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Publisher: Wärtsilä Corporation, Hiililaiturinkuja 2, FIN-00180 Helsinki, Finland |
Editor-in-Chief: Mikael Wideskog |
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Editorial team: Marit Holmlund-Sund, Mari Kankaanranta, Pia Posio, Laura Quinton, Mirja-Maija Santala, Sanni Suominen, Mikaela Terhi | **Layout and production:** Spoon |
Printed: May 2019 by PunaMusta, Joensuu, Finland ISSN 1797-0032 | Copyright © 2019 Wärtsilä Corporation |
Paper: cover LumiSilk 250g/m², inside pages UPM Fine 120 g/m²

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Cover illustration: Wärtsilä

BANKING ON PARTNERSHIPS TO MAKE THINGS HAPPEN

Climate change is a legitimate threat to our planet. This means the decisions we make and the actions we take now will have a direct impact on our planet's future.

We, at Wärtsilä, are mindful of this reality and are working towards a greener future by developing flexible, innovative solutions in the marine and energy industries. Our engines are central to our capacity to fulfil these goals, as they are the very building blocks upon which our solutions are based. While engines may sound like ancient and polluting products, they, too, can be made sustainable simply by flexibly switching out fossil fuel for renewables.

However, we cannot do everything alone. It is only by working together with partners that we will be able to make the desired impact. Many of the stories in this issue will shed light on our collaborative approach and explain how it helps us achieve our sustainability goals.

The Wärtsilä 14 engine is a case in point. Co-developed in a unique collaboration with the Liebherr Group based in Switzerland, the Wärtsilä 14 is the result of Wärtsilä's first cooperation with an external partner to design an engine (learn more on page 24). As the most compact engine, the Wärtsilä 14 boasts features that help reduce nitrogen oxide emissions, thereby complying with the IMO Tier III regulations.

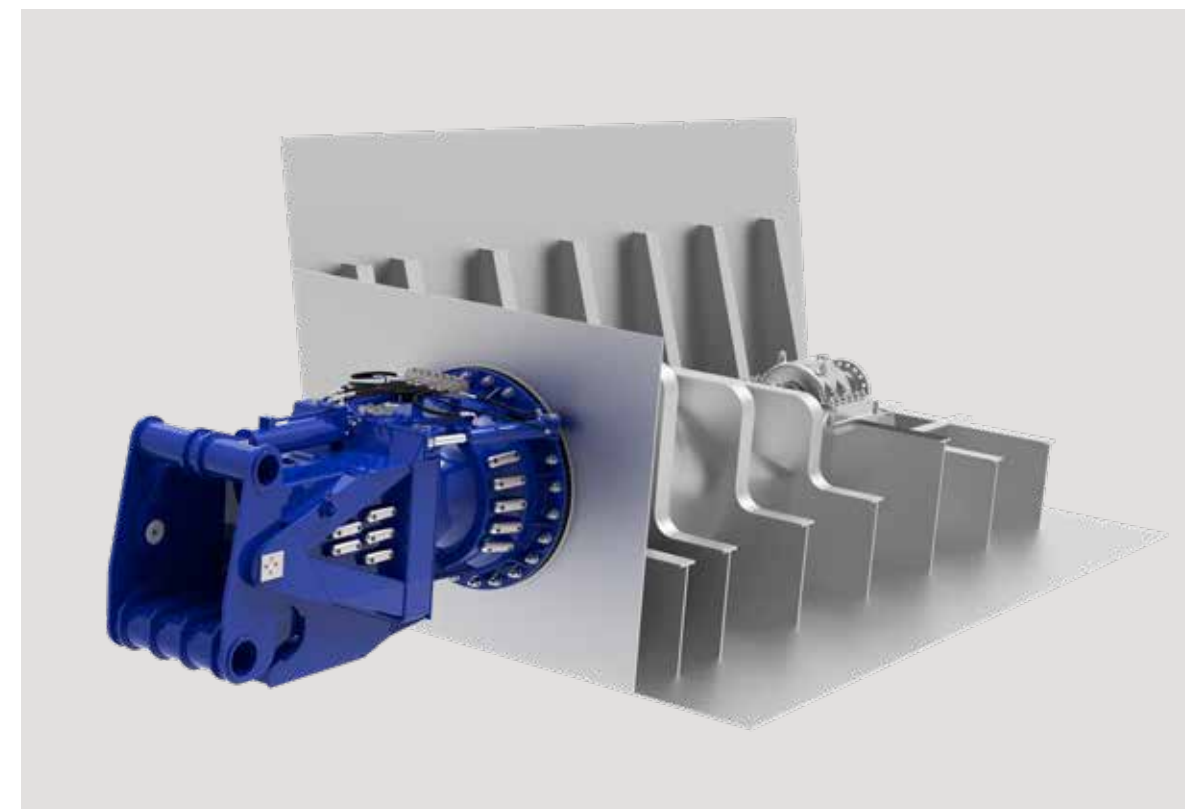
Our solutions are making a difference in the energy sector too. Take the UK energy market for example. After having been heavily dependent on fossil fuels, the country is now slowly transitioning to renewable energy and needs flexibility to make the switch. Wärtsilä 34SG engines that run on natural gas are a perfect fit for this scenario. With a start-up time of under two minutes, our flexible solution promises to balance the grid during times when renewable energy sources are not able to meet the demand. Our project with the British energy and services company Centrica (story on page 22) to develop two 50 MW power plants is a step in the right direction.

I'd also like to mention the winner of this year's SparkUp Challenge – the Icelandic company Carbon Recycling International (CRI). Their innovative idea uses renewable energy to produce synthetic methanol from carbon dioxide and hydrogen. This is very much in sync with Wärtsilä's Power-to-X technology, that is a process to convert excess energy into something which can be used later. CRI's idea is also relevant for both the marine and energy sectors, as renewable methanol solutions can be more feasible than LNG. We are looking forward to collaborating with CRI on future projects to broaden the renewable ecosystem.

It is evident that by partnering with other key stakeholders to develop sustainable, flexible solutions we can assure our planet's future is bright and green.

Mikael Wideskog

General Manager,
 Technology Strategy & Innovation Process
 Wärtsilä
 Editor-in-Chief of *In Detail*



DOES SIZE MATTER?

Wärtsilä's smaller and lighter waterjets power
 high-speed ferries and navy vessels.

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In focus: Myanmar

Cogeneration power solutions can play a huge role in energising Myanmar.

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Demystifying Wärtsilä PCMS

New Propulsion Condition Monitoring Service (PCMS) improves availability, reliability and profitability.

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Fight against underwater noise

Wärtsilä is well prepared to meet the new requirements for quieter shipping.

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Synthetic fuels: Supporting Wärtsilä's vision of a 100% renewable energy future

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As Wärtsilä continues to pursue a 100% renewable energy future, one emerging technology that looks set to play a major part in the process is synthetic fuel production. Find out how the generation of synthetic fuel from excess CO₂ emissions – the so-called 'Power-to-X' process – holds the key to a carbon-neutral future.

Up until now, renewable energy generation has been driven by weather, but renewable energy can also come from a range of other processes where any kind of excess is created, and – perhaps most crucially – from those that generate excess carbon in the form of emissions.

'Power-to-X' is an umbrella term for a number of different emerging technology solutions for electricity conversion, energy

storage and energy reversion, all of which use surplus power in one form or another.

Power-to-X is going to play a key part in the future of energy generation – from power-to-gas solutions, where electricity is used to split water into hydrogen and oxygen through electrolysis, to solutions where hydrogen from an electrolyser is combined with carbon dioxide and the two gases are converted into synthetic renewable methane, as well as other potential power-to-fuel solutions that can be developed to create synthetic fuel.

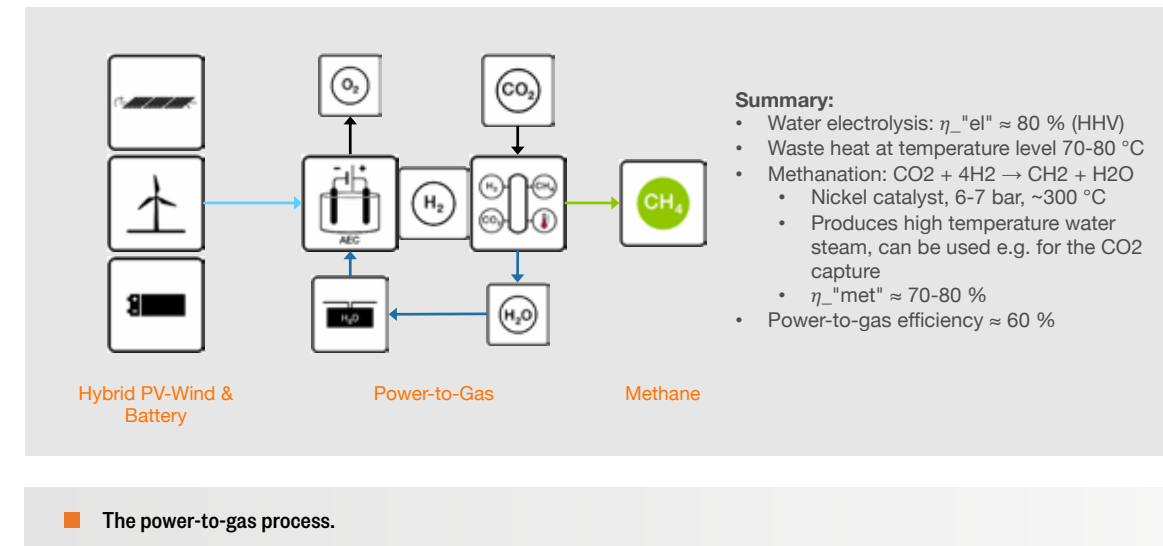
Synthetic fuels to mitigate climate change?

There is a growing consensus that synthetic fuel is set to play an important part in mitigating climate change. What makes the possibility of generating fuel from excess CO₂

such a compelling prospect is that it has the potential to create a circular carbon economy, whereby the CO₂ that would otherwise be released into the environment is instead reused, thus minimising the climate impact of CO₂ and preventing new fossil resources from being exploited for fuel.

Instead of continuously using more and more of the planet's precious fossil fuel reserves, Wärtsilä envisages a future in which it will be possible to capture the CO₂ that is emitted from combustion processes from the air and recirculate it in what could potentially be an infinite energy loop.

Power-to-X currently remains the missing piece in the puzzle as Wärtsilä seeks to achieve its vision of a 100% renewable energy future. However, this year, measures are being put in place to ensure that these



technologies will be made available to be incorporated into future products and services from Wärtsilä.

Direct air capture of CO₂

So what goes into the process capturing and reusing CO₂ in order to form synthetic fuel?

There are three key ingredients: carbon dioxide, hydrogen and renewable electricity. Hydrogen can be obtained from water using an electrolysis process, which splits it into hydrogen and oxygen. Meanwhile, carbon dioxide comes from various industrial processes as a waste stream or is captured directly from air. The two are combined together through a chemical synthesis using catalytic conversion technology and renewable electricity as a power source. The process produces synthetic fuels. There are various conversion processes available to produce a variety of synthetic alkanes.

When combined together, carbon and hydrogen produce hydrocarbons, or alkanes, such as methane, methanol and dimethyl ether (DME), all of which can be used as fuel across a variety of power generation and transportation applications.

Whereas traditional hydrocarbons are refined from crude oil, synthetic hydrocarbons are created through a chemical synthesis process such as the one detailed above. Both synthetic and traditional hydrocarbons can be used as fuel.

Seeking synthetic fuel partnerships

Up to now, "quick-fix" technologies designed to resolve the climate change issue have been regarded with suspicion by

the global scientific community. However, plans to capture CO₂ directly from the air – essentially imitating the natural behaviour of trees – have begun to gain more and more credibility. This concept was, in fact, first developed by German physicist Klaus Lackner in the mid-1990s, but has more recently been adopted by a number of companies around the world, as direct air extraction has become an increasingly viable prospect.

Earlier this year, Iceland's Carbon Recycling International (CRI) was named the winner of the SparkUp Energy Challenge, a competition arranged by Wärtsilä to identify start-ups in the Power-to-X technology field and to jointly develop future technologies with them. CRI's solution is based on a technology that uses CO₂ and hydrogen made with renewable power and turns them into synthetic methanol. Through the SparkUp Energy Challenge, Wärtsilä has taken a new approach in exploring business opportunities in emerging technologies, bringing the Wärtsilä venturing model to life through start-up collaboration.

CRI is already producing renewable methanol from carbon dioxide, hydrogen and electricity on a commercial scale for fuel applications, greener chemicals and products at its production facility in Grindavík, Iceland. It also has the capacity to engineer, build and operate emissions-to-liquids methanol production plants. The company will be collaborating and co-creating solutions alongside Wärtsilä's energy experts, with a view to

maximising the synergies between the two companies.

A future packed with potential

Synthetic fuels can effectively be applied everywhere that fossil fuels are currently in use today – from aeroplane engines to cars, trucks, power plants and seagoing vessels.

From Wärtsilä's perspective, there is also good potential to use synthetic fuels in engine-based power plants as well as across other Wärtsilä engine products. The precise area of application will depend on the type of fuel that needs to be used.

For example, whereas synthetic methane would typically be used in a gas engine, synthetic methanol and synthetic DME would be most suited to a diesel engine with dual fuel pilot injection.

At this time, synthetic fuel production is still in its infancy. The processes, systems and technologies required to make this vision a reality are still in the pilot stage and will need to be extensively evaluated for both commercial and technical feasibility before they can be scaled up and industrialised. However, with evidence suggesting that this fuel option could be 100% CO₂ neutral, it is widely regarded as a very promising prospect, one that could be further developed over the next five to 10 years.

As things stand, Wärtsilä remains firmly committed to developing Power-to-X concepts in general, and synthetic fuels in particular, to the point where they will be ready to realise their full potential and have a truly positive impact on the future of the planet. ●



Photo: 123RF

Reimagining 100% renewable energy

AUTHOR: Payal Bhattar

100% renewable energy target is no longer a distant dream. Several countries, islands and regions across the world are working towards it as cost of renewable energy technologies continues to fall. Find out what's driving this transition.

Åland is a group of 6,500 small islands in the Baltic Sea located between Sweden and Finland. Although this archipelago is part

of Finland's territory, it is connected to a grid in Sweden for its electricity because of its proximity to the country. Åland has an ongoing Flexible Energy System Demonstration project (FLEXe) to pilot and demonstrate that a fully renewable, independent energy system on the island is sustainable, technically and economically.

Inspired by this ambition, a few months ago, Wärtsilä engaged in a power system

modelling of the island to understand the cost-optimal pathways to go 100% renewable in electricity generation.

"In Åland, wind is the main renewable resource. The main point was to understand how much it would cost to take the last step from 85% to 100% renewables," says Jyrki Leino, Senior Manager, Wärtsilä Energy Business.

"In our study and modelling, we

compared different scenarios. In high renewable power system modelling, methods need to be chosen carefully so that all system constraints are considered properly. In this case, in order to reach 100% renewable energy power system, we tested power-to-gas solutions and biofuels. In both the cases CO₂-free fuels were used in Wärtsilä engines to balance intermittent wind production," explains Leino.

Wärtsilä modelled three scenarios for the study. First, a base case where the link to Sweden would be maintained and new capacity would be added on the lowest cost basis. The second scenario had the link to Sweden gradually cut by 2030 and a new Wind, Solar, Batteries, and BioLNG (engine) capacity added on the lowest cost basis. The third scenario had BioLNG replaced with a Power-to-Fuel (PtF) engine to convert

excess energy from wind production to gas and then use this gas in Wärtsilä engines to balance intermittent wind production.

Ground Reality

The study concluded that assuming the existing generation fleet was used as-is (only wind), and that there was a demand growth of 1% per annum starting from 300 GWh, and no electricity was sold outside Åland, the archipelago could make a gradual transition to 100% renewables by 2030 in three stages.

Stage one will be renewables at 50%, which is optimum from a cost perspective given the current cost level of renewables, power-to-gas and biofuels and could be achieved by just adding wind and curtailing excess or balancing power from Sweden. At stage two, up to 80% renewable energy

will be and the balance 20% power would still come from Sweden. During this step, there would be quite a lot of overbuilt of wind generation capacity, some of which would be curtailed during periods of high generation. At stage three, final push to 100% renewables could be achieved either with BioLNG or PtF. Given the current cost level of BioLNG and PtF, the system cost would approximately triple in the case of BioLNG and rise seven times in the case of PtF. However, the costs of both solutions are likely to fall in the future, making the case for 100% renewable electricity production interesting to pursue for.

In addition, local renewable energy potential, geographical conditions and electricity cost level impact the feasibility of going 100% renewable.

"One always needs to analyse the cost

of generation with system/specific input data,” says Saara Kujala, General Manager Business Development, Wärtsilä.

“While we cannot draw any conclusion globally from a single country case, we do see that with the cost of wind and solar falling dramatically, in many cases countries can both lower the cost of electricity production and go up to 80–85% renewable generation even with current cost trends of renewables, storage and flexible generation solutions. And as we build our systems towards higher shares of renewables, we can continue to take advantage of new technologies as their costs fall,” explains Kujala.

According to International Renewable Energy Agency (IRENA), the share of renewable energy in the power sector is likely to increase from 25% in 2017 to 85% by 2050, mostly through growth in solar and wind power generation.

Falling costs

The good news is that the costs of renewable technologies, particularly wind and solar, have fallen dramatically and are likely to reduce even further. According to Bloomberg New Energy Finance’s (BNEF) third-quarter outlook on the Global PV Market, solar panel system costs (fixed axis, utility segment) have decreased by 73% between 2010 and 2018. BNEF’s third-quarter outlook on the global wind market too estimates that the wind turbine price index has dropped from USD 1.75 m/MW to USD 0.85 m/MW from the first half of 2008 to the first half of 2018.

BNEF’s New Energy Outlook 2018, an annual long-term analysis of the world’s power sector until 2050, estimates that in the first half of 2018 alone, the benchmark global Leveraged Cost of Electricity (LCOE) for offshore wind reduced by 5% to USD 118 per MWh. It fell 18% for onshore wind to touch USD 55 per MWh and was 18% lower for equivalent solar PV at USD 70 per MWh. The prices of Lithium-Ion Batteries too have reduced substantially from USD 1000 per kWh to USD 209 per kWh since 2010.

BNEF expects battery prices to fall to USD 70 per kWh by 2030. It predicts that by 2050, the cost of an average PV plant will

fall by 71% and the cost of wind energy will drop by 58%. It estimates that of a total USD 11.5 trillion will be invested in new power generation capacity between 2018 and 2050, USD 8.4 trillion will be invested in wind and solar alone and another USD 1.5 trillion will go to other zero-carbon technologies such as hydro and nuclear.

“It is commercially realistic to reach 85–95% renewable level within the next 30 years throughout the world, but the massive wind and solar power plant investments must be supported with short-, medium- and long-term balancing applications,” says Veikko Kortela, General Manager, Business Development, Wärtsilä Energy Business.

Flexibility mantra

Engine power plants are a good way to ensure the lights never go out. They can be fuel-flexible and can handle varying loads to provide operational flexibility to the entire power system. Operational flexibility is paramount when it comes to increasing renewable energy generation because renewable sources are intermittent as they are dependent on natural conditions like the number of hours of sunlight, wind speed etc.

“Engine power plants will have a big role to play because they can provide balancing power using stored fuel produced with power-to-fuel technologies. During transition period, natural gas will gradually be replaced with PtF fuels,” explains Kortela.

Building excessive renewable capacities is also not ideal because it could lead to idle capacity due to commercially unviable large-scale storage and a scarcity of new technologies to convert excess renewable power to fuel or other forms.

“Huge amount of storage capacities is required in the last 5–15% of achieving 100% renewables. That increases the Leveraged Cost of Electricity (LCOE) heavily. But over the next few years we expect technical improvements for storage and all other renewable production supporting technologies and also heavy price cuts due to mass production for some storage technologies,” says Kortela.

But to achieve ambitious renewables targets that are 10–15 years away, utility companies have to ensure that the capacities



Photo: 123RF

they chose to invest in today remain relevant in the future. This is because it takes years to build power plants and the average life of a plant could range between 30–40 years.

So how can one future-proof their investments? Multi-fuel engine power plants are the best answer.

“In Wärtsilä engines, you can still use fossil fuels but if you want to give the final push to 100% renewables at some stage, you can easily switch to biofuels,” says Leino.

“Typically, the capacity factor of thermal balancing capacity in a 100% renewable system is less than 10%, which means that the thermal units are not used much for

energy and the price of the more expensive biofuel is not that important as it does not have too much of an impact on the total cost. However, it is essential to have this firm thermal capacity in the system for the periods when there is no wind or solar production, or when the duration of the batteries is not long enough,” he explains further. Such solution will also help to reduce the amount of energy storage needed in a fully renewable system.

For greater good

Apart from financial feasibility, there’s also climate change to consider. The

International Energy Agency (IEA) estimates that limiting the rise in global mean temperature to well below 2°C would need the global energy sector to double investments to an average USD 3.5 trillion each year until 2050, decrease fossil fuel investments and offset it with a 150% increase in renewable energy supply investment, investment in nuclear power, carbon capture and storage, and in transmission and distribution grids.

IRENA estimates that renewable energy needs to grow at least six times faster for the world to meet the goals set out in the Paris Agreement, 2015. As climate change-related

regulations get tougher, power companies investing in inflexible new capacities could find themselves saddled with high emission plants that may be unusable in the future.

The overall consensus is that with renewable energy growing at a robust 7–8% annually, 100% renewable energy is not too far from reality. There’s money to back it and it is technically feasible. So even though Åland may take a while before it makes the transition, there is no doubt that several geographies around the world will move towards the 100% renewable energy mark as RE technologies, batteries and synthetic fuels become more affordable. ●



Photo: 123RF

Energising Myanmar's industrial zones

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Myanmar's economy is back on the growth track with economic and political reforms as international sanctions against it were recently lifted. Its strategic location as a land bridge between South and South East Asia is attracting international investors. Find out how cogeneration power solutions can play a vital role in energising Myanmar's economy.

Myanmar's GDP is growing at an average 6–7% annually but its per capita energy consumption of 160 kWh per annum is 20 times less than the world average and is amongst the lowest in the world. Barely 34% of the country's people have access to electricity. Amongst urban areas, the highest access rate has been recorded in Yangon City at 67%, while rural areas, where most of Myanmar's people reside, have an electricity

access rate of just 16%.

Even though electricity consumption has been growing at an average of 14% per annum over the past five years, with peak load demand touching 4000 MW in 2016, shortages and supply disruptions remain prevalent. This is despite Myanmar being blessed with abundant power generation resources.

The country's hydropower potential has been estimated at around 108 GW. The

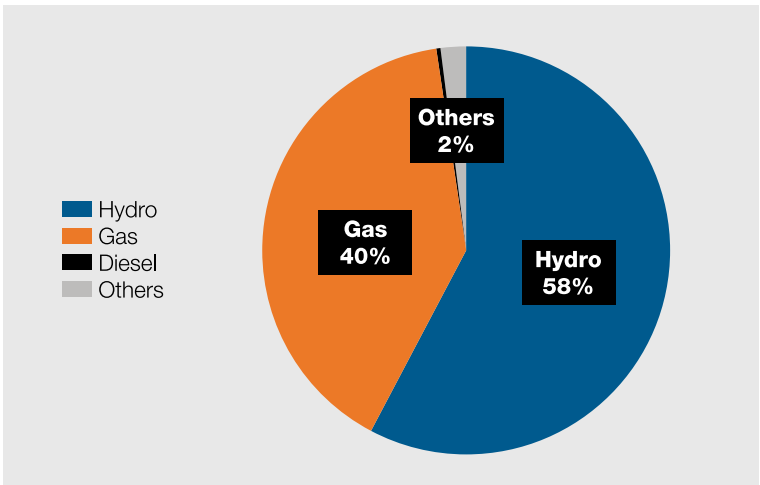


Fig. 1 - Myanmar – total generation capacity. Source: Ministry of Electricity and Energy (MOEE) of Myanmar.

country also has large natural gas reserves, estimated at 11 trillion cubic feet (tcf), which is mostly extracted for export. As of November 2016, Myanmar’s total generation capacity was 5307 MW. Hydropower accounted for 58% of the total energy mix, followed by gas power (40%) and diesel (0.35%). Renewable technologies like wind, solar, bio-power and mini hydro accounted for the balance. (Figure 1)

But accumulated delays in investments in power infrastructure, over-reliance on seasonal hydropower production and a rapid increase in electricity demand (tripled over the last decade), with limited new investments into new generation capacities, have resulted in large electricity shortages in the country. Industries and factories that are tenants in Myanmar’s Industrial Zones cannot solely rely on the national grid and are therefore willing to pay a premium for high-quality utilities with high availability because interruptions could lead to significant financial losses and result in higher costs in the form of penalties from end-buyers and logistics providers.

Industrial parks

Myanmar has a total of 33 industrial areas (19 industrial zones with Yangon North and East Zones divided into 14 areas functioning as independent zones) that are either planned or currently under construction. According to the Directorate of Industrial Supervision and Inspection Department (DISI), approximately 11,000 registered firms exist within the industrial zones, with 56% located in Yangon zones alone and an additional 12% in Mandalay, which have access to significantly larger markets and a greater supply of labour. (Figure 2)

Traditionally industrial zones / parks have leased land to tenants who need to individually arrange for utilities for themselves via a combination of the national grid and their own on-site high-speed diesel engines. This set-up requires industrial tenants to make large individual investments

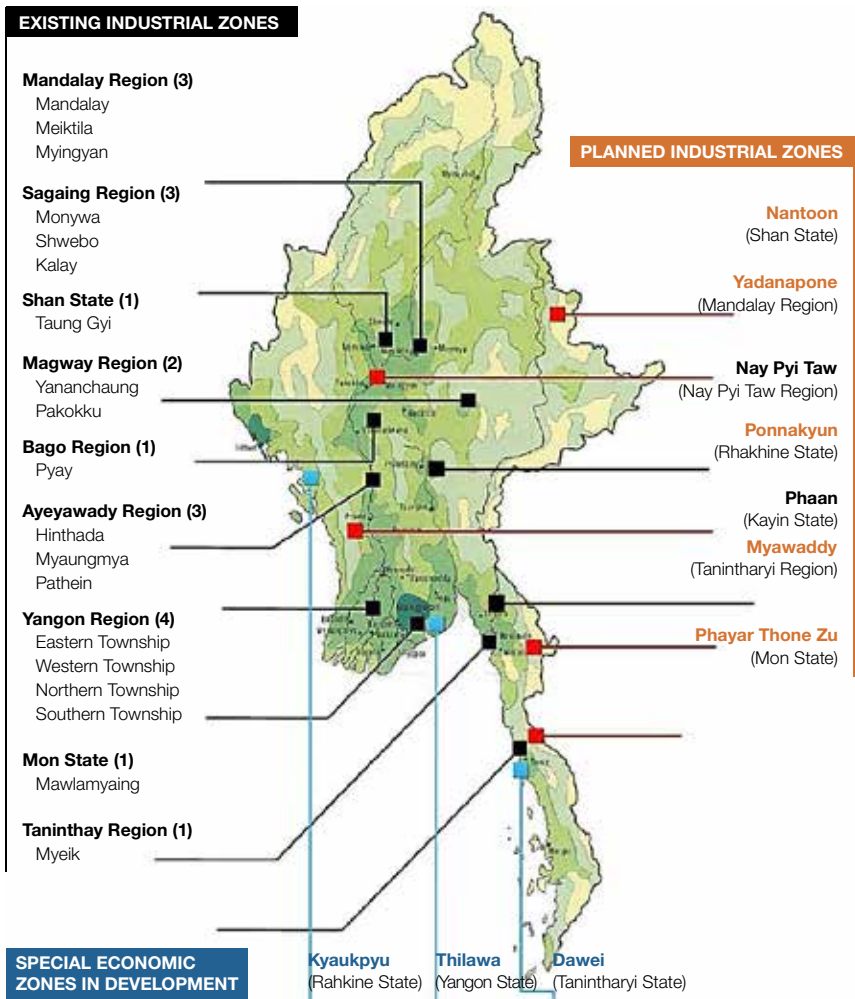


Fig. 2 - Location map of existing and new industrial zones in Myanmar. Source: Department of Urban Housing and Development, Ministry of Construction: Myanmar Major Industrial Zones and Development Plan.

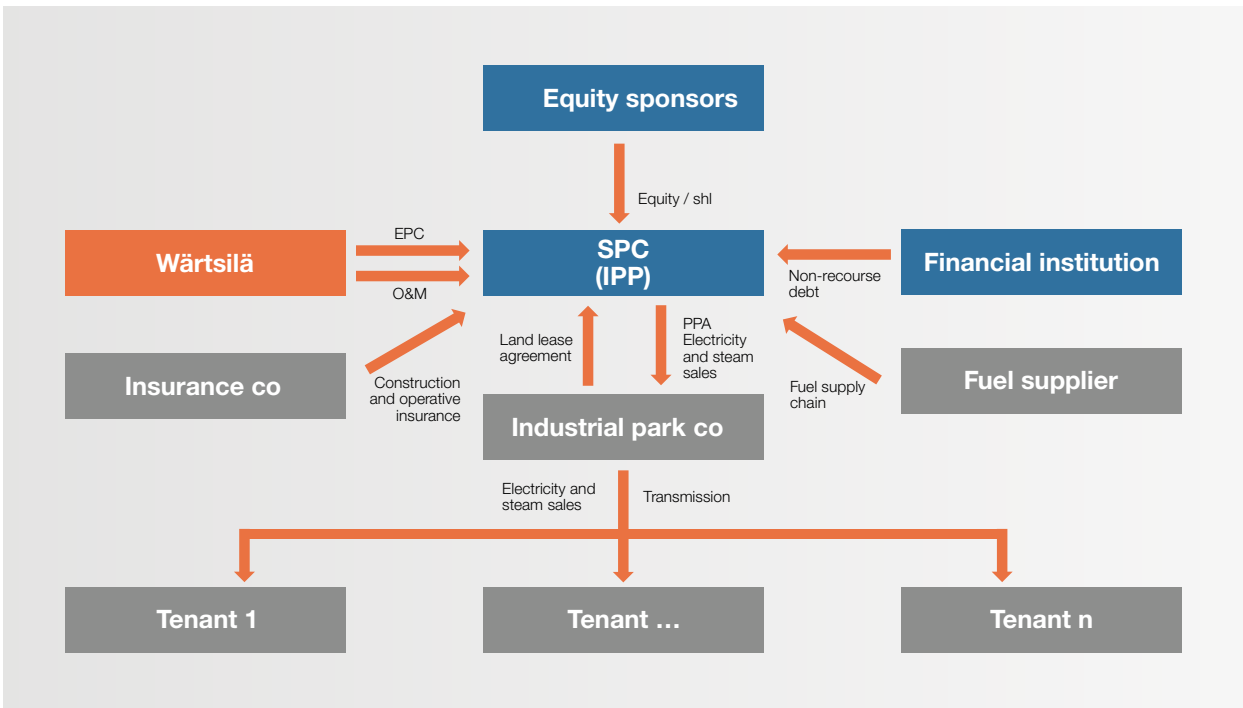


Fig. 3 - Typical IPP structure for an industrial park power project.

in utilities, leading to limited economies of scale in the case where assets are not shared between tenants. This drives them to invest in low-efficiency assets with a high life-cycle cost to avoid high up-front investments, and it has a higher environmental impact.

But now some industrial parks are willing to make investments into providing centralised high-efficiency assets to supply “utilities as a service” along with providing land for tenants. As this means a higher capital cost for development, a classic chicken-and-egg situation has arisen where on one side the industrial park starts constructing the required infrastructure for utilities only after garnering a sufficient number of tenants to support the economics of the investment. And on the other, the tenant has a “wait and watch” approach until the industrial park has constructed or started construction on utility assets.

In focus: Flexibility & cogeneration solutions

Flexibility in scaling up utilities can play a big role in solving this problem. It can equip industrial zones to make smaller initial investments in the utility asset capacity

and allow future extension in capacity in line with growth in the number of tenants. For example, an industrial park can first invest in a 30 MW power plant, and as the number of tenants grows it can extend the generation capacity to 60 MW and eventually to 100 MW.

The other option is for industrial parks to reduce their investment burden in utilities by outsourcing it to third-party private investors who can arrange for the required funds, enter into a long-term commercial arrangement with the park and charge it a fee for making utilities available. Since power generation is usually the largest investment in utilities, it makes sense to consider an Independent Power Producer (IPP) model where a Special Purpose Company (SPC) would invest, construct, own and operate a captive power plant within the park and provide electricity (and potentially steam) to it under a long-term Power Purchase Agreement (PPA). The industrial park could then distribute and sell the electricity and steam to the tenants of the park. (Figure 3)

This structure allows for the use of

non-recourse project financing and is conducive for raising debt to leverage the project and reduce the tariffs. It is also a beneficial way to allocate specific risks to parties most suited to manage them.

Diversifying risks

The industrial park manages the electricity and steam transmission risk, credit risk of the tenants and the off-take risk for arranging sufficient amounts of tenants; the engineering, procurement and construction (EPC) contractor manages the construction risk and guarantees the initial performance of the power plant; the operation and maintenance (O&M) contractor guarantees the availability and performance of the power plant during operations and throughout the lifecycle of the asset; the fuel supplier manages all the risks associated with transporting fuel in an agreed upon quality and quantity; the insurance company insures the IPP against machinery breakdowns, property damage, loss of revenue and terrorism risk and tenants manage the pricing risk of electricity and steam.

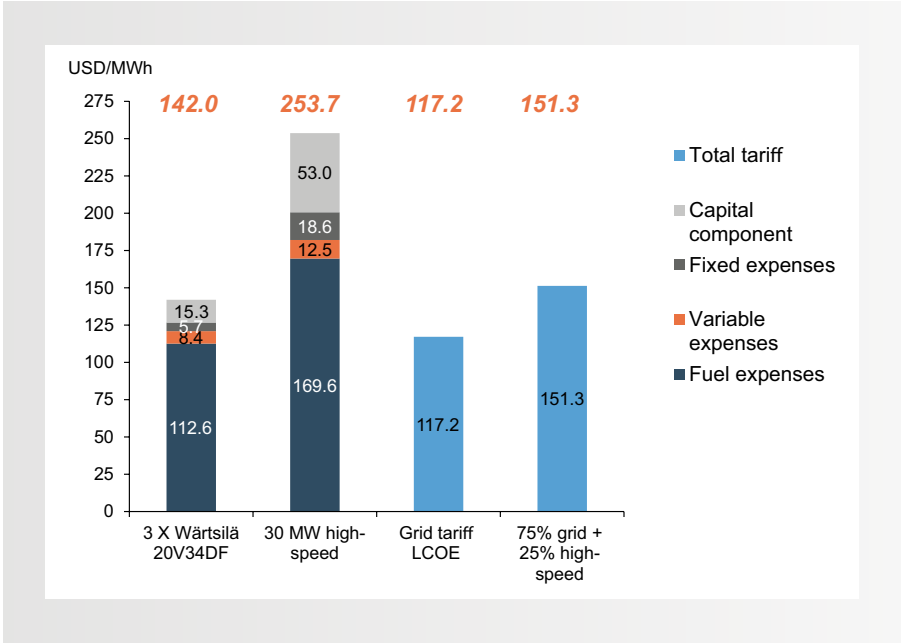


Fig. 4 - The LCOE of the 30 MW power plant.

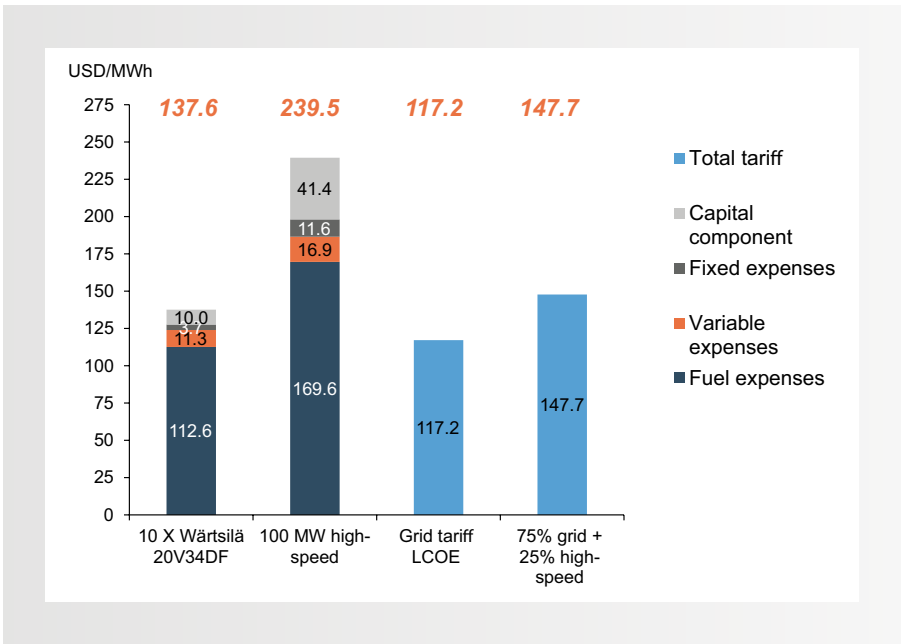


Fig. 5 - The LCOE of the 100 MW power plant.

In this structure, the electricity tariff is linked to inflation and fuel price indices and all costs are passed through to the tenants. The IPP model for a captive power plant with medium-speed combustion engines is optimal for ensuring uninterrupted power supply.

Traditionally, industries have relied on the national grid and used high-speed diesel engines as back-up power when the national grid is not available. However, it is more commercially, economically and environmentally feasible to use medium-speed engines as the main source of power for industrial parks and use the national grid as the backup power option. This method could help increase the lifetime of the power asset to 25–30 years, help increase power generation to 41–45% depending on the fuel used and site conditions, and allow for the use of less expensive and more environmentally sound fuels like natural gas and biofuels.

Even though the initial investment is higher for a medium-speed engine, the life-cycle cost will be decreased as the performance of the plant is significantly improved. Due to the modular design and 10–20 MW unit size of the medium-speed engines, the power plant can be extended in 10 MW blocks, allowing the power capacity to grow with the tenant growth of the industrial park. The plant can use dual-fuel engines capable of running on liquid fuels or natural gas, or else liquid fuel engines can be converted to run on gas at a later stage. Heat recovery boilers can be used to produce steam from the excess heat produced by the engines while generating electricity. Through fuel choice and higher efficiency, the emissions of the power plant are decreased.

Wärtsilä 20V34DF engines vs high-speed engines + national grid

To illustrate this let's compare the Wärtsilä 20V34DF medium-speed engines of approximately 30 MW (three engines) capacity running on heavy fuel oil

General assumptions applicable to all scenarios				
General assumptions		Financial	Medium-speed engines	High-speed engines
FX rate, USD/EUR	1.18 USD/EUR	Debt	70%	70%
Construction time	12 months	All-in Interest rate	7%	7%
Corporate income tax	25%	Repayment term	12 years post-construction	4 years post-construction
Grid electricity price	81 USD/MWh	Equity IRR target	15%	15%
Escalation of the grid price	5%	Lifetime of the asset	20 years	5 years
Steam price	20 USD/tonne			
Fuel assumptions				
HFO price	500 USD/tonne			
LFO price	690 USD/tonne			
Lube oil cost	3 USD/kg			
Fuel scenario	3 x Wärtsilä 20V34DF	High-speed diesel	10 x Wärtsilä 20V34DF	High-speed diesel
Plant performance				
Plant net capacity	29 MW	29 MW	95 MW	95 MW
Plant net heat rate	41%	35%	41%	35%
Steam production	11 tonnes/hour	0 tonne/hour	36 tonnes/hour	0 tonne/hour
Total capacity factor	90%	22.5%	90%	22.5%
Operational assumptions				
Variable O&M	6 EUR/MWh	9 EUR/MWh	6 EUR/MWh	9 EUR/MWh
Fixed O&M	53k USD/month	53k USD/month	130k USD/month	130k USD/month
Plant investment costs				
Total EPC cost EUR/kW	950 EUR/kW	250 EUR/kW	750 EUR/kW	225 EUR/kW

Table 1 - Assumptions table

(HFO) with a 90% capacity factor with a combination of the national grid and high-speed engines running on diesel where the engines contribute 25% of the electricity produced and 75% is sourced from the national grid, resulting in a 22.5% capacity factor. (Figures 4 and 5)

Assuming among other things that the industrial park operates on three shifts most days, the net capacity of Wärtsilä 20V34DF power plant with three engines would amount to 28.5 MW when running on HFO, and with 10 engines the net capacity would amount to 95 MW. The use of three

Wärtsilä 20V34DF medium-speed engines results in a total levelised cost of electricity (LCOE) of USD 142/MWh which is 6% less than the USD 151.3/MWh achieved with a combination of high speed engines (25%) and the grid (75%). (Table 1)

With dual-fuel (DF) Wärtsilä engines, the power plant can run on either liquid fuels or natural gas, and the engines can be immediately and seamlessly switched to run on gas or LNG. HFO is the most feasible liquid fuel as, on average, HFO is 190 USD/tonne less expensive than diesel and is compliant with the emission standards

of the World Bank and Myanmar's local regulations.

Due to modularity and the 10–20 MW unit size of the medium-speed engines, the power plant can be extended in 10 MW blocks, allowing the power capacity to grow with the tenant growth of the industrial park. So even though the initial capital cost investment into a medium-speed engine power plant is higher than the high-speed option, the life-cycle costs of the medium-speed plant are lower. Therefore, it is an optimal solution for Myanmar to power up its economy. ●



Bidding right at CHP auctions

AUTHOR: Sami Anteroinen

It is not electricity alone. Heating energy needs to become clean as well. In an award-winning paper, Wärtsilä Jan Andersson discusses the feasible bidding strategies under the new Combined Heat and Power (CHP) Act with the German CHP auctions as a case in point.

Electricity prices in Germany have been falling thanks to the growing use of renewable energy sources. To spur the transition towards a more flexible and

modern energy system, Germany adopted Electricity Market 2.0 in June 2016. Under this new electricity market system, which is designed to help the country make a smooth transition into renewables, the German Federal Parliament revised regulations under three main categories to reorganise Germany’s power system: the power market law, a capacity reserve decree, and a new law on the digitalisation of the energy transition. While these are new changes, the Combined Heat and Power (CHP) Act (Kraft-Wärme-Kopplungsgesetz, KWKG)

has been in place since 2002 and is another key element in making this energy transition successful. CHP plants generate heat and power simultaneously whilst keeping carbon emissions low. Thus, the German Federal Ministry for Economic Affairs and Energy has been incentivising investment in CHP installations with the aim of raising the level of CHP-based power generation. The Act is quite flexible, and the government has been revising it from time to time to give greater incentives to quicken the adoption of the technology. The

Traditional CHP	Innovative CHP
Technological specifications	
<ul style="list-style-type: none">No additional technological specifications	<ul style="list-style-type: none">CHP plants combined with renewable heat generation technologies and additional power-to-heat technology, i.e., CHP plants with heat pumps, solar thermal or geothermal energyShare of renewable heat at least 30% of the annual total heat production
Subsidies	
<ul style="list-style-type: none">Maximum €70/MWhLimited to 30,000 full load hoursSubsidy per year paid for a maximum of 3500 full-load hours	<ul style="list-style-type: none">Maximum €120/MWhLimited to 45,000 full-load hoursSubsidy per year paid for a maximum of 3500 full-load hours
Auction	
<ul style="list-style-type: none">75 MW of KWKG subsidy auctioned twice a year	<ul style="list-style-type: none">25 MW of KWKG subsidy auctioned twice a year

■ Comparison of the traditional and innovative CHP schemes.

latest amendments came in 2017 when the government decided to have an auction for innovative CHP systems. According to the ministry’s website, “This new category of funding is intended to open up promising new prospects for combined heat and power and to provide incentives for necessary investment in flexible technologies.” This offers great possibilities for German utilities, since an auction serves as a driver to enhance innovation and flexibility in CHP production. Jan Andersson, Market Development Analyst, Wärtsilä Energy Business, has studied the CHP auction scheme closely. In his paper ‘Flexibility is the New Black – How Flexibility Enhances Value in CHP Portfolios’, Andersson analyses three bidding strategies and explains how innovative and flexible technology adds value for utilities in this new market landscape. His work was awarded the Best Paper at Electrify Europe 2018 (formerly known as PowerGen Europe). Here are the highlights of his paper:

Uncertain CHP auctions

When the subsidy rates for traditional CHP plants of 1 MW up to 50 MW were auctioned for the first time in Germany, on 1 December 2017, a pall of uncertainty descended upon the participants before the auction. What results could be achieved through an auction? Which bidding strategy would be successful? And how could

the overall profitability of CHP projects be presented under these framework conditions? These were some of the many questions they worried about. The capacity of the first auction was 100 MW. With subsidy rates of up to EUR 70 / MWh, participation in the auction was attractive for many companies. Finally, the first auction was cleared at the range of EUR 32–50 /MWh for a total of 83 MW. Ever since, there has been an increasing interest among the participants to bid into the upcoming auctions. This is an interest that is also partly fuelled by the fear that the CHP subsidies could be discontinued in the future, and thus any investment needed for replacement or extension should be undertaken as soon as possible and under the regulations of the current CHP Act. The current KWKG Act aims to increase the co-generated power generation to 110 TWh in 2020 and to 120 TWh by 2025. The central instrument here is the auctioning of KWKG subsidies for the generation of CHP electricity.

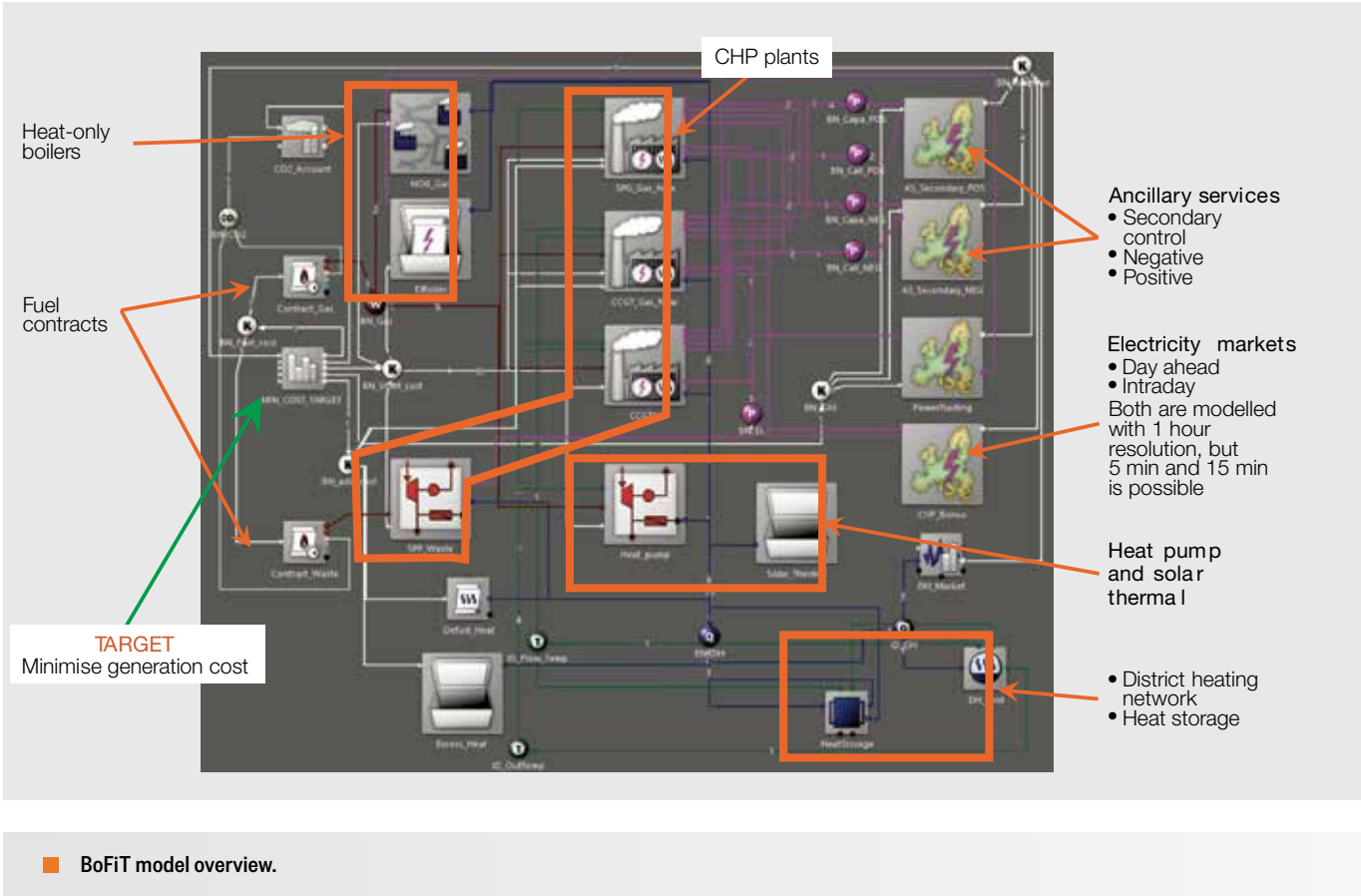
Everything but coal

Participation in the tender is compulsory for all new and modernised CHP plants with an electric CHP capacity between 1 MW and 50 MW. However, a transitional provision stipulates that facilities that were ordered in 2016, or have been granted a permit in

accordance with the Federal Immission Control Act (BImSchG) and were to be put into operation in 2018, are eligible to participate in the tender procedure. The promotion of CHP power generation is basically possible for all fuels except coal. This means that CHP plants, such as biomass-based (solid, liquid, gaseous) or waste-based plants, as well as gas-based CHP plants, are eligible to participate in the auction. The auction distinguishes between traditional CHP and innovative CHP schemes. The auction held in December 2017 only considered traditional CHP, whereas the auction in June 2018 also included innovative CHP schemes.

Traditional versus innovative

Let’s start with the traditional CHP scheme. This focuses on the CHP performance of fuel-fired plants, which is similar to the guaranteed CHP scheme for plants larger than 50 MW. No additional technological specifications are made for this scheme. The legal framework provides for a maximum CHP bonus of EUR 70 /MWh to traditional CHP plants. In addition, subsidies for conventional CHP plants are limited to a total of 30,000 full-load hours. Also, twice a year, 75 MW of KWKG subsidy is auctioned under the traditional CHP scheme. The innovative scheme, on the other hand, includes CHP plants that are combined with



renewable heat generation technologies and additional power-to-heat technology. These are CHP plants that combine heat pumps, solar thermal or geothermal energy. Here, the share of renewable heat must amount to at least 30% of the annual total heat production from the plant.

For innovative CHP systems, the maximum subsidy rate is EUR 120 /MWh and this subsidy is limited to 45,000 full-load hours. Twice a year, 25 MW of KWKG subsidies is auctioned under the innovative CHP scheme.

In addition, there is an annual limit for the subsidised amounts of energy. To encourage more flexible plant operation, the subsidy is paid for a maximum of 3500 full-load hours per year.

Herein lies an optimisation challenge: the plant should run for only 3500 hours during the year with the highest electricity prices. However, it does not mean that the plant cannot be operated after reaching this annual limit of full-load hours. It only means that these excess operating hours will not be eligible for a subsidy.

Select the right strategy

This is where choosing the right strategy comes into play.

Before bidding on the auction, a bidding strategy should be worked out. The art of an auction strategy lies in finding a bid level for the project that accurately reflects the return versus risk appetite. However, this should not be a decision based on gut feeling. Instead, it should be anchored on a sound analysis of the energy market.

There are no simple strategy recommendations. An individual strategy development that includes the following three factors is necessary:

1. **Successfulness:** It is necessary to realise that the project plays an important role, that is, there is a need to replace an existing CHP plant or increase capacity in order to maintain the heat supply of customers.
2. **Risk appetite:** The risk preference differs from bidder to bidder and from project to project. Certain companies will be prepared to accept a lower probability

of success if the expected return is favourable, while others may not.

3. **Competition:** Not only the costs of your own project are relevant, but also the costs and bid strategies of your competitors. This requires an analysis of which projects might be included in the auction round and at what cost. Once an assessment of the above-mentioned topics has been done, a promising bid strategy can be defined based on an optimised bid markup and the probability of winning.

The math behind the bid

In a 'pay-as-bid' auction, every successful bid receives the amount with which it went to the auction. Therefore, the optimal bid is the one that is as close as possible to the last bid still to be cleared. Thus, unlike the pay-as-cleared method, pay-as-bid auctions require strategic bidding behaviour.

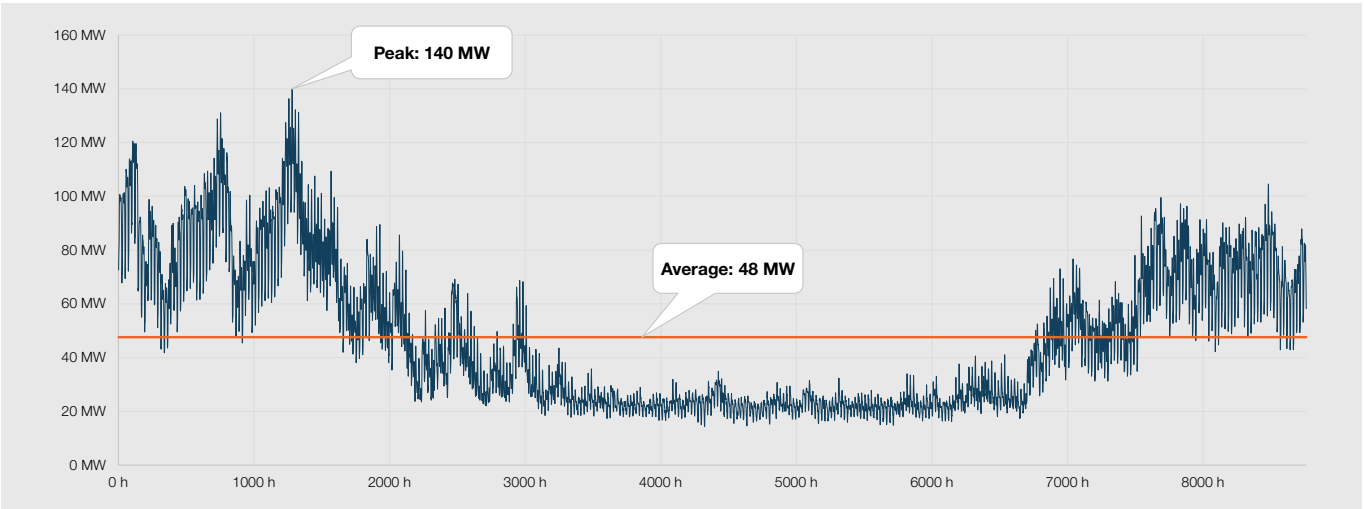
However, since no bidder knows the marginal price at the time of participation, there is an inevitable trade-off: the higher the bid, the lower the probability of winning

Asset	Traditional 10 MW Peaking	Traditional 50 MW Peaking	Innovative 10 MW
Heat demand (peak)	30 MW _{th}	140 MW _{th}	30 MW _{th}
Waste (MHKW)	12 MW _{th}	37 MW _{th}	12 MW _{th}
Gas boiler	30 MW _{th}	140 MW _{th}	30 MW _{th}
Heat storage	100 MWh _{th} 20 MW _{th}	400 MWh _{th} 65 MW _{th}	100 MWh _{th} 20 MW _{th}
Engines	1 x Wärtsilä 20V34SG 9 MW _{th}	5 x Wärtsilä 20V34SG 48 MW _{th}	1 x Wärtsilä 20V34SG 9 MW _{th}
Solar thermal	-	-	10 MW _{th}
Heat pump	-	-	8 MW _{th}

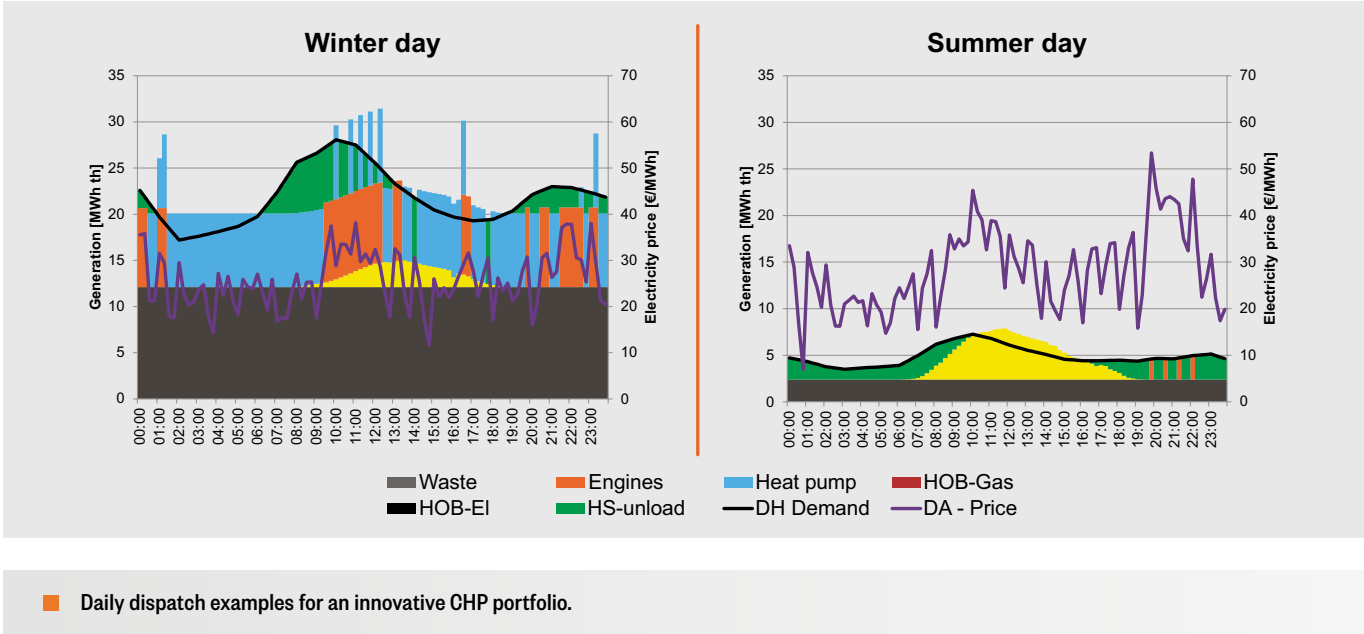
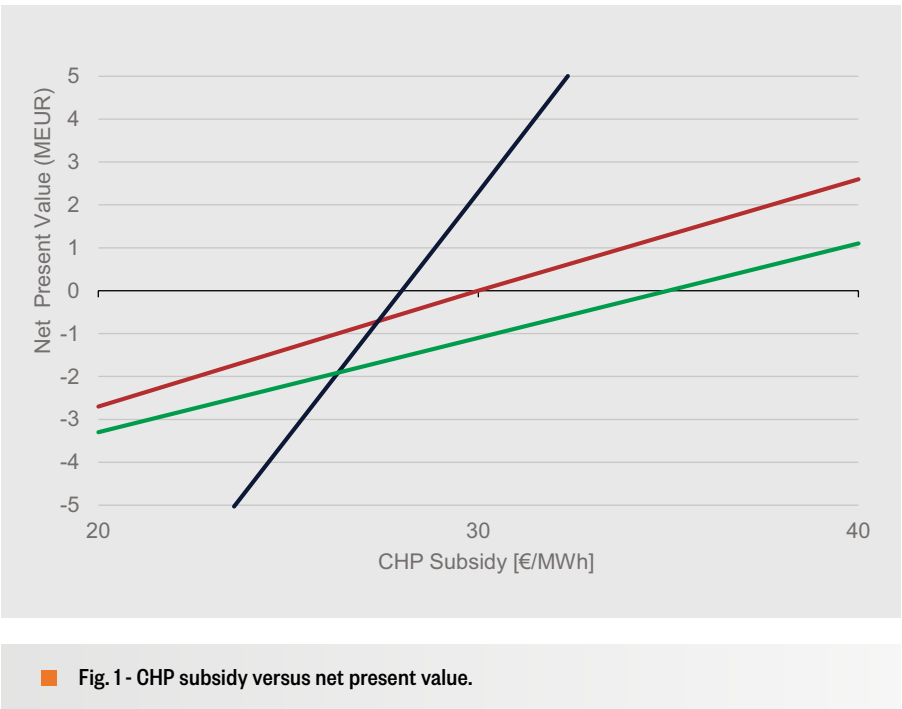
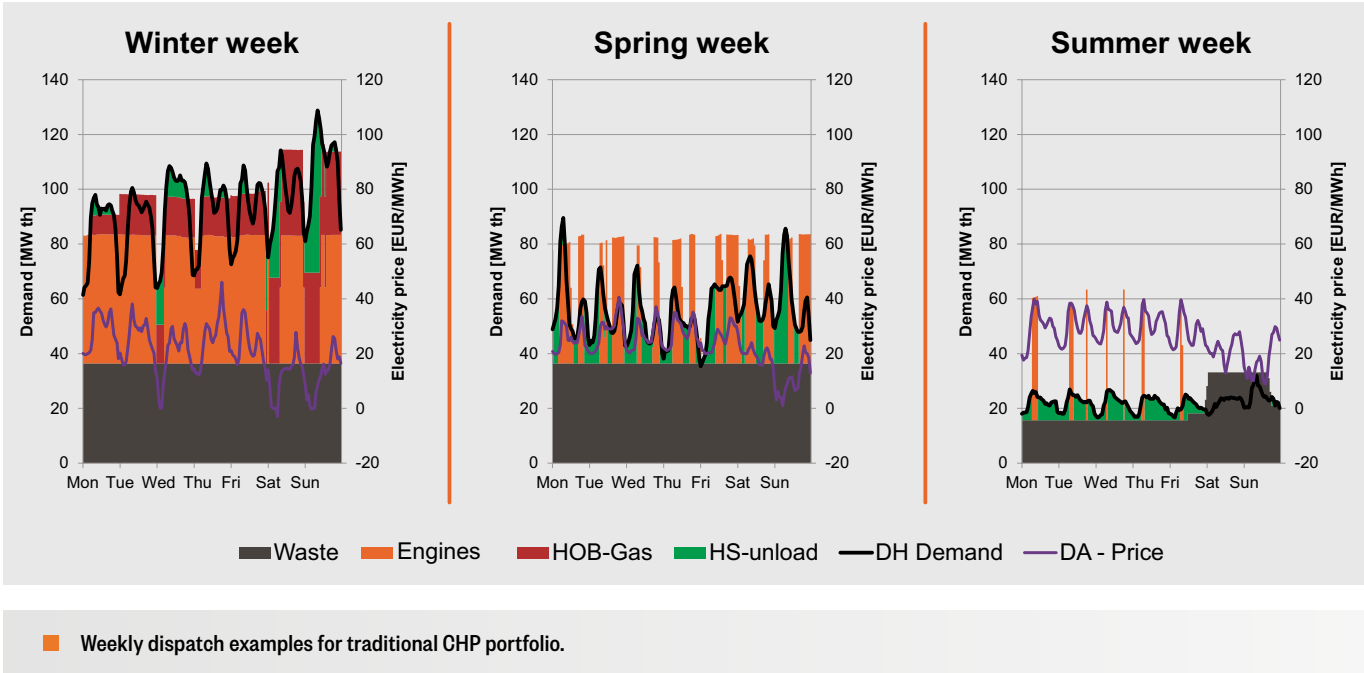
Overview of modelled scenarios.



Investment-related parameters.



District heating demand profile for the large case.



but better profitability in the event of a successful bid.

Traditionally, the successful approach to pay-as-bid auctions has been to determine the bidding strategy in two steps. First, determine the minimum bid, or the so-called indifference price. Second, determine whether it makes sense to bid above the indifference price, also referred to as the strategic bid markup.

The indifference price is the bid price at which the bidder does not care whether he or she wins the bid or not. The basis for determining the indifference price is formed by accurate estimates of cost, revenue and risk structure of the project. Auctions mean competition, and any competitive advantage can be converted into a higher probability of winning or obtaining better project returns. Therefore, accuracy is very important here.

One of the main factors in setting the indifference price is cost, especially investment cost, which can be determined relatively accurately, but the critical point here is to consider the full scope of the project. The second part is determining a risk-adjusted minimum return for the project. It is often seen that most internal discussions are around this topic, since the operation of a CHP plant is not a risk-free

business. Even if the CHP subsidy is safe, technical risks and the electricity price risk remain.

Hence, the next natural step is to make an estimate of future market developments: electricity price, gas price, heat revenue and other variable factors.

It is important to make the decision-making process and calculations to arrive at the indifference price as objective as possible. It is also important to keep in mind the internal interests of the company and, if necessary, include a third-party perspective. If all of the above points are taken into account carefully, the result is a neutral indifference price.

Lessons learned

What is the overall picture of the profitability of the plants? Figure 1 shows the determined break-even CHP subsidies of the plants. The point where the lines intersect the X-axis is the “break-even CHP subsidy rate”.

Overall, the level of subsidy rates required is low. The plants considered here, larger gas engine power plants, can hence be very competitive in the auction.

The level of subsidy required for traditional plants is in the range of EUR 25 to 30 /MWh. The bigger plants tend to have

lower break-even rates; that is, they have a lower need for subsidies. This is due to the lower specific investment and operating costs of the plants.

For the innovative scheme, the break-even value lies at approximately EUR 35 /MWh, which is less than what could be anticipated considering the small size of the plant and the additional capital cost of solar collectors and heat pump. However, the longer eligibility period of 45,000 full-load hours is one obvious explanation. In addition, a couple of conclusions can be made based on the result.

One, the inclusion of renewable heat generation equipment gives more flexibility even to the heat generation side. This gives the opportunity to optimise heat generation irrespective of electricity production.

Two, despite the positive effects of renewable heat generation assets, the related investment cost still outweighs the benefits. However, decreasing investment costs and increasing emission costs could change this rapidly.

Going forward

The first auction held in December 2017 cleared in the range of 32 to 50 EUR/MWh with two plants greater than 30 MW capacity. After analysing the results of the

December auction, it is clear that the above method picked the low end of the subsidy rate and tends to favour larger projects over smaller ones. The higher end of the interval is clearly below the maximum of EUR 70 /MWh, which is also an indication that the bidders did more than speculative bidding.

Since KWKG does not include any fuel switch premiums for coal replacement projects in the auction segment, the economic effects of this additional remuneration were not taken into consideration. However, it is apparent in the market that many projects are attempting to project larger systems (greater than 50 MW) and thus obtain the fuel switch premium outside of the auction segment.

The heating sector is often overlooked when discussing emissions and reduction targets. The fact is that the generation of heat in Germany accounts for roughly the same amount of CO₂ emissions as electricity generation. Therefore, the initiative to include renewable heat generation as a special segment in the KWKG shows the will of the German government to reduce emissions in the heating sector as well. Even though renewable heat generation technology still requires higher investments, it is pointing towards a new, more environmentally friendly future for CHP. ●



Photo: iStock

Flexible energy solutions clear the way for renewables in the UK

AUTHOR: Anne Salomäki

Flexibility is key in making the move to renewable energy sources. In the UK, which has traditionally been heavily dependent on fossil fuels, Wärtsilä's solutions help boost the transition to a greener future.

Half-time of a football match between the two top teams in the Premier League, or a commercial break during the season finale of 'Coronation Street'. Those who've stayed put in front of their tellies return to their

earthly needs: getting a snack, switching on the kettle to enjoy their afternoon cuppa, or flushing the loo.

This is known as 'TV pickup' in the UK: a large number of people glued to the same TV show taking advantage of the breaks to operate all kinds of electrical gadgets and use toilets. However, it's not the only event that puts extra pressure on electricity networks. Sudden surges and mass switch-offs happen for other reasons as well, all of which the electricity and gas transmission

system needs to be prepared for.

"It's impossible to precisely forecast the demand for electricity at all times, and that's why flexibility is of utmost importance," says Jan Andersson, Market Development Analyst at Wärtsilä Energy Business.

"The networks need sources that can be ramped up quickly, which is not possible with nuclear or coal."

This is particularly the case with fluctuating renewable energy, such as wind and solar power. There might not be enough

wind or sunshine to meet the need during peak hours, or renewable energy production has to be limited due to lack of flexibility if the energy is not stored effectively. There can also be weather forecast errors or delays in expected weather conditions.

Centrica backs up wind and solar

One way to balance the grid during peak times is to have power sources that can be switched on rapidly to ensure that the country doesn't shut down. Wärtsilä has been involved in a project by energy and services company Centrica, which has two 50 MW power plants based on five Wärtsilä 34SG engines, running on natural gas. Wärtsilä has the overall role in the project, covering engine supply as well as plant engineering, procurement and construction.

The plants, located in Brigg in North East Lincolnshire and Peterborough in Cambridgeshire, can provide electricity for about 100,000 households in less than two minutes after they've been switched on. Upon completion, the plants will be the biggest medium-speed, engine-based gas power plants in the UK, bringing Wärtsilä's installed capacity in the country to over 250 MW.

"This way, we can support surges in electricity demand or fill the gap when solar or wind power is unavailable, stabilising the grid whenever needed," says Bent Iversen, Senior Business Development Manager at Wärtsilä.

Mark Futyan, Distributed Power Systems Director at Centrica Business Solutions, deems flexibility critical to keeping the grid stable and balanced. Thus, Centrica's strategy focuses on meeting the new challenges of providing and ensuring stability.

"As we're going to have more and more renewable and distributed energy, we must have sources of flexibility on the system to be able to control the frequency," he notes. "The under-two-minute start-up time is a rare feature and very important to the UK grid."

Bye, coal. Hello, renewables!

Britain's heavy reliance on coal stems from its industrial past. The country's coal production increased remarkably throughout the Industrial Revolution to feed, for example, steam engines.

"Just a few years ago, the dominant fuels

in the UK were coal, gas and nuclear," Iversen says. "However, as many of the coal plants are pretty old, they can't comply with new emission regulations anymore. In addition to the emission issue, the coal plants also have financial difficulties with low capacity fees."

By capacity fees, he refers to the government's Electricity Market Reform package. In 2014, the UK government introduced the Capacity Market, which aims to ensure a secure electricity supply by paying energy companies for reliable sources of capacity on top of electricity revenues.

For the government, the annual auction is a way to encourage the investments needed to replace old power stations as well as modernise the existing ones to ensure sufficient and reliable capacity that can back up intermittent renewables. In short, the government wants to provide the nation with reliable energy at an affordable price. Whether this governmental scheme incentivises the need for flexibility in the grid remains to be seen.

Flexibility brings down the bill

However, the competition can get fierce. Power companies look at day-ahead markets, intraday markets and ancillary service markets in calculating their bids – and the ones that are not cleared in the auction will be automatically dropped out.

According to Andersson, the high interconnector capacity in the latest auction was one of the main reasons for the low clearing price, and what happens in the next auction depends on the number of interconnectors that enter the auction.

Whatever the end result is, the need for flexibility isn't going away; the government has committed to increasing the share of renewables in the grid, not least because of the Paris Climate Agreement

The steps towards more sustainable alternatives have been significant: in 2017, the UK saw the greenest year in its history in terms of energy generation. The government also aims to shut down all of its remaining coal power stations by 2025. Andersson points out, though, that if the auction prices remain low, the Capacity Market might force the plants to be decommissioned even sooner.

Andersson says that the country will simultaneously increase its gas capacity to supplement the remaining nuclear and coal plants when renewable generation is low.

"The focus is on renewables, but gas will be used to bring needed flexibility to the system," he explains.

Flexibility also helps avoid peaks in electricity prices, which is good news for end users. As there should always be sufficient energy at hand, the price won't jump as high as it would without flexible resources being fed to the grid when the demand goes up.

Demand response lends a hand

Despite big developments in the renewables sector, both Iversen and Andersson believe that the UK will remain dependent on fossil fuels for quite some time. The best way to speed up the transition is boosting flexibility in power systems and energy storage opportunities. The UK has also increasingly begun to utilise demand response, meaning that consumers are encouraged to reduce or shift their energy usage during peak hours with financial incentives.

"Demand response is definitely a growing trend," says Andersson. "As more and more people get involved, the effect it has on energy consumption patterns will be much more noticeable, too."

Another point Andersson makes is that as the energy efficiency of the UK's housing improves, heating buildings and homes will no longer eat up as much energy reserves.

"Attempting to reduce the carbon footprint of housing with efficient solutions has been trending in other markets as well, so it's likely that the UK will follow suit."

Iversen sees that the developments in energy storage technology will provide new means to respond to sudden surges in electricity demand or failures in ongoing production.

"Energy storage technologies and advanced energy management software will become an inevitable part of the power system in shifting and optimising energy within the day. For years to come, there will also be a need for gas-powered plants and other flexible generation to ensure power system reliability when renewable energy is not available." ●



Wärtsilä 14: lighter, smarter and greener

AUTHOR: David J. Cord

The new engine in Wärtsilä's smart marine solutions range is compact, cost-efficient and more sustainable. It also comes with an improved load-taking capacity and safety features.

Compact, fuel-efficient and sustainable are the top three adjectives to describe Wärtsilä 14 engine, the latest addition to the company's fleet of advanced, high-speed range. Unveiled at the International Workboat Show in New Orleans, USA, that took place between 28 and 30 November

2018, this new product is designed to excel in its power-to-weight ratio aspects. This means it is designed to fit requirements for limited space and weight in order to maximise space for cargo.

"Having the Wärtsilä 14 engine in our portfolio enables us to offer an even wider solution range, which greatly improves the total efficiency," says Janne Klemola, Product Director, Wärtsilä Marine Business. "The market is rapidly changing, and customers demand that we maximise the overall performance of the whole solution, improve safety and advance environmental sustainability." And this new engine checks all the above boxes.

The Wärtsilä 14 engine has been developed in collaboration with the Liebherr Group, a Switzerland-based company that specialises in land-based applications for their large engine products.

"Collaboration with Liebherr began to deepen when we started to develop this engine," says Tomi Kaarniemi, Product Manager at Wärtsilä Marine Business. "We are very excited at what we've accomplished together."

Petite powerhouse

Technologically speaking, the Wärtsilä 14 comes in 12- and 16-cylinder configurations, with a power output between 755 and 1340 kWm in mechanical propulsion and 675–1155 kW_e in an auxiliary generation and diesel-electric propulsion.

The engine is lighter and more compact compared to others in the market, so it saves space and weight in the ship. Its load taking capability is much better compared to medium-speed engines, so it has a fast start and performs better in harsh environments. It is also equipped with the Wärtsilä UNIC automation system modules for monitoring and improved safety.

"There is a huge business potential for



■ Wärtsilä HY Tug 40.



■ Wärtsilä HY Tug 40.

such an engine in this power range,” says Klemola. “If you visit a harbour you might see many ships working around the piers that would be perfect for the Wärtsilä 14, such as tugs, fishing boats or smaller sea-going vessels. The engine also fits auxiliary power generation requirements for merchant ships like container carriers or tankers.”

The Wärtsilä 14 fits those applications that require small high-speed engines: smaller vessels using cleaner fuels on the lower end of the power range, such as the new Wärtsilä HY Tug 40. The shallow-draft tug includes two Wärtsilä 14 engines and a hybrid propulsion system that delivers flexible operating modes, such as one for zero emissions.

“The Wärtsilä HY Tug 40 is really a fantastic showcase for us,” explains Kaarniemi. “We designed the entire ship and propulsion system.”

A prudent choice

Apart from being technologically advanced, the Wärtsilä 14 engine comes with improved cost-efficiency.

“The industry is moving towards cleaner and lighter fuels, so the time is right for the high-speed Wärtsilä 14,” Klemola continues. “One major innovation is the Digital Fuel Injection system which is optimised to operate on marine distillate fuel oils. We want to ensure that our product portfolio delivers the best possible value to our customers”

“Another major customer advantage

is the investment cost,” says Kaarniemi. “The Wärtsilä 14 is designed to be cost-competitive, and thanks to its fuel efficiency, it helps us to be very competitive through the whole lifetime of the machinery compared to other high-speed engine makers. We’re convinced that customers will be very pleased with the benefits they receive and the low total cost of ownership.”

For future needs

The engine is more than just a high-speed, technologically advanced machine. It is designed for the future, designed to be environmentally sustainable.

The engine follows Wärtsilä’s vision of the green ships of the future and complies with global environmental regulations.

The Wärtsilä 14 engines are supplied with Wärtsilä’s innovative system to reduce nitrogen oxide emissions. The Wärtsilä NOx reduction (NOR) system is optimised for the Wärtsilä 14 and maximises the overall performance of the engine and exhaust gas cleaning system.

The new engine is an important addition to the company’s smart marine portfolio, broadening Wärtsilä’s offering and providing its customers with a wider range of options.

Also, the services aren’t limited to just providing engines. The company offers many more solutions and hybrid installations, including complete packages from in-house design, manufacturing, project management services and life-cycle support. “We are able to deliver and support

engines, propulsion systems, generators, exhaust gas treatment systems, automation and hybrid systems – in other words, the whole machinery,” explains Klemola. ●

Wärtsilä 14 specs		
Cylinder configuration	12V	16V
Nominal power (kWm)	755-1005	1005-1340
Nominal power (kW _e)	675-865	900-1155
Nominal speed (rpm)	1500-1900	1500-1900
Bore (mm)	135	135
Stroke (mm)	157	157
Engine displacement (L)	27	36



The new age Propulsion Condition Monitoring Service: Key to predictive maintenance and optimal uptime

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When Wärtsilä's Propulsion Condition Monitoring Service (PCMS) was launched in 2010, it was first of its kind. The latest version of the service is a state-of-the-art tool designed to facilitate preventive maintenance and help maximise uptime for Wärtsilä's customers across the globe. Here's a closer look at the offering.

The Propulsion Condition Monitoring Service (PCMS) is Wärtsilä's Condition-Based Maintenance (CBM) solution for propulsion equipment. By carrying out measurements of critical parameters such as vibrations and oil condition, as well as

operational parameters including steering angles, rotational speeds and pitch angles, the Wärtsilä PCMS provides customers with real-time advice and periodic reports on the condition of their machinery, as well as crucial information for maintenance planning.

Since its launch in 2010, the Wärtsilä PCMS has been successfully installed on hundreds of applications. Late last year, Wärtsilä released a new, more cost-effective version of the solution, based on third-party hardware, featuring even higher-quality vibration data and reduced on-site maintenance requirements.

Why do customers need the Wärtsilä PCMS?

The PCMS enables Wärtsilä customers to improve the availability, reliability and profitability of their vessels while reducing risks and maintenance costs. By monitoring and analysing the parameters that affect the condition of the propulsion equipment, Wärtsilä's experts can predict an upcoming failure and also advise customers on the best action to take to mitigate its impact.

The Wärtsilä employees responsible for analysing the data produced by the PCMS have extensive experience and in-depth knowledge of both the propulsion equipment itself and the operational context in which it is used. Once a problem is detected, Wärtsilä will not only make the customer aware of the issue but also provide expert advice on how to address the problem and minimise operational disturbances. For example, this might involve reducing the load on the thruster in order to complete an ongoing voyage and scheduling maintenance once the vessel reaches a port.

To make optimal use of the PCMS and other CBM equipment of this kind, they are best combined with a long-term Wärtsilä service agreement. This allows Wärtsilä not only to detect a possible future failure but also to schedule and carry out the required maintenance in a way that minimises stoppages and costs and maximises uptime and operational efficiency for the customer.

Reliability of Wärtsilä PCMS

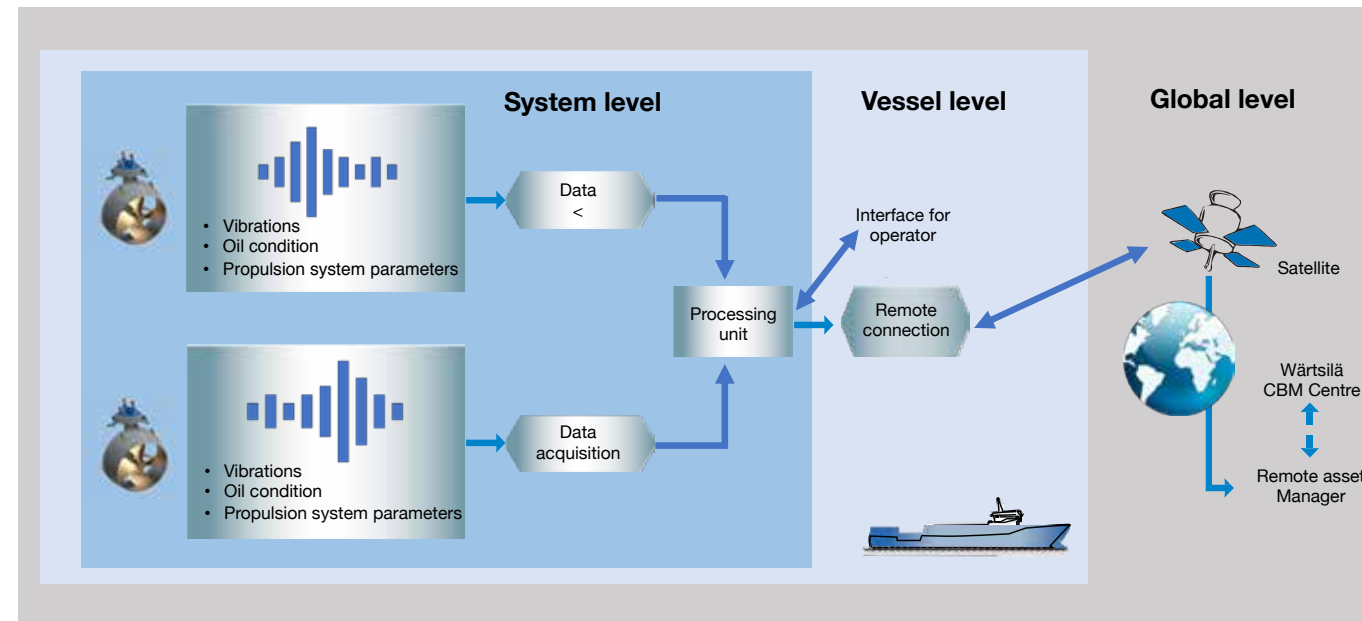
Wärtsilä is recognised as a Condition Monitoring service supplier by four of the world's major classification societies: The American Bureau of Shipping, Lloyd's Register, China Classification Society (CCS) and DNV-GL. These societies have acknowledged that the Wärtsilä PCMS can determine the condition of propulsion equipment and enable the extension of required visual internal inspections.

The exceptional reliability of the equipment enables Wärtsilä to carry out optimised maintenance, whereby service is only carried out when necessary and not according to a fixed, time-based schedule. The result is significantly extended service intervals and the reduction of both service-related costs and downtime. For example, a thruster may only require two overhauls over a 15-year life cycle, instead of three.

What's new?

Released in December 2018, the new version of PCMS, which is based on third-party condition monitoring hardware systems, is significantly more cost-efficient than the previous version of the solution. Customers who sign up for the new PCMS will obtain even better-quality vibration data. Moreover, the new system requires fewer software updates and less maintenance, thereby significantly reducing the need for on-site service.

The PCMS can be installed on all kinds of vessels and is available for both Wärtsilä and non-Wärtsilä propulsion equipment including transverse thrusters, steerable thrusters, electric pods, controllable pitch propellers, gearboxes and water jets. Going forward, Wärtsilä intends to expand the scope of its condition monitoring services to include all types of rotating equipment such as pumps, generators, electric motors and compressors. One of the major benefits of the new PCMS is that, unlike the previous version, which could only be applied to propulsion equipment, the new version has made it possible for this type of generic rotating equipment to be included in the scope.



■ Fig. 1 - The schematic overview of PCMS (Propulsion Condition Monitoring Service).

How does the Wärtsilä PCMS work?

Figure 1 shows the general layout of a vessel with two propulsors, which are both equipped with PCMS sensors and connected to one PCMS cabinet. The cabinet acquires and processes data from sensor readings and the propulsion control system according to the set operational parameters.

The data is processed on board and sent to an assigned technical expert at Wärtsilä. A dashboard (an optional feature) installed on the bridge or in the engine control room allows the operator to monitor the condition of the vessel's propulsion machinery using both real-time and trend data with advice available in case of irregularities.

The central PCMS server continuously processes the data and sends an immediate alert to Wärtsilä's certified experts if an issue arises. If daily follow-up is included in the PCMS agreement, a thorough analysis will be carried out the same day and, if abnormalities requiring immediate attention are detected, the CBM expert will inform the operator.

All Wärtsilä PCMS customers receive a periodic report detailing the latest findings and recommendations from their

propulsion monitoring. The report also describes the condition of the propulsion equipment, the recommended maintenance interval and advice for how best to keep the equipment in optimal condition.

The PCMS and Artificial Intelligence – what does the future hold?

The CBM systems we know today are based on sensors and techniques such as trend and vibration analysis. While they are effective, they rely on the engineering rules and their application is limited to specific failure modes. In short, every issue that needs to be monitored requires an engineer to design a rule to detect it.

Looking to the future, advancements in Artificial Intelligence (AI) and automation stand greatly to enhance the sophistication of CBM systems such as the PCMS. With the advent of Machine Learning (ML) technologies such as Google's TensorFlow, the world of CBM stands before a major paradigm shift. In the coming years, there is reason to believe that these systems will come to rely less on the rigid rules of engineering and more on the flexibility offered by ML algorithms. Holistic solutions

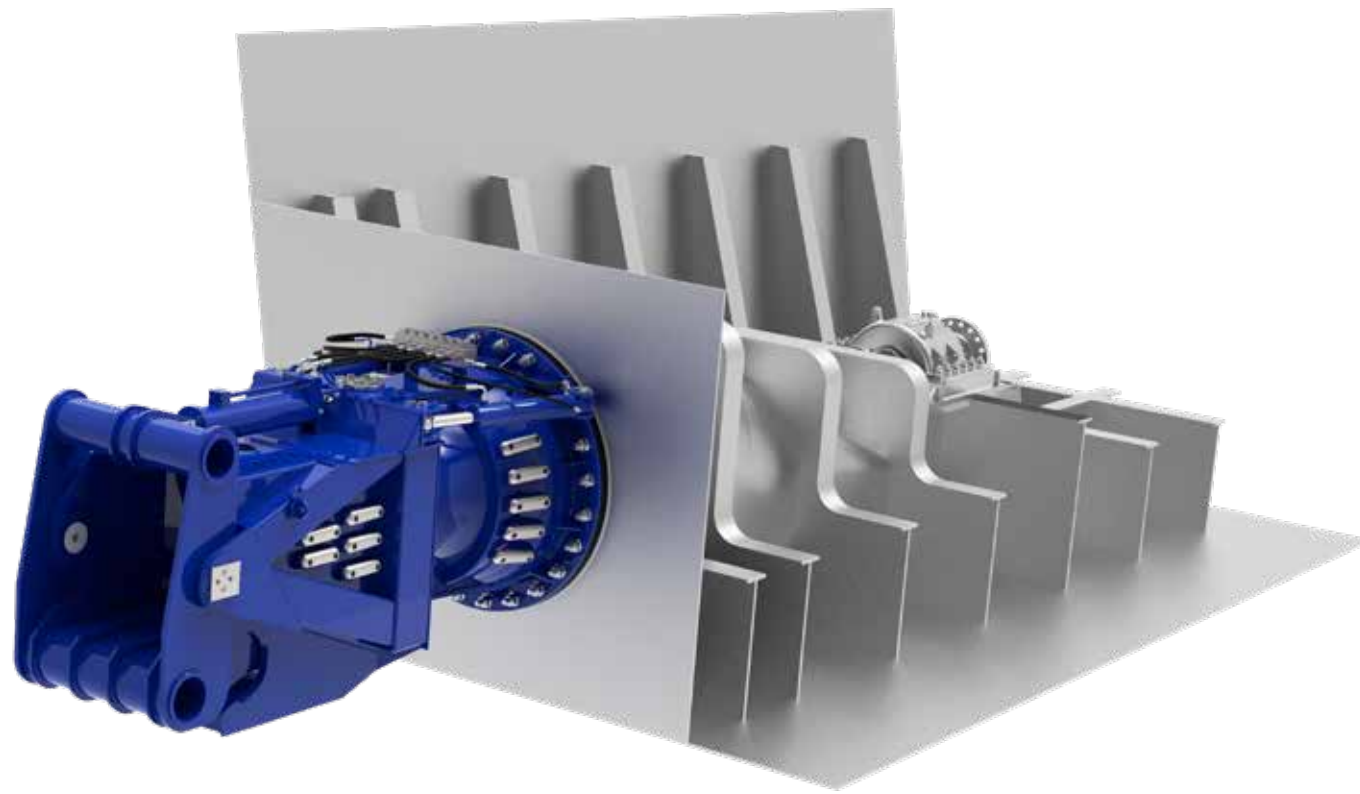
will replace point solutions and periodic reports will be a thing of the past, as real-time reporting becomes the new normal. Backed by the enormous processing power of AI, the ML algorithms will immediately and automatically analyse all incoming data, enabling human experts to dedicate less time to crunching numbers and troubleshooting, and more time to supporting customers, and delivering support and value-adding optimisations.

In short, AI will make us more proactive, helping us detect and solve problems more quickly and accurately. Customers of the future will be able to expect enhanced levels of service, more precise prediction of problems and faster planning and execution of preventive maintenance. The work that currently has to be carried out by humans will eventually only need to be supervised by humans, allowing Wärtsilä to provide a faster, more reliable service than ever before. ●



The Wärtsilä PCMS enables ship owners and operators to:

- Base operational decisions on the actual condition of their equipment
- Maximise the availability of their vessel by performing overhauls only when needed
- Reduce the likelihood of breakdowns by being proactively informed of faults
- Increase the lifetime of equipment and preserve its condition by obtaining feedback on the factors that cause excess wear and failures
- Reduce the total cost of ownership and maximise profitability



Wärtsilä waterjets speed up the world's fastest vessels

AUTHOR: Anna Gustafsson

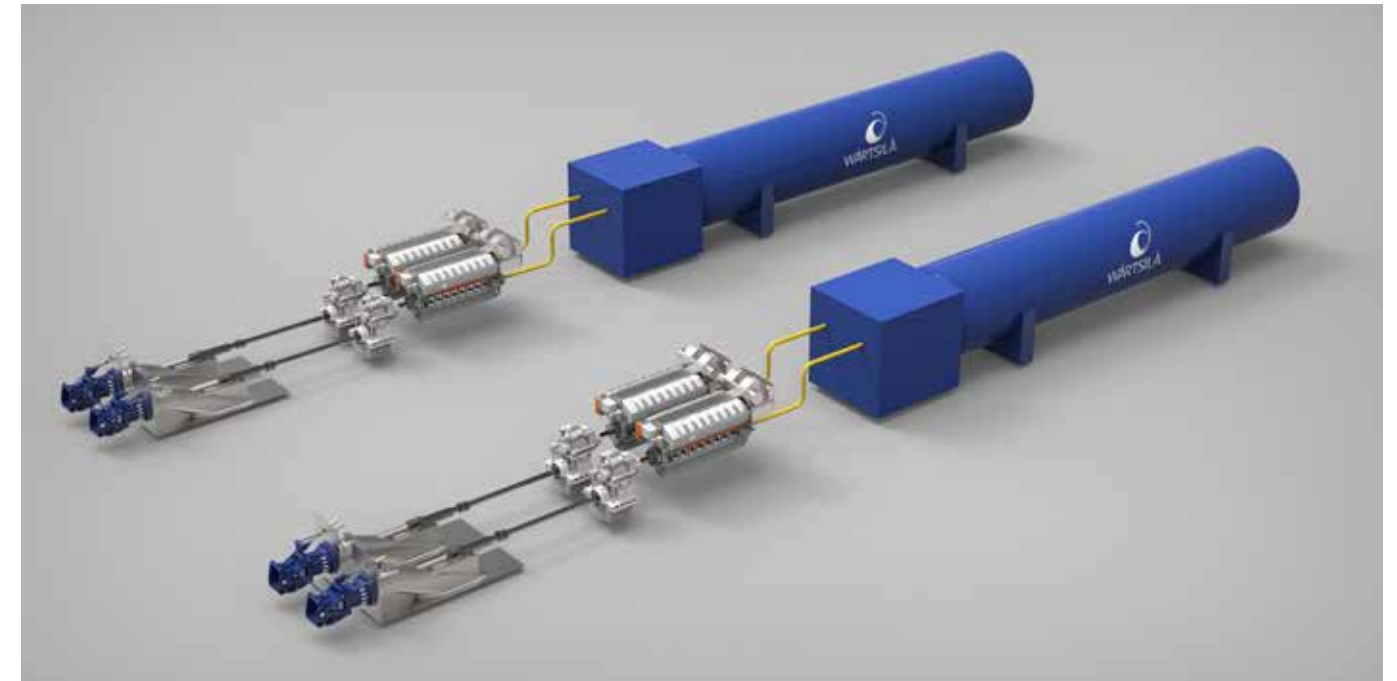
Waterjets have many exciting applications, from navy vessels to big, fast ferries. Wärtsilä has been able to find a great balance of lightweight waterjets, which have strong durability with large engine power. Now LNG-fuelled ferries offer a possibility to open new markets, where both Wärtsilä engines and waterjets can be installed on the same vessel.

The 18th century Swiss mathematician and physicist Daniel Bernoulli is not someone that many outside the world of mathematics recognise. However, his name might ring a bell for people inside the marine industry. In 1753, Bernoulli investigated and proved the theory behind waterjet propulsion as part of his hydrodynamics research in physics. His theory was applied to practice, and vessels that used the power of waterjets were soon sailing at a speed of nine knots.

Flash forward to our time and Wärtsilä

waterjets are powering high-speed ferries and navy vessels, which might sail at speeds averaging 40 knots. An impressive example is the catamaran Francisco, the fastest ferry in the world, which ferries passengers between Uruguay and Argentina at a speed of 53 knots.

Wärtsilä waterjets are a result of persistent innovation and development work. Wärtsilä has an in-house development and sales unit for its waterjet range, located in the Netherlands, and Sales Manager Jeroen



■ Wärtsilä's integrated scope of solutions includes the engines, waterjets and the LNG fuel storage and supply system, along with all the related auxiliary systems.

Vedder has been working for the waterjet unit for the past three years.

Waterjets were added to the Wärtsilä portfolio in 2002, when Wärtsilä acquired the Dutch company Lips, which was a global leader in propulsion products, including waterjets. Lips Jets eventually became Wärtsilä Jets.

"The history of waterjets is long, but I would start the story a lot later, perhaps from 1976. That was the first time Lips waterjets were delivered for engines with a power of 495 kW," says Vedder.

Smaller, lighter and faster

In 2006 Wärtsilä introduced its compact LJX modular waterjet series. In the name, L represents the roots of the innovation, as it means Lips. J stands for Jets and X for the innovation of an axial pump, instead of a mixed flow pump. The new waterjet was 25% smaller in flange diameter, and therefore its weight was reduced by 10%. The cavitation margin was also reduced by 35%. The LJX waterjet range formed a solid base, which future designs could lean on.

"That was probably the biggest milestone until now," says Vedder. "We had executed a big change in the overall design of the waterjet."

Another breakthrough was the introduction of the midsize waterjet series in 2011. The midsize series of Wärtsilä waterjets are designed for engines with power ranging from 500 kW up to 4500 kW. Compared to the modular waterjets, the midsize waterjets are preassembled on a skid and delivered in form, which allows direct installation into the vessel hull during the construction at the shipyard. All components of the waterjet are mounted on the skid, including outboard parts, the PTO, thrust bearing, hydraulics and machinery controls. The skid is formed around the waterjet inlet. This means the inlet is also part of the scope.

"This is a different concept, compared to the modular waterjet, where the inlet design is done by Wärtsilä. The production of the inlet itself is part of the yard scope," says Vedder. "Another big difference is that while modular waterjets are fully executed in duplex stainless steel, the midsize has many aluminium parts instead of duplex stainless steel."

The way in which the modular and midsize series are delivered to customers is also quite different.

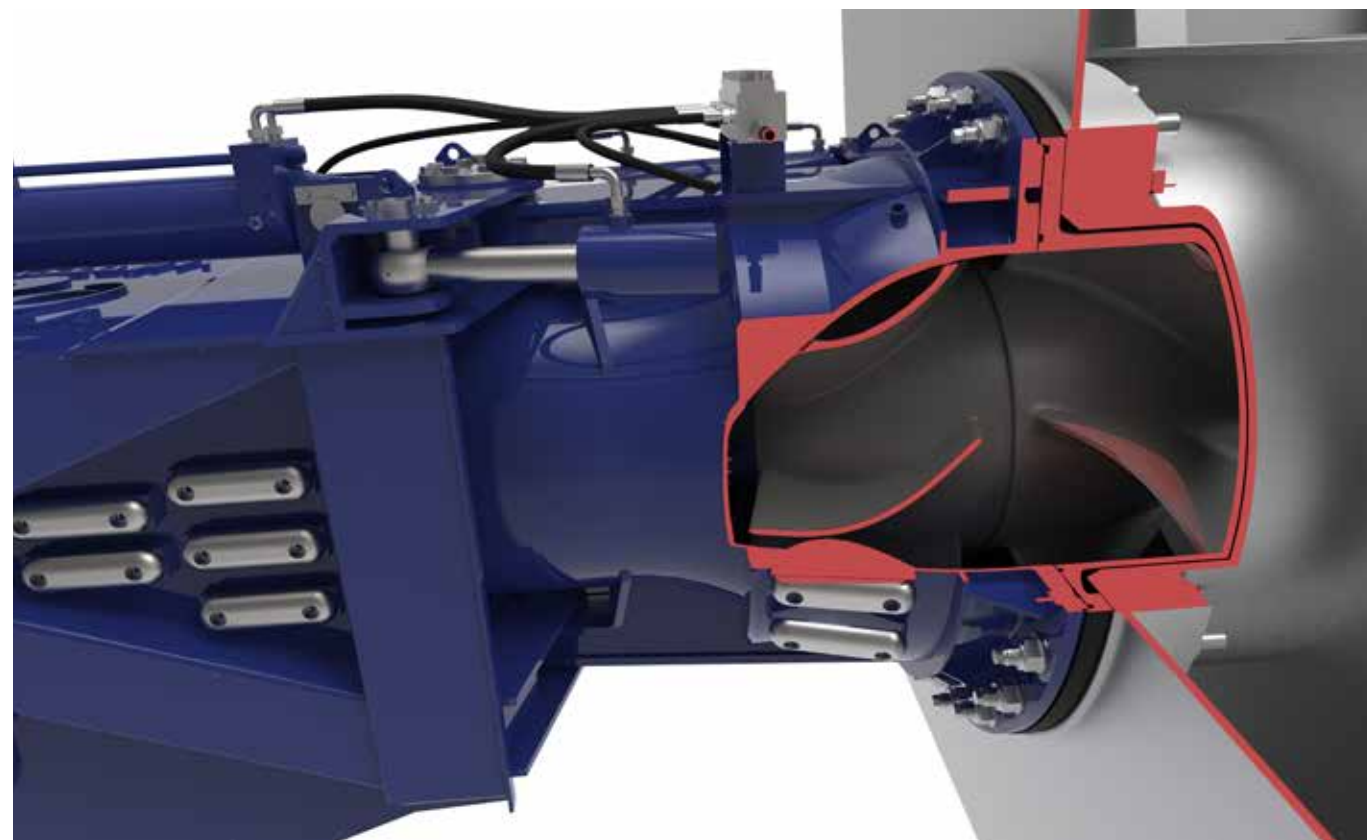
"In the modular type of waterjet, we can do more variations and optimisations,

depending on the vessel type. The strength of the midsize is the shorter delivery time and the use of aluminium components built together on a skid," says Vedder. "The modular waterjet, on the other hand, offers a high level of customisation with a wide variety of options available depending on the vessel type. But there are two things that both types have in common; high quality and a well-proven performance with an identical axial pump design."

Exceptional engineering

Vedder is now looking forward to working with a redesign of Wärtsilä's modular waterjets, revealed in January. The last time the modular waterjet design experienced a revolution was in 2006 when Wärtsilä introduced the LJX range of waterjets. Now the LJX series will evolve and be introduced as WXJ series.

The new modular waterjet series will feature a new axial pump design, which boosts performance with an increased thrust of as much as 3%, while the improved cavitation margins will help reduce the environmental impact by lowering noise levels. This is very much in line with Wärtsilä's Smart Marine vision that aims to



■ WXJ waterjet pump.

lead the maritime industry into a new era of ultra-high efficiency, improved safety and reduced environmental impact.

The new WXJ pump has been tested extensively, both with computational fluid dynamic (CFD) simulation and with model testing. With this successful upgrade, Wärtsilä is now in a position to deliver waterjets worldwide, including to promising markets such as China and other Asian countries.

The axial pump structure is already a factor that sets Wärtsilä apart from its competitors in the waterjet market. Compared to the mixed flow structure, the axial pump means much less space is needed on the vessel's transom, as well as increased cavitation margins for better operational flexibility. Furthermore, there is a significant weight difference in favour of the axial pump compared to the mixed-flow pump.

Vedder also says that another advantage that Wärtsilä waterjets have compared to other products in the market is the fact that they have an inboard mounted thrust

bearing. Because the thrust bearing is not within the water flow inside the jet, there is never a risk for oil leakage in the water.

"Usually the equipment that makes the jets steer and reverse is located outside the vessel, and is being exposed to seawater," he explains. "This means that the maintenance and repair can be difficult to do at times. But we have an option to install the hydraulics, such as the cylinders and hoses, inside the vessel, which also allows early and easy detection of possible oil leakage."

The complete package

In spite of these advantages, waterjets have, so far, not been an obvious addition to Wärtsilä's broad portfolio of marine technology solutions.

"If you look at products within Wärtsilä, waterjets could even be considered to be side-tracked by the other products, and have not had a strong connection to the rest of our portfolio," explains Vedder. "Waterjets are commonly used in combination with high-speed engines, and until the end of 2018

Wärtsilä has only had medium-sized engines. So there have not been many possibilities to offer a complete package before. This is why I am very happy about the introduction of the Wärtsilä 14 high-speed engine."

Over the past decade, due to economic reasons and tightened environmental requirements, the fast ferry market has been faced with similar pressures as the marine industry in general. Vessel operators want to reduce operating costs while being efficient and environmentally sustainable at the same time. As a result, the fast vessel market is looking towards a new era of LNG-fuelled vessels, which in turn mean exciting new possibilities for Wärtsilä waterjets as well.

In fact, the first new vessel equipped with Wärtsilä waterjets, LNG solutions and Wärtsilä engines has already been commissioned by Spanish ferry operator Baleària, which plans to build the largest-ever high-speed catamaran, which will operate on LNG fuel. The 125-metre-long vessel will be the first high-speed ferry that will feature both Wärtsilä waterjets and the

Wärtsilä 31 DF medium-speed engines along with an LNG fuel storage and supply system.

Meanwhile, Vedder is looking forward to the possibilities of offering customers an even broader package from Wärtsilä.

"LNG as a solution for fast ferries was not an option that everyone believed in, as weight in the fast ferry business is an essential thing. Electric marine technology will, for sure, be the future. However, I still think LNG will serve as an in-between solution before marine electric technology becomes more suitable," he says.

Vedder and the whole Wärtsilä waterjet team are already looking ahead and have their sights on serving the high-speed vessel market, which is increasingly looking for lighter solutions to save fuel consumption and, thereby, the environment.

"Sailing with fast vessels is a bit like Formula 1 racing. The lighter you are, the better the performance. Therefore, we are always looking into other solutions to save weight and to improve the performance even more. There are several projects ongoing, but it is obvious we can't say much about it yet. We don't want to help our competitors by giving them our good ideas!" he explains.



■ Baleària's new high-speed catamaran will be the largest such vessel to operate on LNG. It will feature an integrated scope of Wärtsilä solutions. (Image courtesy of Baleària, designed by Incat Crowther)

"We are looking at all parts on the waterjet to see if we can find something to improve the performance even more without compromising the reliability

and durability. The team has listed some revolutionary ideas and I look forward to working on them this year," concludes Vedder. ●



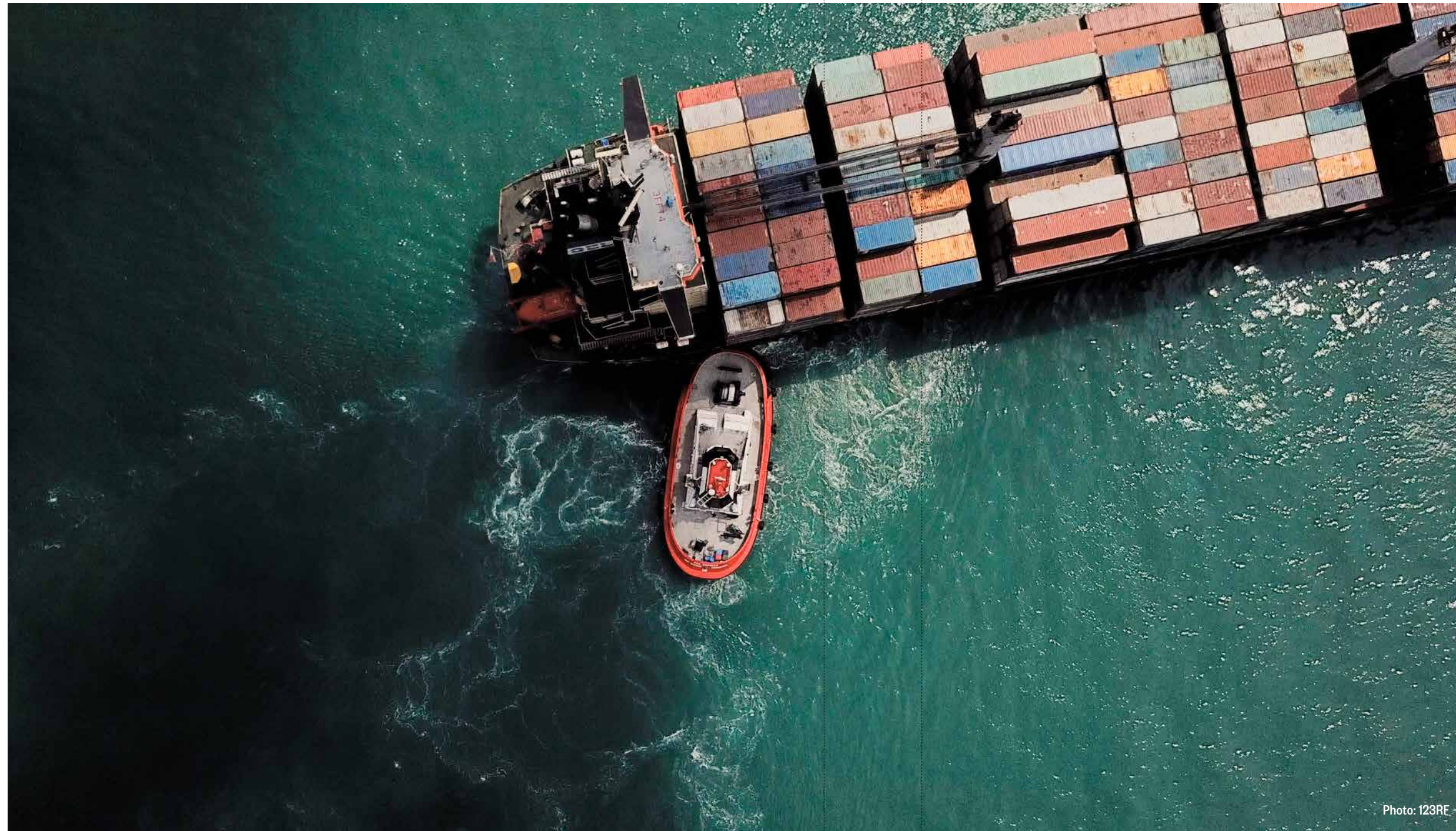


Photo: 123RF

IntelliTug: Assisting Singapore's Tug Masters with smart technology

AUTHOR: Richard Orange

IntelliTug, the first project launched by the Wärtsilä Acceleration Centre in Singapore, is combining some of the most advanced Smart Marine technologies and putting them to the service of PSA Marine's highly skilled Tug Masters.

Even though dark and ragged clouds covered the sky above the Pasir Panjang container terminals in Singapore, the

surrounding waters were still bustling with port activities as the world's busiest container transshipment hub operated throughout the night. At 4 AM, a team of Wärtsilä computer scientists, robotics engineers and UX experts were at work on the bridge of the PSA Polaris tugboat, as part of a user research trip for the IntelliTug project – a joint project with PSA Marine, the Maritime and Port Authority of

Singapore (MPA), Lloyd's Register and the Technology Centre for Offshore and Marine Singapore (TCOMS).

"The weather condition can have a disorientating effect on you unless you're a seasoned mariner," says Jan Grothusen, Director, Wärtsilä Voyage Solutions, "Although the whole horizon and quayside is illuminated, it's surprising how much your perception can be altered at night."

It is possible, the Wärtsilä team discovered, to mistake the twinkling lights of ships in the night for the celestial skies above. They also found it challenging to remain constantly fully aware of the busy surroundings. "The situation can be highly complex and unpredictable, like many operations when different humans and multiple vessels are involved," explains Grothusen.

PSA Marine's fleet of 40 tugs carry out more than 90,000 towage jobs per year in the busy waters of the Singapore port. By 2040, when the final construction phase of the Tuas next-generation mega port completes, Singapore's port capacity and traffic are envisaged to double.

Keeping the human in the loop

The IntelliTug project has grown out of the Singapore's Sea Transport Industry Transformation Map, which calls for the development of autonomous systems, robotics, data analytics and AI to maintain the port's global edge. It is also the first project to be launched by the Wärtsilä Acceleration Centre in Singapore and part of the MPA Living Lab initiative.

The goal of IntelliTug is to deploy smart technologies in such a way that they will



■ Smart navigation system.



■ The Guard Circle alerts the Tug Master if anything enters his safe zone.

help skilled mariners like Amir Hamzah Hasan, PSA Marine's Senior Tug Master, carry out one of the most challenging jobs in the industry. That is why Wärtsilä is retrofitting the PSA Polaris with an advanced marine-grade sensor suite and joystick manoeuvring system, all integrated in a lightweight, human-centric smart navigation system which, collectively, will provide collision avoidance capabilities and smart navigation support during transit and when virtually anchored.

Chris Chung, Wärtsilä's Singapore-based Director of Digital Innovation & Strategic Projects and IntelliTug's ecosystem and overall programme lead, says the aim of the co-creation partnership is to combine Wärtsilä's Smart Marine capabilities with PSA Marine's wealth of experience and expert knowledge to develop and testbed smart capabilities.

Bernard Wong, Head of Fleet Management at PSA Marine, is convinced that his Tug Masters will maintain the central role but will have amplified capabilities through the IntelliTug. "There are many instances in towage operations

where we feel that the Tug Master is still very much needed," Wong says. "They rely a lot on their skills and the training provided, and even their instincts. But we believe that more can be done to aid them in their day-to-day work."

This, he says, might include the ability to "fuse sensor data and incorporate it into a human-centric interface that will allow Tug Masters to digest and make sense of all the information more easily."

In summary, the planned features include passage planning with collision detection and avoidance, and virtual anchoring with enhanced situational awareness at night and in complex conditions. Wärtsilä is using the data gathered to further refine its sensor fusion algorithms, test new features, study how the tug behaves under manual operation, verify sensor detection capability under different conditions, and look for any anomalies and performance issues.

The role of regulators

In January, the IntelliTug project had its kick-start week, where it brought together experts from various Wärtsilä business units

in true 'OneWärtsilä' spirit.

Wärtsilä's Voyage Solutions team is currently creating a 'digital simulation' of the PSA Polaris, which will be used to test capabilities in both real-life recorded situations and imagined scenarios. Meanwhile, next steps for Wärtsilä's Dynamic Position team include equipping the tug with its joystick module, which can then work with both the simulator and the new smart navigation system.

Much of the ecosystem development and partnership is led by the Singapore digital team, which is leading the engagement with ecosystem stakeholders and ensuring that a user-centric approach will solve a real-world challenge.

Chung stresses that it is important to work with forward-thinking partners and regulators to ensure technology is deployed safely and sustainably.

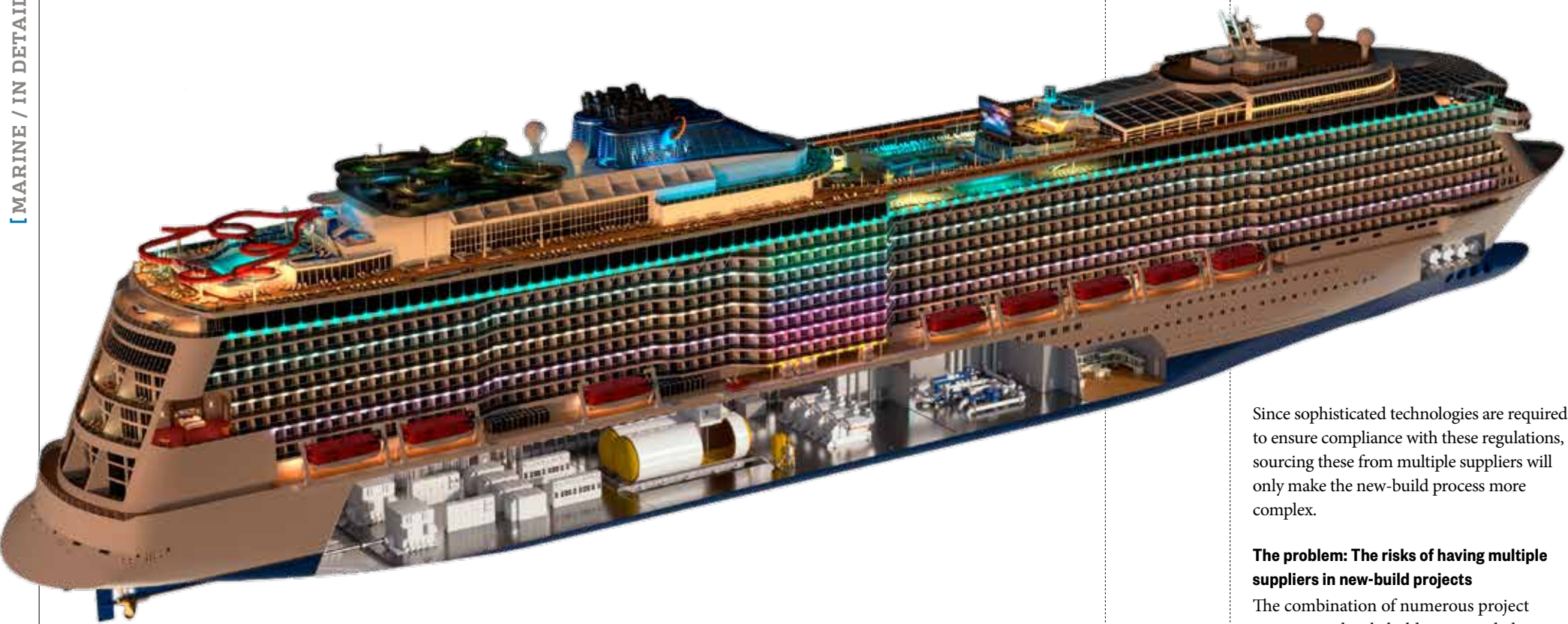
The MPA is providing a "regulatory sandbox" for IntelliTug. This is a set-up that is used to accelerate innovation and testbedding in Singapore – with many successes in adjacent industries such as fintech and tele-medicine services. The

sandbox provides a controlled environment, allowing technology to be tested safely. Data and learnings will mean MPA can continue developing the appropriate regulatory framework based on real-world experience whilst the technology develops. The tug's capabilities will also be thoroughly tested in a virtual environment before the technology is released into the testbed. Experts from Lloyd's Register have been closely involved from the start of the project, providing expertise and insights to ensure potential technology risks are identified, managed and mitigated.

Next steps

Wärtsilä will spend the coming months intensively conducting user tests with a Wärtsilä tug digital simulator before testbedding in the sea – all the while working alongside PSA Marine's experienced Tug Masters to develop a fit-for-purpose and useful system that will bring together smart technologies to amplify the capabilities of the crew – enabling them to be safer, smarter and more effective than before. ●





Avoiding risks worth EUR 15 million in passenger and cruise new-build projects

AUTHOR: Maikel Arts, Segment Sales General Manager, Cruise & Ferry, Wärtsilä Marine Business
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Since sophisticated technologies are required to ensure compliance with these regulations, sourcing these from multiple suppliers will only make the new-build process more complex.

The problem: The risks of having multiple suppliers in new-build projects

The combination of numerous project partners and stakeholders, extended technology requirements, shipyards with limited experience, and multi-continental ecosystems inevitably raises the risk levels for new-build projects. The risks include:

Interfacing issues:
Modern cruise ships require a multitude of complex systems and sub-systems, all of which need to exchange information correctly, efficiently and optimally. However, the sheer volume of signals, standards and systems involved means that a harmonious systems interface can be difficult to achieve.

Communication failures:
As ship designers, suppliers and engineering specialists, with varying levels of experience (and varied work cultures), are located in different countries, the chances of communication failures leading to delays and increased costs are high.

Inability to conduct performance verification:
New-build projects are broken down into systems and ultimately products that are defined by specification documents. The specifications relate to individual items, for example, the performance of equipment provided in a supplier, and not to the overall performance of systems. This means the performance verification of a full system cannot be guaranteed until the ship is built.

Improper system Integration:
Considering the various elements and building blocks in a new build, there is a risk that the various systems will not have been integrated properly, which will lead to a deterioration in performance. This is something that may not be immediately apparent upon commissioning of the vessel but can have unfortunate consequences that emerge only after the vessel is delivered.

Unavailability of life-cycle support:
Maintenance and repairs of installed equipment and systems are required throughout the life cycle of a ship. However, due to equipment and systems being sourced from different suppliers, the availability of trained personnel and original spare parts cannot always be guaranteed.

This, in turn, increases the risks of systems breaking down and significant downtime in cruise ship operations.

The potential for a snowball effect:
Systems that involve significant integration, such as those on cruise and large passenger vessels, are only as good as the weakest part. A system or part that looks fine on its own may, when working in synchronisation with other parts of the system, not function properly. This can lead to a snowball effect of failures throughout the system and last well into the life cycle of the vessel.

Counting the cost of the risks
But what do these challenges mean in terms of costs for a new-build project? Let's break it down on and use a small size cruise ship of EUR 100 million value for an American owner and a Chinese yard.

Correction/modification cost EUR 2,5Mn:
Often during the procurement phase of new-build projects, more attention is given to CAPEX than to the value delivered by the equipment or system over the life cycle of the vessel. This results in situations where the systems integration is often underestimated – requiring additional time, resources and cost during the construction phase and operational issues that impact the vessel once it is commissioned. (Table 1)

Time-related cost EUR 2Mn:
With numerous suppliers involved, considerable time is required to manage all the communications and meet their deadlines. The financing costs alone can add several percentage points to the building

Shipbuilding has come a long way from being a large but straightforward business to evolve into a highly complex process that involves various stakeholders. We break down the risks that accompany a typical new build in modern times and tell you why the answer lies in having a single supplier.

The first sailing ships that cruised along the coasts of ancient Egypt and Mesopotamia in 3,500 BC were humble affairs, typically constructed using planks of wood, tar and rope. Fast-forward to the current day and age, and there is no denying that shipbuilding

has become a monumental feat, using exotic materials, cutting-edge technologies and involving numerous suppliers, sub-suppliers, engineering companies, classification societies, equipment providers and, of course, the ship owners themselves.

This is especially true of the cruise ship and passenger ferry sector. Construction here often involves multi-continental projects with, in a typical scenario, vessel owners being based in one continent, for example, America, the technology providers in another, usually Europe, while the shipyard labour and finance costs are controlled from Asia.

There are a number of reasons for this trend. While extended delivery times from the established yards, due to full order books, are causing cruise and ferry operators to seek new project partners, Asian yards are stepping in with lower costs and attractive financing. But these yards have only limited experience in this segment. In addition, a plethora of stringent regulations on emissions, ballast water management and wastewater handling procedures that are particularly relevant to ferries and cruise ships (since they operate close to coastlines and in protected waters), complicates matters even further.

Item	Detail*	Cost*
Additional costs for design and engineering	20 engineers × 8 hours/day @ EUR 100/hour × 40 days	€640,000
Corrections during installation plus additional commissioning costs	6 commissioning engineers @ EUR1500/day plus 20 yard engineers @ EUR 500/day for a total of 60 days	€1,140,000
Corrections, modifications and overcoming interfacing issue	Estimated cost	€750,000
Total additional costs	2.5% of the price for a 100 million euro cruise ship	€2,530,000

■ Table 1 - Estimated correction costs during multi supplier new-build stage.

price when delays occur. For a EUR 100 million cruise ship, a 6 months delay can easily lead to an extra 2 million* due to problems trying to integrate different systems from different suppliers. In addition, the cost of lost or cancelled cruise bookings or having to charter other ships in order to cover contractual route obligations makes a further dent to the budget.

OPEX cost EUR 4,5Mn:

Another ‘knock-on’ effect is when, during the procurement phase, the focus is primarily on products with low CAPEX often resulting in increased OPEX. For instance, having non-optimised equipment as part of the ship’s system can add 3% to OPEX = EUR 150,000 (based on annual fuel costs of EUR 5 million). This can add up to EUR 4.5 million over a 30-year life of the vessel.

The solution: The case for a single-supplier model

The key to unravelling these complexities and minimising the risks involved in modern new-build projects lies in optimising the number of players involved. Companies, such as Wärtsilä, that have in-house capabilities in ship design, engineering, project management, performance insight and a broad portfolio of products, systems, and integrated solutions, can offer ‘end-to-end’ responsibility with services to support each element required, which delivers benefits throughout the life cycle of a vessel.

The benefits are as follows:

Guaranteeing the outcome:

A single supplier is able to provide the complete scope of integrated systems and equipment required and ensure proper systems interface and coordination. Additionally, with deliveries made from the same source, the procurement process is significantly simplified, quality and progress can be monitored and controlled at every stage and the risk of building delays is greatly reduced, effectively guaranteeing the outcome.

Providing life-cycle support:

When it comes to maintenance, companies are looking beyond short-term cost savings and investing in longer-lasting, safer and truly global solutions. A supplier like Wärtsilä can provide preventive

maintenance to ensure day-to-day operations remain unaffected, and also assist with reactive maintenance for quick repairs that reduce downtime. A smart maintenance approach combining spare parts and field services from a reliable original equipment manufacturer (OEM) enables better maintenance planning and execution, supporting long-term business goals.

Streamlining the project:

By reducing the number of suppliers and sub-suppliers involved, and taking a ‘one-stop-shop’ approach through having a qualified single provider with the right capabilities, solutions and experience, communication between the yard, the owners and the equipment provider is simplified. In addition, legal, finance and logistics can be dealt with in a unified way too. Advanced project and site management skills allow the overseeing and verifying of the project’s status, progress and quality every step of the way.

Ensuring respect for the environment:

Environmental and Social Governance (ESG) must be taken very seriously today. For Wärtsilä, it is an embedded element in how the company sees its role in the developing marine ecosystem. This makes it the ideal partner for cruise ship operators who are keen on improving their environment and social governance goals.

Improving the new-build process

That said, how exactly can Wärtsilä help cruise new-build projects save money? Procuring a complete and fully integrated system from a single OEM partner, such as Wärtsilä, who can deliver a ‘first-time-right’ proven solution removes these extra expenses, thereby optimising overall costs. It mainly adds up in two ways:

Time savings:

With numerous suppliers involved, considerable time is required to manage all the communications and to keep all on track and meeting their deadlines. Conversely, with a fully integrated system ordered from a single supplier, the work is handled by an experienced team of colleagues, working in unison, each with a complete understanding of the methods, standards and processes required. The engineering team is up and running quickly, and the entire operation

from the design phase through to vessel launch is handled seamlessly.

OPEX savings:

The recommended approach for new-build projects is to employ a strategy of assessing the *Total Cost of Ownership* (TCO). Here, the aim is to achieve the highest possible overall output avoiding sub-optimisation and striving for uninterrupted operations. Having a complete and fully integrated system, designed and supplied by a single OEM provider who is prepared to undertake life-cycle management of that system through a service agreement can significantly reduce the TCO.

For instance, avoiding costs related to managing the maintenance of the equipment and handling downtime issues can save OPEX personnel costs of an estimated EUR 6,000,000* over 30 years. Based on 200k / year (1 shore side technical assistant and 1 administrative clerk) over a 30-year operational life cycle of a cruise ship.

Wärtsilä, a one-stop shop for new builds

The risks arising from a cruise new build can be alleviated by using a single supplier, like Wärtsilä, who has the experience to support and deliver new builds in line with the project requirements.

Wärtsilä’s expertise gives owners the option to select less experienced or newcomer shipyards for their new-build projects. After all, many of these yards have the ambition and the competitive edge to handle cruise and passenger ship construction but lack the necessary experience and supply base.

Choosing a single supplier and placing orders with the newer yards can potentially result in 20 percent cost savings, as evidenced by recent cases.

Additionally, the highly complex process of managing resources when building modern passenger and cruise vessels requires competent advisory support in order to overcome the various challenges outlined in this article.

This can only come from a reliable and strong partner with a global presence, a supplier like Wärtsilä. ●

**These are indicative estimates for illustration purposes only. They are based on standard industry hours and resources required for each element. Costs and values may vary depending on specific requirement.*



How much can problems with integration add to the cost of a new build?

Improper systems integration thanks to sourcing non-standard equipment from multiple suppliers can mean additional time, resources and cost spent to correct it. For a 100 million cruise ship this means:

• Cost of corrections and modifications during project execution	= EUR 2,500,000
• Cost of project financing due to delays	= EUR 2,000,000
• OPEX cost of non-optimised equipment is EUR 150,000/year	= EUR 4,500,000 over 30 years
• OPEX personnel cost managing equipment maintenance: EUR 200,000/year	= EUR 6,000,000 over 30 years

Total savings potential = EUR 15,000,000 over 30 years

These are indicative estimates for illustration purposes only. They are based on standard industry hours and resources required for each element. Costs and values may vary depending on specific requirement.



Photo: 123RF

At the forefront of preserving marine life

AUTHOR: Wärtsilä Noise & Vibration team

Evidence has been mounting that underwater noise emitted by the shipping industry has a negative impact on the oceans' wildlife. As awareness about the issue grows, the demand for quieter shipping is increasing. Soon, new requirements on low-noise-emitting ships will be imposed on the marine industry. Luckily, well-timed research work started by R&D a few years ago has prepared Wärtsilä for this challenge.

Globalisation of the world economy means stronger connectivity between different countries. Over the past years, global

shipping has increased steadily to sustain the demand for an effective, safe and cheap way to transport goods, worldwide. Today, the oceans don't look like a lonely blue desert anymore.

However, with global shipping, underwater background noise has increased along the main oceanic routes, along the coast and especially at the main harbour locations (Figure 1). It is estimated that underwater noise in the oceans has risen steadily by +3 dB every ten years, and there is no sign of the trend being reversed. This has a negative impact on marine wildlife and their ability to communicate and search for

food as shown by the latest studies in marine biology. The relevance of the underwater noise control cannot be neglected anymore, and it is now up to government leaders to take a stand.

Canada leads by example

Vancouver Fraser Port Authority's EcoAction Program is a case in point. The program offers harbour dues discounts to vessels that embrace environmental best practices in the field of emissions reduction. For instance, ship operators demonstrating low underwater noise emission are awarded a 23% discount. The aim is to encourage shipping companies to lower



■ Fig. 1 - The global shipping footprint.



■ Fig. 2 - The SONIC project team visiting Wärtsilä's multi-product factory in Trieste during a project review meeting. Carlo Pestelli (third from left) and Hannu Tienhaara, in the centre, hosted the event.

their noise emissions, since they affect the at-risk whale population in the Vancouver area.

The Canadian department of transportation sponsored the Quietening Ships to Protect the Marine Environment workshop hosted at the International Maritime Organization (IMO) headquarters (London, UK) early this year. The aim of the technical workshop was to assess the benefits and barriers of using new ship designs and to evaluate technologies to reduce underwater noise from ships. The workshop aimed at bringing more than 140 world experts and policy makers together to share knowledge and work on quiet ship

designs and technologies with the purpose of protecting the marine environment. Carlo Pestelli, R&D manager, Noise & Vibration, was invited to represent Wärtsilä at this important event because of his participation in one of the key recent projects on the topic: SONIC, funded by the EU.

The feat of developing silent technology

Wärtsilä's R&D team participated in an international, collaborative project funded by the EU 7th Framework Programme. The project's name was **SONIC: Suppression Of Underwater Noise Induced by Cavitation**. The project started in autumn 2012 and lasted three

years. The SONIC consortium comprised world-leading institutes of hydrodynamics, noise experts, propeller designers, reputable universities with specialised centres in this field, major European shipyards and classification societies. SONIC brought together a wealth of knowledge on propeller cavitation and noise reduction. (Figure 2)

Interaction with the marine biology network was established by obtaining necessary knowledge for the project from renowned institutes in the field of marine biology. The final goal was to develop guidelines and regulations for the marine industry.

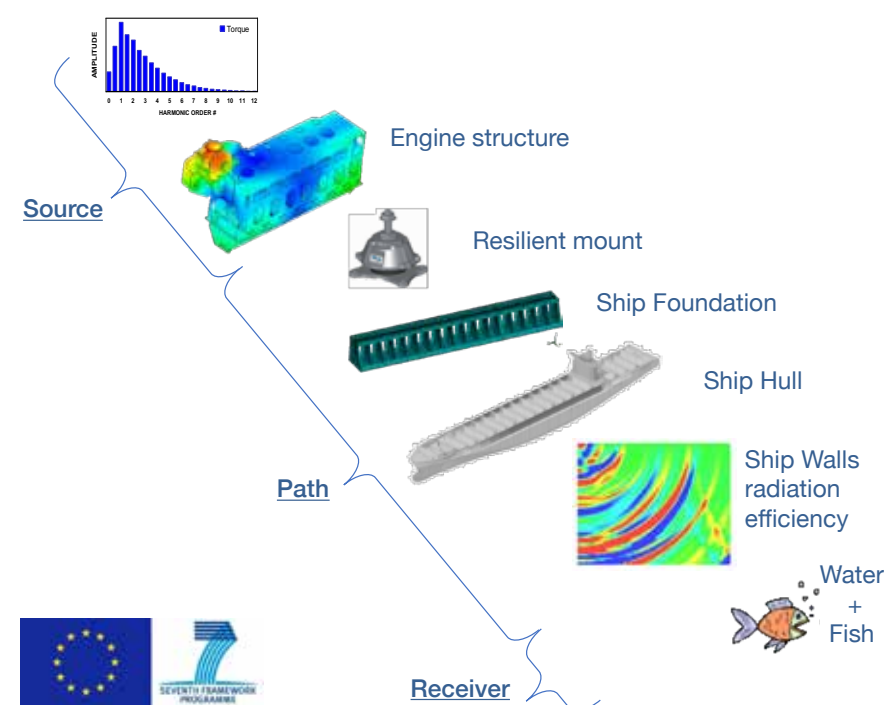


Fig. 3 - Generation process of underwater noise from mechanical source.

by shipping in general and to propose mitigation measures for quietening the oceans. The cavitation of ship propellers has been identified as the main source of background noise. However, other onboard noise sources, such as propulsion machineries, have also been identified and studied during the execution of the project. Figure 3 shows the underwater noise generation process from a mechanical source such as a propulsion engine studied by Wärtsilä.

Expanding knowledge from experimental structural dynamics to underwater noise signature analysis

Being part of the SONIC project was a strategic goal for Wärtsilä: the new guidelines created during the SONIC project would have been included in the major Classification Societies Regulations and this would have resulted in new requirements for Wärtsilä in the Marine Business. Wärtsilä R&D had an intuition about the growing importance of the topic and thus recognised the need to be involved in SONIC from the very beginning and to create a strong network within the underwater noise community.

In autumn 2012, Wärtsilä joined the SONIC project and started to invest resources in it. Wärtsilä's leading role was taken by the Noise and Vibration (N&V) team in the R&D department. The N&V team was selected due to their specific knowledge of the field, together with their practical approach of experimental investigation and their experience in managing complex, innovative projects. This unique mix was perfect to create a fruitful dialogue and real cooperation between universities, research centres, shipyards and machinery manufacturers that were part of the SONIC project team (Figure 4). The biggest challenge for the project team was to organise and perform full-scale underwater noise measurements to be compared with scale-model noise measurement at a towing tank and in underwater noise simulations. In Figure 5, Carlo Pestelli and Moreno Almerigogna are performing underwater noise measurements in the North Sea during sea trials on board the research vessel Princess Royal, owned by Newcastle University.

The research work of the N&V team focused on the contribution of the

machinery to the ship's underwater noise signature (see Figure 3). The research conducted led to an innovative idea for the direct measurement of the force transmitted by a resilient mounted machine to the ship hull: a new concept of "force sensor" was designed, manufactured and tested by the N&V team for this purpose.

The idea of the force sensor was proposed as a patent to the EU patent office under the name: *Mounting element and method for monitoring vibrations of internal combustion engine*.

The SONIC project provided Wärtsilä with the knowledge to manage the future requirements from silent ship applications as well as to get the connection to the wide network of stakeholders in the underwater noise field.

Wärtsilä's technical heritage built in its history of 185 years is very well known and respected in the industry, and it was further enriched by the SONIC experience. For this reason, the publishing company John Wiley & Sons proposed that Wärtsilä participate in the *Encyclopedia of Maritime and Offshore Engineering: The Machinery Noise and Vibration Sources* section was prepared by Hannu Tienhaara, Carlo Pestelli and Moreno Almerigogna from R&D.

Our Purpose and Smart Marine Vision in action: An Oceanic Awakening

In autumn 2018, Wärtsilä launched the SEA20 initiative, a global league of cities dedicated to rethinking their roles in marine and energy ecosystems, hastening the adoption and deployment of best practices, embracing digitalisation and legislating new environmentally friendly, sustainable and smarter ways of doing business across the oceans. It is called *An Oceanic Awakening*: an inspiring *One Wärtsilä* global initiative which will raise awareness on a wider societal scale, ask tough questions and suggest that the time has come for radical improvements in addressing inefficiencies from marine to energy businesses, from oceans to ports, cities and beyond.

The Vancouver Fraser Port Authority's *EcoAction Program*, the technical workshop "Quieting Ships to Protect the Marine Environment" at IMO and the EU-funded project SONIC are clear examples that the need for *An Oceanic Awakening* is growing.

The world is looking for new ways of doing business and Wärtsilä is in a position



Fig. 5 - Carlo Pestelli (left) and Moreno Almerigogna (right) performing underwater noise measurements onboard the R/V Princess Royal during sea trials.



to lead this change and show the way forward. With the widest product portfolio in the marine industry and a strong focus on R&D with investments of about 3.2% of net sales in 2018, Wärtsilä is in the unique position to be a smart technology company capable of supporting the change towards a sustainable society and quieter oceans.

Acknowledgments

When a relevant achievement takes place, it is not because of one person or even one team. The success of Wärtsilä R&D lies in its history and all the people who helped create

its legacy of technical competence to shape a better future. A few names of those who always cooperate in the Noise & Vibration field: Hannu Tienhaara, Kari Saine, Peter Sundström, Jan Holmberg, Claus Paro, Zengxin Gao, Francesco Degano, Moreno Almerigogna, Giampaolo Fabro, Francesco Licciulli and Manjunath Patil. ●

The aim of the SONIC project was to develop tools to investigate and mitigate the effects of underwater noise generated by shipping. Three objectives were pursued during the execution of the project. The first objective was to enhance the understanding

of noise generated by a cavitating ship propeller. The second objective was to validate predictions of noise levels for individual ships, and to classify ships based on simplified noise models. SONIC's third objective was to map the noise generated



Carbon Recycling International wants to make an impact with Power-to-X

AUTHOR: David J. Cord

Icelandic company Carbon Recycling International won the Wärtsilä SparkUp Challenge. See how their innovative idea to produce renewable synthetic methanol helped them beat the odds.

The winner of the 2019 SparkUp Challenge is Carbon Recycling International (CRI). Their inventive solution for renewable methanol helped them stand out from nearly 70 other competitors and win a capital grant of EUR 50,000. “It feels really good to win,” says

Benedikt Stefánsson, Director of Business Development at CRI. “We are ready to get to work with Wärtsilä, to collaborate on finding new opportunities together and make an impact.” “We have much in common with Wärtsilä and I see a lot of synergies between us,” says Margrét O. Ásgeirsdóttir, CFO of CRI. “It is important for small and large companies to work together. With a combination of agility and strength, we can broaden the renewable ecosystem.” While CRI is the official champion of

the challenge, Matti Rautkivi, Director of Business Development at Wärtsilä Energy Business, says that in reality, there was more than one winner. “Wärtsilä is the real winner of this challenge,” he explains. “We get the opportunity to collaborate with these great companies.” **An invitation for collaboration** The SparkUp Challenge is a way for Wärtsilä to accelerate collaboration with start-ups and scale-ups. Young growth companies



About Carbon Recycling International

- Uses renewable energy to produce synthetic methanol from carbon dioxide and hydrogen.
- Based in Kopavogur, Iceland.
- Founded in 2006.
- About 40 employees.
- www.carbonrecycling.is

are invited to pitch their ideas to Wärtsilä, and winners receive a cash prize as well as opportunities for collaboration. While the first SparkUp Challenge in 2017 was based around Smart Marine technology, this year the focus is on Power-to-X, which is key to achieving Wärtsilä’s vision of a 100% renewable energy future. Power-to-X is a process to convert excess electricity into something that can be used later. This is particularly important with renewable energy because we still need power when the sun isn’t shining or if the wind isn’t blowing. Power-to-X stores this energy in a form that can be accessed as and when it is needed. Out of about 70 applicants to the SparkUp Challenge, a shortlist of 14 were chosen to be screened and evaluated. The four finalists were Carbon Recycling International, Green Hydrogen, Sunfire and Climeworks. They came to the SparkUp Challenge Day at the Wärtsilä Campus in Helsinki, where they pitched their ideas to a jury composed of Wärtsilä and independent energy experts. They were judged on their knowledge, solution and their readiness to collaborate with Wärtsilä. **Ready to make an impact** Jury member Petteri Laaksonen, Research Director for the Department of Electrical Engineering at Lappeenranta University of Technology, studies carbon capture and the production of hydrogen and synthetic

methanol. He says all of the contenders were interesting and it was difficult to pick a winner. “Some of this technology is still in the development phase and there are questions on how to scale it up,” Laaksonen explains. “Pilot projects have small volumes, but we hope CRI is ready for big volumes. That’s one reason why we picked CRI.” Rautkivi was also on the jury and says all the finalists created value from different angles. CRI stood out from the crowd because they already have experience in developing and commercialising their solution. “CRI has done the entire process from the beginning, and we need to understand that process,” he says. “CRI has great people and a great solution, and they have already been involved with major co-creation projects.” **Producing next-gen energy solutions** CRI has already commercialised Power-to-X technology. At the George Olah Renewable Methanol Plant in Grindavik, Iceland, they obtain CO₂ by processing gas emissions from a geothermal power plant and obtain hydrogen by electrolysis of water using renewable energy. Their renewable methanol product Vulcanol is used by companies in Europe and China. Currently, the plant has an annual production capacity of 4000 tonnes of synthetic methanol. “The world needs liquid energy storage,

and our solution to convert CO₂ to methanol is already being used in several projects,” explains Stefánsson. CRI’s other ventures include the FreSMe project in a Swedish steel plant and MefCO₂ in Germany, both of which receives support from the EU Horizon 2020 research programme. **Towards a 100% renewable future** The winner of the SparkUp Challenge has been announced, but this is only the beginning. What’s the next step? “We’re going to Iceland!” Rautkivi says and laughs. “We want to go there and see what CRI is working on, to understand Wärtsilä’s role and how we can help with this technology. We will collaborate on real projects. Our Smart Energy vision is to have a 100% renewable future, and we believe Power-to-X technology is an important key to achieve that goal.” Moving towards a 100% renewable future is necessary from an environmental standpoint, but Stefánsson also stresses that it makes financial sense. Renewable methanol solutions can be cheaper than LNG, which makes it relevant for both the marine and energy sectors. “To get costs down we need to scale up,” explains Ásgeirsdóttir. “We are working in an ecosystem, and this now includes big new opportunities with Wärtsilä. We already have some great ideas on how we can collaborate.” ●

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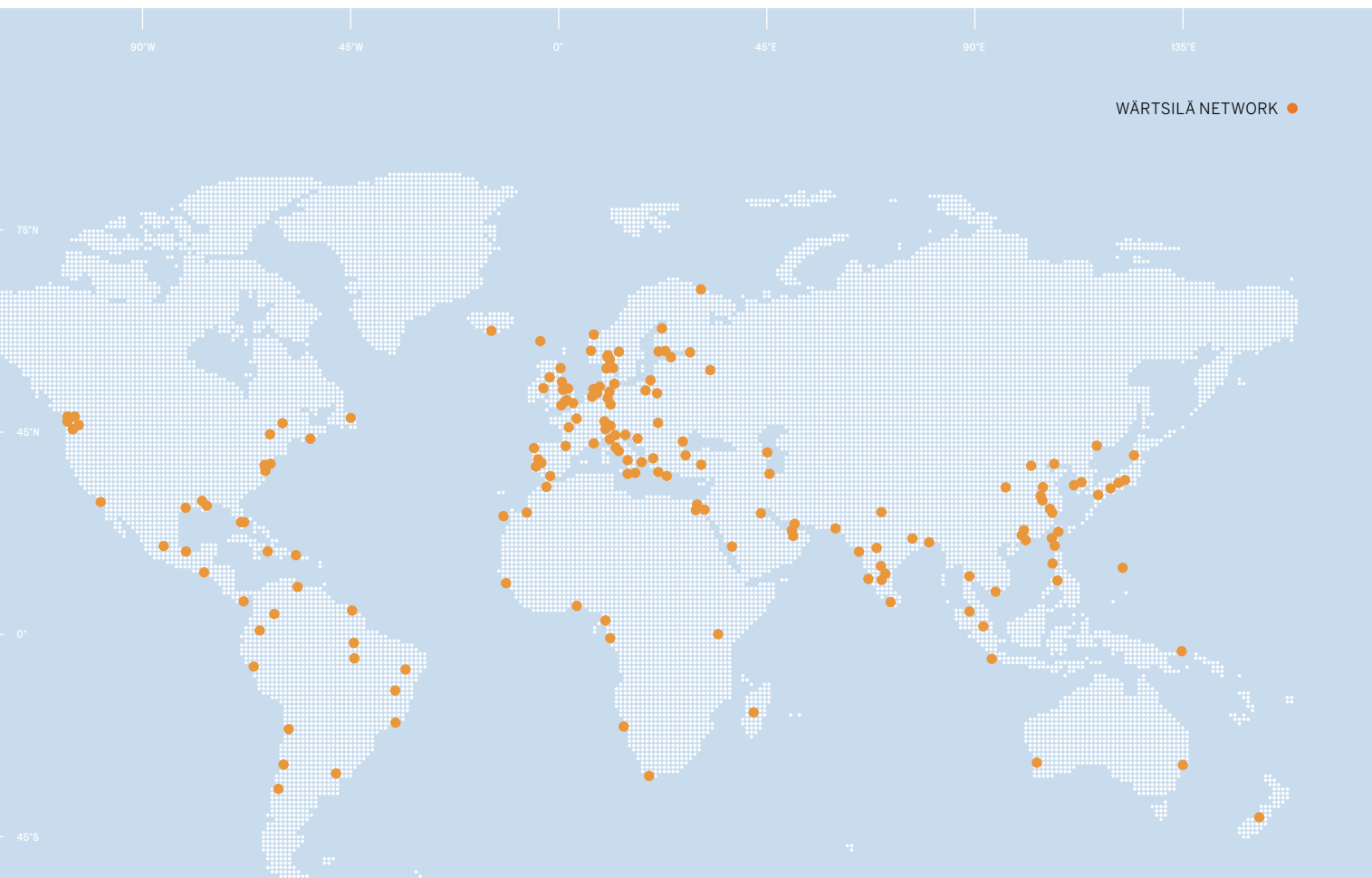
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in detail

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