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COVER STORY

MODELLING
The way to incorporate renewables into the grid
14 page

Contents

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EMBRACING THE POSSIBILITIES OF A CHANGING WORLD

We are living through unprecedented times, to say the least. The first months of 2020 have upended how we experience the world, the way we do business, and our vision of the future. This moment, as we plan a new path forward, offers us an opportunity to examine the old ways of doing things and assess how we might change them for the better.

As economies around the world ramp up following shutdowns imposed due to the novel coronavirus, we have a chance to look at the way we power our industries, and make choices for the coming decades that are affordable, reliable, and sustainable.

Africa offers several examples of how taking a chance on something new offers the opportunity to unlock previously unharnessed potential. With a growing, dynamic population, the continent has enormous possibilities for economic growth, but is being held back by a lack of reliable electricity. These energy shortages have ramifications for every aspect of social and economic development. Apart from reducing the quality of life, they limit the continent's attractiveness for doing business. In some parts of Africa, investors who want to build a new factory, for example, have to provide all their own infrastructure – from the facility, to the electricity to power it, to the transport system to get the products to market.

But Africa's lack of infrastructure is also an opportunity. Unhindered by outdated technology and outmoded thinking, African countries can leapfrog over outdated fossil fuel installations and go directly to renewables, making choices that are both environmentally friendly and economically competitive.

Deciding to take a chance on a new way of doing things always requires managing uncertainty, but energy modelling can add some clarity. Modelling provides actual data that decisionmakers can use to make informed choices about where to invest to make the most of renewables. Modelling is playing an important role in building an argument for sustainable energy generation in places as disparate as post-Soviet Ukraine and the Azores island of Graciosa.

Making the most of this opportunity to write a new future also requires finding new uses for resources we already have available. Biomass is one such resource. Biomethane, a synthetic gas produced from excess biowaste, could be the fuel source the world has been waiting for. It can be used with the same infrastructure as natural gas and significantly reduces greenhouse gas emissions. While at the moment it is challenging to produce at scale and transport, it represents one example of how we can find different uses for available assets.

Change is difficult, but it offers opportunities as well as challenges. As we work to discover the post-coronavirus economy, it's important to look to these possibilities.

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

POWERING AFRICA

The continent's economic future depends on reliable energy.

Can renewables lead the way?

REFERENCES

The gas of the future?

Biomethane might be the catalyst that drives a 100% renewable energy future, but bringing it into wider use is not without its challenges.

MORE ON PAGE **24**

Getting to port just in time

A new solution for improving ship-to-shore communication makes shipping more efficient and decreases emissions.

MORE ON PAGE **26**

Maritime's digital revolution

A groundbreaking deal between Wärtsilä and Anglo-Eastern could dramatically increase digitalisation in shipping.

MORE ON PAGE **36**

Photo: 123RF

Sun, sea, and software: Islands are at the forefront of a renewable energy revolution

AUTHOR: Sarah Hudson

Machine-learning software and advances in energy storage are changing the landscape of solar and wind power. Together, they form the building blocks of a 100% renewable energy future.

When it comes to getting smart about renewable energy, exotic locales like the Azores archipelago and the Caribbean make excellent testing grounds thanks to their high fuel costs but abundant wind and solar resources. On the islands of Graciosa and Bonaire, machine learning is hard at work, harnessing wind and solar energy output and optimising the power grids. In conjunction with next-generation energy storage systems, such as E.ON's Texas Waves, these projects represent the intertwined sides of the smart energy equation: optimisation and storage. Combined with the expansion of AI capability, they are leading the way towards a smart energy future based on cheap, reliable and 100% renewable sources.

Learning curves

When a smart energy project was first conceived for Graciosa in 2006, the island had been relying on a diesel-generated power plant for decades. The aim was to achieve 65% renewable energy for the entire population with 100% renewable power capability depending on real-time availability. According to **Luke Witmer**, General Manager, Data Science, Wärtsilä Energy Business, things are on track to meet this goal.

While the most visible step might be the construction of functional wind farms and solar collection, behind the scenes it is energy management software that's making renewable energy security a present reality.

"Wind and solar are potentially excellent renewable energy sources, but they're also volatile and unpredictable," explains Witmer. "You have to have ways of keeping the electrical grid sound if you're to let those energies into it."

Endlessly switching between collecting, storing, and doling out power as the needs of the grid fluctuate, energy input rises and falls, and battery capacity drains or maxes out is a delicate dance. It relies on hard logic, forecasting, and statistics. With the right human guidance, machines excel at it.

Does AI play a part?

Witmer explains that while there's been some hype about the potential role of artificial intelligence in managing the volatility of wind and solar, we are not quite there yet.

"Computers are trained by humans, with large swathes of data that's been cleaned, processed, and filtered. Humans are still heavily involved in making sure we feed good info to the computers," he says.

While in the future AI will have an important role to play in operational planning, true "self-learning" isn't yet a feature of energy generation, says Witmer.

However, in the case of Graciosa, which has a battery big enough to power the whole island for just under an hour, machine learning makes reliable wind and solar energy possible for the whole island. On Bonaire, which has a notably larger population, it's a matter of scaling up the optimisation and statistical forecasting.

Meanwhile, E.ON's Texas Waves facility is working on the storage side of the equation. These energy storage systems not only store an increasing amount of energy from wind and solar, but they also monitor the electrical quality of grid conditions, very quickly responding and balancing supply and demand shortages with bursts of power in both directions.

As complex systems are augmented with AI, it has become clear that machines are now able to process information with a level of intelligence that allows them to capably operate autonomously in ways that humans cannot. That said, sucessful operation is more about augmenting the human operator condition than replacing the operator.

Disrupting the industry

Machines aren't the only ones getting an education, though. **Risto Paldanius**, Director of Business Development at Wärtsilä Energy Business, highlights the disruption wind and solar power represent for a slow-moving industry.

"Non-renewable energy has been stable and dependable. It has existed for good reason," says Paldanius. "But we have to admit that in the new world of renewables, it almost feels like a dinosaur."

The industry needs to get used to the idea of being more agile, he says. A nuclear power or gas plant used to stay viable for up to 50 or 60 years, now we're talking about plants that can be built in six months, operate for a decade, and then be replaced with newer technology. It's a game-changer for investors, but this smart investment will have huge pay-offs for those who get it right – not to mention for the planet.

No looking back

Towards the end of the commissioning and the beginning of the endurance testing, Witmer's team realised that they were a button click away from delivering 100% renewable energy to Graciosa's entire population for the first time.

"We thought: OK, no looking back," recalls Witmer. They clicked the button.

For the first time in decades the diesel power plant fell silent. The wind blew… and the lights stayed on. It was one of the highlights of a job that regularly takes Witmer through the full gamut of emotions.

"I love what I do. It has spiritual meaning – for humanity as well as the rest of the planet and everything in it. The technology is here. If there's one thing we should be able to figure out, it is this."

Photo: HowardScott

Machine learning makes reliable wind and solar energy possible for the entire island of Graciosa.

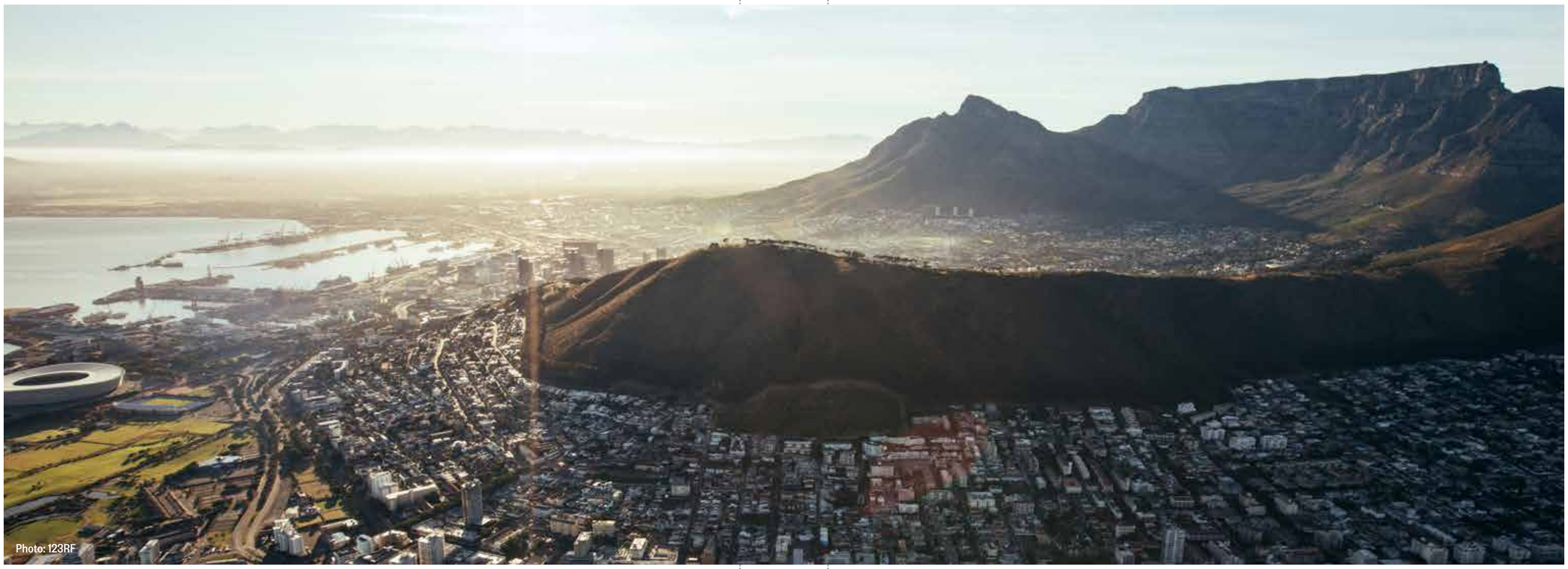

Photo: 123RF

Fulfilling Africa's potential for economic growth depends on reliable energy

AUTHOR: Lorelei Yang

Experts are calling Africa the next bright spot in the global economy, with several African nations registering strong economic growth. However, for this trend to continue, the continent's energy supply and distribution grid must be modernised.

In 2017, NASA released a series of satellite images of Earth at night. The images breathtakingly illustrated the massive intercontinental disparity when it comes to lighting at night. Europe, North America, parts of the Middle East, and East Asia were well lit, whereas Africa, Australia, Latin America, and Central Asia were much dimmer.

In Africa's case, the lack of light reflects a sobering reality: over half a billion Africans have no access to electricity, and even more have access only to very expensive and intermittent electricity.

"South Africa is experiencing rolling blackouts and brownouts (drops in voltage in a power system). In Zimbabwe, they've only been able to count on eight hours of electricity each day since March 2019. In Nigeria, only 30% of the population can count on electricity. In the Democratic Republic of Congo, it's even worse," explains **George Ayittey**, a Ghanaian native and president of the Free Africa Foundation.

Marco Wirén, President, Wärtsilä Energy Business, says: "Although there are major differences between countries, with some having large electricity deficits and others being further along in meeting their citizens' energy needs, the continent as a whole is behind Europe and the US, and there's a huge need for electrification."

A complex problem

Africa's electricity struggles are all the more striking when you consider the fact that the African economy is growing steadily, albeit at rates lower than the World Bank previously projected. Data from the African Development Bank shows the continent's GDP growth reached 3.5% in 2018, up from 2.1% in 2016.

Likewise, data from the EY Attractiveness Program Africa (2019) shows foreign direct investment in the continent has remained largely steady, even if it has not returned to the highs seen in 2014. In 2018, 710 projects attracted USD 75.5 billion in capital and created 170,000 jobs, a five-year high.

So why, in spite of this, are large parts of Africa deprived of access to regular electricity? In short, supply hasn't kept pace with demand. This is due to a number of factors, including rapid urbanisation, failure to make necessary investments, and high costs for existing electricity supplies.

Pekka Tolonen, Europe Energy Business Director for Wärtsilä Energy Business, who has also worked on developing the company's projects in Africa, notes that the African continent has the world's fastest urbanisation rate. It is forecast that by 2040, more than half the population of Africa will be living in urban areas. Lagos, Nigeria doubled from eight to 16 million residents from 2009 to 2015. However, supporting infrastructure – including power grids – hasn't kept up.

"Consequently, there are frequent blackouts, brownouts, and load shedding. Reliable power infrastructure is a major challenge today. This is partially because of a lack of generation, but also due to lack of transmission," he says.

"African governments have failed to make the necessary investments to expand electricity production," adds Ayittey, who says the current situation is dire. "Even South Africa's power utility company, Eskom, has failed to upgrade its generating capacity."

Wirén adds that lack of infrastructure

and a dearth of funding also contribute to African utilities' challenges. "There needs to be the ability to build power plants and generation capacity. The African Development Bank, International Finance Corporation, and other institutions that can give grants and funding need to negotiate with governments to fund these projects," Wirén says.

The urgent need for capital means many African countries are also open to foreign investment in the energy sector. Ayittey points to the Zambian power utility, ZESCO, as an extreme example of this. In 2018, ZESCO's management and financial woes led to a full takeover by the Chinese Exim Bank, as confirmed in a January 2019 post by the bank.

National utilities' operating costs are also a challenge, as the bottom line is that their generation costs are higher than what they can legally charge consumers. As a result, they need to be continually subsidised, which is impractical if countries are working towards a healthy power market.

"When you don't have self-standing utilities, it becomes a very difficult situation," says Tolonen. He also explains why raising prices isn't a viable solution. "In the short term, if you want to sanitise the utilities, you would increase the power price – but that might kill the industries and wouldn't enable healthy economic growth. So, you're in a sort of lock-in situation."

Historical mismanagement of state-run energy companies by unqualified political appointees is also a problem. Ayittey argues that political change is necessary in these cases. "To be blunt, there are some countries that won't move forward without a new crop of leaders to undertake energy reforms under new leadership."

Finally, even those African consumers who are lucky enough to have access to a regular supply of electricity must contend with high prices. According to Tolonen, "A ballpark power price is two to three times more for energy in Africa versus Europe or America, while at the same time the population's purchasing power is much lower than in those comparable regions."

Left without power

According to the World Bank's latest RISE (Regulatory Indicators for Sustainable Energy) report (2016), many countries in

[ENERGY / IN DETAIL]


Photo: 123RF

Sub-Saharan Africa lack officially approved electrification plans. Households and firms in these countries endure several hours of the day and night without access to power.

These energy shortages have ramifications across the board. Apart from reducing citizens' quality of life, they decrease the continent's attractiveness to businesses, preventing it from reaching its full potential. Ayittey offers the example of Nigeria to illustrate this point. "In Nigeria, the energy situation is so bad that foreign investors who want to establish a business have to provide their own electricity, water supply system, and possibly even their own road to take products to the market."

According to Tolonen, power instability is one of the factors contributing to high unemployment rates in many African countries. "You really can't create jobs in certain fields without reliable and stable power," Tolonen says.

The renewable energy option

However, new technologies, especially renewables, offer hope. Many experts wonder why one of the sunniest spots on the planet is not leveraging the benefits of renewable energy to solve its energy problems.

In fact, hydropower by itself could serve the entire African continent's needs. According to Ayittey, the Congo Basin alone has enough hydroelectric potential to power all of Africa. Ethiopia, for one, has already caught on to hydropower's potential, investing in a EUR 3,397 million dam project, the Grand Ethiopian Renaissance Dam Project, that will generate 15,000 GWh/year once completed.

Wirén is broadly optimistic about the African energy sector's future. He believes that it, like the telecoms sector, could leapfrog outmoded technologies and skip straight ahead to the latest developments.

"The African continent didn't build landlines; they went straight to mobile phones. Similarly, countries don't need to build up a huge fossil fuel capacity first and then go to renewables. Instead, they can use energy modelling to determine the most economically viable mix of generation," he explains.

Although Wirén believes many countries will still continue using fossil-fuel-based generation, he believes that growth in the sector will come from renewables, flexible solutions, and storage solutions coming online.

The Fekola mine in Mali is one example of this kind of hybrid solution. In December, Wärtsilä signed an agreement to provide an energy storage solution for the mine, allowing Fekola to add solar to its electricity production. Wärtsilä's advanced GEMS energy management software solution will optimise energy production for the entire mine through the use of the new storage system and a 30 MW solar plant currently under construction. GEMS technology uses artificial intelligence and automated decision-making based on real-time and forecasted data to maximise efficiency. Hybrid systems with energy storage are ideal for providing energy stability in operations like remote mining locations where the conditions are often challenging.

Tolonen believes that since investors the world over are generally backing away from more polluting power generation methods in favour of options that don't produce CO_2, their preferences might encourage the adoption of renewables.

Tolonen also says that renewables are more promising from a pure cost perspective. In his opinion, their lower cost will crowd alternatives out, particularly in Africa, where fuel costs are high. "If you can sign PPAs (power purchase agreements) at two to three cents – the latest solar price record in Africa is 2.4 cents per kWh in Tunisia in September 2019, and we're seeing solar power plants signed in several countries just above 3 cents per kWh) – across the African continent, that's a price that's a fraction of what we were seeing even two years back," Tolonen says. "The knee-jerk reaction is: 'why would we build anything else if we can get this so cheaply?' The next reaction is: 'I want to get more of this inexpensive thing.'"

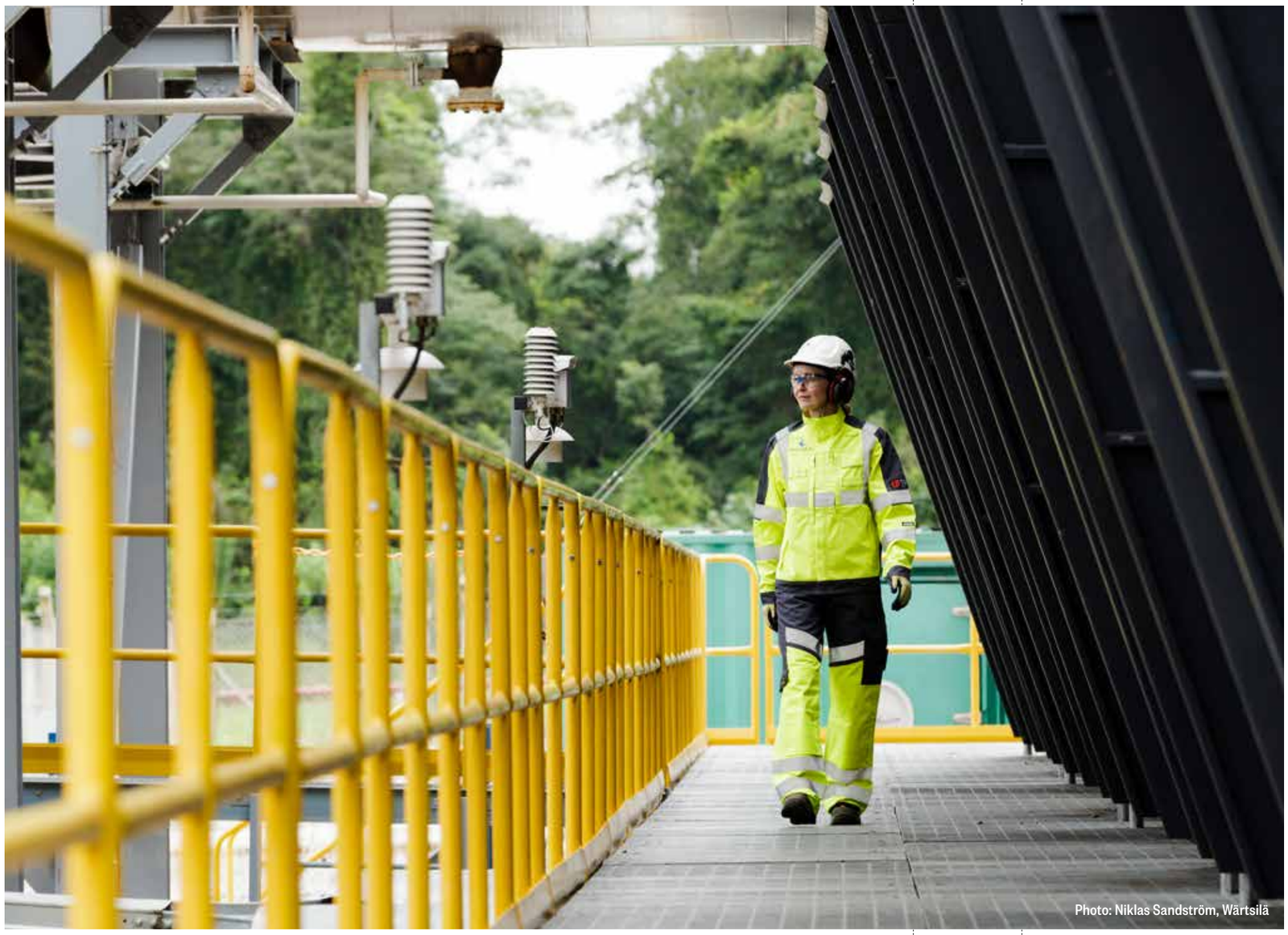

Photo: Niklas Sandström, Wärtsilä

Making power plants better neighbours through collaboration and technology

AUTHOR: Anne Salomäki

A number of measures have been put in place over the years to keep power plant noise levels at an acceptable level and in line with regulations. Now, Wärtsilä and its partners have found a way to increase the quality of life for people who live near power plants while also boosting the plants' efficiency.

Today more and more people are moving into cities, causing urban areas to grow and spread. With this increase in population comes a surge in demand for energy. And with the share of intermittent renewable energy sources on the rise as well, there are more opportunities for locating flexible power plants near where people live.

However, energy production also generates noise. To address the issue before it becomes – literally – too loud, Wärtsilä and VTT Technical Research Centre of Finland launched a project to create innovative solutions to further reduce noise levels at power plants.

The project, known as SOPEVA, is funded in part by Wärtsilä and partly by Business Finland, a public agency for research funding and international promoter for Finnish industries. The project's name is an abbreviation from the full Finnish title, which translates to "socially acceptable energy production in varying environments." SOPEVA is taking place in tandem with a public project known as Anojanssi, headed by Turku University of Applied Sciences, which has been in charge of developing the perceived annoyance quantification methods utilised in SOPEVA.

The goal of the project was to lower noise emissions by developing both equipment and co-operation within the entire subcontractor network.

"The aim of SOPEVA has been to respond to a need before it becomes urgent," explains **Eirik Linde**, General Manager, Environment, Wärtsilä Energy Business. "It's not a technology we could develop on a whim; when customers ask for it, we want to meet their expectations."

The science of noise reduction

The most notable sources of power plant noise are cooling radiators, exhaust gas stacks and ducts, combustion air intake, and ventilation, as well as the running of the engines themselves. The management of this noise has significant impact on the ways nearby areas are affected.

"Traditionally, the exhaust system has been provided with individual components that reduce noise, especially at a certain frequency," says **Antti Hynninen**, Senior Scientist at VTT. "Now, we considered the entire acoustic chain from the sound source to the recipient across the hearing zone. We also used the noise cancellation principle, where components attenuate each other based on the phasing of sound. At the same time, the need for insulating materials was reduced, making the components more durable and environmentally sound."

These technologies can be utilised anywhere, from a busy metropolis to a small and remote island nation. Germany and the south of the UK, including the Channel Islands, are all places with potential for the technology. These regions have strict local regulations requiring that certain levels of noise emission be met before planning permits for new power plants are issued.

A lot can be done with how the building is constructed, but not all of the possible options are practical. For example, building very thick walls to silence the noise would make a power plant project so expensive that it would no longer be a viable option.

Part of the change

After three years, the project team had developed various solutions that reduced noise emissions by 10 to 20 decibels. In practice, this means a smaller noise footprint for a power plant, of up to 90 to 99% – a significant improvement for living conditions in nearby areas.

"In the open air, this would be equivalent to moving a kilometre away from the noise source, such as a large outdoor concert arena," Hynninen says. He adds that for city dwellers, the change is equivalent to wearing earplugs or closing windows to alleviate traffic noise.

The project's success depended on the SOPEVA team bringing its best ideas together.

"Previously it was common in the industry that organisations were more protective of their innovations," Linde says. "Today, however, collaboration is the only way forward. Through combined effort and co-operation, we can bring together the best skills from all sectors and be as agile and robust as the market expects us to be."

SOPEVA is a clear demonstration of Wärtsilä's overall vision: enabling sustainable societies with smart technology, a goal that depends on open collaboration with partners such as VTT.

Photo: 123RF

How advanced modelling is transforming Ukraine's post-Soviet power sector

AUTHOR: Kira Egorova

Ukraine is experiencing a boom in renewable energy generation, the result of a decade of multiple government attempts to stimulate the sector. But integrating the post-Soviet power system that makes up the base of the sector with wind and solar has not been easy.

Ukraine provides an interesting case study into the challenges of integrating green technology into non-flexible energy systems. Changing the country's existing infrastructure – both physical and regulatory – requires politicians, officials and businesses to sign on to a programme whose benefits are difficult to see. But power system modelling based on big data analysis can help bring clarity and create a clear path to a carbon-neutral future.

An ambitious challenge

In 2017, Ukraine's government adopted Energy Strategy 2035, setting the ambitious challenge of adapting the country's existing power system to integrate it with the European one. In practice, this means the physical integration of the Ukrainian power network to ENTSO-E, the power network of the European Union (EU).

"These changes would not only give the country the ability to begin trading energy with the EU – they would also promote energy efficiency and security," says **Igor Petryk**, Senior Market Development Manager at Wärtsilä Energy Business.

In order to stimulate the renewable energy production required under Energy Strategy 2035, the Ukrainian government set special fixed green tariffs of EUR 0.10–0.15 per 1 kWh – more than twice the tariffs for power produced from nuclear and coal sources, which fluctuates with the market but cost around EUR 0.06 per 1 kWh. To guarantee demand for the more expensive renewable energy, the Ukrainian government created a "guaranteed customer" system and required the purchase of energy from renewable sources.

As a result, over the past couple of years, these tariffs boosted production of green energy. Plenty of solar panels and wind generators have been placed on Ukraine's fields and valleys. According to Petryk, the capacity of wind and sun energy generators will reach 7.5 GW by the end of 2020. For comparison, average energy consumption in Ukraine is around 18 GW, ranging between a peak of 26 GW in winter and a low of 12 GW in summer. But these same conditions that boost renewable energy production also add to its cost.

"As the price of solar panels and wind turbines has gone down over the past years and installations became viable without subsidies, many countries switched from feed-in tariffs to auctions, which reduces the electricity price for consumers," says Petryk.

"Ukraine failed to introduce the auction system on time. As a result, the super-generous tariffs have attracted massive investments into the generating capacity that enjoys guaranteed payments. The cost of renewable energy is now becoming disproportionally high, and this may create an unbearable burden for consumers and a threat for further development of clean energy."

An additional problem, Petryk says, is the inflexibility of the power system dating back to the Soviet times. "We at Wärtsilä believe this system is probably the most inflexible power system in the world. It is simply unable to absorb the rapidly growing volumes of intermittent green energy."

As a result, the transmission system operator will have to curtail about 30% of renewable power generation, which under current law would still need to be paid for. As a result, the Ukrainian economy risks losing up to EUR 580 million producing green energy that can't be consumed or stored.

Not just Ukraine

Ukraine isn't the only country facing the challenge of integrating renewables into their energy mix. The main difficulty comes from the fact that renewable energy generation depends on sources – wind and sun – that are not regular and sometimes not even predictable. Making the most of these sources requires a power system to be very flexible: there should be sources of extra energy in case renewable ones are temporarily not available. Ukraine however has a particular problem based on its Soviet-era energy infrastructure. The main sources of power are nuclear power plants, which are difficult to bring on- and off-line, and coal-fired power plants, which contribute substantial CO_2 emissions to the atmosphere.

From post-Soviet problems to power modelling

For more than two years, experts from Wärtsilä have been modelling Ukraine's power system in cooperation with the state transmission system operator (TSO) to look for alternative options for flexible power generation.

The kind of complex calculations needed to do the modelling were made by PLEXOS, an advanced data analytics program. PLEXOS software, which was developed for the purpose of optimising power systems, allows TSOs, utilities and consultants to build a model of the power system and analyse various strategies for adding capacity or dispatching the assets, according to **Jan Andersson**, Market Development Manager, Growth & Development, Wärtsilä Energy Business.

"The model takes into account important parameters such as renewable generation, power system reserves, costs, and emissions as well as power-plant-specific parameters such as start cost, ramp rates, and minimum up and down times," Andersson explains.

All of these parameters are necessary to build the most realistic model of the power system possible, thereby generating accurate and reliable results.

In the Ukraine case, Wärtsilä calculated 20 different scenarios, combining the power generation capacities of renewable sources and internal combustion engines. The researchers came to the conclusion that the country needs an extra 2 GW of flexible energy, which can be generated by internal combustion engines running on natural gas.

"By implementing these engines rather than relying on coal-powered power generation, the country can save approximately EUR 300 million," Petryk says.

The internal combustion engines also produce fewer CO_2 emissions compared to coal-fired power generation. In fact, according to Wärtsilä's calculations, using the internal combustion engines will shrink the CO_2 emissions of power generation in Ukraine by 15%.

"Our results show that by adding 2–3 GW of flexibility in the system, renewable energy can be fully utilised, CO_2 emissions can be reduced significantly and at a lower cost compared to the business-as-usual case," says Andersson.

Andersson says that Ukraine's power system presents an interesting challenge. The current system, largely based on nuclear and coal power generation, is not suited to flexibility. Nevertheless, flexibility is exactly what is needed to utilise as much as possible of the increasing amounts of renewable energy promoted by government programmes. Looking ahead, Andersson says, it would be sensible for Ukraine to keep its nuclear power systems as long as possible, as this energy source is already CO_2-free. Coal should be reduced in favour of renewables, and flexible thermal plants running on gas would support integration of renewables in the power system. In the future, these flexible thermal plants can be converted to bio or synthetic gas to become carbon neutral.

Read more about Wärtsilä's power system modelling on page 18.

Photo: 123RF

The power of Advanced System Modelling

AUTHOR: Payal Bhattar and David J. Cord

More and more countries want to increase the share of renewables in their power systems, but figuring out how to do so efficiently and affordably is a challenge.

Say that Country A decides to add renewables to its power mix and sets a target of having 50% or 100% of its energy come from renewable sources at a particular year in the future. Country A's experts can quite easily calculate how much installed wind and solar it needs to meet this target. But how will it evaluate how the rest of its power system will look at the same future year? How flexible should the system be? And most importantly, how will this optimal system look, how much will it cost, and how can Country A pay for it?

The country has to consider what its future requirements will be based on where it is today. For example, it could install inflexible power plants today that may fit well in its system for a while but could become redundant in five or 10 years because this choice of asset hinders renewable penetration due to its inflexibility. Advanced System Modelling can prevent this kind of stranded asset, as it helps find the most optimal solution with the least cost while at the same time considering all the technical constraints.

"Advanced modelling involves optimisation of the power system in a way where power plants' system flexibility and the ability to balance intermittent wind and solar is considered truthfully," explains **Jyrki Leino**, Senior Manager, Business Development at Wärtsilä Energy Business. "In contrast, the traditional approach uses approximations, which have worked OK in the past when power was generated mainly from large centralised power plants like coal and nuclear and no intermittent renewables were in the systems on a large scale. As renewables increase in a power system, the results tend to go even more wrong, which leads to wrong decisions and hence wrong investments."

Building smart systems

Advanced System Modelling takes different factors into account, such as real-life systems operating alongside balancing renewable generation or system reserve provisions. It considers all the technical constraints of the system and its existing power plants, such as maximum capacity, minimum stable level, maximum ramp-up, variable production profiles of wind and solar, cost-related parameters like fuel costs and heat rates, variable operation costs and ramping-up costs. Once the software knows all these parameters, it is operated by running power plants in an optimised way where the demand every hour of a year is met in the most cost-efficient manner. In this system, modelling is done precisely and chronologically, unlike other approaches that use approximations, such as the duration-curve approach.

As more and more countries rush in to add renewables to their portfolio to lower carbon emissions, they need to make investments that will remain meaningful 20 to 30 years from now.

"We have conducted modelling and system studies for 175 systems globally since 2011," says Leino. "At that time, people didn't see a need for advanced power system modelling because power systems were not yet facing any severe lack of flexibility issues. While we saw that there is an increasing need for flexibility in the future, widely used traditional modelling approaches did not reveal the need for it at that time. Today the advanced modelling approach has been very well received and has helped countries realise that their previous master plans were not capable to integrate as much renewable sources as they had planned."

Real world examples

Advanced System Modelling has been used to optimise power systems in countries with a variety of challenges.

In 2015, the South African government received guidance from Wärtsilä to examine and understand the gas flexibility requirements for the country's power system and how these requirements link to the complexities apparent in the LNG supply chain. Through rigorous analysis and complex power system modelling using PLEXOS, it was determined that a 3GW LNG-fuelled power plant would generate system savings in excess of USD 250 million per year.

This recommendation was made considering the high degree of LNG supply flexibility (which comes at a premium) and the variable energy and reserve load factors that are required to support the intermittency associated with renewable energy. In essence, the modelling revealed that the system-level benefits of having a flexible solution far outweighed the project-level cost savings with a cost-optimised LNG supply agreement that traditionally favours high volume and stable offtakes. An energy transition like the one in South Africa demands huge capital outlays, superior technical expertise, and a dramatic change in the social and political mindset. Power system modelling helps maximise all those factors for the best possible solution.

Italy's power system also was recently the subject of a study by PLEXOS power system modelling. Italy's National Energy and Climate Plan calls for an increase in the share of renewables in total energy consumption to 30% by 2030. Energy efficiency targets aim to reduce consumption by 1.5% annually. At the moment, baseload in Italy is generated primarily by gas turbines. The country has no nuclear power plants and only a few coal-fired power plants. It has a large hydroelectric sector and was an early adopter of wind and geothermal power. The use of solar power increased dramatically over the past decade and will continue to grow.

"There are major challenges, both in installing this huge amount of new capacity as well as handling the intermittent nature of wind and solar," says **Jan Andersson**, Market Development Manager, Growth & Development, Wärtsilä Energy Business. "We need to introduce new solutions as well as utilise the assets that are already there through upgrades and conversions to make the system more flexible."

Wind and solar generate power intermittently, but the demand for electricity has no relationship to when it is generated. Increasing flexibility in the energy system would give utilities the ability to quickly and efficiently switch from one source of power to another as needed in order to ensure grid reliability and stability. Italy already has some flexible generating capacity with hydropower plants, but these depend upon hydrological conditions, and it isn't viable to greatly expand hydropower. The country plans to develop 5 GW of energy storage capacity, but this alone will not provide the flexibility needed.

In Italy, preliminary results show the need for 5–7 GW of additional flexible gas-fired power generation capacity after the expansion of renewables and addition of energy storage capacity.

Ingenious solutions for a 100% renewable energy future

A move towards a more efficient and flexible energy system requires some ingenious ideas. For example, one possible solution is the use of flexible combined heat and power (CHP) generation that supports the integration of renewables. A CHP plant generates electricity, but also heat to be used to warm homes and businesses.

"We can also add more flexibility with the cogeneration of heat and power in the same way as conventional gas engine plants. With heat storage, electricity and heat generation can be decoupled," says **Marco Golinelli**, Senior Manager, Business Development, Wärtsilä Energy Business. "This increases efficiencies, provides district heating and contributes to balancing the market."

Wärtsilä has already begun CHP solutions in Germany, with KMW in the Mainz-Wiesbaden area and DREWAG in Dresden. The fast start-and-stop capabilities of Wärtsilä engines add flexibility to the energy system and can achieve total efficiencies as high as 90%. An added benefit of CHP plants is that heat can be stored to use later.

There is no doubt that Advanced System Modelling will play a crucial role in shaping future power systems. It is the only system that takes real-life system challenges into account and provides a fundamental understanding into multiple future scenarios while identifying most sensitivities.

Photo: HowardScott

Microgrids use renewables to offer efficient, effective solutions to power challenges

AUTHOR: Lorelei Yang

Renewable energy sources are increasingly seen as a viable option for areas with unique challenges for energy production. Microgrids may be a way to help expand renewable capabilities while also increasing operational efficiency.

Microgrids – smaller, isolated power systems and grids with lower loads – have exploded in popularity worldwide. A broad range of projects, including microgrids for resilience, post-disaster building and economic development, have come online in recent years. It's also easier to incorporate renewables into microgrid power generation thanks to their size and structure.

Risto Paldanius, Director of Business Development at Wärtsilä Energy Business, says there are generally three types of places where microgrids are deployed: physical islands where there is a dependence on imported fuels but there is an abundance of renewables; isolated areas with high energy consumption for industrial applications, such as industrial mines, which require isolated grids to support high industrial energy demand; and remote inhabited areas, which require electricity for residential use, but don't have enough energy demand in total for more traditional energy grids.

The usefulness of microgrids in these situations is due to two key features, according to Paldanius.

The first is their simplicity as compared to traditional power grids.

"The complexity of microgrids is lower. There are fewer assets, fewer transmission lines, and fewer substations. So, there's more controlled, limited environments that need to be operated and maintained. This makes it easier for the microgrid owner, which is typically a local power operator, to maintain the microgrid. So, advanced microgrids are easier to get off the ground," says Paldanius.

Second, microgrids typically have a lower generation capacity and are easier to calibrate to changes in consumer demand throughout the year.

"Wärtsilä's GEMS energy management system can easily optimise the microgrids," Paldanius says. Using GEMS, Wärtsilä is able to use AI and machine learning to get an accurate prediction of energy use and demand. It can also forecast how much solar power or other renewable sources will be available for use and optimise their generation.

Once deployed, microgrids deliver three key benefits: lower electricity costs and tariffs; lower emissions as compared to thermal power generation or gas generation; and improved electricity stability, which can be especially valuable on islands where poor grid management often leads to brownouts or even blackouts.

A successful track record

Wärtsilä has successfully deployed microgrids on the Caribbean island of Bonaire and in the Azores, an archipelago in the mid-Atlantic.

On Bonaire, an island of 19,000 residents, Wärtsilä's 6MW/6MWh energy storage solution integrates multiple generation assets – including all of the island's existing power generation, energy storage, and wind assets – with GEMS. Using GEMS to control the microgrid is a key to increasing Bonaire's power system reliability, according to Paldanius. Now that the energy storage system and GEMS both have been installed on the whole island, Bonaire has "achieved social benefits, lower energy tariffs, reduced emissions, and greater energy supply stability," Paldanius says. The system has boosted wind penetration from around 20% to 33%, fuel consumption has decreased by 5% and CO_2 emissions have fallen by 8%.

The Azores, which installed a 6MW/3.2MWh energy storage system solution with engines, wind and solar, has also optimised its entire grid in the Graciosa Hybrid Renewable Power Plant project with GEMS. The system will eliminate the use of 17,000 litres of diesel fuel per month on the island and boost renewable energy consumption from 15% to 65%.

"While we still need more wind, solar, and to add some batteries, this is a great example of how microgrids are the first to achieve the goal of 100% renewable electricity," says Paldanius.

The Graciosa project's ability to continuously operate fully on renewables is proof of its success.

"The developer says the longest continuous period of operating fully on renewables was three days," says Paldanius. "The wind was blowing well, sun was good, and the batteries were managing the overnight consumption – that's a great success."

Co-creating solutions

Over the long term, Paldanius expects that microgrids will continue to be developed in partnership with utilities by combining historical data and the local utility's renewable energy vision.

"It is a process of understanding all the assets on the island and co-creating a microgrid that delivers on the customer's need," Paldanius says.

Today, the value proposition of immediate results using Greensmith's GEMS platform is expanding the market for Wärtsilä technologies for microgrids.

"With today's technology and software control systems, we're able to improve operations of the assets and predict load much better even without adding new technology," says Paldanius. "It's about data, machine learning, and optimising the system better. Yes, sometimes you'll need to add energy storage, but the key thing here is that we at Wärtsilä now have the capability to do optimisation through powerful computing data and real-time systems operations."

[ENERGY / IN DETAIL]

Photo: 123RF

Wind power has an important role to play as Europe pushes for carbon-neutrality

AUTHOR: Alex Stevens

The European Commission has set a goal for Europe to become the world's first carbon-neutral continent by 2050, and wind energy has an important role to play in this transformation.

Today, 14% of energy in Europe is produced by wind farms. The potential for this type of renewable energy is much higher, however.

Europe is already a world leader in the wind energy market, but the plans of the European Commission are even more ambitious. Offshore wind power generation is central to its plan to transition to a carbon-neutral economy by 2050. The goal to increase the offshore installed capacity from the current 20 GW up to 450 GW by 2050 is achievable, according to WindEurope, an association promoting the use of wind power on the continent. The key factors for success are the right spatial maritime planning along with investments in the offshore and onshore grid.

Creating clean energy and jobs

Wind farms remain one of the cheapest and cleanest sources of renewable energy available, and they create new jobs in the communities where turbines are installed.

Technologies such as Internet of Things (IoT) promise to make wind energy even more cost-efficient and reduce maintenance costs – an issue that is especially important for offshore farms, according to **Alexander Vandenberghe**, Research & Innovation Advisor at WindEurope.

"With IoT, each turbine will be able to communicate with the others, and the operator will be able to identify how to adjust each turbine in order to increase the output on the farm level," Vandenberghe explains. "We are moving towards real-time, condition-based maintenance, when the condition of every component of a turbine can be measured in real time."

This data would enable operators to adjust the workload and performance of any particular turbine and plan the maintenance process, so that a repair crew, once deployed to an offshore farm, could replace several components in different turbines at one time. The ROMEO project, an EU Horizon 2020 venture, is currently testing IoT technologies on several sites in the UK and Germany to reduce the maintenance costs and increase the overall efficiency of wind farms.

When it comes to the short-term outlook, a lot depends on the national energy and climate plans of each individual EU member state as well as permitting issues. According to WindEurope, up to 90 GW of new wind energy capacity could be installed across Europe in the next five years, if national plans are extremely ambitious and the permitting processes improve significantly.

A promising investment from Google

One recent bit of positive news for the wind energy market was Google's announcement in September 2019 to invest USD 2 billion in renewable energy. About half of the investments will be made in Europe, including large wind energy projects in Finland (255 MW) and Sweden (286 MW). The new wind projects will produce power for Google's data centre in Hamina, Finland.

"We are glad to see these long-term power purchase agreements with Google," says **Marja Kaitaniemi**, chairperson of the Finnish Wind Power Association.

More good news for wind power in Finland is the first domestic power purchase agreement between state-owned energy company Fortum and the refining company Neste, which signed a 12-year contract to purchase wind energy from the Kalax wind farm.

"It is a good sign. I have been expecting for years that there will be domestic buyers of wind power. In Finland, there is a big domestic energy demand from the industry," says Kaitaniemi.

Wärtsilä is positive about these developments in Finland. The company develops technological solutions for data centres powered by renewable energy. In case of a gap between the data centre's energy demand and wind and solar energy supply, Wärtsilä's flexible gas engine power plant can step in, dynamically adapting to the gap. This mode of operation is called "wind chasing" and it has been used by power plants based on gas engines for years.

"Our role is to provide flexibility and stability to the grid, which allows for more wind power and renewables," says **Anette Danielsson**, Financial Analyst for Market Development at Wärtsilä Energy Business.

Wärtsilä is also doing modelling for flexible energy generation involving wind energy. This modelling is aimed at optimising power systems and finding the right balance between renewables and flexible gas plants. "By moving technology forward, Wärtsilä is working on making a renewable energy future possible," says Danielsson.

Recently published research in the journal *Energy Policy* shows that Europe has enough space to install new onshore turbines that could theoretically generate enough energy to meet the energy demands of the whole world in 2050. Practically, however, this option has a number of challenges as it would require a huge amount of surface area and a massive expansion of transmission systems – both of which involve substantial investment. At the moment, the most economical way of achieving carbon neutrality is a combination of renewables, storage, and solutions bringing flexibility. Because renewable sources are variable, the flexible thermal capacity can quickly step in when they are unavailable. Initially, this capacity will come from fossil-based fuels, but in the future, it will rely on renewable synthetic fuels.

Sönderjysk II – Installation of the second train of a biogas upgrading plant, April 2020 (Denmark). Photo: Tom Rohde, WSE

Biomethane: The next natural gas?

AUTHOR: **David J. Cord**

Could methane provide the catalyst for a 100% renewable energy future? Biomethane is the new kid on the renewable energy block, but it is ready to come of age by providing real solutions to our future fuel needs.

There are many potential sources of renewable energy, but one is often overlooked. In fact, we can't even see it: microorganisms. Microbes can help us create clean, renewable energy in a process called biomethanation.

"Biomethanation is biological methane production. It is a natural process carried out by natural organisms known as methanogens," explains **Anni Alitalo**, R&D Director at Q Power.

Methane is a gas that is formed mostly by biological processes, such as the breakup of organic matter in anoxic soil environments or from the digestive process of cows. It is the main constituent of natural gas and produces less carbon dioxide than other hydrocarbon fuels for each unit of heat released. Unlike other fuels, and depending upon the engine, burning methane results in less nitrous oxide, sulphur dioxide or particulate emissions. It becomes even more attractive when it is produced sustainably.

Carbon-neutral or carbon-negative energy

Methane can be produced from carbon dioxide and hydrogen. Q Power is a start-up that uses renewable energy to produce hydrogen from water using electrolysis. They obtain carbon dioxide from various sources, for example an anaerobic digester, which uses microorganisms to break down organic material and produce biogas. In September 2019, Wärtsilä and Q Power signed a cooperation deal designed to accelerate the development and commercialisation of renewable fuels.

The anaerobic digester can use a variety of organic material to create methane and carbon dioxide, such as waste from the forestry, food, or agriculture industries. Carbon dioxide that would have been released into the atmosphere is instead used to create fuel. Q Power combines the hydrogen and carbon dioxide to produce synthetic methane.

"The big advantage of using methane as fuel is the reduction of CO_2 compared to using traditional liquid fossil fuels," says **Reetta Kaila**, Technology & Development Manager, Renewable Gases at Wärtsilä Marine Business. "According to a greenhouse gas emission study by a third party, Thinkstep, last year, using LNG can reduce CO_2 emissions by 12 to 15%, depending upon the engine, but using biomethane can actually be a net negative CO_2 process, depending upon the source of the biomass."

Wärtsilä partners with Q Power

This is an example of the Power-to-X process, in which renewable energy is converted into a form that can be used later. In this case, power is ultimately transformed into synthetic methane gas. Wärtsilä believes the Power-to-X process is a key to a sustainable future when there is an excess of renewable energy available.

"Wärtsilä is the global leader in marine and energy technology, and both of our companies see a 100% renewable energy future," Alitalo explains.

The first step of the partnership between Wärtsilä and Q Power is a demonstration of the process. There are plans to take a small, mobile plant to the Finnish pavilion at the Expo in Dubai in 2021 to show how Q Power's biological methanation process works and the benefits of synthetic methane.

There are other ways to create methane, such as catalyst technologies, but currently some of these methods need high pressure and high temperatures. Q Power has a different approach.

"By using microorganisms in our unique bio-reactors we can do the process using low temperatures and no pressure," Alitalo says. "In addition, we don't need to mix or constantly pump fluid. Our technology solves the problem of needing lots of energy to create biomethane."

Current challenges: cost and scale

A major benefit of bio- or synthetic methane is that it doesn't require extensive new infrastructure, although the focus is more on how to collect the necessary feedstock. The world already uses LNG for energy generation and transport, and bio-LNG, liquefied biomethane, and liquefied synthetic methane can replace LNG with no changes to existing systems.

"Biogas has the same methane molecule as LNG and, in fact, is a better-quality fuel," says Kaila. "It can be used in an LNG engine on a ship or a power plant. Liquefied biomethane or synthetic methane is 99.99% methane, with only 50 ppm of CO_2. Thus, the methane number is high and it will not cause knocking issues. With fossil LNG that has heavier hydrocarbons and a methane number ranging from below 70 to almost 100, there is a risk that one cannot always operate on full load."

Biomethane sounds like the holy grail, but it does have issues that need to be addressed. Firstly, it needs raw material, but biogas plants could be built close to major forestry, food or agriculture centres where they could source biomass such as residues. The biggest challenge currently is cost. Biomethane can cost several times as much as natural gas. However, as biogas plants scale up production, costs are expected to come down, in the same way as wind and solar power. Even more importantly, if the costs of carbon emissions are included in the price of fossil fuels, then biomethane begins to look much more attractive.

"We're very excited about Q Power's technology and are happy to be partnering with them," Kaila says. "We only have a small carbon budget left to keep the global temperature increase to 1.5 degrees, and serious decisions need to be made today. We believe biomethane can play a huge role in fuelling the energy and maritime sectors."

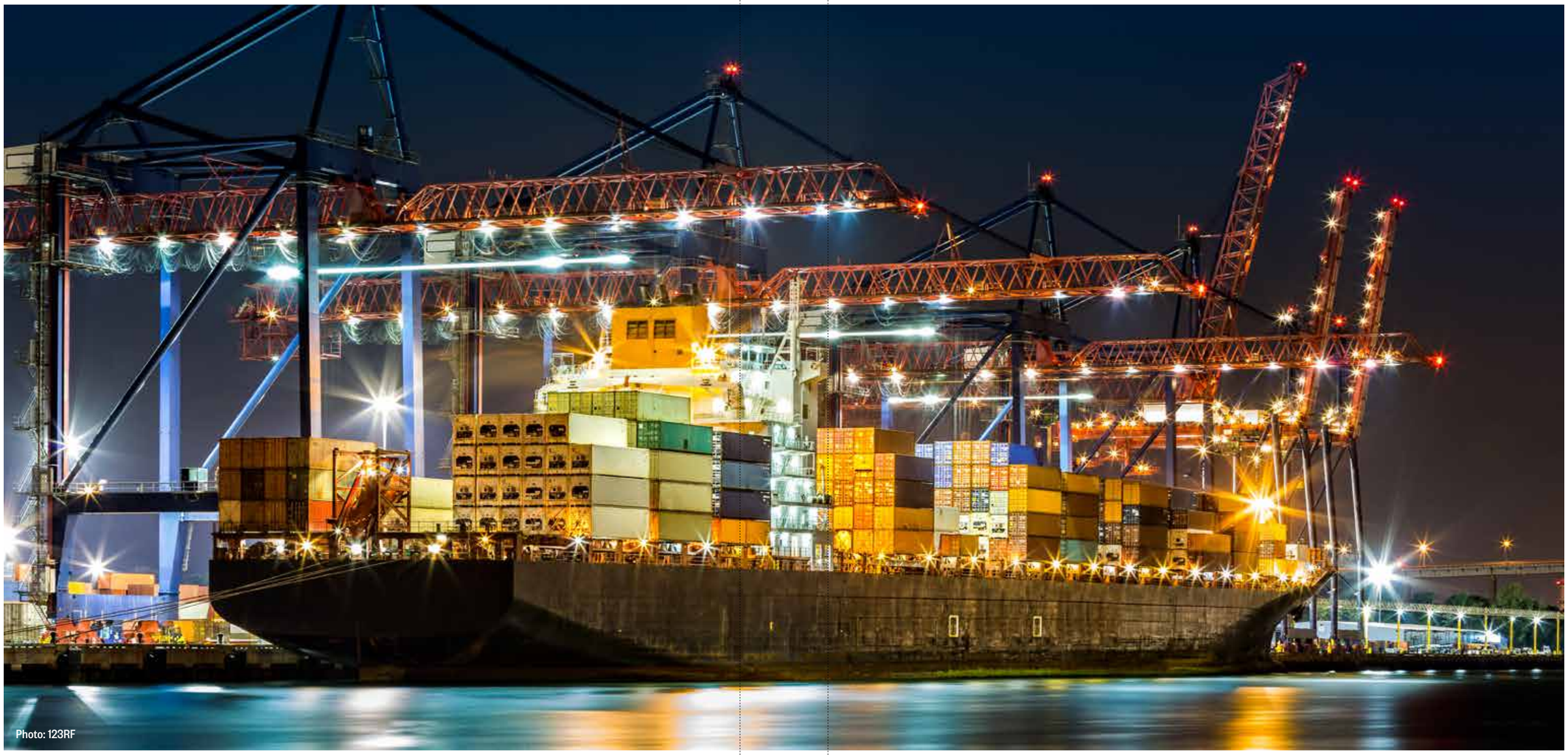

Photo: 123RF

A new digital solution for revolutionising port operations arrives just in time

AUTHOR: **Hunter B. Martin**

At ports around the world, anchored vessels sit in the distance, waiting for permission to dock, resulting in fuel waste, higher carbon emissions, and congestion. Is there a way to solve this problem?

In most cases, cargo ships arriving at port are assigned a docking space on a first-come-first-served basis. This method of port arrivals has, in effect, created a queuing system that wastes fuel and produces excess greenhouse gas emissions. It's also a source of increased workload for captains and crews, who often work on tight schedules only to sit in congested ports waiting for a berth.

A major source of inefficiency in port arrivals is that ships use "unnecessarily excessive speeds" only to reach port and have to wait for berthing slots or access to piloting or towage, according to **Matteo Natali**, General Manager of Business Development at Wärtsilä.

"Container ships spend on average 6% of their time at anchor waiting for berthing," says Natali.

If a port implements a scheduling system that allocates berths to specific vessels and maintains continuous communication with the vessels to achieve just-in-time arrival,

[MARINE / IN DETAIL]

Photo: 123RF

the need to anchor is significantly reduced. Additionally, even small adjustments to a vessel's speed have dramatic impacts on fuel consumption.

Emil Katajainen, Business Development Manager at Wärtsilä, describes the problem this way:

"Imagine a situation where three vessels are arriving around the same time to the same port and the same berth, and berthing slots are allocated on a first-come-first-served basis. There is a big incentive for all three vessels to 'race to the finish line' and try to secure the first possible slot. Two of the vessels will speed up for nothing, and even the extra fuel consumption for the winning vessel could've been avoided if the slots were allocated dynamically.

"Now imagine the exact same situation, but with dynamic slot planning. The exact same berthing slots are available, and the only difference is that they're given in advance. Each vessel will know their laytime in advance, and each vessel can schedule their arrival according to the slot availability, thus leading to less fuel consumption," Katajainen says.

An important reason just-in-time sailing has drawn support is the maritime industry's focus on achieving the sustainability goals to reduce greenhouse gas (GHG) emissions set forth by the International Maritime Organization (IMO) for 2050. Reducing the industry's carbon footprint requires making changes on many fronts; compared to many other GHG reduction methods, aiming for just-in-time arrivals is impactful, cheap, readily available, and able to improve operational efficiency if the industry is willing to adapt. While there are emission abatement technologies available on the market, the just-in-time concept optimises voyages so that unnecessary fuel consumption and emissions are avoided in the first place.

Better communication, better planning

Moving away from the current system isn't easy, however.

"For just-in-time arrivals to work, ports need to move to an orchestrated system where berth slots are allotted based on operations and availability," says Natali.

To achieve an optimised system of just-in-time arrivals, ports and vessels need an open platform for transparent communication. While ongoing exchanges of information are crucial to achieving a system of just-in-time arrivals, currently a significant portion of communication in the maritime transport segment occurs via old-fashioned interactions including mail, telephones, and telefax. Wärtsilä technology is revitalising the outdated methods for an updated and integrated solution.

The company recently launched Wärtsilä Navi-Port, a middleware that enables a real-time digital arrival time exchange between the port and the vessel. When the berth is allocated, it will automatically send out the recommended arrival time information to the approaching vessel. The vessel can then act on that information to either continue sailing as it is to meet the original arrival time or slow down if the proposed slot is later than it planned to arrive. The arrival time exchange works two ways, so the ship can notify the port as well if it can't make the proposed time.

"Sharing the recommended arrival time gives the approaching vessel more flexibility and awareness for its decision making. Sharing the arrival time information across stakeholders also helps to keep the port services running smoothly, as port services such as tug operators, pilots, and bunkering facilities can receive the same information," Katajainen says.

A solution for all segments

A variety of factors can affect port arrivals and departures, which means that delays must be built into any maritime scheduling system. Navi-Port enables ship-to-shore communication to optimise voyage planning, weather routing, and fuel consumption. This streamlined communication is especially helpful at a time of distress, such as during a storm, which impacts everyone's schedule and causes a lot of changes in arrival times.

Navi-Port technology has undergone successful testing as part of a joint project between Wärtsilä, Carnival Maritime and HVCC Hamburg Vessel Coordination Center. The Bureau Veritas Marine and Offshore approved the technology's cybersecurity protocols.

The Wärtsilä Navi-Port middleware enables just-in-time operations by improving communication.

The tests highlighted the impact of just-in-time arrivals on improving efficiency, resource planning, reducing fuel consumption and carbon emissions, and also underscored the importance of just-in-time arrivals for all segments of the maritime industry dedicated to optimising sustainability solutions.

"We are committed to making cruising more sustainable, and to setting an example in greener and safer operations," **Michael Salzmann**, Senior Nautical Superintendent at Carnival Maritime, says in a press release. "We have tested the [Wärtsilä Navi-Port] solution with two of our ships, the AidaSol and the AidaPerla. The ships' onboard Wärtsilä NACOS Platinum navigation systems were connected directly to Hamburg Vessel Coordination Center, which allowed continuous communications, resulting in just-in-time arrivals."

Creating a new mindset

For the Navi-Port technology and a system of just-in-time arrivals to be wholly successful, however, more than technological developments are needed; maritime stakeholders must shift their ways of thinking about the traditional means of operation. In the shipping sector, there are certain legacy processes or contractual frameworks that may be impacting the attractiveness of just-in-time sailing.

"When it comes to the operational side of things, there are still some incentive schemes and contractual structures that are preventing the adoption of just-in-time arrival. For example, demurrage clauses and arrival clauses can specify that the original target time must be applied even when a berthing slot is not available at the original target time," explains Katajainen.

Through demonstrating the "unprecedented saving" and other benefits of just-in-time arrivals, Natali believes that it is possible to create a new mindset.

"It is essential to create a wide network of connected ports and vessels," Natali says. "While Navi-Port can bring immediate benefits to ship operators and the port community, the wider the network of connected users, the stronger the value of the system."

Navi-Port was also built to adapt to the infrastructure and technology in the current fleet.

"The key behind Wärtsilä Navi-Port is flexibility and inter-operability – Navi-Port can connect easily to any kind of vessel, navigation system, or port system," Natali says.

Katajainen says that there is an argument to be made for just-in-time arrivals from both an environmental and business perspective.

"I think we're in a fortunate position because I think we are offering both environmental and financial benefits at the same time. By removing this wasted time, ships are both saving on their fuel bill and bringing about environmental benefits. It's one of the cheapest, most bang-for-your-buck methods of reducing emissions, which is also a clear IMO goal for the future. You will get both benefits when you are executing just-in-time arrivals," Katajainen concludes.

[MARINE / IN DETAIL]

Propelling the maritime industry forward, one device at a time

AUTHOR: Lorelei Yang

Wärtsilä's partnership with MARIN and Grimaldi on the LeanShips initiative has yielded exciting fuel improvements and long-term business opportunities for all involved.

In June 2019, the Grimaldi Group's Grande Portogallo, a 165-metre-long pure car and truck carrier fitted with a controllable pitch propeller (CPP), set sail with a ground-breaking piece of technology onboard: a pre-swirl stator (PSS) designed for CPP application that influences water flow to the propeller. Being able to control the inflow of water, the device's designers say, has been scientifically proven to lead to less fuel consumption, improving the vessel's energy savings. This aspect has never been investigated for CPPs, making this a truly innovative product.

The test was a success, with the Grande Portogallo achieving confirmed fuel efficiency gains of up to 3.5%. This was a momentous achievement, especially considering the maritime industry's drive to adopt new technologies that help in reducing emissions, improving efficiencies and, in turn, increasing profitability.

"This represents a breakthrough in making ships with controllable pitch propellers more efficient, and therefore less polluting," said **Dario Bocchetti**, Corporate Energy Saving Manager, Grimaldi Group.

Expert partnership to produce optimal results

The test was part of the LeanShips initiative, which is funded by the EU's Horizon 2020 European Innovation project. It aims to demonstrate the effectiveness and reliability of energy-saving and emission-reducing technologies at full scale while supporting

The Grande Portogallo was able to achieve significant fuel efficiency gains thanks to its CPP. Photo: Grimaldi

developments to make new and existing vessels more efficient and less polluting.

Wärtsilä worked with its partners, the Netherlands-based Maritime Research Institute (MARIN) and Italian shipowner Grimaldi, to prove the efficiency of the PSS in meeting the project's goals. The device was the culmination of a collaborative design and development process that saw each party bring its best to the table, providing the expertise and resources to test its energy-saving capabilities.

MARIN had previously collaborated with Wärtsilä on other propeller design projects including the GRIP project funded by the European Commission under the Seventh Framework programme. The synergies and learnings from these partnerships made working with Wärtsilä on the LeanShips project a foregone conclusion, says **Maarten Flikkema**, Senior Lead Project Manager at MARIN.

Long-term benefits for Wärtsilä and MARIN

Initiatives like LeanShips have spurred a round of innovation and out-of-the-box thinking across the board.

This, in turn, has implications for future development as well. For instance, MARIN hopes to eventually integrate the optimisation of the four main components of a ship's propulsion – the hull, energy savings device, main engine, and propellers – to develop optimised systems. The theory is that optimising a ship's whole system might lead to different (and better) outcomes than optimising each piece of the system in isolation.

"We think if you have a slightly less efficient hull, it could be that the interaction with the propeller goes up enough to offset the loss in efficiency due to the hull," adds Flikkema.

This has huge implications for ship owners and ship operators who are scrambling to find ways and means to optimise their vessels and fleets.

"The development knowledge acquired in the LeanShips project will help with the commercialisation process for the PSS," says **Michel Ebben**, Product Manager for Propulsion at Wärtsilä Marine, making it more readily available for the maritime industry to adopt.

Future collaboration opportunities

Both MARIN and Wärtsilä continue to work on propeller design projects, building on past learnings and providing incremental improvements. Since the PSS has to be customised for different ship types, they are already looking for ways and means to make the process more efficient.

This is important. An increasingly strict regulatory environment has made reducing marine emissions a necessity. For fleet operators like Grimaldi, the benefit of energy-saving devices is apparent: using less fuel to power a ship reduces operating costs and helps them meet environmental regulations.

In this context, demand for CPP and similar technologies emerging from the LeanShips initiative will only increase. Open collaboration and a smart marine ecosystem are the only way to ensure the development of tried and tested technologies to meet this demand.

Cruise lines have been at the forefront of electric propulsion.

Electric propulsion is key to a zero-emissions future in cruise

AUTHOR: **Hunter B. Martin**

Technological advancements are a natural part of the evolution of the cruise industry – from oars and sails to steam and diesel. Electric propulsion systems are the latest step in this progression.

In the last few years, regulators in the maritime industry have set lofty goals for carbon emissions reduction and improving energy efficiency. While much of the progress towards these goals depends on adopting future fuels, electric propulsion systems also can play a critical role, especially in the cruise segment, which is uniquely sensitive to public pressure and customer feedback.

Fortunately, the cruise segment has been at the forefront of adopting electric propulsion technology.

In 1995, a landmark project on the Costa Victoria became the first integrated electric propulsion system installed on a cruise ship by Wärtsilä. The electric propulsion system linked all onboard systems from bridge to propeller including automation, navigation, electrical distribution, the switchboard, and complete cabling.

By connecting to Costa Victoria's decentralised power management system, the electric propulsion system optimised load sharing, frequency control, protection for gensets, and automatic blackout recovery. It was seen as a revolution in the cruise segment, and electric propulsion systems have continued to evolve ever since.

Costa Victoria's 25-year-old propulsion converters are still in use, but they are upgraded with modern control electronics.

Approximately 60% of ships were using electric propulsion systems by the end of the 1990s, and today it is the cruise industry standard to implement electric propulsion systems for newbuilds, according to **Uwe Heine**, Chief Technologist, Marine Electrical Systems at Wärtsilä.

Heine has been working in the industry for 27 years and has witnessed the dramatic expansion of electric propulsion systems. He remembers the installation of the first electric propulsion system on the Costa Victoria and has monitored the progression of the technology ever since.

"It's an evolution, not a revolution," he says. "The basics are still the same. Diesel engines are driving electric generators that form the power station that supplies everything onboard the vessel."

Optimising efficiency

Maritime vessels need constant sources of power to operate not only the propellers, but also every other system onboard. Ship engines, the tunnel thrusters, galleys, air conditioning and the hotel load require electricity to operate, and without it a vessel would cease to function. Without the power station principle, vessels require at least two power sources in order to maintain both electrical systems and propulsion. On the other side, an electric cruise ship is able to operate with only one engine at low load.

With an electric propulsion system, a vessel's engines are not connected to the propeller shafts. Rather, engines are linked with electricity-producing generators that power electric motors. The newest technology for these motors is with permanent magnets at the rotors. By this evolution in design, the propeller shaft optimises efficiency at a 25% reduction – from 8% losses with a traditional electric excited motor to only 6% losses with permanent magnet technology from generator shaft to the propeller shaft.

Benefits to passengers

Electric propulsion systems not only optimise ship operations in a variety of capacities, but also help improve the number one focus on cruise ships: passenger safety. According to Heine, Wärtsilä specialises in crafting an integrated electric propulsion systems portfolio with safety features that go above and beyond what regulations require. These extensive backup systems are necessary since losing total electrical power is not an option onboard a cruise ship full of passengers.

Electric propulsion systems can also help increase passenger comfort because these systems make very little noise and produce no vibrations.

Hybridisation

In the 1990s, when the landmark project Costa Victoria was delivered, electric propulsion was an attractive option due to efficiency and reliability, and its potential for enabling OPEX savings.

Seen as such, it existed in competition with more traditional propulsion systems, to be judged on a fairly typical ratio of investment to measurable value.

Today, with the advent of hybrid, electric propulsion can be considered in a different context.

While the systems themselves perhaps demonstrate only modest "evolution," according to Heine, the introduction of an electric power system to a vessel paves the way towards total hybridisation. This has also guaranteed a future-proof, sustainable, and efficient upgrade path for customers

who made the decision to invest in electric propulsion systems.

The key to a zero-carbon-emissions future is hybridisation between electric propulsion systems and diesel engines, batteries, and fuel cells, because at the end of the day, all systems are linked by electricity.

Wärtsilä's electric propulsion systems were designed to have low lifecycle costs for maintenance, repairs, or spare parts and are even hybrid-ready for older vessels. Electric propulsion systems also decrease carbon emissions and fuel consumption, improving the overall sustainability of the vessel, as well as maximising efficiency and optimising gensets to meet power requirements across a range of speeds.

"At Wärtsilä, we have people who specialise in the engines and systems integrations and hybridisation and the electric propulsion systems," Heine says. "Everyone at Wärtsilä is available and is working jointly together to develop a cohesive portfolio. Wärtsilä has developed energy management systems that link together all of the hardware and the software which produce energy."

Digitalisation

Connecting electric propulsion systems to computers and utilising remote service options have been a part of the cruise segment since the 1990s. According to Heine, even the earliest electric propulsion systems utilised remote service, and today increased digitalisation plays a key role in data collection to continue to advance technology onboard cruise ships.

Digitalisation also plays a key role in data collection, which helps continue to advance the technology onboard cruise ships. By digitally connecting a vessel's systems to shore, voyages can be optimised to reduce fuel consumption, cruising speeds, port arrival times, and routes based on weather patterns and other factors. Data also becomes more transparent as it can be shared with stakeholders in real time.

By investing in digitalisation, ship owners are able to make the most of technological advancements and capitalise on enhanced optimisation, data collection, and interconnection between onboard systems. The future of the maritime industry is increasingly digital, and vessels that invest in digitisation are at the front of the curve.

Looking to the future

Heine says that given the technology available today, running diesel engines on liquefied natural gas (LNG) in combination with batteries is more efficient than using fuel cells. It is also cleaner, since the engines run with no visible smoke and produce less nitrogen gas. This make batteries particularly desirable as the cruise segment expands into developing more exploration cruises into remote or protected locations, such as the Norwegian fjords.

"Evolution is driven by society," Heine says. "Society is now aware that we have environmental issues we need to solve, and electric propulsion systems are the base for zero emissions."

Ships that operate with hybridisation using batteries also can decrease operating hours, maintenance needs, lube-oil costs of the engines, and increase fuel savings. With diesel propulsion, ships can also use bio-hybridisation to allow for better utilisation of the engine. Someday, Heine predicts, larger batteries will even be able to power ships without an engine.

Ultimately, the goal, according to Heine, is to continue to advance and find better sources of green energy. Batteries and fuel cells are only the beginning, but new types of fuel – such as liquid hydrogen or ammonia – that have been expensive up until now may play a greater role in the future.

Wärtsilä is currently investigating several future fuels including synthetic methane, ammonia, hydrogen, and methanol with the goal of providing fuel flexibility around the globe and across engine types. With modern technology, internal combustion engines are adaptable to burn all fuel types. Dual-fuel, or spark-ignited engines, are capable of burning LNG, while diesel engines can run on liquid biofuels, biodiesel or e-diesel. Other sources of power are being explored such as solar hybrid power plants, which also provide clean, sustainable energy to power the maritime segment.

"The sources of energy create an ecosystem; everything is linked to each other," Heine says.

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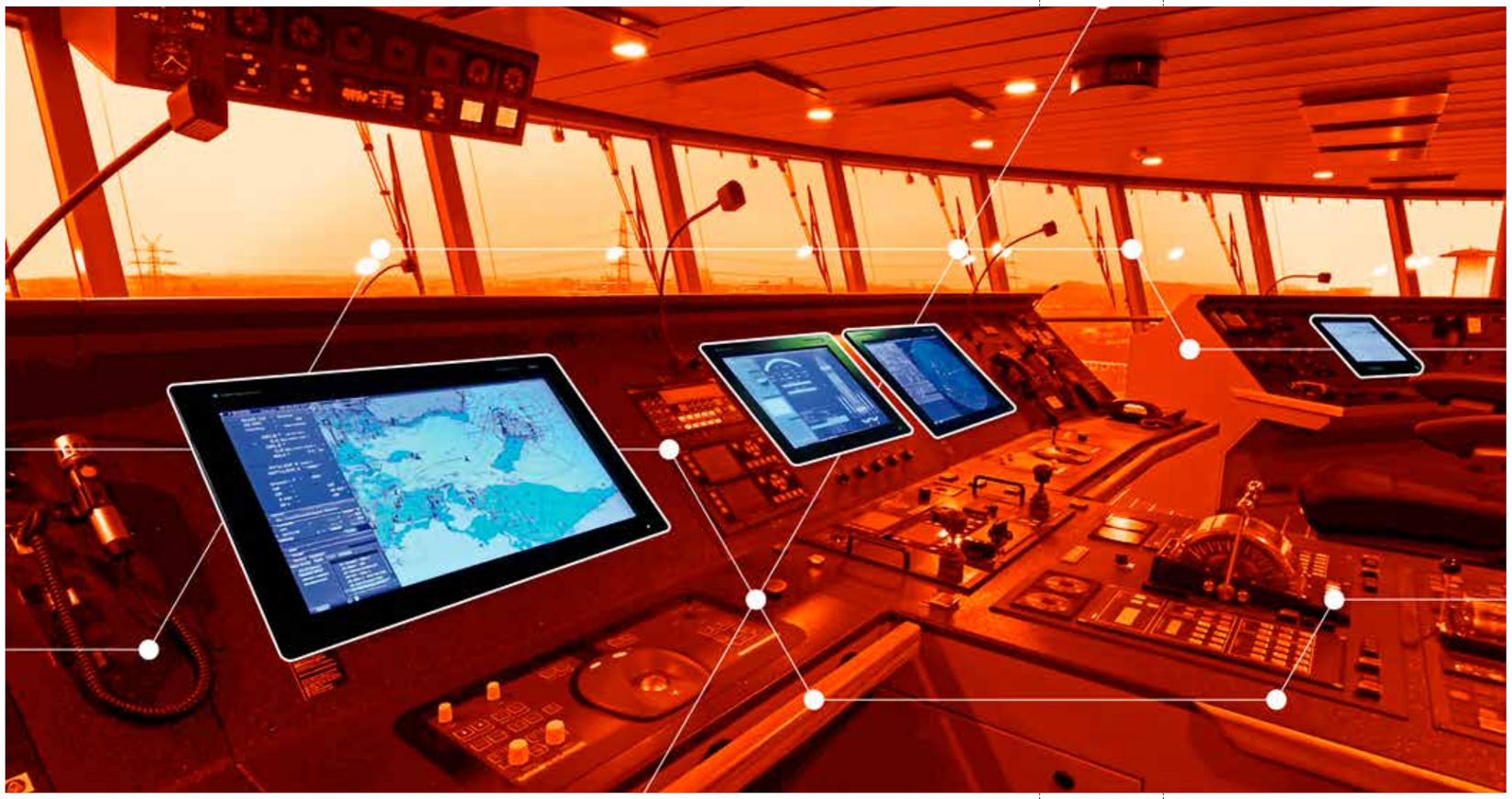


How a digitalisation deal could revolutionise the maritime industry

AUTHOR: Payal Bhattar

In December 2019, Anglo-Eastern agreed with Wärtsilä on a programme to digitalise its global fleet of more than 600 vessels in what was one of the maritime industry's largest digitalisation deals ever. What does this mean for the sector?

Hong Kong-based ship manager Anglo-Eastern and its technology partner Wärtsilä spent more than two years working on the right path for digitising the Anglo-Eastern fleet, but the programme the two firms developed is a game changer for the maritime industry. The solution supports full voyage planning and execution as well as engine performance and fuel-efficiency monitoring.

"It is a lighthouse deal. We deliver our solution to 600 vessels managed by AESM, but there are 60 ship-owning companies behind Anglo-Eastern as the ship management company. That makes it very important and valuable," says **Kay Dausendschoen**, Solutions Manager, Wärtsilä Marine Business. "It will have a multiplier effect. These owning companies are already asking us, 'I have half of my fleet with Anglo-Eastern. Can I also apply Wärtsilä's solution to all my other vessels?' So, the deal with Anglo-Eastern is a door to a much larger pool of potential customers."

The power of connectivity

This multi-year milestone deal puts the focus on Wärtsilä's Fleet Operation Solution (FOS). FOS integrates individual processes that are otherwise separate from each other. It enables voyage planning, weather routing, ship-to-shore reporting and fleet performance management to reduce fuel consumption, and takes into consideration charter party compliance and speed management, as well as the condition of the hull, propeller, and engine.

"We are keen to leverage the advantages of the latest digital solutions to maximise the efficiency of our voyages and the performance of our fleet. Realising the opportunities made possible by the Wärtsilä Fleet Operations Solution, we look forward to contributing to the further development of the solution as an early adopter," says Capt. **Bjorn Hojgaard**, Chief Executive Officer of Anglo-Eastern.

Wärtsilä's FOS is based on the connected Electronic Chart Display and Information System (ECDIS). This equipment is already mandatory on every ship, but the Wärtsilä FOS gives it a new and more significant importance. FOS is the common platform that integrates a connected ECDIS with a ship's planning station via cloud computing, machine learning, data analytics, and mobile applications.

"Fleet Operations Solution is exactly what we mean when we at Wärtsilä talk about utilising a Smart Marine approach to raise efficiencies, improve safety, and reduce the carbon footprint of shipping. We are excited to be bringing these benefits to the 600-vessel Anglo-Eastern fleet over the coming 12 months," says **Torsten Büssow**, Managing Director of Wärtsilä Voyage Solutions/Transas.

A recent trial of Wärtsilä FOS by Danish Shipping company J. Lauritzen A/S estimated that fuel worth USD 15,000 can be economised in just one voyage of one ship by using the system. Apart from fuel savings, there are several other touch points for savings, such as reduced friction between maritime stakeholders that help improve operations, reduce emissions, increase safety, and reduce crew workload.

For example, a ship owner and a charterer can close chartering deals with increased transparency, thereby reducing potential claims. FOS leads to better closure of commercial deals based on the ship's performance as well as a reduced risk of financial burden for the owner, since it provides early warnings of situations such as violations of charter party agreements.

"Better connectivity is a game changer for us," says Dausendschoen. "In the past, the connection bandwidth and overall connection between ship and shore was extremely limited. Connectivity for the merchant market was a very big problem because of bandwidth. Now that we have it, there are a lot of possibilities including data transfer between ship and shore."

Off to a flying start

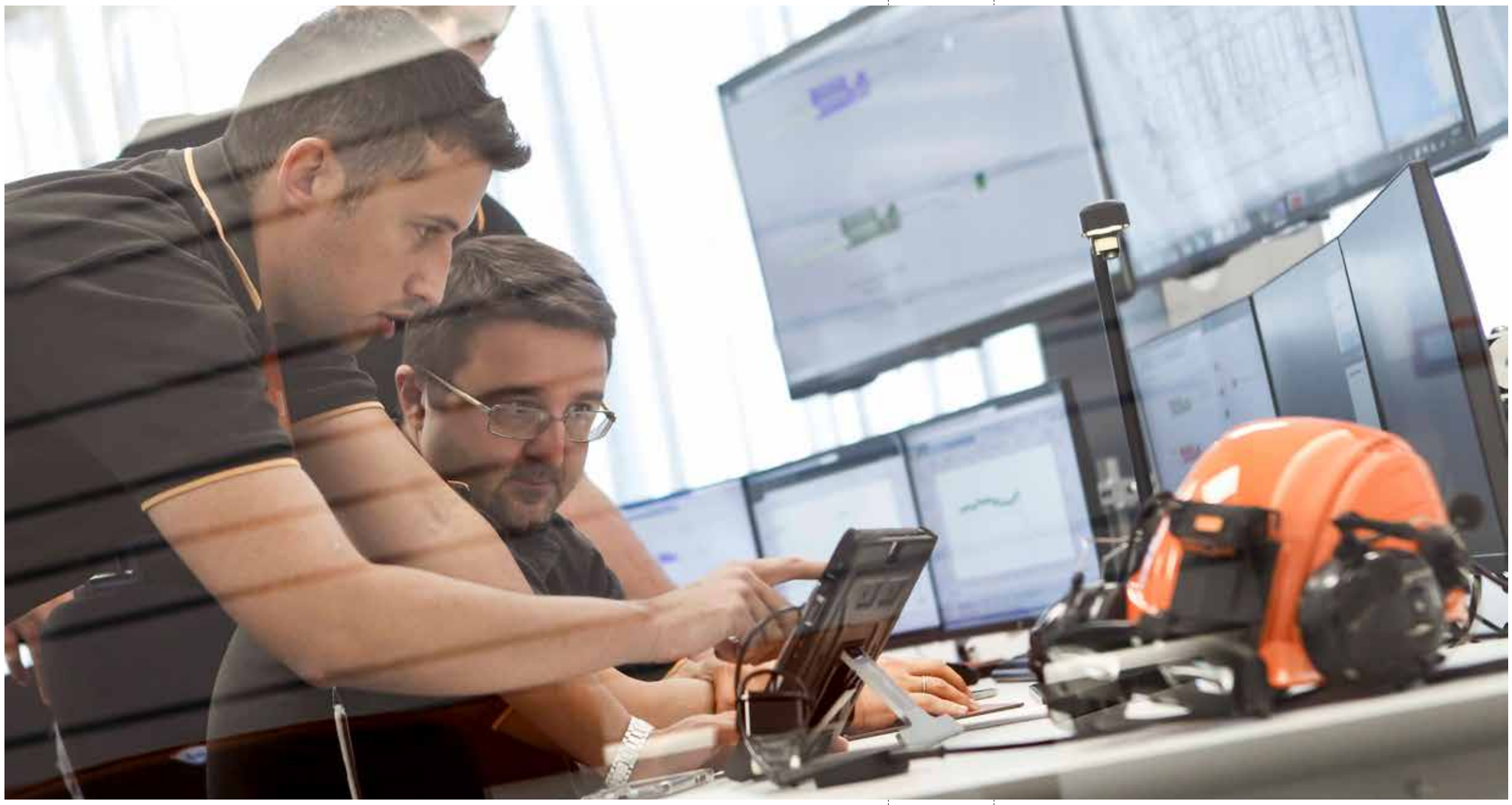
The deal with Anglo-Eastern raises the bar for more transparency and efficiency in the maritime sector. It enables different stakeholders such as ports, ship owners, and ships to plug in to one common platform to share or exchange data on a real-time basis. For example, it allows ports to connect with vessels via ship traffic control solutions to better manage arrival times. So, if all the berths in a port are occupied, FOS could share relevant information such as the expected time of arrival with approaching vessels. That in turn enables ships to adjust their speed and operations, leading to fuel savings and lower emissions.

In some ways, FOS brings the shipping industry closer to achieving the same fleet management efficiencies as the aviation sector.

"If you look at aircraft, they have a slot system where the arriving airport already tells the departing airport when your arrival slot will be. It's kind of a similar approach. However, in the maritime industry it's a bit more complicated and very hard to implement because there is very little standardisation and sometimes conflicting interests among stakeholders," explains Dausendschoen.

He adds, "There are too many stakeholders and all very different from each other. Ports are different from each other, vessels are very different, etc. Low standardisation is one of the reasons why the maritime sector is lagging behind. Fortunately, we have technology as an enabler so it's possible to do it now."

Experts agree. As a "new normal" characterised by increased market volatility, fluctuations in trade, and geopolitical and environmental risk emerges, ship owners and operators will have to rely on smart solutions like FOS to stay afloat. The deal between Anglo-Eastern and Wärtsilä is a giant leap in this new direction.



Wärtsilä Power solution for normally unattended offshore installations takes offshore operations onshore

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Get set to crank the efficiency of unattended offshore oil and gas operations up to the max thanks to the new Wärtsilä Power solution. Now, offshore assets will be able to operate for up to six months without the need for on-site personnel or scheduled on-site maintenance.

As oil and gas companies continue to look for more efficient, less expensive, and safer ways to operate offshore, demand is growing for power solutions that do not require regular inspections and maintenance onboard. The Wärtsilä Power solution for normally unattended installations (NUIs) is a cost-effective, safe and reliable power-generation concept that combines highly efficient, low-emission Wärtsilä dual-fuel (DF) engines with sophisticated digital solutions, and is suitable for a wide variety of NUIs.

While some types of platforms are already adapted for unmanned operations, Wärtsilä's objective is to take this development a step further and extend unmanned operational capabilities to floating production storage and offloading (FPSO) units, floating storage and offloading units (FSOs) and production platforms. Since these types of installations have a significantly greater power requirement, their need to identify and develop cost-effective solutions is also more urgent.

No need for permanent on-site crew

The Wärtsilä Power solution has been developed to enable all maintenance activities for NUIs to be performed efficiently using "walk to work" support vessels during scheduled maintenance campaigns, eliminating the need for permanent operational and maintenance crew on site. The solution can be extended to include the maintenance of power management, automation and auxiliary equipment. It is a holistic power solution that can be tailored according to the requirements of each individual installation and is supplied together with a power system, including high-efficiency Wärtsilä DF engines, generators, and auxiliary systems installed in the engine room and designed for fully unmanned or reduced-crew operations.

The solution is also supported by a variety of cutting-edge digital solutions. First, the installation is continuously monitored using Wärtsilä remote condition monitoring and condition analysis. Operational data is measured by meters and sensors installed on site and transmitted via cyber-secured data transfer utilising a Wärtsilä Data Collection Unit to the Wärtsilä Expertise Centre, where it is analysed by Wärtsilä Expert Insight, which combines Wärtsilä's unique OEM expertise and advanced artificial intelligence (AI) technology. A Wärtsilä expert at the Expertise Centre analyses trends and remotely tunes engine performance via secured remote access through a service PC installed on site to diagnose the operating condition and determine what actions are required. Last but not least, predictive maintenance is planned and scheduled, based on the collected data and remote equipment condition analysis, and is performed at optimised intervals by Wärtsilä's highly skilled field service crew.

Service intervals of up to six months

Whereas traditional offshore power solutions require monitoring and regular

The Wärtsilä Power solution for NUIs extends intervals between maintenance campaigns up to six months.

inspections in which maintenance is carried out depending on the number of running hours of the engine, the Wärtsilä Power solution requires no such activities. The interval between maintenance campaigns can typically be extended for up to six months, and in the meantime the equipment and its performance are constantly monitored and evaluated from a remote location, enabling remote detection and diagnosis to define actions to be taken during the next maintenance campaign, or immediately if required.

The Wärtsilä Power solution offers a wide variety of advantages designed to make power generation leaner, safer, and more cost effective. The use of highly efficient Wärtsilä DF engines leads to reliable power generation with low emissions, combined with increased fuel efficiency and fuel flexibility. Meanwhile, Wärtsilä's remote monitoring and expertise help maximise uptime, leading to reduced operational expenditure (OPEX) Fewer man-hours on site also help reduce lost time incident frequency.

It is important to note that the Wärtsilä Power solution does not seek to eliminate the need for personnel, but to transfer activities that previously had to be carried out offshore to an onshore environment, minimising the need for costly offshore monitoring and inspection activities and maximising maintenance activities onshore or in the workshop. For oil and gas companies, this has the potential to secure considerable cost savings, since onshore hours are significantly less expensive than offshore hours. Other factors that contribute to leaner operations include the cutting of costs and emissions due to the reduced need to transport personnel into the field, and the elimination of offshore accommodation and facilities needed to support day-to-day life on the unit. This also reduces capital expenditure (CAPEX), since there is no need to invest in building accommodation and the cost associated with classing the asset for living quarters is also eliminated.

Digital solutions to maximise uptime

The cost-effectiveness of the facility is further enhanced by the use of Wärtsilä's state-of-the-art digital solutions, which maximise uptime and massively reduce the risk of unplanned incidents. Unlike a standardised approach, whereby the condition of the equipment is monitored through visual inspection, Wärtsilä's remote condition-based monitoring and analysis ensures proactive monitoring and analysis of the engine's running data, allowing anomalies to be detected and addressed before they become serious enough to cause a breakdown or, worse still, a safety risk.

In the oil and gas sector, where safety continues to be the number one priority, the Wärtsilä Power solution does not just offer cost-saving advantages. By transferring activities from a potentially hazardous offshore environment to an onshore remote control room and workshop, worker safety is dramatically enhanced. Furthermore, the opportunity to work onshore also contributes to improved work-life balance for personnel who will no longer be required to spend long weeks and months at sea.

Last but not least, remote condition-based monitoring and analysis can be used to detect operational changes at an early stage, providing additional time for corrective action to be taken to minimise the risk of serious incidents occurring at sea.

All these reasons show how digital solutions can help improve efficiencies across the board, ensuring safer and more reliable operations, making the Wärtsilä Power solution a key element of Wärtsilä's vision for a Smart Marine ecosystem.

A customer-driven solution

At Wärtsilä, we work closely with our customers to develop solutions that directly fulfil their needs and expectations. This project was driven to a great extent by the North Sea oil companies, who are increasingly looking for "lean" ways to make their operations safer, more cost-effective and more efficient. The Wärtsilä Power solution for NUIs is the result of a joint development project involving Wärtsilä, oil companies and engineering companies.

This groundbreaking solution is currently the only reliable, highly efficient solution of its kind using fuel-flexible DF engines, which can provide up to six months' operational time without any planned maintenance activities on site. Another factor that makes it unique is the unrivalled standard service based on cutting-edge digital and AI solutions in combination with Wärtsilä's market-leading expertise and experience as an original equipment manufacturer (OEM).

Wärtsilä is an innovator and thought leader in its field with decades of experience developing equipment for the offshore market. The company also designs, engineers, and delivers remotely monitored and remotely operated power plants all over the world. All this expertise and experience have been combined to develop this unique power solution concept specifically for NUIs.

Going forward, this kind of operational model will become more and more commonplace in newer oil and gas developments. This solution is simply the next logical step in the development of a smart offshore ecosystem for the future. At this stage, the leap to completely unmanned operations may only be something the most progressive, innovative oil companies are ready to consider. However, the same philosophy, lessons learned and knowledge gained can also be utilised to make manned operations leaner – which will perhaps be the first step in this evolution. We believe remote monitoring is the future, and we are prepared to assist customers who are ready to get on board.

World's largest semi-submersible crane vessel gets a boost from Wärtsilä

AUTHOR: Lorelei Yang

Creating state-of-the-art features for Sleipnir, which will remove and install structures in the open sea, required extensive knowledge, creative thinking, and open communication.

Last summer, Wärtsilä delivered the biggest steerable thruster in its new thruster portfolio for Sleipnir, the world's largest semi-submersible crane vessel (SSCV). As a feat of engineering, Sleipnir is impressive on multiple levels. The environmentally friendly LNG-powered vehicle features two revolving cranes that can lift up to 20,000 tonnes in tandem – that's the equivalent of two Eiffel Towers.

The delivery was the culmination of a five-year effort that began with conversations between Wärtsilä and Sleipnir's owner, Dutch offshore contractor Heerema, in 2014.

Before the project began, Heerema studied market requirements and evaluated several vessel concepts, and concluded that it wanted a semi-submersible-type hull for its new vessel. Based on past projects, Heerema knew that Wärtsilä would be a reliable partner for developing innovative new solutions to meet these requirements.

Lauri Tiainen, Director, Thrusters, Wärtsilä Marine Business, notes that close collaboration between Wärtsilä and Heerema throughout Sleipnir's development was integral to the project's success.

"Having a direct customer [Heerema] involved in the development helped better align the development with the customer's desires. So, we came together and said, let's commit to doing this together," Tiainen says. This cooperative process allowed Wärtsilä and Heerema to develop the never-before-seen technologies that made Sleipnir possible.

First-of-its-kind technology

Through joint discussions, Wärtsilä and Heerema developed 360-degree rotatable, retractable thrusters with underwater mountability for Sleipnir. The project is the first time both retractability and underwater mountability features have been brought together in a single thruster design.

The underwater mountability was especially important.

"Because Sleipnir is so big, there are only a handful of dry docks in the world that a vessel this big can enter," says Tiainen. "Thus, from a risk mitigation perspective for the customer, not having to go into dry dock for assistance is valuable."

In addition to their unique design, Sleipnir's thrusters are also mounted at an 8-degree downward angle. Tiainen explains the rationale: "From Wärtsilä's research in hydrodynamics, we've found that this angle ensures water isn't pushing against the ship's hull. It doesn't make sense to burn a lot of energy to produce water flow if it's hitting your own vessel. This configuration – which minimises that problem – is much more efficient and effective for both moving the ship forward and keeping it stationary. With these thrusters, the ship can travel the globe fairly quickly with its own thrusters, which allows it to cover the broad geographic area that's needed to fulfil jobs. With the

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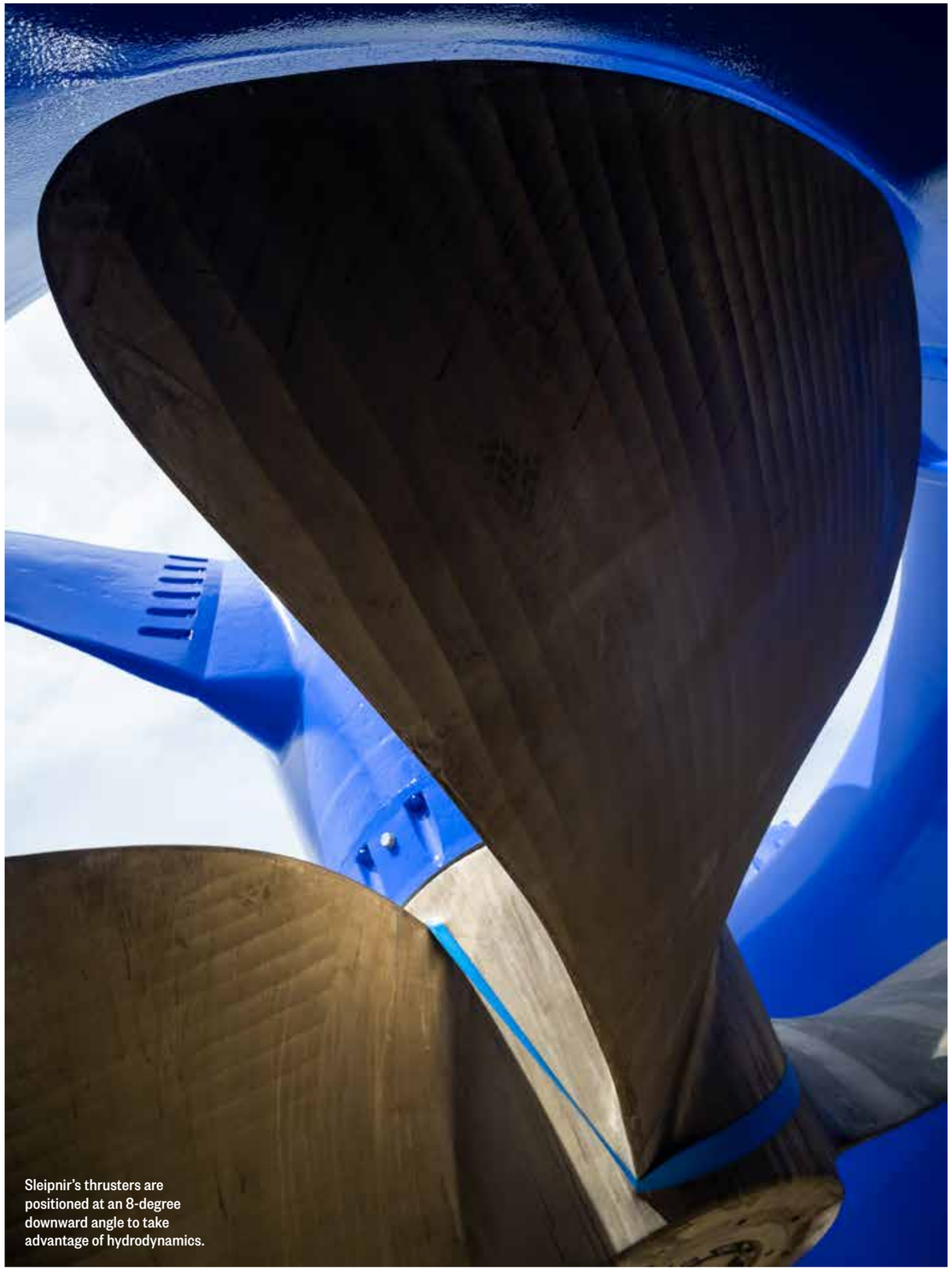
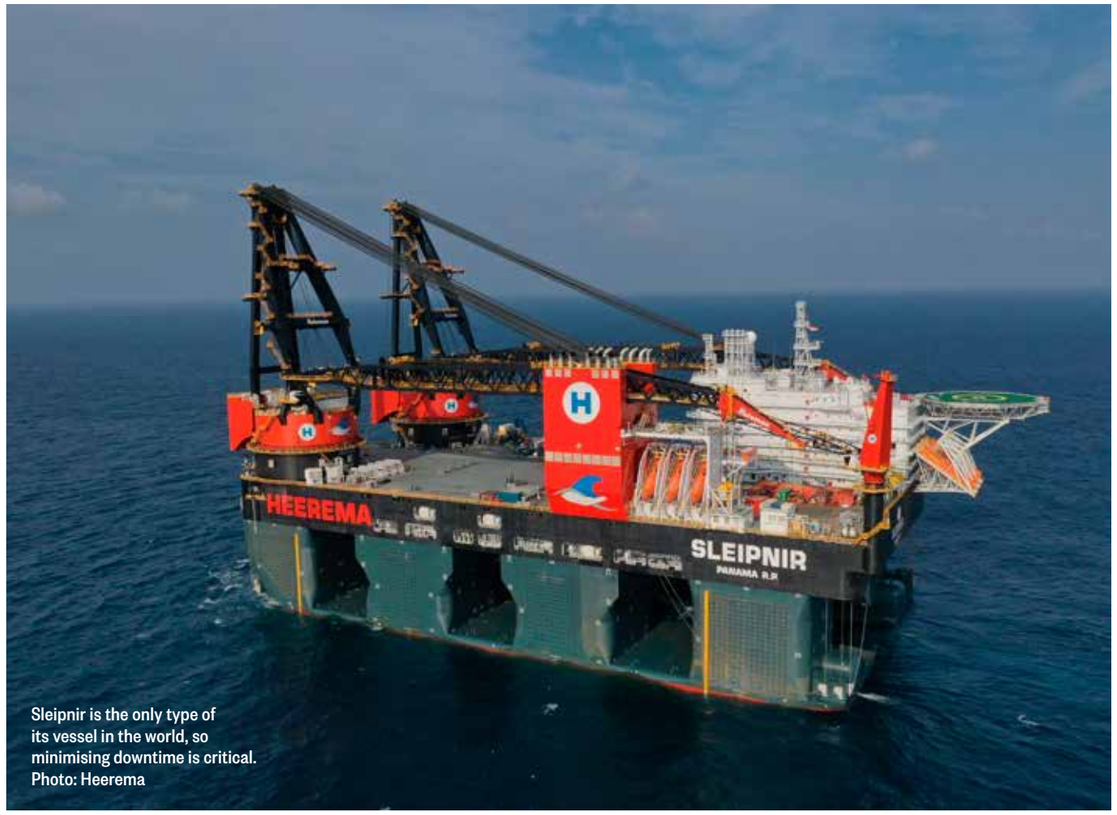


Sleipnir's thrusters are positioned at an 8-degree downward angle to take advantage of hydrodynamics.



Sleipnir is the only type of its vessel in the world, so minimising downtime is critical. Photo: Heerema

thrusters, the ship can also be maintained very precisely in position during lifting jobs."

To account for the large amounts of ballast that Sleipnir takes in and the depths to which the vessel may sink (up to 32–40 metres into the baseline for the ship itself, and even deeper for the thrusters), significant R&D was needed to ensure the thrusters would remain water-free even at deep depths. Sleipnir's thrusters are sealed with Wärtsilä Ocean Guard anti-pollution face-type seals, constantly monitored for possible leakages to ensure that lubrication oil from the thrusters doesn't enter the sea and is drained for oil recycling. Similarly, seawater leakages can be drained in a controlled manner to avoid water intrusion into the thruster unit.

Precision in challenging conditions

As the world's largest crane vessel, Sleipnir is used for heavy lifting jobs, largely in the open sea. On 8 September 2019, it completed the world's largest-ever lift (15,300 tonnes), installing the topsides for Noble Energy's Leviathan development in the Mediterranean. In total, Sleipnir installed its two main topsides with a total weight of 24,500 tonnes in less than 20 hours for the Leviathan development.

"In the jobs it performs, Sleipnir must lift huge loads very precisely to install wind turbines or install big offshore platforms while fighting against constant wind and waves," observes Tiainen. "So, the thruster system and positioning system need to work together in precise cooperation to maintain the position and avoid safety risks regarding the load that's being lifted."

With these challenging conditions in mind, Sleipnir was built to have the highest possible degree of system redundancy at all levels as well as dynamic positioning (DP3).

"Whatever failure happens, you won't lose your position," Tiainen says. "There's a lot of extra engine capacity, and even if you lose two of the thrusters, you're still able to stay in the same position, despite the wind and waves."

The features ensure that Sleipnir is maximally safe and mitigates as much risk as possible.

Finally, Sleipnir has an extensive condition-monitoring system that optimises inspection and monitoring procedures towards predictive maintenance and helps avoid nasty surprises as the thrusters experience normal wear and tear. This increases predictability and reduces the risk of unexpected downtime, which according to Tiainen is important because Sleipnir is the only vessel of its type in the world. If it's out of commission, there are certain jobs no other vessel could perform in its place.

Even though the thrusters are completed, Wärtsilä's work on Sleipnir is far from done, as the two companies will be working together to maintain the vessel for at least the next 30 years.

To achieve a sustainable maritime future, we must act now

AUTHOR: Reetta Kaila, Technology & Development Manager, Renewable Gases, Wärtsilä Marine Business
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The journey towards a zero-emissions future in the maritime economy involves using fuels and technology currently available while working to scale other options.

Thanks to a new, ambitious International Maritime Organization (IMO) strategy aimed at reducing greenhouse gas emissions and calls from the European Parliament and European Commission to reduce global emissions from shipping, the maritime industry is waking up to the reality that change is coming.

Shipping is a derived demand, and that demand is growing. A growing global population demands more consumables, more transport, and more technology, which in turn drives energy consumption. To steer humanity towards a more sustainable future, we need to find new ways of producing that energy, moving towards circular economy thinking and the use of sustainable fuels.

Helping our customers navigate mounting pressures to combat rising emissions while securing sustainable profitability is of paramount importance to us at Wärtsilä. The challenge lies in the fact that the industry has yet to discover an elixir that will enable a zero-emissions shipping ecosystem. A combination of energy-saving applications, smart propulsion technologies, and broader collaboration can nudge us significantly closer to achieving full decarbonisation. But the single biggest intervention is fuel choice.

The path to a zero-emissions future

For the shipping industry, the path to a zero-emissions future is likely to encompass the journey from LNG to bioLNG and synthetic LNG. While hydrogen, methanol, and ammonia are potentially viable future fuels, for the moment there are considerable obstacles to overcome, including lack of regulation, supply chain infrastructure, and poor economic feasibility. LNG only attained commercial viability after a long period of R&D and testing covering the whole supply chain followed by acceptance by marine classification societies. BioLNG and synthetic LNG can leverage the fossil LNG infrastructure since these can be blended in all ratios with fossil LNG as soon as their production rates and economics are in place.

Given this likely progression, the internal combustion engine will remain the best option for upping our climate change mitigation game. It offers the most realistic emissions-reduction potential because there's nothing that can be done with heavy fuel oil (HFO) that cannot be done with liquefied natural gas (LNG) and future fuels. Wärtsilä dual-fuel engines, which entered the market more than three decades ago, are capable of being converted to use almost all liquid and gaseous fuels, including blends of green ammonia, hydrogen and methanol. With the internal combustion engine, the fuel doesn't matter because the engine is fuel-flexible.

Fossil LNG is not without its challenges, however. While it burns cleaner than distillate fuels – burning LNG in a modern combustion engine immediately reduces GHG emissions by 7–21% compared to the diesel engine – it also results in small levels of methane leakage during production and combustion.

BioLNG is, morally speaking, the correct route to take, since it works on the principle of waste-to-energy using manure, forest residue, and many other types of waste. A lot of R&D has gone into testing carbon-neutral biofuels. However, the critical aspects to consider when selecting a fuel for a new vessel are availability and energy density. Biomass-based fuels are only sustainable when local availability of feedstock is plentiful and guaranteed. Today, the supply chain is unevenly developed, but the latest studies suggest that a sustainable energy supply could be in place by 2030. It is estimated that biomass-based fuels extracted from forestry products and residues, agricultural residues, and crops grown for energy on surplus land could yield enough volume to supply the whole marine industry and most heavy road transportation with bioLNG, assuming all vessels would be converted to LNG.

Potential fuels of the future

On paper, hydrogen fuel cells present an exciting proposition because they convert clean hydrogen into electrical energy and steam without the need for an emitting combustion process. However, the cost of producing fuel cells and the lack of a green hydrogen refuelling network means that this technology is not yet scalable, especially for huge ocean-going ships.

Large-scale hydrogen production based on electrolysis demands large amounts of energy and has low total efficiency. This is perhaps one of the biggest challenges for hydrogen as a fuel itself, and for any other synthetic fuels based on hydrogen. Due to the challenges with fuel cells, other sources for hydrogen recently have gained attention, such as side streams from the chemical industry, or gasification of biomass or recovered waste, i.e., plastics. This has kick-started research into circular economy thinking through which we might well see future business and economic growth.

Even if renewable energy becomes available with even lower costs, however, the production of hydrogen is not the biggest challenge to its use as a fuel. Another significant challenge is the storage of hydrogen as fuel. To achieve higher energy densities, hydrogen has to be stored as either compressed gas or as liquid. As a gas, it typically requires high-pressure tanks, while storage as a liquid requires cryogenic temperatures because the boiling point of hydrogen at one atmosphere is -253 degrees Celsius, which adds to the complexity.

This challenge makes synthetic fuels that can be considered hydrogen carriers more attractive. Hydrogen can be bound to CO_2 or N_2 in the form of CH_4 (methane), CH_3OH (methanol) or NH_3 (ammonia), which makes the transportation, storage and the conversion of the energy much easier. But these options also have challenges. I do not see ammonia as a viable option any time soon due to low readiness levels, its toxicity, and a lack of rules and regulations. Methanol may become commercially viable to some extent, and fuel cells will be applicable for certain segments in shipping with lower power demand or short distances as well as for road transportation. Large-scale adoption of the hydrogen fuel cell as the primary energy source is unlikely for many years to come and cannot be considered a solution for meeting the IMO 2050 GHG targets.

Today, the only established fuel that takes us towards the IMO goals is LNG. Fossil LNG, however, is only an intermediate fuel, and we must work towards a parallel increase in production capacity for making bio- and synthetic LNG from renewable energy sources.

A new ecosystem

At Wärtsilä, we're taking a big picture approach to tackling the targets and improving sustainability in general. We are working towards a Smart Marine Ecosystem that involves all aspects of the maritime economy. In a Smart Marine Ecosystem, ships are technologically smart, using cloud-based software and digitalisation to minimise the use of energy and reduce fuel consumption. These vessels travel between smart ports that dynamically manage traffic so that ships no longer need to queue to dock. A connected ecosystem will see greater cooperation between shippers so that vessels sail with full cargo loads, thus enabling more cargo to flow using the optimal number of vessels. Improving efficiency across the value chain will certainly reduce waste in day-to-day operations.

But the biggest success in reducing emissions will involve the fuel mix used by engines. The fuel-flexible combustion engine presents itself as a future-proof technology that will enable the industry to meet future targets as and when alternative and renewable fuels become available. What we really need to see are fiscal policies, regulatory frameworks and long-term contracts that encourage expanding capacity investments for biogas and synthetic fuels.

We have the technology; the time to act is now.

Photo: 123RF

Cybersecurity looks to the cloud to protect data at sea

AUTHOR: **Mike Peake**

When it comes to cybersecurity, it's not just IT that needs protecting, but operational technology (OT) as well. A holistic approach to data security has helped establish Wärtsilä solutions as among the safest in the business – something that has now been recognised by Lloyd's Register.

Until relatively recently, topics relating to cybersecurity have been the domain of the IT department. Today, however, securing operational technology (OT) is becoming critical for business. In the marine industry in particular, ships are becoming more reliant on smart, cutting-edge tech. The IMO has recognised the need to make sure these systems are secure with its requirement that all maritime administrators appropriately address the cyber risk of their safety management systems by January 2021.

Operators who use Wärtsilä solutions are already ahead of the game, however. In December 2019, Wärtsilä's network architecture for main and auxiliary machinery, which integrates the company's Data Collection Unit, was awarded system-level cyber certification by maritime classification society Lloyd's Register. It is one of the first certifications of its kind to be awarded globally and helps cement Wärtsilä's reputation as a force to be reckoned with in the fight against cyberattacks, unauthorised access, or software failure on ships.

The convergence of IT and OT

Jonas Blomqvist, General Manager, Cyber Security, Wärtsilä Marine Business, says OT is being taken more seriously because IT and OT are steadily converging.

"There is a growing appreciation of the interconnected nature of IT and OT, and this has raised the awareness of possible risks that could be introduced through OT systems that are now everywhere in the maritime industry," Blomqvist says. "IT security processes and controls have been part of IT systems for many years, and OT had been thought of as being disconnected from that. But that's just not the case anymore."

Blomqvist points out that the sheer quantity of information transmitted from ship to shore has increased dramatically thanks to falling costs for sending and storing data in the cloud and an ever-increasing reliance on tech-enabled onboard systems. This data pertains to a multitude of support services that Wärtsilä offers its customers, involving everything from route planning to maintenance.

"As we start to talk about autonomy and unmanned ships and so on, then we have an ever more important role to play in protecting this data," says Blomqvist, adding that mesh networks and, potentially in the not-too-distant future, long-distance radio traffic networks all bring extra layers of complexity to the data mix that need to be handled with care.

Towards a new cyber culture

When Wärtsilä introduced its vision for a Smart Marine Ecosystem in 2017, the goal was to lead the industry towards a new era of digitalisation, connectivity, improved efficiencies, and enhanced environmental performance. Harnessing the power of new technologies like AI, Wärtsilä mapped out how waste could be cut and productivity boosted, among other things.

Maritime intelligence agency Lloyd's List praised Wärtsilä's ambition, stating that the company "stands out for going above and beyond short-horizon maritime technology."

Keeping data safe and secure continues to be a cornerstone of this vision. However, not everyone in the industry has been quite so quick to follow suit.

"If you'd asked me a year ago if the maritime industry was taking cybersecurity seriously, I would have said no," says former naval officer **Chronis Kapalidis**, a maritime cybersecurity researcher at HudsonAnalytix and an analyst at Chatham House. Things started to improve, he says, following the IMO's insistence on cyber-resilience by 2021.

Digitisation is now a key issue in the shipping industry, notes Kapalidis. "All newbuilds are based on software that runs systems within the ship pertaining to safety and security, and also for monitoring of operations," he says. "It's important that cybersecurity across IT and OT becomes part of a new cyber culture. It shouldn't be something that ship owners are requesting and pushing the vendors for – it should be something vendors have in place to demonstrate their competitive advantage."

As with turning a container ship, industry-wide change won't happen in the blink of an eye. Kapalidis says he was recently in discussions with a large shipping company that was developing a cyber IT policy completely separately to the one their OT department was working on. "And yet there still is only one connection to the satellite, only one network in use," he laments. "There should have been a single, unified cybersecurity approach."

It is a philosophy that has certainly been embraced by Wärtsilä. As IT and OT converge, it is those businesses in the maritime industry who take a holistic approach to data security that will help their customers sleep most soundly at night.