 2.5 MW for hotel load and 1.5 MW for propulsion, plus 2 MW peak power for manoeuvring. This offers silent operation in harbour and at very low speed, and fully-electric operation for zero emissions.



Propulsion concept for fuel-cell diesel-electric cruise vessel
(Diagram courtesy Wärtsilä)

Bulk Carrier Hybrid with PTO/PTI and Shore Connection
The fully-integrated Wärtsilä hybrid solution will enable the vessel to sail in and out of port, and to perform cargo operations, completely emissions-free. In addition, the battery will handle the variable load when sailing, allowing the main engine to work on a stable load. This will meet port regulations where reduced emissions are required.

Tug Hybrid
The variable load needed for tug operations is ideally suited to a hybrid configuration—offering peak shaving and load balancing so that the engines can operate at their optimal level. The hybrid system also allows the tug to run fully electrical in low-load conditions in and out of harbour and when waiting, and power boost when additional power is needed. Hybrid can also allow smokeless start.



Propulsion concept for hybrid tug
(Diagram courtesy Wärtsilä)

Fishing Vessel Hybrid
For a fishing vessel with variable loads, the hybrid system allows the main engine to run at optimal load and the total installed power can be reduced, thus allowing the main engine installation to be smaller to match the power needed. The battery and auxiliary engines supply additional power for propulsion boost in harsh weather conditions and offer peak shaving.

Shore Connection
When a ship docks in a port, it can be connected to an onshore power supply, enabling the engines to be shut down; this reduces harmful emissions, visible smoke, noise pollution and ensures the use of more-efficient/greener energy to meet its power requirements.

The Wärtsilä SAMCon system comprises
- Cable reel
- Cable reel control box
- Monitoring and control cabinet
- Medium voltage switchboard
- Transformer
- 2nd reel for connection to ship.

Container Features
- Up to 7.2 MVA transferable power at 6600 V 60 Hz and 45°C
- Usable on port and starboard sides
- Container including CSC certificate
- Design according to IEC 80005-1
- Safe operation area
- Electric cable reel drive including tension control
- Shore interface designed for ports of West Coast California (others on request)
- Maintenance-friendly technology.

Wärtsilä's SAMCon shore-connection container
(Photo courtesy Wärtsilä)

Summary
Wärtsilä's goal is to be the leading power solution in the smart marine ecosystem!
There is no one single future fuel—there will be a whole variety of fuels in use. Investing in fuel flexibility and the combustion engine will mitigate compliance and business risks introduced by future fuels. Wärtsilä will continue to be a supplier of complete systems and energy-saving solutions, regardless of the fuel. When it comes to Engines, Wärtsilä dual-fuel engines are an excellent choice for introducing future fuels. This presentation has shown a major part of what Wärtsilä can offer at the moment, but there is more on the horizon
—there are projects under development to increase Wärtsilä's offerings. Customers most probably need to take a step-by-step approach and do different kinds of upgrades over the coming years to comply with CII and EEXI.

Questions
Question time was lengthy, an raised some further interesting points.
The certificate was subsequently posted to Ashar, and the "thank you" bottle of wine delivered via an eGift card.
The presentation was recorded, and is now available on the RINA YouTube channel.