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12 Reliable power supply for data centers

Modern gas-fired engines have an enormous potential

FUTURE

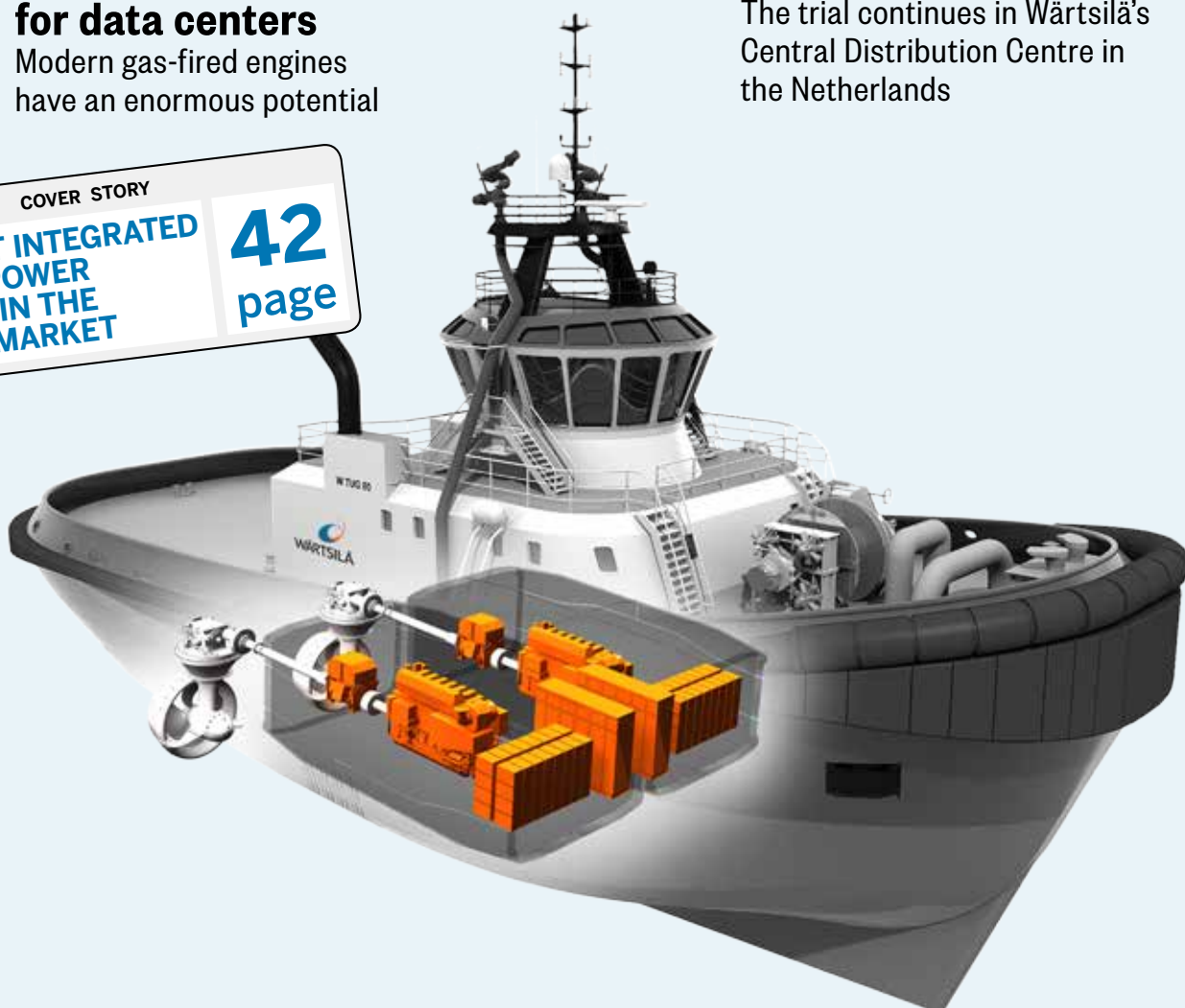
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TOWARDS A SMARTER AND SAFER FUTURE

In late August this year, the offshore vessel Highland Chieftain conducted a series of manoeuvres, off the North Sea coast of Scotland. What made this voyage a milestone was that the vessel was operated from 8000 kilometres away, in San Diego, with a combination of Dynamic Positioning (DP) and manual joystick control.

This development speaks volumes about autonomy finding its way into the marine industry. Maritime has always been a people's industry – there's always a human in the loop. But it is important to note that autonomy doesn't necessarily mean unmanned. All systems and functions are being built keeping people in mind, locally or remotely.

Digitalisation and autonomous systems are changing complete value chains, but they also help people make better decisions and reduce the number of errors. It can significantly improve safety in the marine industry, where about 90 per cent of the accidents are caused by human errors, often due to fatigue. To avoid tired and disoriented crew, dull and repetitive tasks can be left to the machines, while people can focus on making important decisions with the help of analytics and predictive technologies. At Wärtsilä, we strive to make all our products and services user-centric. On land and at sea.

Our vision for Smart Marine ecosystem is to combine smart vessels with smart ports to enable more efficient use of resources. Remote operation capability is one concrete step in that journey.

A case in point is our interesting story from Kampen, the Netherlands, where robots are helping make logistics faster and safer. The piece explains, in simple terms, how people and autonomous systems can work together to achieve great successes.

This edition promises to bring you closer to our fast-changing realities at Wärtsilä, give you the latest technological updates in the industry, and leave you with some food for thought.

Ilari Kallio

Director, Digitalisation
 Wärtsilä Marine Solutions, Engines
 Editor-in-Chief of *In Detail*



DECODING SMALL-SCALE LNG SUPPLY CONTRACTS

LNG has all the potential to become easily
 available for everyone who wants it.

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Power to isolated grids

Combining internal combustion engines with an energy storage battery system has great potential for savings.

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Decoding small-scale LNG supply contracts

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At an accelerating pace, the world is transitioning from liquid hydrocarbons to other fuels. While renewables are increasing their market share, natural gas is not far behind. The use of pipeline natural gas and liquefied natural gas (LNG) has for a very long time been commonplace in some geographical markets and industries, albeit an unattainable dream for others. Pipelines can only stretch so far, and LNG has previously only been available if consumption correlates with what a large LNG carrier or a tanker truck can deliver. But now, diversification is taking place to fill the market gap and, with time, LNG has the potential to become easily available worldwide for every consumer who wants it.

	Large-scale	Small-scale
Supply situation (near future)	Oversupply	Few alternatives for buyers
Contract duration	Trend towards shorter contracts and spot trading	Medium-term contracts
Pricing model	Trend towards market-based pricing	Indexed slightly below alternative fuels; or Cost+ from hub's price
Payment and delivery obligations	Take-or-pay for long-term and Cargo-by-Cargo for spot trading	Take-or-pay
Impact of logistical and port costs	Low-Medium	High
Buyer's pricing intelligence / experience	High	Low / none

Table 1 - Differences between large-scale and small-scale LNG.

With a new fuel comes the question: How much is it reasonable to pay for it? Crude oil is traded globally on a scale that leads to a completely liquid market with transparent pricing. It is not difficult to contract heavy fuel oil (HFO) or light fuel oil (LFO) as there are benchmarks and multiple suppliers available. It is also feasible to transport these fuels fairly long distances. The picture is very different for small-scale LNG. In many parts of the world, there is only one supplier or, in the best-case scenario, a few. Furthermore, the prices published for conventional, large-scale LNG deliveries have very little use for someone interested in contracting smaller quantities.

When the buyer has no or little experience, the seller has the power in negotiations. Therefore, this article aims to provide a few pointers to level the playing field. In order to understand the small-scale LNG contracts, one has to have some knowledge about how large-scale LNG is contracted.

Unlike the crude oil market, the gas market cannot be considered a uniform international market, as regions are not interconnected and trading is still fairly uncommon. Therefore, pricing mechanisms have developed differently in different parts of the world. So while LNG prices have

largely been linked to crude oil or a basket of oil products in Asia, they were initially linked to Brent oil in Europe, but are now increasingly moving towards hub prices following the increased liquidity of the NBP (United Kingdom) and TTF (Netherlands) gas hubs.

In North America, gas markets are hub based, with Henry Hub being the most well-known. When prices diverge between regions, arbitrage opportunities are created. This means excess large-scale LNG will go to the region that is willing to pay the highest price. There is currently, and for several years to come, an oversupply of LNG, which has improved the bargaining position of buyers. This is leading to more variation in price indexation, more spot trading, shorter-term contracts (previously 25-year contracts were common) and destination flexibility: Free On Board (FOB) instead of Delivered Ex-Ship (DES).

Large buyers hedge their LNG prices by having a portfolio of contracts with different suppliers and pricing mechanisms. This is a luxury small-scale buyers do not have. If a small-scale buyer has only one supply contract, there is less room for error. Therefore, there are some clauses in an LNG sales agreement which small-scale buyers should pay extra attention to.

Start date

Since there are not many alternative buyers and sellers for small-scale LNG, the delivery of LNG in accordance with the timetable of the contract is crucial for both parties. But during this time, if either the buyer or the seller of LNG is constructing a new facility, this could present a major risk. As LNG sales agreements should be negotiated and signed before the construction of the facility, assigning a realistic start date is of utmost importance. There should be a funnel where the start date of the contract is specified in an increasingly tighter time range as the facility comes closer to commissioning. Schedule slip could have serious financial consequences.

Logistics

In large-scale LNG, the trend is towards increased destination flexibility. The buyers want FOB contracts instead of DES, so that they can divert cargoes to spot buyers in case they do not need them. This is not really applicable in the small-scale market, since LNG cannot be economically transported very far on small-scale carriers and there are few alternative customers. However, having the shipping component in one's own hands might save some money for the buyer, but FOB contracts would also

require the buyer to assume responsibility for ship charters, insurance, boil-off gas and port costs. In some cases, DES contracts are advantageous if the supplier can utilise the same ship for other customers and share the costs. Those new to the market would be better off with a DES contract. But to shave off some hidden cost, considering FOB may be a good option.

Contract length

The contract length is often determined by the financing needs of the parties as financial institutions require certain guarantees. For a utility looking to build an LNG terminal for its power plant, this means a fuel supply contract that is back-to-back with the length of the power purchase agreement. But even without such requirements, a medium-term contract might be preferred. The trend in large-scale LNG is towards shorter contracts and spot deliveries, but in small-scale LNG one wants to make sure that supply of fuel is guaranteed for a longer time. However, if one expects that the number of suppliers in the region will increase, it might be a good idea to have a shorter contract, so that a new contract can be negotiated when the buyer's bargaining position is better.

Annual Contract Quantities

One challenge with a long contract is that the quantities required may change considerably. Given the fact that a liquefaction facility wants to produce at a steady rate and there seldom are other takers for a cargo, the seller wants to make sure that the buyer takes the cargoes that have been assigned to him. Also, the buyer wants to be certain that his fuel needs can be met. Therefore, the contract specifies an Annual Contract Quantity (ACQ). These clauses generally allow for some downward flexibility. The buyer has to pay for the cargoes whether he takes them or not (Take-or-Pay), but the outstanding cargoes should be taken the following year, in addition to the normal ACQ. Strict ACQs and

Take-or-Pay work fairly well for national gas grids and baseload electricity production, but for power plants running peak loads, the buyer would like considerable flexibility when it comes to annual quantities. If the LNG supplier is the only source of fuel (meaning there are no alternative suppliers and alternative fuels cannot be used), it is also important to specify what happens in case of failure to deliver.

Timing

The timing of negotiating an LNG sales agreement also matters as these contracts contain a price review mechanism with the purpose of restoring the conditions of when the agreement was signed. The **base period** of an index is defined in the contract and constitutes the reference period for the price. The base period values will affect future prices, so it is important not to accept one that would result in a future disadvantage.

A **review period** for determining the index to be applied is also specified. Instead of choosing a particular day as reference point for the index, an average over a longer time period is chosen. The intention of this is to smoothen out peaks. The period is usually with a lag if time is needed in order to collect the data for calculating the index.

If the contract is increasingly disadvantageous to one of the parties of the contract, it should be returned to equilibrium. The contract should state a **price adjustment frequency**. With a suitable frequency, the price is kept close to the market level. Buyers would ideally want to mirror the same price adjustment frequency they have with their own customers.

Pricing mechanism

The price of LNG is obviously one of the most important points when negotiating an LNG sales contract. With few suppliers to choose from and a low level of experience among buyers, it is often the suppliers that have the upper hand in deciding the terms. The principles of a fair agreement should

be that the price provides an acceptable return on investment for its facilities and operates at a reasonable profit. The seller wants the price to reflect the market value of the gas, while the buyer wants an advantage over competing fuels. Buyers also want the price to mirror the price risk in the sales of their products or services (e.g., electricity). In case of a new market with poor credit ratings, the seller would also require a premium in order to cover the credit risk.

Prices are linked to different indices in different parts of the world, and generally small-scale LNG is influenced by large-scale LNG. Most often in South-East Asia, prices are linked to Brent crude oil, in Northern Europe to TTF hub prices and in the western hemisphere to Henry Hub. This is understandable as LNG suppliers don't want to absorb the price risk of buying according to one index and sell according to another. But this is not necessarily in the interest of the buyer. Ideally, a consumer wants to make sure his fuel costs are lower than the competitor's. If the competitor is using HFO or LFO, this is the preferred index. For the buyer, it would be ideal if the price would be linked to a local index, but as they seldom have sufficient liquidity, the seller probably insists on an international index. It is common to use Brent crude as an index, which is beneficial since it is easy to hedge, but there is no guarantee that the price of crude oil and refined products cannot diverge in the future.

Other, more experimental indexing can be considered if the buyer, e.g., a dual-fuel power plant, can use other fuels. Then a different index can be chosen, e.g., Henry Hub or NBP, so that one can play with price differences and produce using the fuel that is currently most affordable. Such a strategy might, however, be difficult to align with the Annual Contract Quantities.

What can be seen in reality is that suppliers of small-scale LNG offer a hub or oil products index plus a fixed component. The fixed component comprises not only the logistical costs in a DES contract, but

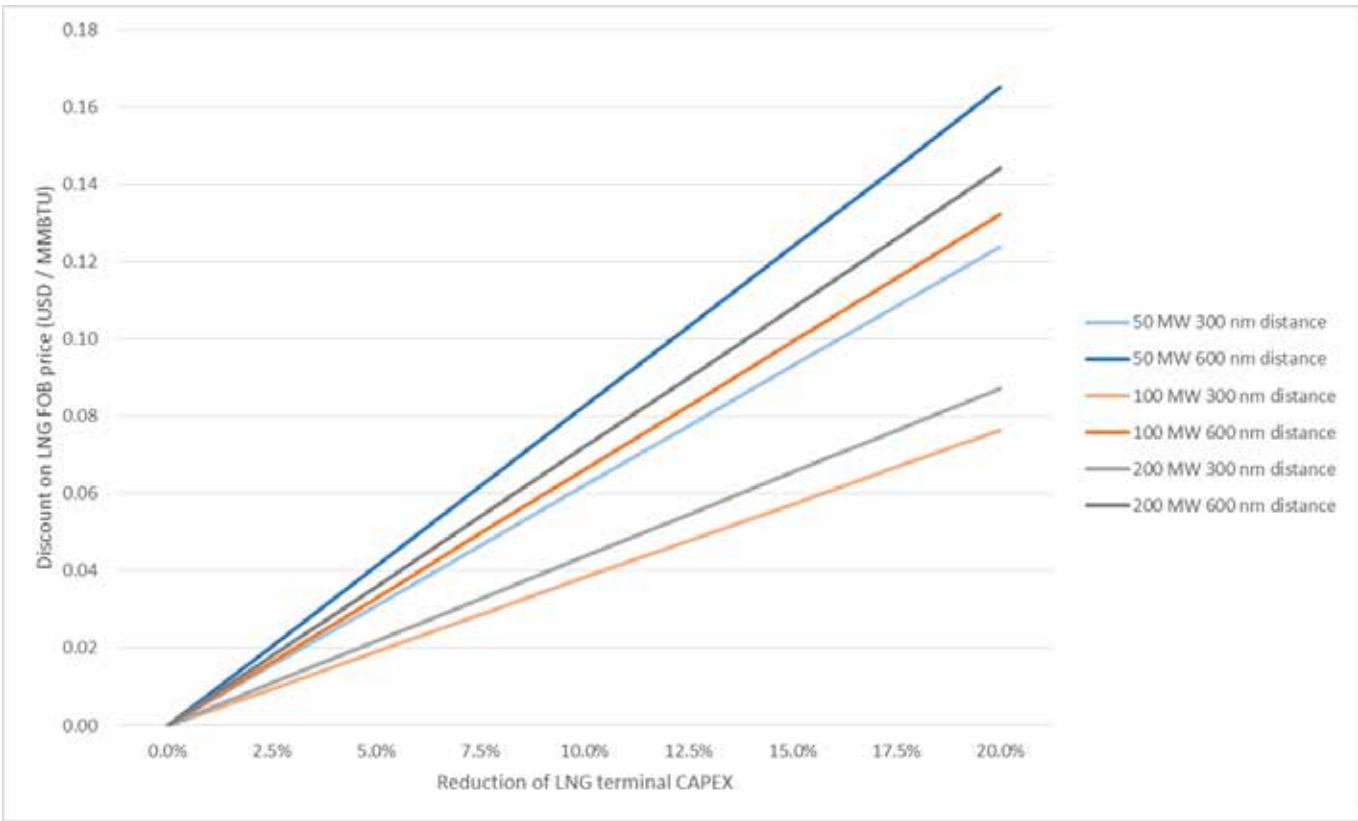
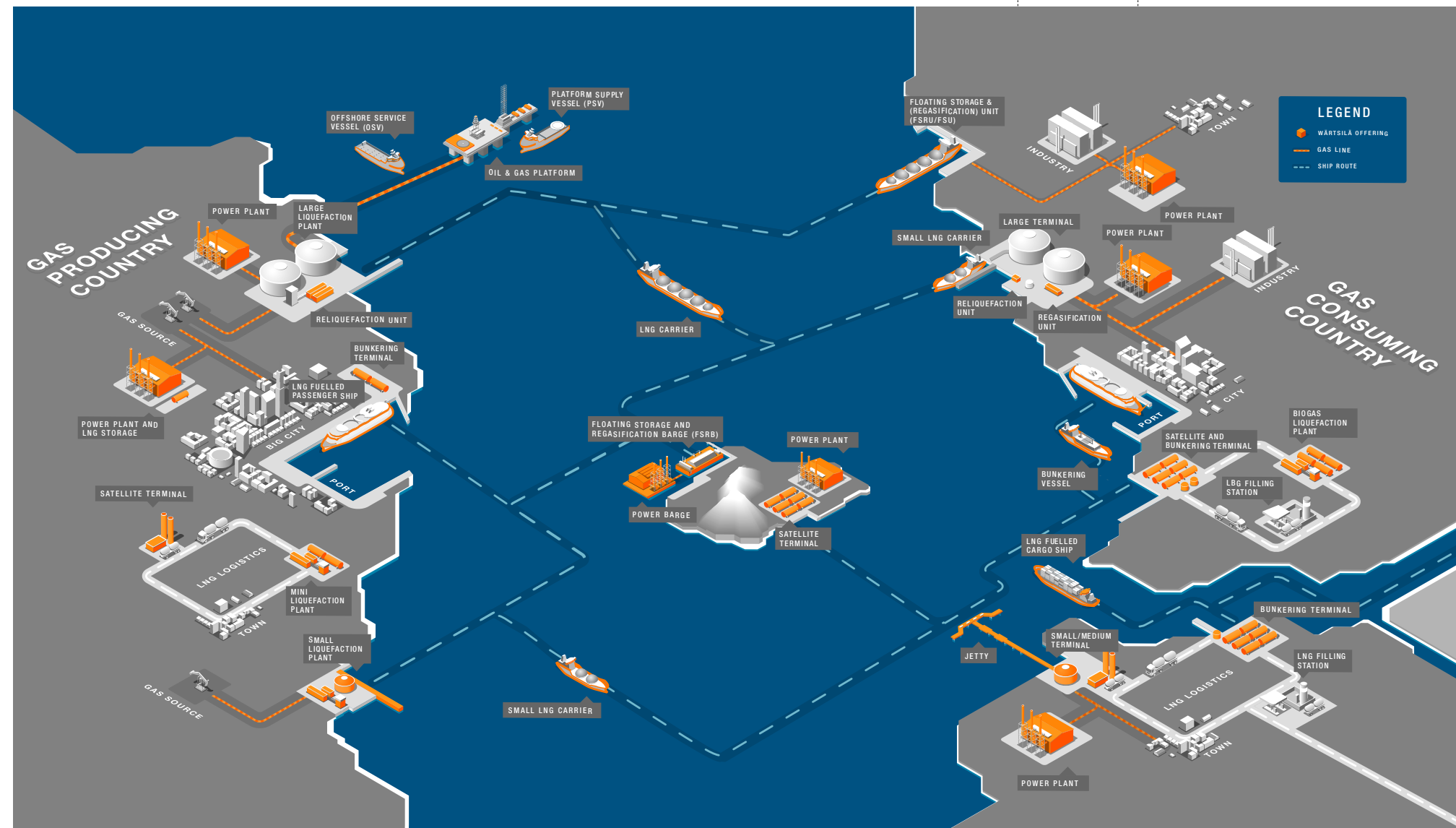


Fig. 1 - Discount on LNG FOB price compared with a reduction of LNG terminal CAPEX.

also reduces the transparency of the pricing mechanism. By coincidence or not, the final price often ends up close to the cost of the competing fuel.

A few cents per MMBTU might sound trivial, but it has a substantial impact on the cost price of gas for the LNG terminal. Figure 1 illustrates the significance of a discount on the FOB LNG price compared with a reduction in total infrastructure cost for a generic LNG terminal (including marine infrastructure) designed to supply gas to a 50, 100 or 200 MW power plant located at a distance of 300 and 600 nautical miles, respectively, from the LNG supplier.

From the figure, it is apparent that even a minor discount on the LNG price has the same impact as reducing CAPEX spent on the LNG terminal by several million USD. While spending less on the LNG terminal will result in lower performance, reliability and perhaps safety, the properties of LNG will not change when lowering the price. The savings also remain more or less the same in both low and high price environments. Therefore, the LNG sales contract should be given considerable deliberation and if needed, an experienced consultant should be brought in to support negotiations. ●



Expanding small-scale LNG with private-sector investment

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Private sector participation through the Build-Own-Operate-Transfer (BOOT) model may hold the key to supporting the expansion of the small-scale liquefied natural gas (LNG) market. Although small-scale LNG could

help solve many of the energy challenges of developing countries and remote, off-the-grid locations, the lack of financing and infrastructure remains an obstacle to its more widespread acceptance.

8 **in detail**

There is currently an abundance of LNG available for large-scale applications, with new LNG supplies coming from Australia, and increasingly also from the United States. With the supply base growing, leading market players, such as international oil majors and state-owned oil companies, are expressing a growing interest in making LNG available for small-scale applications, as well.

The primary drivers for the growth of small-scale LNG market will be its use as shipping fuel, driven by the upcoming IMO 2020 regulations, which will limit the sulphur in fuel oil used in ships to 0.50% m/m (mass by mass) from 1 January 2020; and its use as a less expensive, more sustainable alternative to diesel for power generation in remote and island locations. Although the industry is aware that LNG has the potential to be more cost competitive than other alternatives, the high up-front costs related to establishing a small-scale LNG supply chain are still causing doubts.

A number of recent market developments support the growth of the small-scale LNG market. In South-East Asia, both the Singapore LNG and Tangguh Train 3 terminals will soon be able to load small-scale LNG carriers, thereby expanding the options for small-scale LNG sourcing. Meanwhile, the global LNG carrier fleet is gradually growing. There are currently some 25 small-scale LNG vessels with capacities of less than 40,000 cubic metres in operation, with eight more expected to be commissioned in the next two years.

Despite these developments, the small-scale LNG market needs to solve three challenges for its potential to be realised.

Three key challenges

The first challenge is the high up-front capital cost of establishing a small-scale LNG supply chain, resulting in increased perceived project

risks. At the present time, there is a distinct lack of both small-scale LNG terminals and a dedicated small-scale LNG carrier fleet, with few players willing to invest in both terminals and vessels to support a relatively small LNG delivery volume.

Secondly, while demand for small-scale LNG is driven by power generation, power utilities often lack the necessary expertise and resources – including labour, know-how and capital – to develop and implement LNG projects.

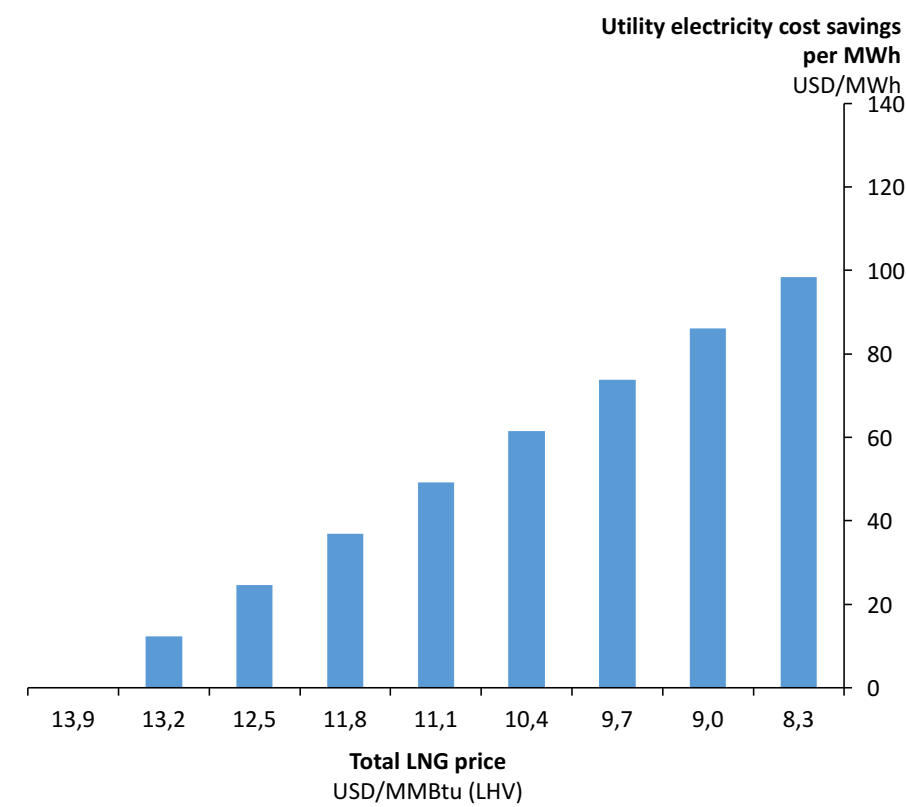
The third major obstacle in the expansion of small-scale LNG is the need to adapt the methodologies used for large-scale projects to the small-scale context. The methods that exist at present are often too complex and costly to be viable for small-scale plants. However, by developing new processes that are leaner and less expensive, but still safe, the small-scale LNG market has the potential to be profitable for various applications.

The power of BOOT

A potential solution to the first and second challenges is a funding model known as BOOT (Build-Own-Operate-Transfer).

It is a form of project financing in which a private or, more often, public-sector player, such as a government agency or government-owned utility, awards a contract to a private organisation to develop, finance, construct, own, and operate an infrastructure project during a defined concession period. The fees collected during the operational period generate a return on investment for the concession holder. At the end of the concession period, the project is handed back to the concession counterparty. The BOOT model has been used since the late 1980s to finance large infrastructure projects such as toll roads, railways and power plants.

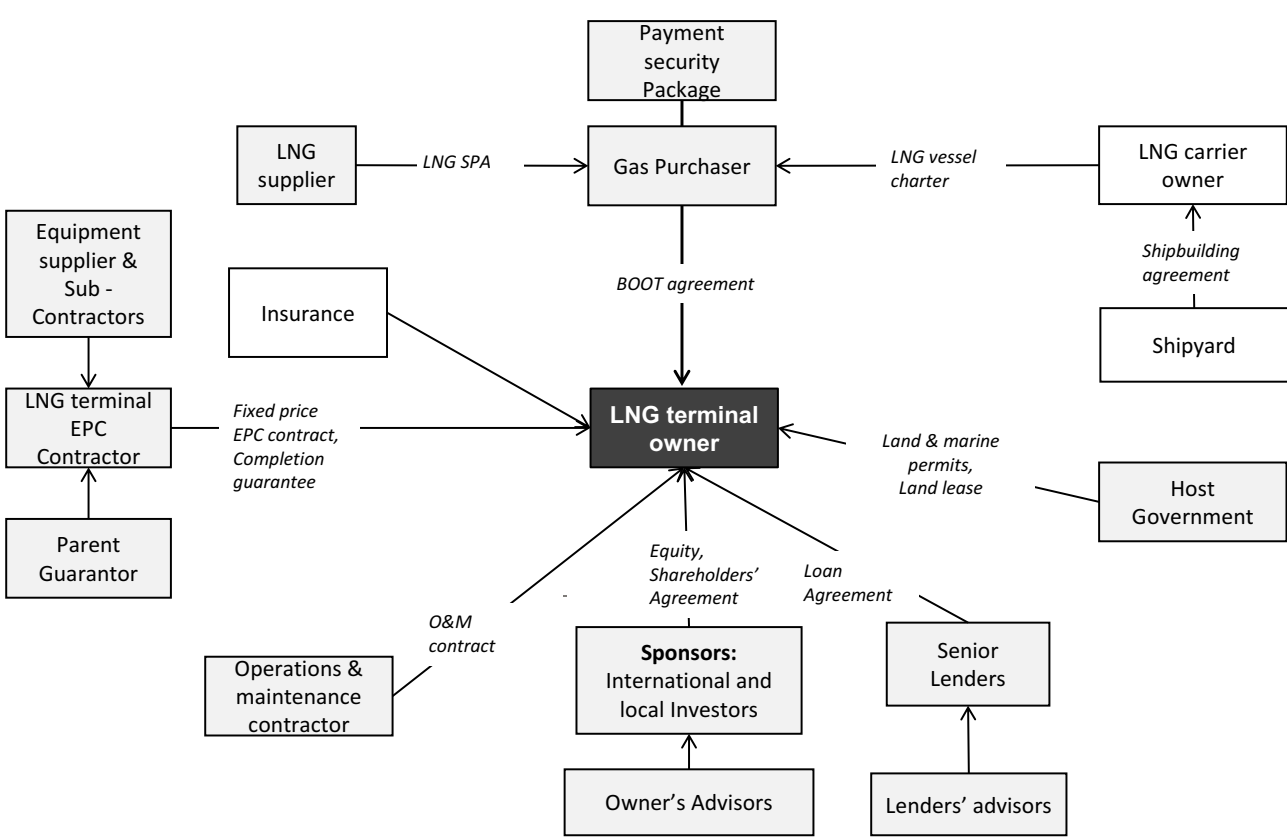
The advantage for the public sector player is that, by awarding the concession



■ The diagram above shows the electricity tariff reduction in USD/MWh for a power plant at different prices of LNG, in comparison to the diesel price. The break-even point for small-scale LNG feasibility depends on the delivered price of diesel and the price of LNG. As an example, if the delivered price of diesel is 520 USD/tonne, the price of delivered LNG should be below 13.9 USD/MMBtu for generation with LNG to be feasible. If the base price of LNG was around 6 USD/MMBtu, the all-in price of break-bulk transportation, storage and regasification should not exceed 7.9 USD/MMBtu to achieve savings in comparison to use of diesel.

Main assumptions:

Item	Value
Delivered price of diesel	520 USD/tonne
LNG price slope (FOB basis)	11% of relevant crude oil price index
Crude oil price	50 USD/bbl
Efficiency difference between diesel and gas power plant	4% lower efficiency for diesel power plant (including combustion efficiency difference, equipment ageing over life cycle and fuel losses)
O&M cost difference	2 USD/MWh higher for diesel power plant



■ The above diagram presents a typical business structure with BOOT model, including project key agreements and counterparties. Successful project financing with BOOT model is based on a solid contractual structure and proper allocation of risks between the project parties.

to a private company, it can attract private-sector funds for projects, allowing the public budget to be prioritised for other projects. Moreover, it can attract technical, project management, and operational and maintenance expertise from the private sector in areas where its own know-how may be lacking. For the private company, the contract length is designed to ensure that investment costs can be recovered and a profit can be made.

Wärtsilä's role in small-scale LNG

Wärtsilä has a key part to play in the development of small-scale LNG markets as it can help remove the three major challenges that the market is currently experiencing. As a total solutions provider, Wärtsilä is the market leader in developing lean, cost-effective technical solutions both for

small-scale LNG shipping and for terminals that allow project developers and owners to implement small-scale LNG projects. Moreover, Wärtsilä has the capability to construct small-scale LNG terminals on a turnkey EPC basis and operate and maintain them under long-term contracts.

Wärtsilä also has experience in implementing small-scale LNG projects under BOOT arrangements. Wärtsilä's project development and customer financing arm, Wärtsilä Development & Financial Services Oy (WDFS), has been developing and investing equity into Independent Power Producer (IPP) power plants using Wärtsilä engine technology for the past 30 years. Its track record includes the successful development, financial closing and construction of more than 30 projects, representing around 3,7 GW, globally. Since

2013, Wärtsilä has also expanded its mandate to cover project development and equity investments into small-scale LNG terminals, with several LNG projects currently under development in South America and South-East Asia.

As a total LNG-solution provider, Wärtsilä has the advantage of being able to deliver the complete project scope: from development and investment, to supplying the EPC for the small-scale LNG terminal, and to ownership, operation and maintenance. In addition, through Wärtsilä's expertise in LNG carrier design, interface to LNG terminals can be optimised. Last but not the least, Wärtsilä has the capacity to bring all these aspects together to create a total solution that is optimised from the point of view of cost, efficiency and feasibility. ●



Transforming data centers

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Did you know large data centers consume power equivalent to the power consumption of an average-sized town? But a solution, in the form of modern

gas-fired engines, holds the potential of providing affordable and reliable power and also generating additional profits.

The phenomenal use of information technology has made data centers an indispensable part of modern day business needs, as they store an enormous volume of data that is generated on a daily basis. Every data center, thus, needs an extremely reliable and affordable power supply to ensure uninterrupted functioning, 24/7.

The traditional mode of power supply, which involves a combination of grid electricity and diesel generators, has its own drawbacks in the form of unstable power prices and high local emissions.

But what if these emergency power generation facilities helped in revenue generation? Can a back-up power supply

facility become the primary source of power supply? And can this be achieved using cleaner forms of energy? The answer to all of these is a big YES. Our white paper – Smart Power Generation for data centers – substantiates that the solution lies in modern gas-fired engines.

The modern approach

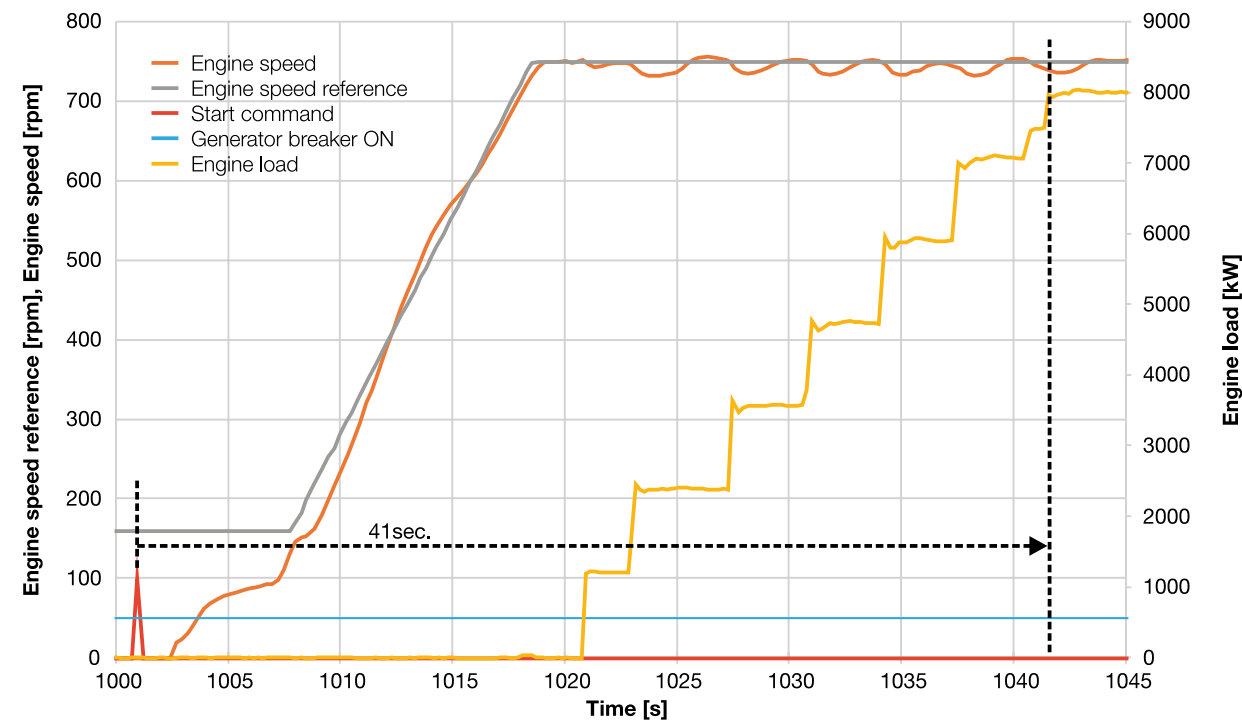
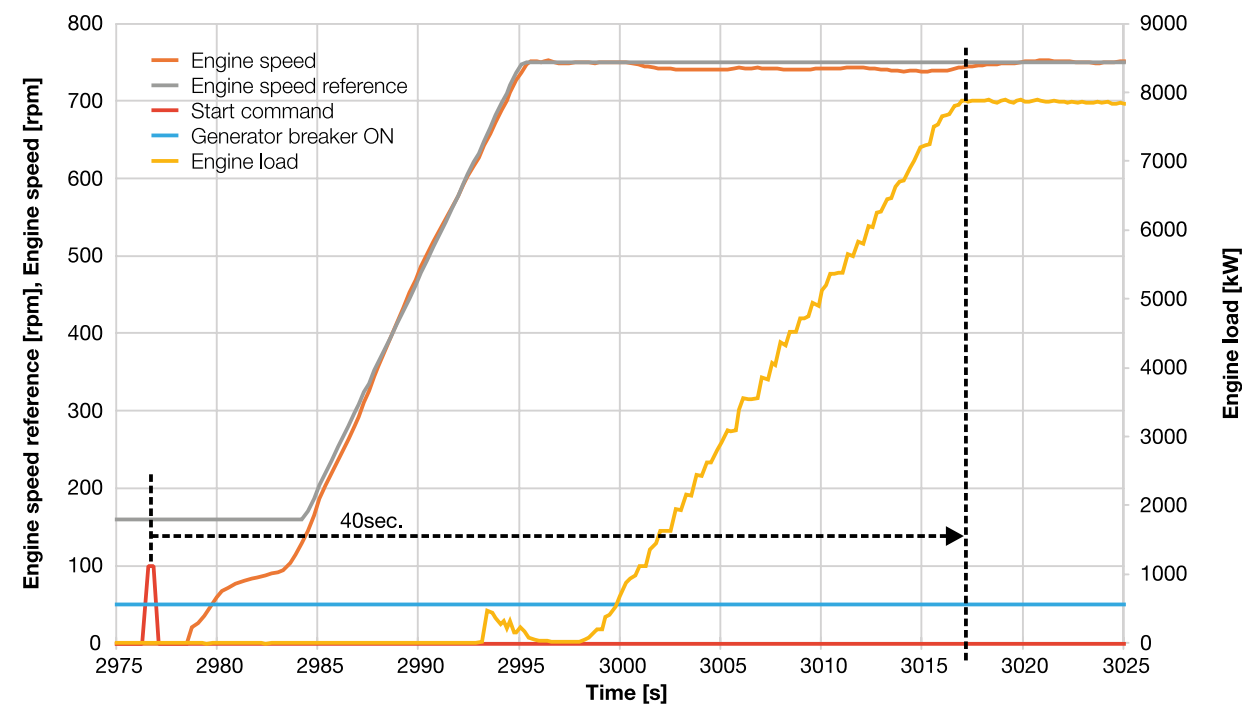
The need for a smarter solution for emergency power supply has led to the advent of modern gas-fired engines that are cleaner than diesel engines and work faster.

To understand how gas-fired engines are changing the dynamics of emergency power back-up mechanism for data centers,

one needs to understand the functional requirements of an emergency back-up system. They are:

- **Very rapid automatic start-up:** Data centers use Uninterruptible Power Supply (UPS) systems based on electrochemical batteries. They are typically dimensioned to last a couple of minutes and are very expensive.
- **Modularity of capacity:** A good emergency power supply system needs spare capacity in a separate independent generator set, sufficient to cover the capacity lost due to maintenance or isolated failure.
- **Ability to run on locally stored fuel:** The facility needs some locally stored





■ Fig. 1 - Start-up curves of a modern medium-speed gas engine. These are direct screenshots from engine control systems and were made during tests of a rapid start-up of a medium-speed gas engine operating in island mode. The top diagram shows a case of linear loading, while the bottom one involved pre-programmed load steps. In both cases start-up duration (40 and 41 seconds respectively) is measured from the start command until full output. Testing was performed in island mode.



■ Fig. 2 - MS Viking Grace, a cruise ferry powered by liquefied natural gas, has been safely carrying passengers since January 2013.

fuel to ensure an uninterrupted supply for a certain amount of time until the external power supply can be restored.

■ **Technological maturity:** Finally, the requirement of maturity is natural for a system where reliability is of fundamental importance.

An internal combustion engine still remains to be the only solution capable of meeting the above mentioned functional requirements. But such an engine does not have to run on diesel fuel anymore – especially, when there is a cleaner and more economically effective alternative: natural gas. Compared with other fuel-based technologies used in large-scale commercial power industry, gas engines meet all the features of a smart power backup system. It is fast to start, cheap to build, and extremely flexible.

Gas engines, come of age

But not long ago, gas-fired engines suffered a major drawback in terms of very delayed start-up timing – at times as high as 10 minutes. But recent years have seen huge progress on this front. Now these state-of-the-art gas engines can be started and brought to full power in considerably less than one minute of the starting order, ushering them into the world of emergency power supply.

In Figure 1, there are some exemplary and representative start-up sequences obtained during actual engine tests performed by Wärtsilä.

Gas engines have also taken care of the issue of fuel storage. Recent years have seen emergence of small-scale affordable gas storage technologies, especially in the form of liquefied natural gas (LNG). As a

matter of fact, small-scale LNG storage and regasification plants are so reliable and safe that they are currently being installed on passenger ships. (Figure 2)

Clearly, modern gas engines hold enough power to become a potent alternative to diesel generators. However, gas engines go far beyond merely providing an equivalent solution. Restricting carbon emissions is very important amid growing environmental concerns. And adopting gas engines is the need of the hour as natural gas is the cleanest of all fossil fuels. Using gas means less CO₂, which in turn means corporations can reduce their carbon footprint besides reducing costs. (Figure 3)

This means operating the generating sets continuously instead of relying on electricity grids would have a positive effect on the carbon footprint of the data center.

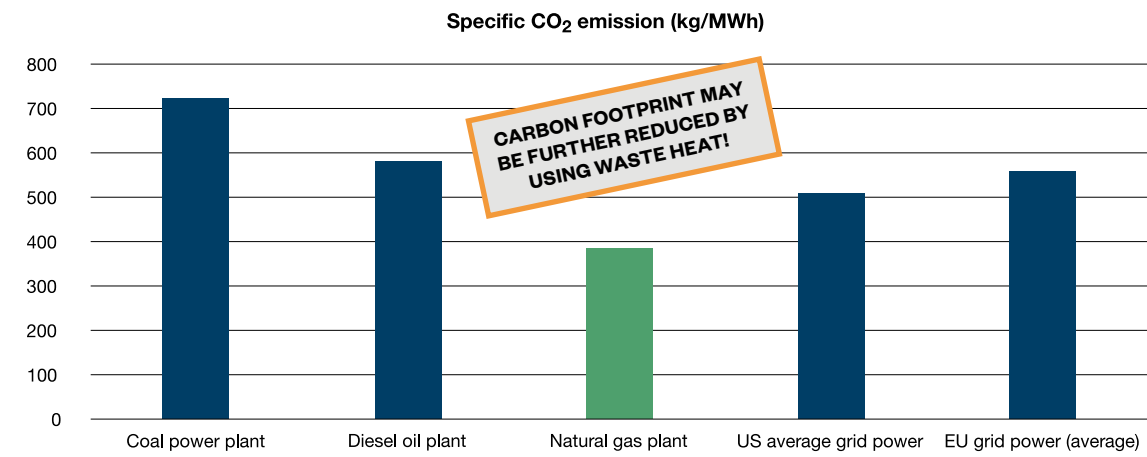


Fig. 3 - Carbon footprint of different sources of electricity. Note that generating power with on-site natural gas power plant has lower footprint than the grid electricity.

The real power

That modern gas engines are the future of emergency power back up systems, has been established beyond doubt. But gas engines are not merely futuristic alternatives to diesel generators. In fact, gas engines are the game changers – because they can go beyond emergency.

Once an emergency power generation system is built using a solution that is neither legally nor technically restricted from operating beyond emergencies, there are two essential ways of using this capability:

- Self-generation
- Merchant operation

Self-generation model

This model shifts the source of primary power from the electricity grid to the emergency power generation facility. If a data center has a power-generation facility that can be operated continuously on an inexpensive fuel with very low emission

footprint, then it may very well be used as a primary source of power.

This would make the local power plant the primary source of electricity, while the grid functions as a backup. This approach protects the data center operator from higher power costs and reduces carbon footprints too.

Data center operators can generate additional revenue as data centers do not operate on full design load. That time can be used to generate additional power & sell it to the electricity market along with the spare and redundant capacity of power plant. (Figure 4)

Merchant plant concept

Unlike the self-generation model, in this case the gas-fired power plant can be used only as an emergency back-up power source while operating independently as a merchant generating station co-existing with data center and selling its production to external customers. In the event of

any disruptions in the grid power supply, it would automatically switch to the emergency power supply mode. This might be a preferred approach for markets with high electricity cost. (Figure 5)

With the phenomenal advancement in gas engine technology and the advent of LNG solutions, there is no denying that the future of gas-fired engines, in data centers, holds immense potential. ●

- 1 IPP or data center operator builds a gas engine power plant at the data center site
- 2 Power plant operates as the primary source of power, at the same time providing required redundancy.
- 3 Extra electrical capacity needed for redundancy is used to generate extra electricity sold to the market.
- 4 Optional heat recovery systems are used to generate cooling power for data center or heat for local consumers

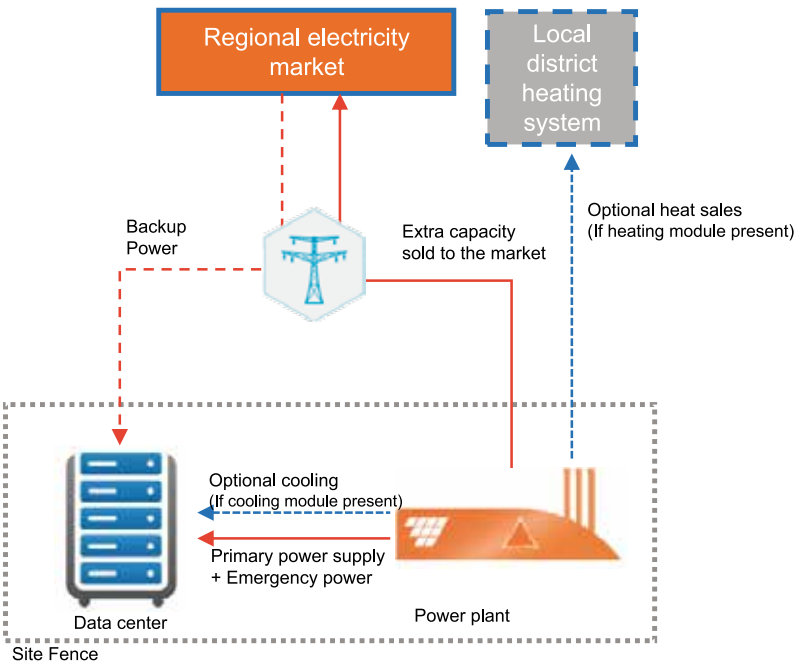


Fig. 4 - The self-generation model for a gas-fired data center power plant.

- 1 IPP or data center operator builds a gas engine power plant at the data center site
- 2 Data center owner and IPP sign an emergency supply contract
- 3 Data center purchases electricity for data center from the electricity market
- 4 IPP operates the power plant on a merchant basis, selling electricity and system services to the market

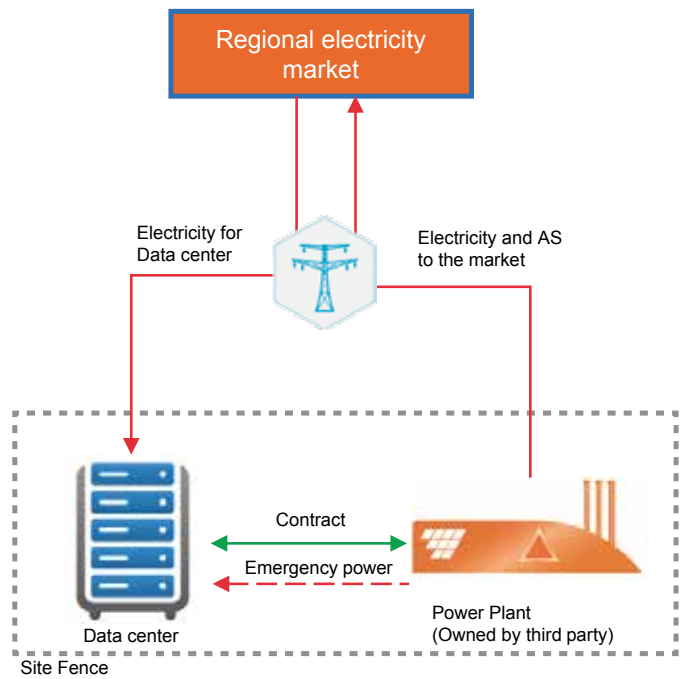


Fig. 5 - Merchant plant model for the gas-fired data center power plant.



Powering isolated grids

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Fast-starting internal combustion engines – integrated with an energy storage battery system – provide great potential for fuel and cost savings, especially in isolated grids.

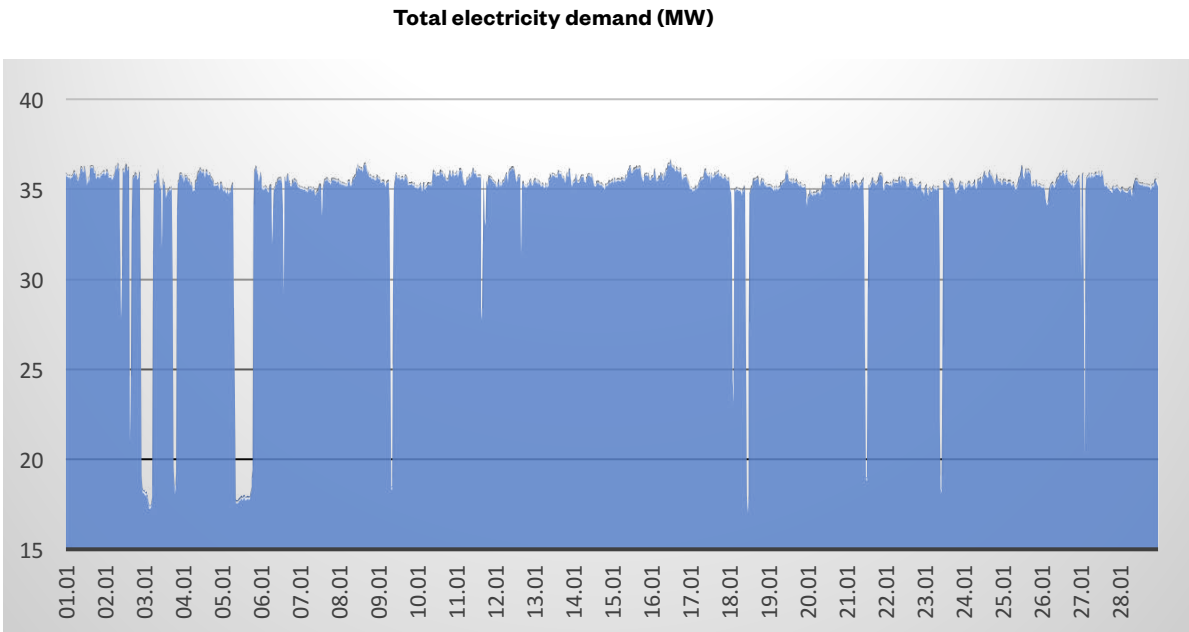


Fig. 1 - Load demand without solar generation.

The authors of this paper studied the added value a Wärtsilä hybrid power plant (with internal combustion engines and energy storage) can provide its owners and operators in terms of economical savings and enhanced performance. The case study and simulations were made based on actual load data from an islanded industrial operation.

The hybrid power plant in question comprises six Wärtsilä 20V34DF dual-fuel (DF) engines, capable of running on natural gas, light fuel oil and heavy fuel oil, providing the plant extremely valuable fuel flexibility. The Wärtsilä 20V34DF engine delivers nearly 10 MW each with a total plant output of 58 MW. With the energy storage available in the system, the total hybrid plant capacity is 68 MW; and if solar photovoltaic (PV) generation with a performance ratio of 11 MW would be added to the system, the maximum generation capacity would be 79 MW.

As the case study is in an isolated grid, there are requirements on the generating assets to have spinning reserve capacity. For the generation units, it was selected to have contingency reserve equal to the generating unit operating at highest load and in addition also 80% of the actual solar PV generation.

Providing spinning reserve

The integrated energy storage system comprises Li-Ion batteries with peak power of 10 MW and 2.5 MWh of energy. The energy storage size was selected to be slightly bigger than the generating unit's size, thus having sufficient capacity to provide the spinning reserve capacity equal to one unit at full load. In the case of a generating unit trip, the energy storage has the capacity to provide power for 15 minutes, which is more than enough time to start one of the standby units and take over the load.

Therefore, the energy storage can replace the spinning reserve capacity from one generation unit. In case there is solar PV generation in the micro grid, there will be additional spinning reserve requirements from the solar PV due to intermittent nature of solar generation. Hence with the selected approach, the presence of solar PV will increase the need for spinning reserve capacity.

The demand data of the industrial site including solar PV generation was simulated with the plant dispatch modelling tool PLEXOS®, a tool commonly used by utilities, consultants, system operators and regulators globally.

30-minute resolution

The demand profile has a 30-minute resolution and the load profile for this time period is presented in Figure 1. As the grid is an isolated grid, i.e., microgrid, the demand profile equals the load that the generating units have to produce. In Figure 2, the same demand data is presented, but here also solar PV generation with a performance ratio of 30% of total demand has been included.

When evaluating the demand profile, the power need is relatively stable with a load slightly above 35 MW. It can also be noted from the profile that there are eight major events where the load is dropping rapidly with nearly 20 MW.

The trips in the system are causing additional stress on the generating units. However, it is also important to note that demand data with second resolution would be required to be able to study the real impact on, for example, frequency of these load drops.

The Wärtsilä DF engines can ramp to full load in 60 seconds and are capable of taking single load steps of 30%, giving it sufficient fast and flexible generating capacity to respond to these load changes.

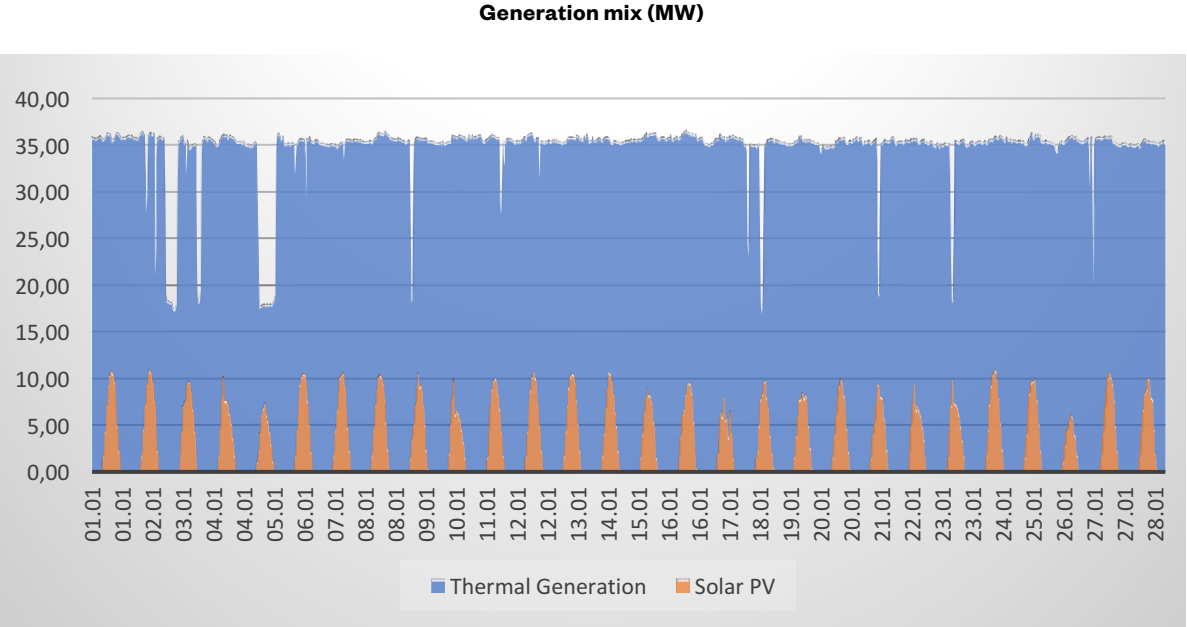


Fig. 2 - Generation mix including thermal units and solar PV production.

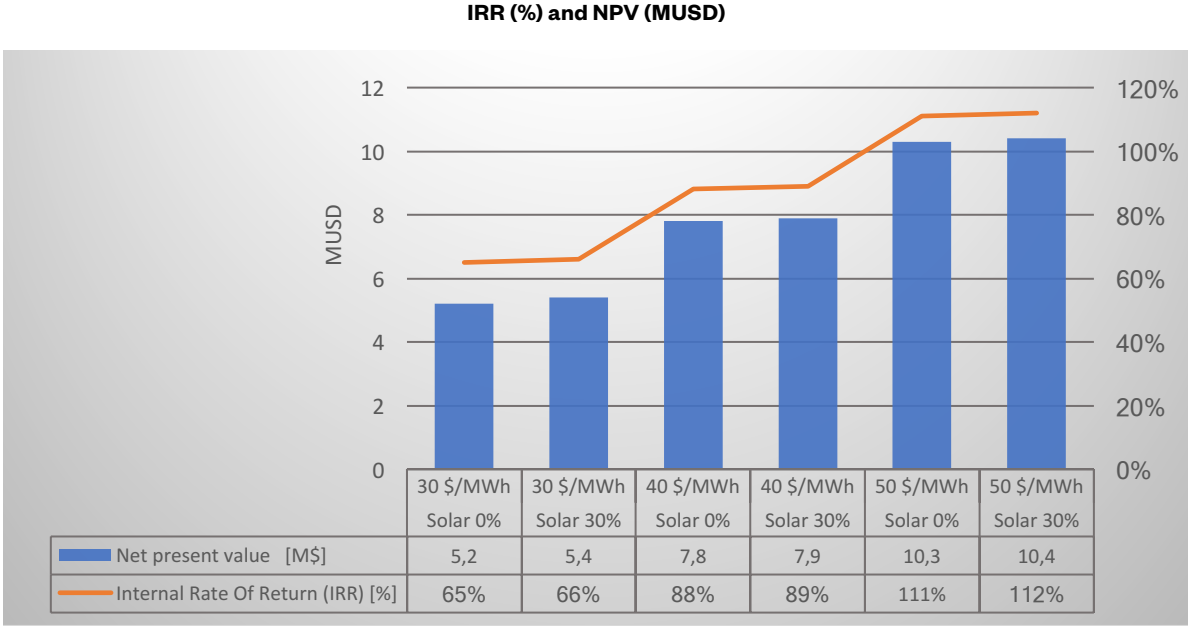


Fig. 4 - IRR (%) and NPV (MUSD).

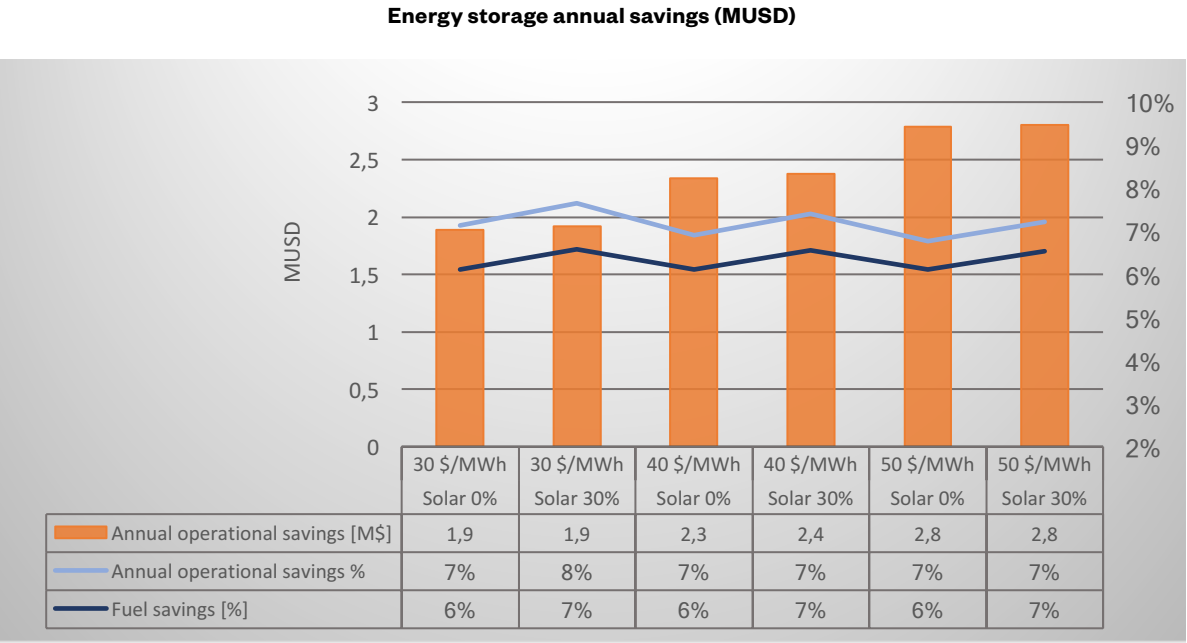


Fig. 3 - Energy storage annual savings (MUSD).

Strong feasibility

The feasibility of energy storage, particularly for industrial usage in isolated grids, as an integrated hybrid power plant is solid. In this study, the energy storage was only used as contingency reserve, i.e., to free spinning reserve capacity from the generating units. However, in industrial use, the energy storage could as well be used for other applications. The energy storage can e.g., act as a peaking unit and take on load steps from the isolated grid, momentarily.

The energy storage could also smoothen load fluctuations, and if stable power is required the energy storage could be used for power quality purposes to stabilise the isolated grid and hence ensure the production process for the industrial plant, eliminating production losses for the plant. (Figure 3)

What already can be seen today is that there are solid financial grounds for investing in hybrid power plants with integrated internal combustion engines + energy storage. For the energy storage, the internal rate of return (IRR) in the most feasible case was 112% and net present value (NPV) 10 MUSD. In all analysed cases, positive NPV's and IRR's over 30% were reached, hence there are no doubts about favourable

investment decisions. Especially in remote locations, the potential enhancement that can be reached by integrating energy storage to the power plant are directly linked to the fuel prices and thus have potential to save millions on annual basis. For instance, in remote mines, factories and islands, where fuel prices are generally high, there is great potential of fully integrated and optimised hybrid power plants combining internal combustion engines, solar PV and energy storage.

Hybrid opportunity

With the available energy storage technology and the decreasing prices of the Li-Ion batteries, the authors argue that hybrid power plants with energy storage will come strong into the future power generation markets. The possibilities to optimise the power generation by developing hybrid power plants are increasing all the time; already today it is apparent in, e.g., Europe and the USA that there are genuine interests for hybrid power plants with internal combustion engines and energy storage, integrated and optimised with an energy management system.

It should also be noted that existing power plants can be enhanced by integrating

energy storage, and solar PV systems, which will improve its performance. (Figure 4)

The demand for 'greener' electricity production keeps rising, and this is normally achieved by adding renewable generation to the system. However, as renewable generation depends on actual wind speed or solar irradiation, flexible generation assets are a must to be able to balance the network. Hence, by optimising the thermal power plant with energy storage, the complete system can be operated at higher efficiency, and by this also the total amount of emissions can be reduced as less fuel is consumed with same amount of energy, thus providing optimised system with 'greener electricity'.

In the study, fuel savings of 7% and annual savings of 8% were reached by adding only energy storage. For the multi-hybrid power plant, the operational savings were as high as 13%. Hence, there is a clear case also to integrate renewable generation to thermal generating systems. Also, all the generating assets shall be sized and optimised taking into account how the complete system works with the actual or forecasted load profile. By integrating all generating assets with an energy management system, the full potential of the complete system can be unleashed. ●



Wärtsilä partners with AW-Energy adding wave power generation to its capabilities as energy system integrator.

Catching the 'surge'

AUTHOR: Richard Orange

Capturing the power of the waves is a complex task, as the sea is constantly changing. One of the most promising wave energy devices is WaveRoller, a submerged panel equipped with Wärtsilä's components.

When the British naval architect Chris Ridgewell visited Wärtsilä's Vaasa offices at the start of the project to develop the first LNG-fuelled passenger ship at Turku shipyard, as a surveyor for Lloyd's Register, he saw first-hand how adept Wärtsilä can be with developing technologies.

So after he returned to Finland to become Chief Technology Officer for the wave energy start-up AW Energy, he knew where to turn.

"LNG has now really taken off and Wärtsilä is a main player," he says. "They've built it from a new technology to an established industry. Now we are at the same point in the development cycle, and Wärtsilä again is involved in that transformation."

Wärtsilä has supplied AW Energy's first full-scale WaveRoller with metallic

bearing housings, composite bearings, lip seal housings, and hydraulic couplings. The equipment is being fitted this summer before the device is shipped to Peniche, Portugal, for a year's trial operation in the early autumn. In September Wärtsilä announced it will partner with AW-Energy adding wave power generation to its capabilities as energy system integrator.

WaveRoller is unusual among wave energy devices, because it generates energy from the 'surge', the back-and-forth motion waves make when they travel from the deep ocean to shallower waters. It has the potential to be one of the most popular devices for power utility customers.

The device consists of a steel panel, which is fixed to the seabed, near the shore, at a water depth of about eight to 20 metres.

The back and forth movement drives a closed hydraulic circuit, which in turn drives a generator. An energy storage system then turns the pulsating output into smooth, grid-compliant electricity.

Being near the shore brings the advantage

of a short grid connection, while being fixed to the seabed, under the surface, means the device is not as exposed to extreme waves as most rival devices. For power utilities the more even generation and easier maintenance WaveRoller promises bring clear advantages over rival devices.

The wave forward

Wärtsilä's parts are essential to the device's durability as they withstand rough weather and require minimal servicing.

"The majority of the year, the waves are quite small: one to two metres," Ridgewell explains. "And that's why the bearings are so important: they allow the panel to move in small wave heights. Because we're structurally efficient, we're very responsive to the waves."

Ridgewell approached Wärtsilä. The request filtered down to Les Creak, Wärtsilä's Business Development Manager for Hydro, largely because his team had worked extensively with other developers and start-ups in Ocean Energy over the past decade.

"AW Energy have come up with a fantastic invention, which has been proven to work at sea, but the information they are able to extract on the longevity of the bearings and seals is from simulated exercises," Creak explains. "What we're giving them is a balance of mature technology in the equation – so they're able to use the past performance figures to a degree."

Even if the core technology is new, both investors in AW Energy and the company's potential customers will gain assurance from the fact that key components have been used for decades, and come from a reliable supplier such as Wärtsilä.

"They're able to use the past performance figures to a degree," Creak says. "Derivatives of the seal and bearing technology have been operating in other applications for over 50 years. This gives a sense of security and reliability."

Ridgewell, who spent 17 years working for Lloyd's Register, says WaveRoller has tapped established, respected suppliers for other parts as well.

"We try to take as much off-the-shelf technology as possible to limit the risk. There's lots of new stuff in there already."

Wärtsilä's seals and bearings business, based in Havant, UK, has unrivalled experience supplying seals to the emerging wave and tidal energy industry.

When the Marine Current Turbine device was pulled out of Strangford Lough at the start of 2016, it had produced most of the world's tidal energy. So Wärtsilä, by extension, had at that point sealed 90 per cent of the world's tidal power produced.

"We had experience, and still have to this day, we believe, that no other seal manufacturer has," says consultant engineer Simon Thompson, one of Creak's team members.

Striking the right balance

But AW Energy was drawn to Wärtsilä for the company's expertise as well as for its equipment.

"When you look at a technology there are a lot of rules and standards that people use. However, there's a lot of conservatism in that, and it's really unravelling that conservatism," says Ridgewell. "With renewable energy, you cannot justify having a lot of the costs."

When Simon Thompson, Kerry Jones and Ross Strickland first met Ridgewell at Wärtsilä's in-house composite manufacturing

facility in Slough, outside London, it did not take long to find ways that Wärtsilä could improve the WaveRoller product.

"I think AW Energy had limited in-house resources and expertise available," recalls Creak. "They certainly understood about the bearing and what they wanted the bearing to do, but they had limited understanding of what the performance limitations and requirements could be on their seal."

Wärtsilä consulted on the overall seal and bearing arrangement and recommended a transition towards a totally water lubricated solution. This simplified the application and at the same time addressed another environmental concern.

"There are studies and papers out there that look at the portfolio of seal offerings in the market and the general consensus, specifically in tidal applications, is that a mechanical face seal is the go-to choice," Thompson says. "But those don't respond well in high-duty reciprocating motions."

Wärtsilä also decided to invest more time into supplying the WaveRoller by developing a structural composite housing for the lip seals at its in-house composite manufacturing facility in Slough. This will reduce the weight of the device, making it easier to install and service.

The other attraction for AW Energy is Wärtsilä's Services Division. Ridgewell is aware that operation and maintenance is key to the WaveRoller's cost-effectiveness and appeal to utilities. It has ballast tanks that allow it to float back to the surface for easy servicing, limiting the need for expensive and dangerous diving operations.

The 'glocal' touch

Having a global supplier such as Wärtsilä manufacturing key parts means that when the device is rolled out globally, it will be easy for utilities to service and replace these parts wherever they are located.

"If you look at the service centres and representative offices of Wärtsilä and then you place on that a global map of the world wave resources, they pretty much match," Ridgewell points out.

But there are challenges as well as benefits for a small start-up in working with a company of Wärtsilä's scale, particularly in navigating through Wärtsilä's many divisions.

"There's a lot of expertise, but it is finding the expertise that's the challenge," says Ridgewell. "You need to find that person who has sufficient contacts to find the

person that knows."

Creak is similarly conscious of the challenges that come with working with a much smaller company.

"We are very aware that we're a very, very big company and they're a very, very small company. That can create some challenges in communications," he says.

The other issue is financial. The value of the equipment sold to AW Energy for its maiden project provides very little immediate return for the time Creak's team has spent.

"We would be disingenuous to say that it's a major contribution to our annual turnover and profitability. However, we make these investments because there's a potential," says Creak.

If WaveRoller is successful and deployed around the world, it has the potential to be one of the most popular devices for power utilities.

"It's a really big opportunity for them at the end of the day," Ridgewell argues. "When this industry really takes off, which it will, we're talking tens of thousands of units. And for every WaveRoller, you need two bearings, so we're talking about a very large business opportunity."

With AW Energy, the opportunity is considerably greater, but so is the competition, with more than 200 devices under development.

But Wärtsilä believes AW Energy, which is the first device to receive a technology certification from Lloyds Register and to be certified against DNVGL standards, is among the most promising.

"There are a lot of players out there, but it doesn't take a lot of time and investment to work out the likely winners," Creak says. "And then we would typically offer our services to the ones that we perceive have the greatest chance of success."

The double certification, together with reliable, time-tested components, and the knowledge that service engineers are nearby, will help utility customers convince their own financial backers and project insurers that the risks have been as much as possible contained, making it easier to get the first projects off the ground.

It seems to be working. AW Energy has a pipeline of commercial projects and active business development in six countries on four continents. And when WaveRoller ends its trial on Portugal's Atlantic coast in late 2018, AW Energy's device will be one step closer to the market. ●



Steering into a new future

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The family of Wärtsilä Steerable Thrusters (WST) have introduced a new wave of solutions for the tugboat business. The new design is marked by outstanding propulsive performance, manoeuvring capability, reliability, high overall efficiency, and advanced

system integration. So what are the advantages for owners, operators and yards, what are the hallmarks of Wärtsilä's robust maintenance strategy, and how compliant is the new design to the stringent requirements on environmental performance?



Tugs are sturdy powerful vessels capable of delivering the highest performance in assisting, towing or repositioning a vessel. This performance is commonly measured in tonnes of bollard pull (BP) or the towing power and is obtained by the effective performance of the propulsion components and their integration. The newly developed WST thruster series is versatile and can be tailored to comply with specific vessel requirements, without compromising on safety, performance, cost, simplicity, reliability or efficiency. Designed for integration with any electric motor, diesel, dual-fuel or gas engine in the speed range 720-1800 rev/min, this series covers a power range of 800-3200 KW in eight different sizes. Wärtsilä also delivers a hybrid propulsion package with Wärtsilä engines, electrical and automation equipment, power management system and thrusters for 40-80 tonne BP tugs. This hybrid system allows on the one hand emission free propulsion when in 'green mode' and on the other

hand availability of maximum power when in ship-assist operation. This makes the solution relevant for tugboats, and other vessel types requiring thrusters.

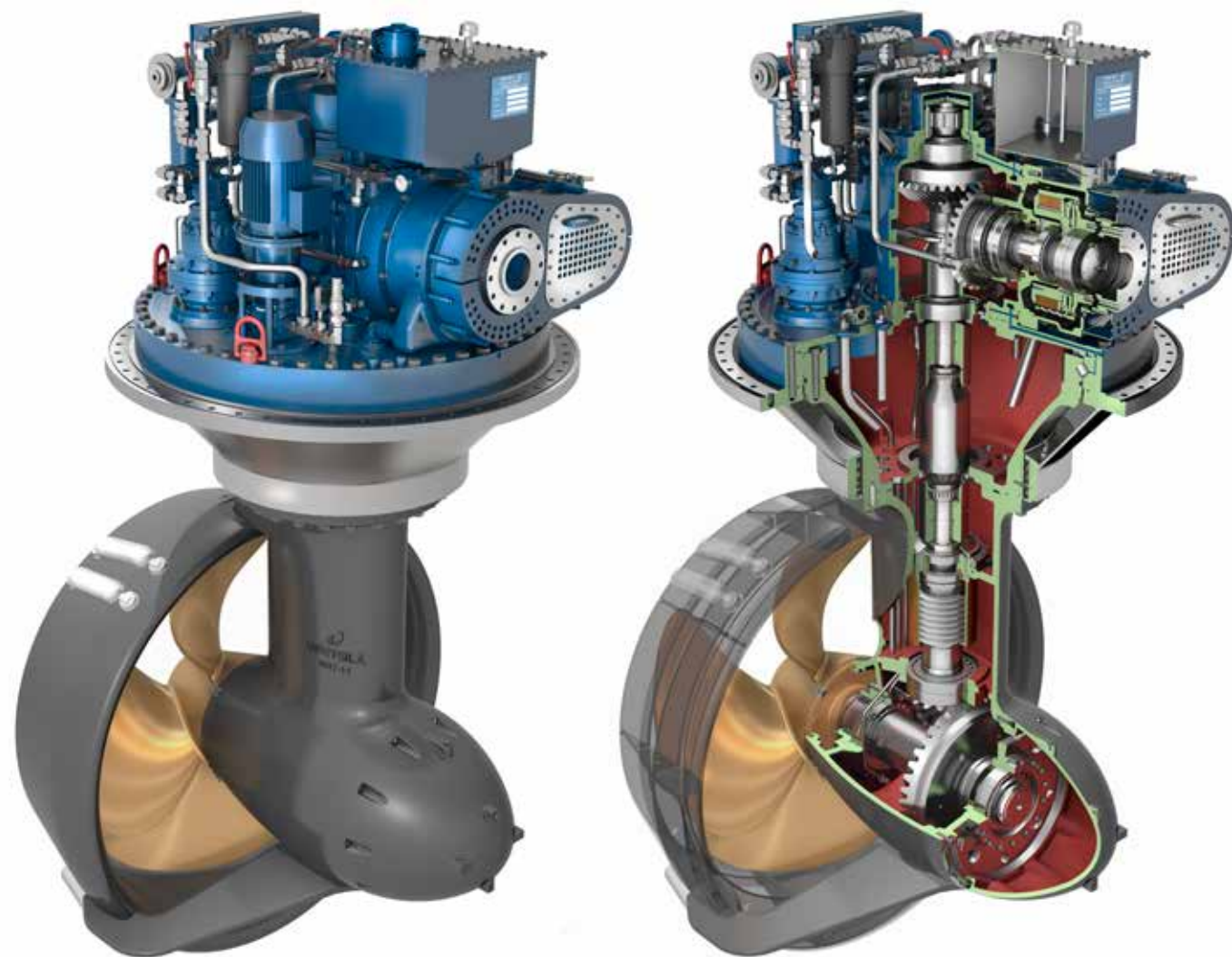
Design plays a vital role in making the thruster configuration relevant to a wide variety of vessels. Take for instance, the hydrodynamic design of the series. It allows propellers to efficiently transfer all engine power into the water and convert it into a thrust force without compromising on cavitation, noise and vibrations. For the WST series, computational fluid dynamics (CFD) analyses have been extensively used to align the design of the propeller, the thruster housing, the nozzle, and its connections with the housing to achieve optimum hydrodynamic performance. In the development of the new WST series, detailed analyses were also made to determine the hydrodynamic performance of thrusters with ducted controllable pitch (CP) propellers compared to ducted fixed pitch (FP) propellers.

Choosing the propeller configuration (CP or FP)

So what is the difference in performance between CP and FP propellers? The hydrodynamic efficiency of an FP will be the highest, but the difference between an FP and a CP propeller is less than 2%. The choice for a certain propeller configuration depends, primarily, on the needs of the application.

A CP propeller is a good choice over an FP propeller if both free sailing performance and bollard pull are important. In this case the difference in efficiency will be compensated, for, by operational gains.

Designers or shipyards can select a thruster with a CP propeller for vessels with power take-off (PTO) driven fire-fighting (fi-fi) pumps. A CP propeller allows the fi-fi pump to be operated at nominal engine speed, while maintaining full vessel manoeuvrability. A thruster with a CP propeller provides a cost effective alternative to an FP propeller with a heavy duty slipping



■ Wärtsilä Steerable Thruster with PTO for diesel-mechanical drive.

clutch integrated in the driveline, needed to provide similar fi-fi functionality.

FP propellers feature in certain types of thrusters (WST-11 and WST-14) that have been designed to comply with Ice Class requirements - Russian and Russian river ice classes (RMRS up to Ice 3 and RRR up to Ice 40) as well as the Baltic Ice Class 1C. Larger WST sizes with FP propellers fulfil the requirements of Baltic Ice Class 1B.

Propeller diameters range from 1.6m up to 3.2m, and for each size a minimum of two propeller diameters is available, covering most of the needs of vessel installations in this market sector.

The power of a nozzle

Next in line is the variation in nozzles. A nozzle maximises the thrust at lower vessel speeds and is hence a key element. Steerable thrusters are used for bollard pull or free sailing for which two different nozzles have been developed. The bollard pull nozzle has a length of 0.5 of the propeller diameter ($L/D=0.5$) and a specifically designed exit area. It is most effective at low ship speeds, while also allowing efficient sailing at speeds of 12–14 knots.

For free sailing applications, a dedicated nozzle design has been developed, which has improved performance. It is shorter,

40% of the propeller diameter, and effectively contributes thrust up to the speed of 16 knots by reducing ship's water resistance or drag.

The choice of nozzle depends on the vessel's operational profile. In general, the bollard pull nozzle is more applicable to tugs and workboats while the free-sailing nozzle is more suitable for vessels operating in transit conditions, like platform supply vessels (PSVs) and inland waterway cargo vessels.

Taking control

Additionally, Wärtsilä's next-gen thrusters also come with a new machinery control

automation platform. The Local Machinery Control System (LMCS) contains redundant embedded controllers and a full colour Human Machine Interface (HMI) 7" touchscreen at the cabinet door. The HMI's user friendly graphical interface supports local control of steering and thrust, calibration and test modes, as well as trending and logging, since the thruster's sensors and transmitters are connected to the LMCS.

Smart instrumentation set-up and fieldbus technology have significantly reduced installation and commissioning times. The LMCS can communicate with an external remote control system through fieldbus and with the Wärtsilä ProTouch System to remotely control the thruster from the bridge and engine control room. With its slick levers, touchscreen displays and indicators, the contemporary ProTouch system can easily be fitted into even the most compact bridge designs, while providing the user with full manual control.

Vessel integration

Tugs are extremely compact and agile vessels, where the equipment installed onboard should occupy minimum space. Thanks to compact and advanced system integration, thrusters have remained small, thereby reducing the need for additional space in the machine room. There is no need to install a separate header tank, nor fit any separate hydraulic system. It is a one package installation, where the thrusters can be installed from either below, above, or split mounting. To accommodate different vessel dimensions there are two propeller arm lengths (PAL) available for each thruster size, a short and a long variant.

Drive train

Additionally, the drive-train of the thrusters is designed based on experience from the field and latest insights in gear and bearing design. The gear teeth flank topology of the WST-series is optimized by compensating for gear misalignments caused by

operational conditions, loads, temperature expansion, bearing preloads and clearances. By means of loaded tooth contact analysis a good initial contact position is determined, leading to a well-centred, full torque contact even in the most severe loading conditions.

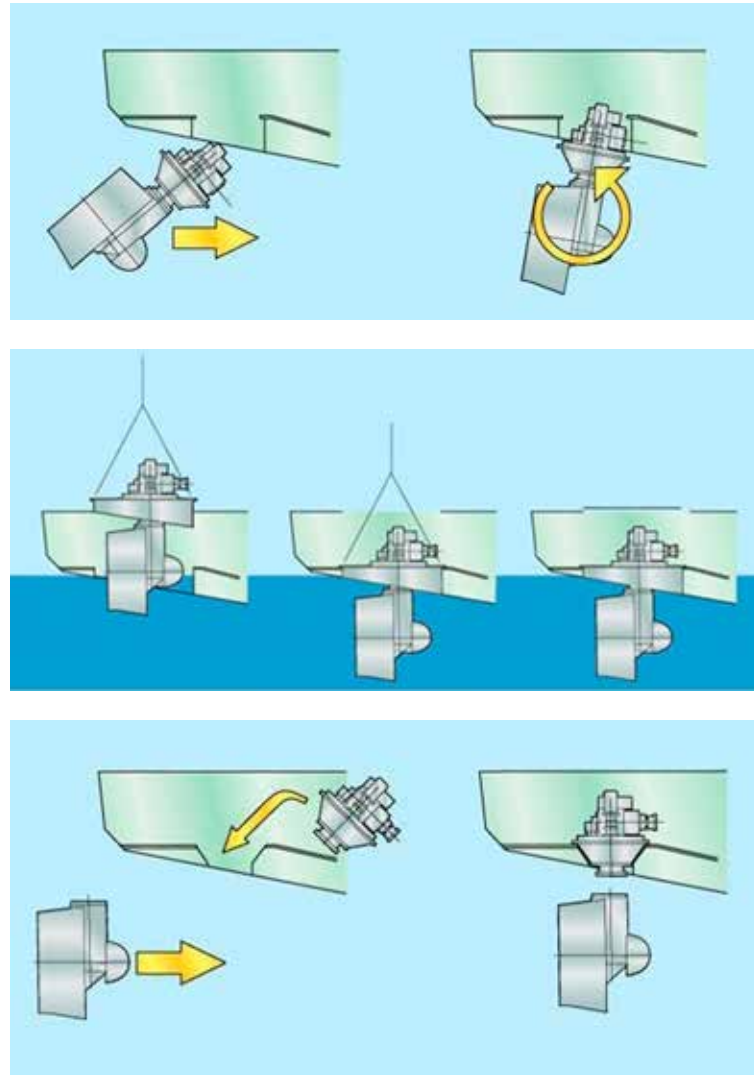
This systematic approach leads to lower tooth stresses and thus increased reliability. With selected bearings, the WST series has a single maximum rating, allowing up to 8000 running hours per year with a standard mission profile.

Integrated clutch

The WST series for diesel-mechanic drives is standardly equipped with an integrated medium duty wet clutch. The clutch itself was specifically developed for the WST thrusters along with one of the main clutch suppliers, and offers either on/off or slipping execution thus enabling optimal operation of the engine and thruster under all conditions. The clutch suits both a CPP and FPP thruster application. The continuous



■ The ProTouch system with its levers, touchscreen displays and indicators.



■ The thrusters can be installed from either below, above, or split mounting.

slipping mode allows a vessel with an FPP application to operate at slow sailing speeds, in the range of 0-50 per cent of the nominal diesel engine rev/min.

Stroke of flexibility

Given that agility and manoeuvrability are key for tugs, the steering system of the WST series thrusters is capable of rotating the thruster 360 degrees in both directions. With a maximum speed of 2.5 rev/min the thruster can be fully reversed in 12 seconds. The steering system can bring the thruster back to neutral position from any allowable angle at any propeller and vessel speed. Besides, it has the ability to hold the thruster in a fixed position under all conditions.

The steering system consists of two steering units with pinions that drive one common slewing gear via three-stage

planetary gear boxes. The standard steering system of the WST series is a hydraulic closed-loop one. Alternatively, Wärtsilä has also developed an electric steering system which is more energy efficient, holds fewer components and has hardly any wear parts (no pump, filters, valves or seals). The electric steering system provides equal or even greater performance levels for positioning accuracy and system loads.

Environmental performance

That's not all. Today's environmental performance requirements set additional requirements for the lubrication system and components.

The propeller shaft and steering seal package form a barrier system between oil and sea water. As a standard WST design, both barrier systems are connected, and provide

a basic seal monitoring functionality for the vessel crew. Ingress of sea water or oil leakage can be monitored through visual inspection of the separate seal monitoring tank level.

Tested to perfection

The journey, so far, has included numerous performance and validation tests. Various prototypes were tested on a full scale test rig to validate its performance under controlled conditions. Those with different dynamic loading cases and multiple endurance runs under maximum load and even overload were tested. An advanced measurement system with a grid of over 140 sensors, outside and inside the thruster, recorded the exact test conditions and thruster behaviour.

The slipping clutch was given specific attention amongst other validation objectives. Three main issues were verified

to demonstrate its performance and reliability - the torque transfer during synchronisation, clutch oil temperatures in continuous slipping mode, and the ability to cope with torque variations.

As part of the design assurance process, more dedicated system validation tests were designed and executed alongside the full scale thruster tests. The electric steering system passed the test with distinction by executing all pre-set steering actions against pre-defined loads without overheating. The system was also able to accurately position the thruster at any azimuth angle and without overshoot. Torque synchronicity between the two electric steering motors was proven by comparing the individual current consumption of each motor.

In short, the new thruster series successfully navigated the rigorous tests and real time conditions with its versatile, cost-effective, powerful and environmentally efficient features.

The results are for all to see. Several

vessels with thrusters from the WST series are currently being built. The first vessel to be delivered is a 55 tonne BP eco-tug for Dubai Dry Docks World. It's equipped with two WST-18 CP thrusters driven by Wärtsilä 9L20DF dual-fuel engines and a Wärtsilä LNGPac. A series of 79m PSVs for Nam Cheong International Ltd is equipped with WST-18 FP units with electric steering in a diesel-electric (DE) propulsion layout. The third reference is for a research vessel for the Guangzhou Marine Geological Survey Bureau. The geological exploration vessel is equipped with two WST-21 FP units as part of a DE propulsion system.

A robust maintenance framework

There's more to the offering though. The discerning marine market of today seeks insight into long term operational costs even before purchasing the equipment for new-builds, which has been the driving force behind a robust maintenance strategy by Wärtsilä comprising the four main pillars

that answer the who, what, when, and how of getting it right.

For starters, there's a clear distinction of maintenance levels - from tasks that can be executed by the vessel crew to tasks that need to be executed at, preferably, a Wärtsilä service station. Then each thruster is accompanied by a specific maintenance schedule describing all tasks to be performed.

Next are the work cards detailing the step-by-step actions and required parts, tools, consumables, and duration, as well as inspection criteria and limits. Lastly, the measurement records give the customer an opportunity to record trends in the performance of an installation. Based on the maintenance schedule and work cards, Propulsion Services can support customers with a lifecycle calculation tool which can be used to pre-determine the overhaul and maintenance cost for a specific operating period.

With all its ducks in a row, Wärtsilä is steering into a new, exciting future. ●

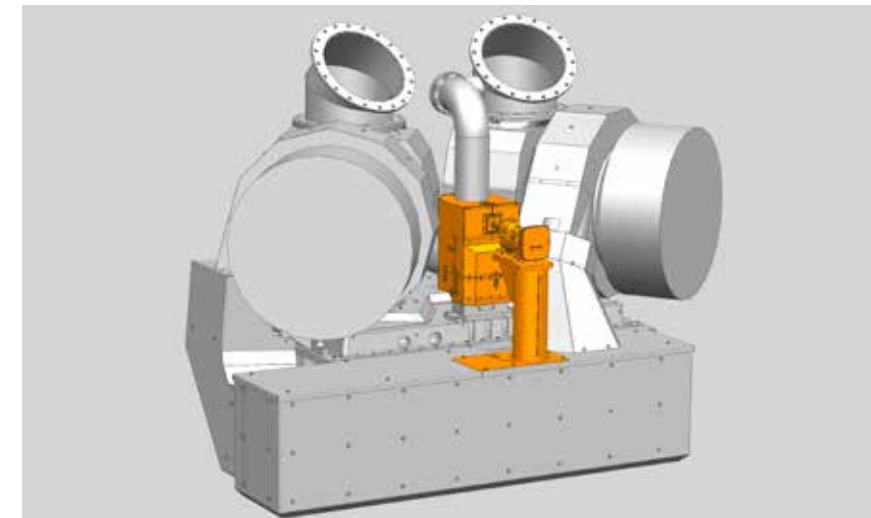




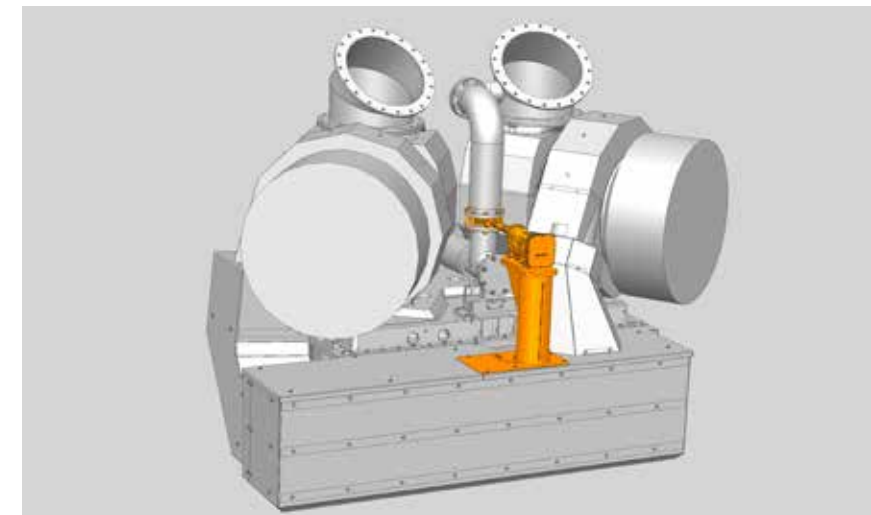
Taking control to the next level

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Offered as a standard feature on all new Wärtsilä 31, Wärtsilä 46DF, Wärtsilä 20V34SG and Wärtsilä 18V50SG engines, the performance-enhancing Wärtsilä Electronic wastegate is now also available as a retrofit starting with Wärtsilä 34SG engines.



■ Electronic wastegate with insulation.



■ Electronic wastegate without insulation.

As of mid-June 2017, the multipurpose Wärtsilä Electronic wastegate, developed by Wärtsilä, is now offered as an optional retrofit package – starting with the Wärtsilä 34SG range – regardless of power application, and operational profile.

The exhaust wastegate valve is used to adjust the amount of exhaust gases passing through the turbocharger turbine, thereby adjusting the turbocharger speed and the charge air pressure. Accurate and fast control of this charge air pressure is essential for the optimum running of the engine at all times.

The Wärtsilä Electronic wastegate and its

associated properties – engine reliability, stability, diagnostics and simplicity – were developed by Wärtsilä for these new engines, and simultaneously the technology refined as a retrofit for older Wärtsilä 34SG engines because it had the same benefits of improved performance and reliability, and offered improved diagnostics as well. This is an example of Wärtsilä's innovativeness and how the latest technology benefits both customers buying a new engine and those already operating Wärtsilä engines.

The development of the new Wärtsilä Electronic wastegate was made in close

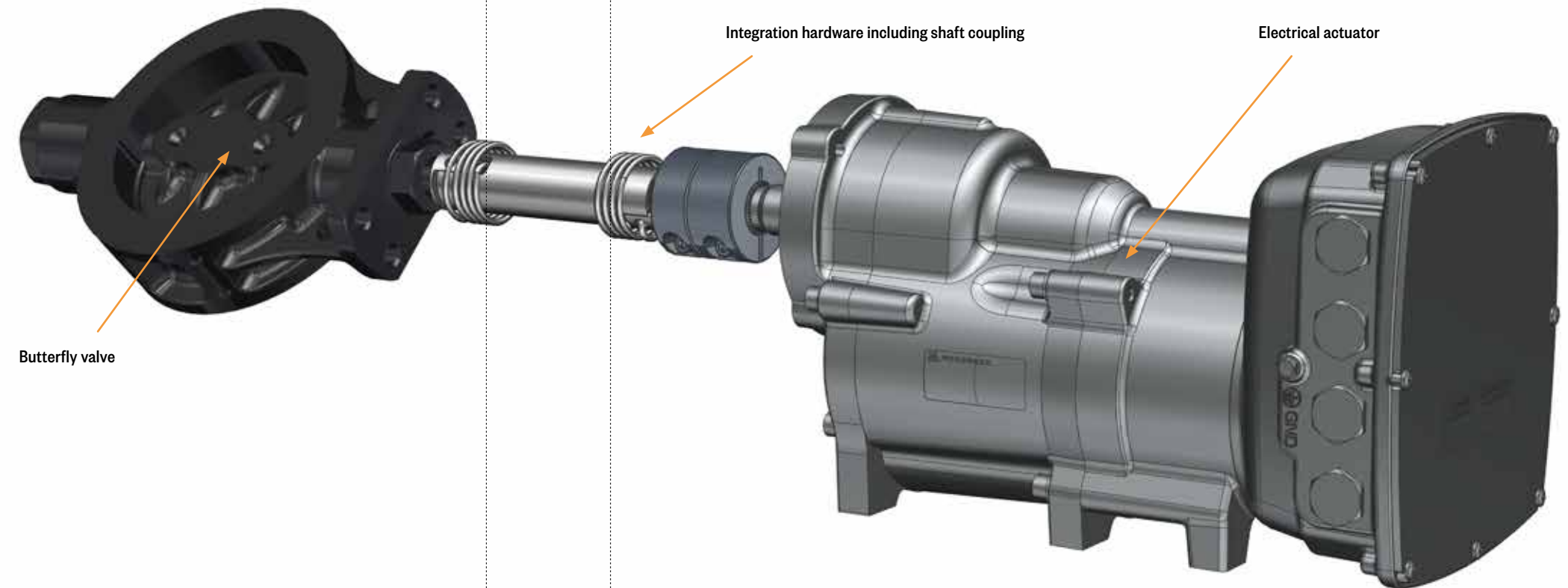
co-operation between Wärtsilä and the valve supplier. The project aimed to develop a wastegate valve package that could be used on new engine platforms and would also be suitable for retrofit purposes for current portfolio and field engines.

The validation of the new product required a vast number of various rig and on-engine laboratory tests performed by both the valve supplier and Wärtsilä on several different engine platforms. The Wärtsilä Electronic wastegate gathered more than 20,000 hours of on-engine testing before it was released for production. The

The load on stability

Key points of the Wärtsilä Electronic wastegate valve for new engines as well as for engines already in use.

- The Wärtsilä Electronic wastegate is now a standard feature on all Wärtsilä 31 engines, all Wärtsilä 46DF engines and on all new Wärtsilä 20V34SG and Wärtsilä 18V50SG engines.
- Wärtsilä Electronic wastegate is available as an optional upgrade on Wärtsilä 34SG engines to allow the charge air pressure to be adjusted depending on the engine speed and load.
- An upgrade on an older engine yields faster valve reaction time and improves engine stability. Comprehensive operation data, such as the actual valve position compared to its set position, allows for better diagnostics.



validation process also included an 8000-hour field test on a Wärtsilä 20V34SG engine at a power plant in Turkey.

The Wärtsilä Electronic wastegate and its built-in diagnostics capabilities make it possible to know what is happening inside the actual valve of the engine, whereas previously the only known factor was what was requested of it, such as the actual valve position compared to its set position. Another advantage is an alarm signal if a set point gets exceeded. All this yields faster engine reaction time, improves engine stability and improves the parameters required for condition monitoring.

Small footprint

The Wärtsilä Electronic wastegate upgrade on Wärtsilä 34SG engines requires only two days to install and its footprint is equally discrete, measuring less than one metre in length and weighing around 20 kilograms. Not only does it fit into existing engine layouts, the system is service-free and requires minor piping and hardwire connections, and some thermal insulation. It works seamlessly with WOIS, the

Wärtsilä Operation Interface System, for valve diagnostics. Previous control systems of this type used electro-pneumatic systems, but the wastegate system is electrically activated with a high-speed electrical motor making it faster, more responsive and accurate, and trouble-free.

With the information it provides, the electrical wastegate-equipped engine is more stable and more efficient. The precision diagnostics also improve condition-based monitoring.

Precision cooperation

The Wärtsilä Electronic wastegate was originally developed for new engines but the benefits as a retrofit on older engines soon became apparent for the Services division. The system was developed in collaboration between the departments and the project serves as an example of innovative way of working within Wärtsilä.

Putting the Wärtsilä Electronic wastegate into context, the effort is part of a company-wide initiative to digitalise engine operations to help maximise performance, reliability and thus business benefits for customers.

Irrespective of operational profile – if the engine has a base load output, or is used as backup – Wärtsilä aims to support its customers with intelligent solutions.

Bottom-line impact

The Wärtsilä Electronic wastegate is an intelligent product from a lifecycle perspective because it has a positive impact on an engine operator's bottom line by minimising downtime due to fewer overhauls.

It must be noted that it was a challenge to develop the electronic (software and sensor-based) wastegate valve system due to the harsh environment these engines work in, and the high exhaust temperatures, vibrations, and moving parts.

Another challenge was to adapt the system to the changing needs of power plant customers where loads peak at different hours, ramping up and ramping down production, depending on the need for electricity in the grid. This variable load profile creates special temperature and pressure requirements on ancillary machinery and systems. ●





The new Shuttle Tanker

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The new Shuttle Tanker concept developed by the world's largest provider of shuttle tanker services, TEEKAY, in close cooperation with Wärtsilä, will offer a new level of ecological and economical solutions by using Wärtsilä's high-quality equipment and systems in innovative ways. Find out how this has reshaped the business of the industry.

It is raining innovations in Wärtsilä. The new Shuttle Tanker concept allows tankers to operate both on Liquefied Natural Gas (LNG), as the primary fuel, and Volatile Organic Compounds (VOC) – which is the environmentally harmful gas evaporating from the oil cargo tanks – as secondary fuel.

The new innovative solution aims to reduce annual emissions of CO₂ equivalents by up to 42% compared to conventional shuttle tanker. The reduction equals the emissions from 22,000 cars per vessel per year.

The main task for a shuttle tanker is to transport oil from offshore fields to land-based oil terminals. As shuttle tankers operate in offshore conditions, these vessels are the most advanced merchant vessels with unique varieties in operation modes including loading in Dynamic Positioning

(DP) condition, transit in laden, unloading and ballast conditions.

All of these operating modes have their own requirements, but traditionally these requirements have led to equipment installed on board not being used efficiently in the various operation modes.

The new Shuttle Tanker will have the following three features compared with a conventional shuttle tanker:

- **Reduced emissions:** VOC emissions from the cargo will be eliminated, the NO_x from the engine exhaust will be reduced by 84% which is well below IMO Tier 3 levels, while the SO_x emissions will be practically eliminated, and finally the particles will be reduced by more than 96%, thus resulting in an astonishing reduction of emissions.

- **Operation flexibilities:** an efficient use of the installed machinery and propulsion systems in the vessel secures an unmatched manoeuvring capability while the built-in system redundancies ensure an inherent system robustness when managing unexpected events.
- **Improved economics:** 22% reduction in total fuel consumption and with the use of VOC as fuel, resulting in considerable reduction in bunkering needs, and combined with fewer running hours hence lower maintenance costs for machinery.

Reduced emissions

During operation, conventional shuttle tanker design has high levels of emissions, mainly from the emissions of VOC to the atmosphere during loading, storage, and transportation of crude oil. For instance, the storage and loading of crude oil onto ships are responsible for more than 50% of Norway's VOC emissions. The Norwegian authorities have thus implemented stringent emission reduction regulations for all shuttle tankers loading crude oil from offshore processing platforms located in the Norwegian continental shelf.

The loading operations take place when crude oil is loaded to the Shuttle Tanker directly via a loading hose connected to a Floating Production Storage Offshore (FPSO) unit, fixed platform or via a loading buoy. This operation can take place in harsh environments and with difficult sea stages. The crude oil need to be loaded with high transfer speed to ensure predictability in weather conditions throughout the DP operation.

During the offshore crude oil loading, the VOCs are emerging from the crude oil cargo tanks and must be captured by a VOC recovery plant, avoiding harmful emissions to the atmosphere

Wärtsilä has long experience in developing VOC recovery plants that can satisfy the requirements from the Norwegian authorities. With these experiences, Wärtsilä has now designed a new generation of VOC recovery plant that will satisfy also the more stringent authority requirements expected from 2030.

The Wärtsilä VOC recovery plant uses compression and cooling phases to liquefy

the heavier hydrocarbons to Liquid VOC (LVOC) that is stored in a tank on the deck of the vessel.

The lighter hydrocarbons that are not liquefied, referred to as Surplus VOC (SVOC), which mainly consists of methane gas, will be burnt in a gas turbine for electricity generation, chosen because of the two times better efficiency than the traditional use of boiler with steam generator.

From a typical North Sea platform installation, each crude oil loading of a cargo size of 850,000 bbls, will recover 100 tonnes of LVOC and 10 tonnes of SVOC. By avoiding these amounts of VOC escaping into the atmosphere, the yearly reduction of emission goes from 43,000 to 25,000 tonnes of CO₂, i.e., a reduction of 42%, assuming around 32 loadings per year.

Use of LNG and LVOC as fuel for engine

Today's shuttle tankers are equipped with direct propelled 2-stroke diesel engines running on heavy fuel oil (HFO) or marine gas oil (MGO) and the recovered LVOC has so far been considered as a waste product. The 2-stroke engines are mainly used for propulsion during transit, and the 4-stroke auxiliary plant is providing power for the extensive thruster system used during DP operation.

With an average of 100 tonnes of recovered LVOC per loading, the recovered amount could represent up to 30% the total fuel consumption of the Shuttle Tanker should we be able to use the LVOC as fuel.

TEEKAY has therefore replaced the conventional 2- and 4-stroke engine configuration with fully electric propulsion with generator sets driven by Wärtsilä 4-stroke dual-fuel (DF) engines.

With electric main propulsion motors and 4-stroke DF generating sets as the only power plant onboard the vessel, flexibility and overlapping functionality is achieved. This power distribution concept is part of Wärtsilä Low Loss Hybrid concept reducing the total installed power on board from 26 to 23 MW with further reductions in fuel consumption and resulting in an increased overall efficiency of the vessel.

To achieve full SECA and NECA compliance, the new Shuttle Tanker will be

further equipped with Wärtsilä LNGPac to enable operation in gas mode throughout the shuttle tanker operation with LNG as primary fuel for the engine.

With both LNG and LVOC onboard, Wärtsilä started to develop and performed testing of the possibility of mixing LNG with LVOC in gas form for potential valuable fuel for the engine.

LVOC comprises heavier gas hydrocarbons such as propane and butane that have relatively low methane number (MN) of 25, making them less suitable as fuel for our gas engines (to avoid knocking). By mixing the LVOC with LNG with an MN between 70 and 90, we will achieve an acceptable MN for the gas engine at any required power. Depending on the MN of LNG the engines will run a maximum continuous rating (MCR) less than 100% due to the de-rating mode. This de-rating mode is fully acceptable due to the operational flexibility built into the new Shuttle Tanker concept. (Figure 1)

Utilising LNG as the primary fuel and LVOC as secondary fuel, the new Shuttle Tanker enables the utilisation of 100% of the recovered LVOC as fuel for electric power generation. (Figure 2)

Operational flexibility

The power distribution system will be based on the Wärtsilä Low Loss Hybrid (LLH) system using batteries for further fuel savings, peak load shaving and added overall system redundancy.

Wärtsilä LLH does not only offer the highest efficiency over all electrical components, but a great benefit comes from its superior capability to minimise the impact of a failure during DP operation. In addition to the required trial speed of the vessel, the size and functionality of the power plant is determined from the power requirement in DP condition. While a traditional electrical distribution system could lose more than 50% of installed power and several thrusters, the LLH will lose only 25% of the installed power and not more than one thruster.

Thanks to the LLH system, the system efficiency is improved and together with electric propulsion, the required total mechanical installed power will be reduced

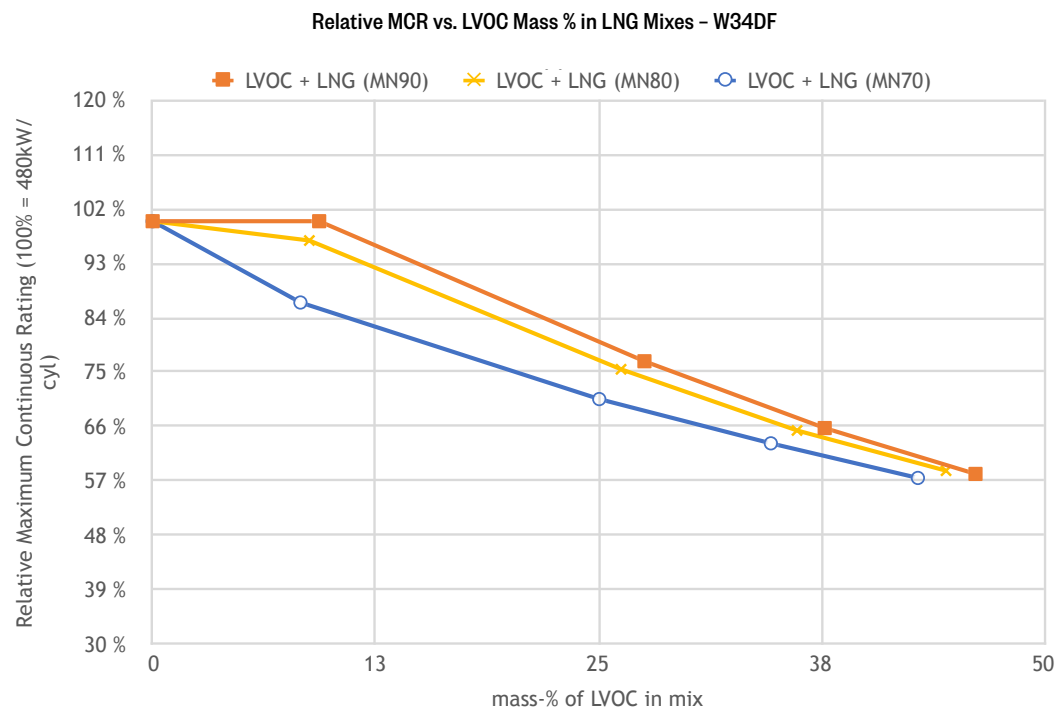


Fig. 1 - Relative MCR vs. LVOC Mass % in LNG Mixes - W34DF

by 14%, which will improve overall fuel performance compared with traditional power distribution concepts.

As a result of the new Shuttle Tanker concept, the total energy consumption will go from 110 GWh to 75 GWh per year compared to a traditional shuttle tanker.

With increased efficiency, we will also improve the DP (manoeuvring) capability. A conventional system will use 60% of thruster power, whereas in LLC concept only 40% will be used, thus giving the master a much better manoeuvring capability.

Moreover, the LLH electric equipment room is more compact compared to a conventional electric room. The Shuttle Tanker power distribution system utilises a Low Voltage arrangement also with excess of 23 MW of installed power, which will again have a large benefit for the crew on board.

When installing batteries on board, the vessel has a hybrid energy system that will continuously support the dynamic capacity of the energy production system and, through the stored energy of the batteries, enable engines to operate in a load area where fuel consumption is optimal. The batteries will handle the dynamic load variations and the

engines will get a stable load and therefore could operate in a higher load area without risking the startup of additional generators due to transient load variations. The New Shuttle Tanker is the first ship of this size utilising batteries for improving efficiency during transit operation.

For crude oil offloading operations at the onshore terminals, Wärtsilä can supply either electric-driven pumps for pump room installation, or electric-driven deep well cargo and ballast pumps that enable a distributed pump solution, eliminating the need for a separate pump room and interconnecting pipelines in the cargo holds.

The space gained from eliminating the pump room can be used either to increase the cargo capacity or to shorten the engine room with a shorter hull, giving lower building cost and better DP capability thanks to the leaner side profile.

With the efficient and environmentally friendly electric power plant installed on board the vessel, electrical-driven pumps for cargo off loading and ballast are utilised in the most efficient way.

In connection with ballast pumps, Wärtsilä can supply its Ballast Water

Management System (BWMS) named AQUARIUS® EC. It uses an in-situ chlorine generation technology known as electro-chlorination (EC). AQUARIUS® EC is a modularly designed BWMS. The system is installed in a bypass loop to the main ballast line to provide a safe, flexible and economical process for the treatment of ballast water and eradication of aquatic invasive species.

Improved economics

The new Shuttle Tanker concept represents an absolute game-changer for the shuttle tanker sector. To put it in simple terms, the concept enables shuttle tankers to travel from the oil fields on its own waste gas rather than releasing it in the atmosphere. Both emissions and bunkering requirements will be considerably reduced and the chosen propulsion solution will increase overall efficiency compared with conventional systems.

With this concept, the overall running hours will be lower, which will mean lower maintenance costs for machinery.

Wärtsilä is also ready to support and provide active assistance during the

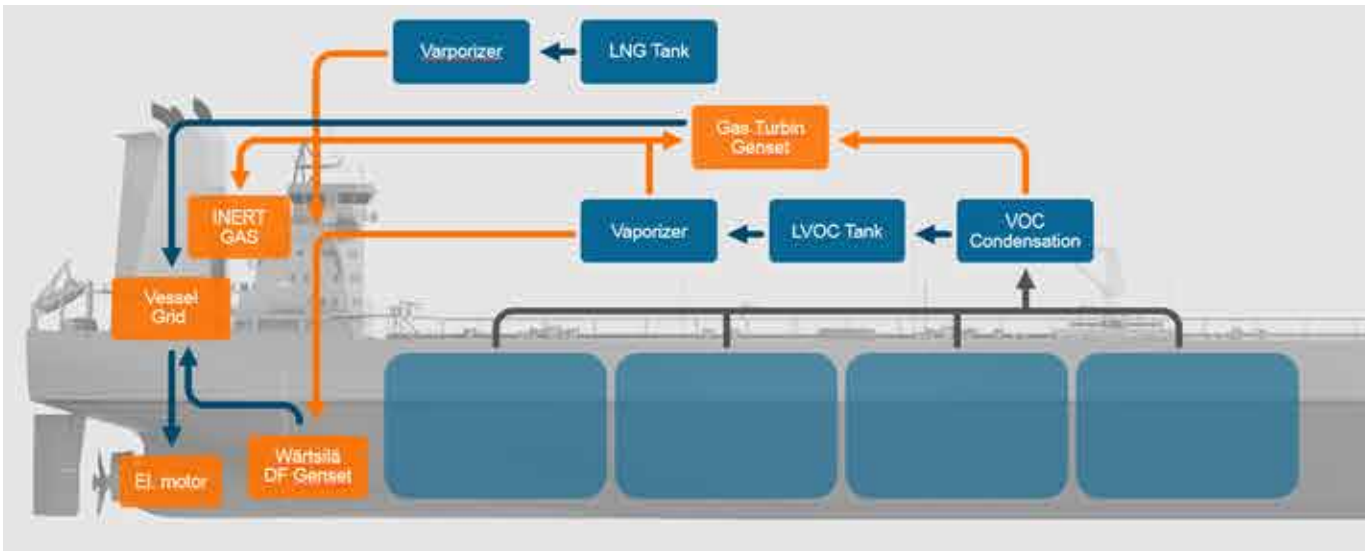


Fig. 2 - With an average fuel consumption of 8750 tonnes per year, 3200 tonnes will be generated and used onboard as LVOC.



Fig. 3 - The new Shuttle Tanker is the first ship of this size utilising batteries for improving efficiency.

operation of the new Shuttle Tanker vessels, to accomplish a total life-cycle solution to the owner. Such support and assistance will comprise both training of the crew and the officers for the equipment and the systems together with varied technical and operational real-time online support and monitoring. Such operational follow-up directly with the owner is crucial to ensure that the vessel achieves the objectives set for the new Shuttle Tanker in respect to emission reduction, fuel efficiency and with operational flexibility.

These benefits have been made possible with Wärtsilä's advanced technology and through integration capabilities between different business segments in Wärtsilä supplying the various equipment and systems.

Market potential

TEEKAY has contracted two firm and two options of the new Shuttle Tanker vessel at Samsung in Korea, all based on Wärtsilä's high-quality equipment and systems in this new and innovative concept solution.

We estimate that half of all offshore oil

production in Norway and the UK will be transported to land using shuttle tankers. About 40% of this existing tanker fleet is ready for replacement due to the 20-year age limitation for new shuttle tankers.

We see an exciting time ahead for similar contracts in the near future for this ecological and economical Shuttle Tanker concept developed in cooperation with TEEKAY and Wärtsilä. ●



Wärtsilä engineers offer technical solutions for cold ironing

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Wärtsilä Electrical & Automation has carried out more than 100 installations of its container solution SAMCon for 'cold ironing' to connect cargo ships to local power sources at California's ports.

A decision taken by the Hollywood movie legend Arnold Schwarzenegger in 2006, when he was the governor of California, has had far-reaching consequences for the business of Wärtsilä Electrical & Automation. The 'Terminator' opted to promote shore power, known as 'cold ironing', or 'Alternative Marine Power', to reduce pollution and greenhouse gases from the state's ports. As a direct result, California became the epicentre of shore power and there was a boom in business for Wärtsilä SAM Electronics, which provides its SAMCon cold ironing container solution to cargo ships.

Cold ironing is the process of providing electrical power from the local grid to a ship at berth in a port while its engines are turned off. It allows refrigeration, heating, lighting, and other equipment to receive power as it unloads. Cold ironing provides cleaner power for ships at berth in ports by connecting them to local energy sources so they can continue to run electrical equipment while unloading. Many ships are equipped to carry out the process when built, but others have to be retrofitted. As a result of Schwarzenegger's legislation, Wärtsilä has carried out more than one hundred retrofits for ship owners going into ports of California. Wärtsilä's customers include major shipping companies carrying cargo from Asia and Europe to the US.

First container solution

The first cases of cold ironing were in the cruise industry, in Alaska, in 2001. But LA started to use the process for commercial ships three years later and around the same time, Wärtsilä SAM Electronics produced the first container-based solution, which means installing the components required to connect the vessel to the shore power in a container and fitting it onto the ship.

Many suppliers provide only the most basic services. They supply the components

required for cold ironing and the ship owners have to install and integrate them on the ships themselves. Some provide container solutions, but they don't install the containers and equipment on the ships. In contrast, Wärtsilä's approach involves high-level engineering from the cable reel plugs until the main switchboard, from connection on the shore to synchronisation with the ship's network. Teams of about six engineers take care of the installation of the SAMCon system. Wärtsilä's expertise involves onboard visits and offers different solutions so that customers can choose what suits them.

The Wärtsilä process begins with the modification of standard, empty containers. The vast majority are 40ft high cube containers, but 20ft ones are also available as an option. Wärtsilä's team creates openings for the cables, insulates the containers and fits the components, including a medium-voltage cable reel, a cable reel control box and a medium-voltage switchboard. A container may also include a transformer, or a second cable reel for the connection to the ship, which depends on the customer's specifications. SAMCon container features include an electric cable reel drive, including tension control, and a shore interface designed for the ports of the west coast of California and therefore IEC 80005-1. The system is made to provide up to 7.2MVA transferable power at 6600 Volts and 60 Hz.

Engineer checks

Wärtsilä's engineers check the vessels carefully to find the best cableways, installation possibilities, and location to install the containers. Usually, they are placed on a standard container slot above the winch deck. They are always on the outer edge – port or starboard side – of the vessel. Sometimes they are stationed in front or just behind the accommodation area.

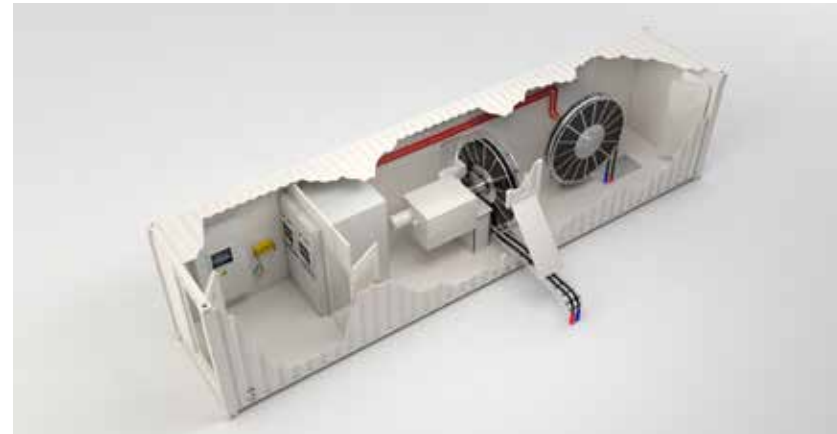
Many customers choose a 'bolted'

installation, meaning the cable connections between container and vessel connection point are screwed into place. This is the solution for vessel owners who intend to fix the containers in place for long periods of time. Another option is the plugged solution which requires Wärtsilä to fit a second cable reel next to the shore connection reel. The extra cables with plugs connect the container to the vessel's connection point with installed sockets and allow customers to take the containers off the vessels at short notice. It means they can remove a connection and take the container off in 15 minutes. A third option includes adding a 'step down transformer' to the containers. Shore power is always 6600 volts and some low-voltage vessels have only 440 volts so a transformer is required.

Some ship owners reject the container solution and ask for the components to be taken out and fitted on board. This is because they think the ship is too small to accommodate the containers or that it might be a cheaper solution. However this approach doesn't save money as it involves more coordination work for Wärtsilä's engineers than installing a container and it is also less flexible. Once the large components are welded into place it is also much harder to remove them than it is to take off a container. So, when they have been fitted on board and the vessel takes a route that doesn't offer shore power, the components tend to be left on board unused while the vessel sails around the world.

Flexible system

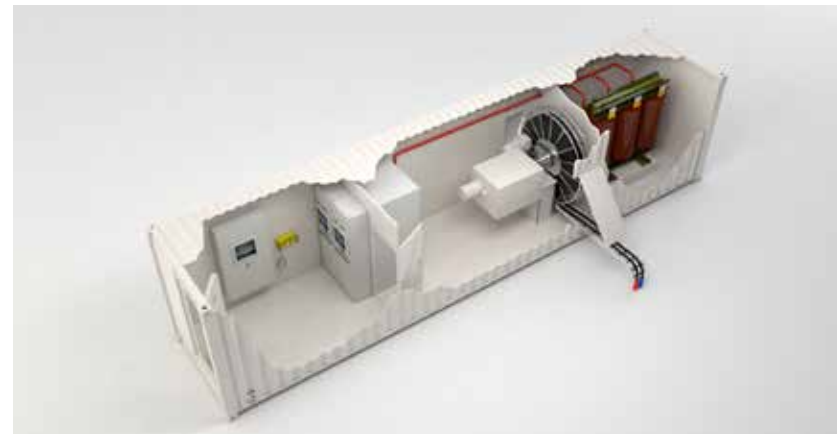
The onboard inspection takes around three hours. During the boom years of 2012 and 2013 the team was visiting vessels around the world every week, depending on where the ships were sailing. Wärtsilä has to be flexible as ship owners change routes at short notice and the teams could be asked to fly long distances. An ideal installation would be



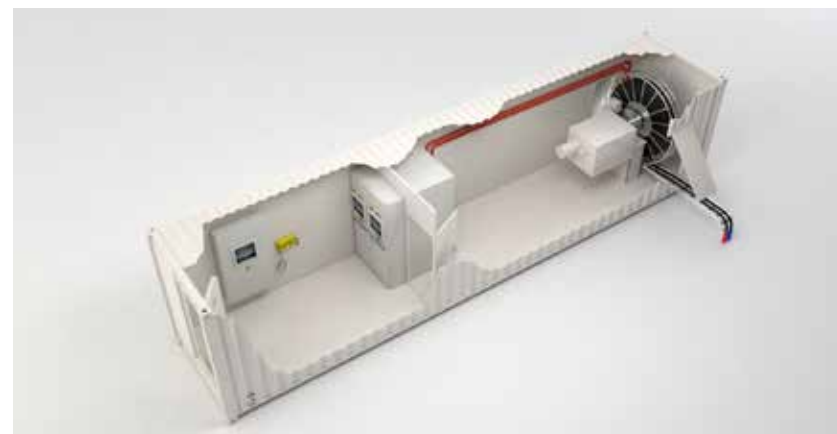
■ Connection between container and ship: plugged type.



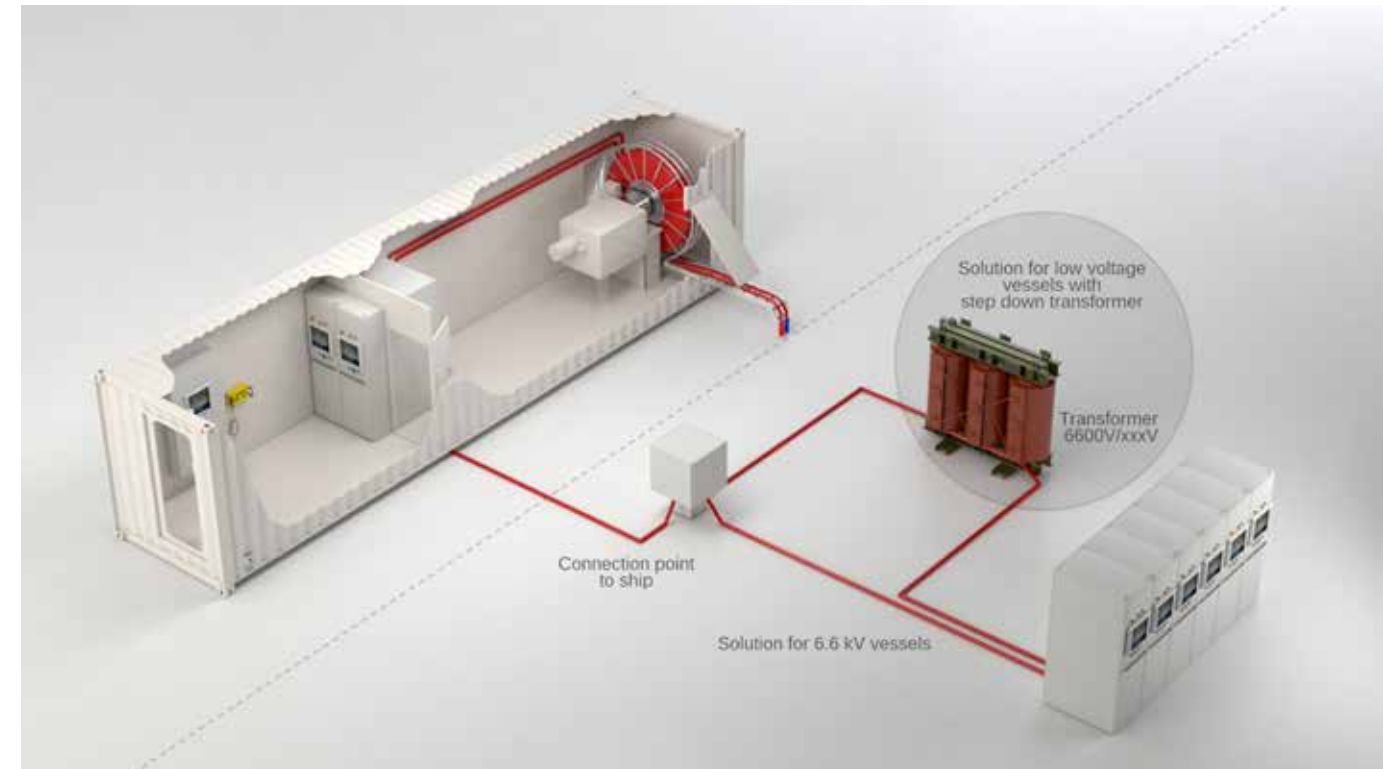
■ Connection between container and ship: bolted type.



■ Connection between container and ship: bolted type.



■ Connection between container and ship: bolted type.



■ Connection solution.

in Europe, but it usually doesn't work out that way. Ship owners won't want to take the vessels out of service so the Wärtsilä installation teams fly around the world to join the vessels. Wärtsilä technicians might have to fly to China, load the materials for two days, then stay with the ship to do the assembly and connection works until it reaches California.

California continues to set the pace for cold ironing. By 2020, 80% of the ships need to be 'compliant'. A 'compliant' call is reached if a vessel needs less than three hours for arrival, connection to shore power, disconnection, and leaving the harbour. Few places have such a strict regulatory regime as California, however, and in 2012 the International Maritime Organisation (IMO) discussed making shore power mandatory at all the world's ports. At the time, the IMO concluded there were not enough ports – only around 20 – ready with the technology to make it viable.

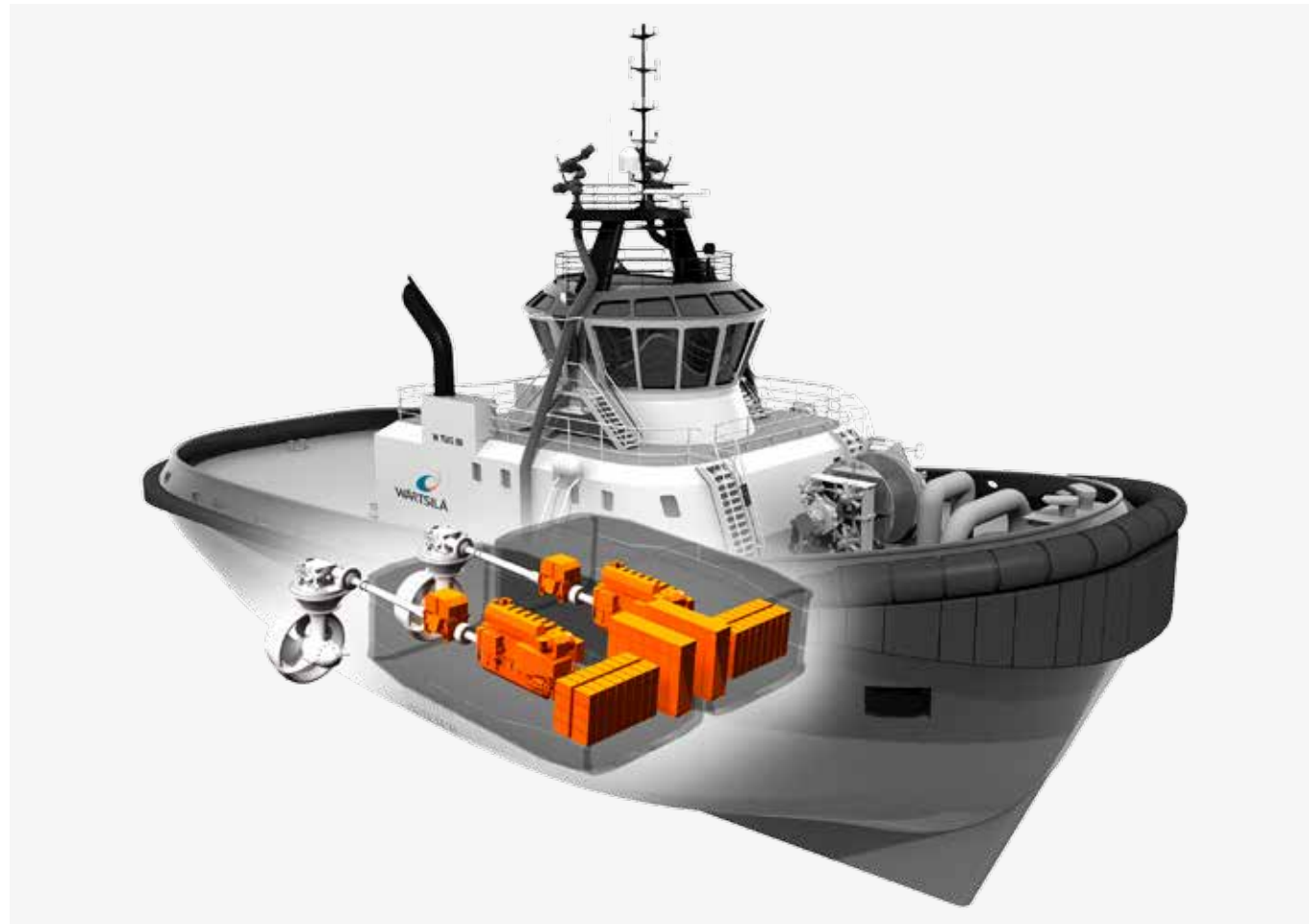
Market opens up

There are signs, however, that the market is opening up. Outside the US, several ports in Scandinavia are offering shore power, but they serve the ferry industry, which requires a different type of installation. Wärtsilä also offers cold ironing solutions for ferries and cruise liners. Furthermore, in Canada, the government provided USD 27.2 million to implement cold ironing in Halifax and Vancouver ports. In Europe, Sweden, followed by Germany, Belgium, Norway, and The Netherlands, have already moved towards this solution, mainly for ferry and cruise berths. Additionally, a 2014 EU directive mandates member states to implement alternative infrastructure networks, including shore power, by 2025. In the long-term, the IMO's Marpol 6 regulations, which aim to progressively reduce the emission of fuel particulates NOx and SOx, should encourage shore power.

In Asia too, there are indications that cold

ironing is becoming more common. The Chinese government has recommended cold ironing to be part of the construction for all new bulk and cruise terminals. For cargo vessels, the harbour in Ningbo has already been modified. Altogether, seven Chinese terminals are in testing mode. This year, V.O. Chidambaranar Port in Tuticorin, India, became the first to offer cold ironing.

Going forward, both China and European nations could provide more ships to Wärtsilä for retrofit. This spells good news for the company, since it can then develop and reach new markets for cold ironing. ●



Achieving full hybrid potential by mastering synergies

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Wärtsilä HY is the first integrated hybrid power module in the marine market. An alternative to belching smokestacks, this green and efficient propulsion module was developed by maximizing synergies in the group. With Wärtsilä as a single supplier, it is a new benchmark in alternative propulsion.

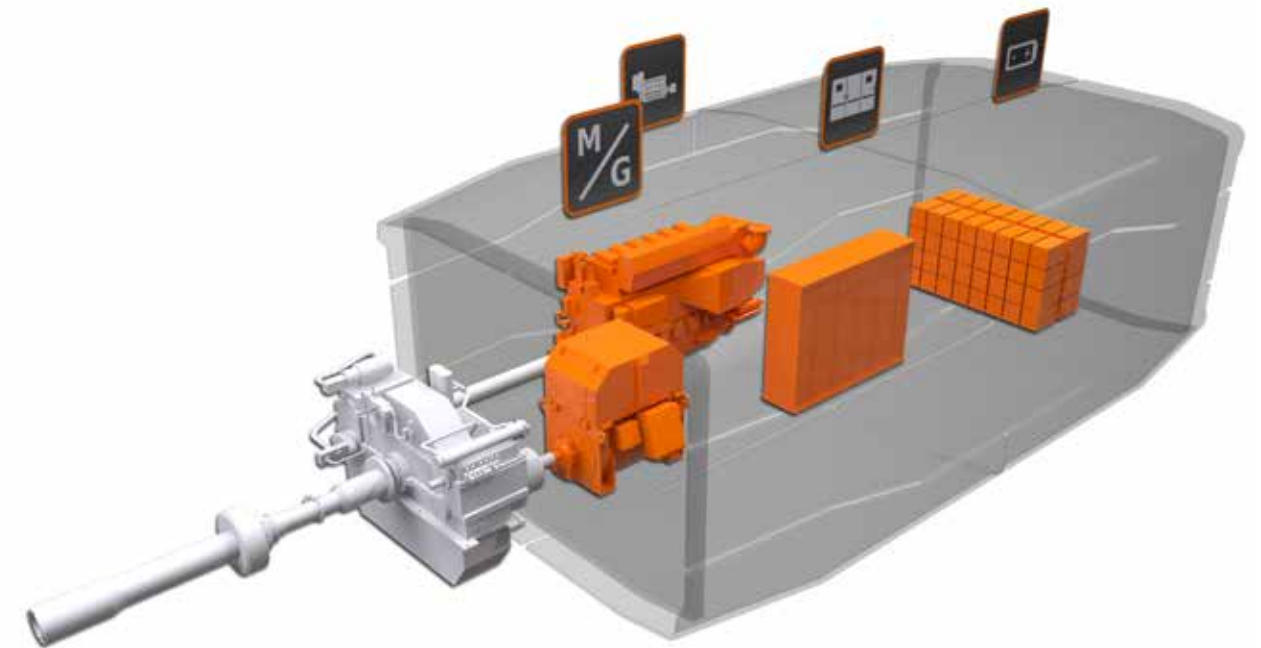
For vessels like tugs, ferries, dredgers and others, this single Wärtsilä HY hybrid power module represents a giant stride towards achieving a greener international fleet, cutting costs and improving vessel performance and services.

Wärtsilä HY was unveiled in May 2017 at the Nor-Shipping trade fair in Norway and has already achieved the 'Approval in Principle' classification with Lloyd's Register. At the event, the Genoese tug operator

Rimorchiatori Riuniti, the biggest tugboat operator in Italy and the Mediterranean, signed a historic deal with Wärtsilä to contract the Wärtsilä HY integrated hybrid power module for its fleet of 60 harbour tugs, 18 offshore vessels and three ocean going ships.

Hybrid is now

Some key macro trends are responsible for the Wärtsilä HY roll-out today. For



■ Wärtsilä HY – Diesel-mechanical.

one, the automotive industry has for years championed the use of hybrid technology, or battery-assisted propulsion. As a result, battery costs have dropped while their performance has increased, shoeing in hybrid technology into other fields such as shipping, where traditional engine technology is now quite mature.

Boosting ship performance has been on the wish list of many operators. Stricter environmental demands are also looming ahead for the industry.

Hybrid propulsion is expected to be the technology of choice for a substantial part of the shipping industry in the near future. Technological advances have reached such a level that the incremental improvement of conventional diesel engines is just not enough anymore as any small gain requires disproportionate resources. What is required instead is a drastic change of mindset to go beyond the physical limits of the individual product. And this is where Wärtsilä HY comes into play.

What is Wärtsilä HY?

The Wärtsilä HY integrated power module consists of a smart and well-driven combination of mechanical power and energy storage. It is the culmination of Wärtsilä's industry-leading expertise in both engines technology and electrical and automation systems, including hybrid applications, and is the result of a unique range of in-house competencies.

What differentiates the integrated Wärtsilä HY module compared to a traditional hybrid system is that Wärtsilä delivers the whole package so that all the elements can seamlessly work together controlled by one integrated software system, the Energy Management System, or EMS. Some call it the 'brain' of the system.

Using batteries for marine propulsion is not new per se, but the Wärtsilä HY marine hybrid power module is special because it is a single innovative product steered by the EMS software. This core or 'brain' of the Wärtsilä HY makes the

electrical components one integrated product, whereas previously this integration was an afterthought stitched together by different suppliers. This harmonisation creates an entirely new level of interaction between its internal components and with the ship's onboard systems, thereby providing enhanced operability and greater predictability.

Specifically, this unified EMS means that the energy flow is optimized to achieve the best performance in each operational mode. This kind of total control was not possible when an energy storage system was simply added to the mix without all the corresponding components working in unison.

In order to match the specific demands of different market segments, Wärtsilä HY comes in highly customizable forms which is made possible by tuning the proprietary EMS software and by optimally sizing the internal components.

The standard mechanically-driven

An eco-friendly tug

Wärtsilä's new portfolio of tug designs emphasises environmental sustainability. They draw inspiration from Wärtsilä HY technology – which provides flexibility and efficiency to the operation of the tug – and the company's proven LNG technology.

The Wärtsilä HY Tug designs have been created in close cooperation with the ABS, BV and Lloyds Register classification societies, and have received the Approval-in-Principle (AiP) certification. The new tug designs feature a very distinctive outlook while providing the power and manoeuvrability for practical tug operations. Its total installed main engine power is less than the conventional hybrid tug designs, while maximum bollard pull is achieved via power boosting from the batteries.

These newly launched Wärtsilä HY Tug designs come in three different hull sizes, namely a 28m harbour tug with a 50t bollard pull, a 29.5m harbour tug with a 75t bollard pull,

and a 35m escort tug with a 75t bollard pull, delivered via Wärtsilä WST thruster series. The propulsion configuration is such that each design comes with the option to select either diesel mechanical hybrid or diesel electric hybrid propulsion, and the designs are able to cover a 40 to 90t bollard pull range with the appropriate Wärtsilä equipment.

The technology represents a unique innovation in marine propulsion systems. Through its in-house expertise in engine design and electrical & automation (E&A) systems, Wärtsilä has developed a fully integrated hybrid power module combining engines, an energy storage system, and power electronics. These are all optimised to work together through a newly developed energy management system (EMS). It is the marine sector's first produced hybrid power module of this type, thereby establishing a new industry benchmark in hybrid propulsion.

Applying hybrid technology is expected to reduce harmful emissions and achieve operational cost savings when compared with conventional tug designs. In addition to the hybrid technology, LNG-fuelled engines and thrusters, Wärtsilä will also provide shafting and control systems, meaning the entire propulsion system will come from a single supplier. This enables full integration of the overall system for greater efficiency, while also reducing possible scheduling risks for the owner and shipyard.

The new tugs will, going forward, rely more and more on battery and hybrid propulsion, which complement today's tug operational requirements. With unmatched in-house capabilities combining ship design, engine technology, propulsion and E&A solutions, Wärtsilä's new tug designs are uniquely positioned to meet the future needs of the industry.

Stay tugged.



configuration includes a main engine with clutch, an in-line shaft generator/motor, an energy storage system, DC link and power drives and the EMS. The standard electrically-driven configuration includes a generating set, an energy storage system, a DC link and power drives, and uses the EMS as well.

How it works

The Wärtsilä HY configuration is based not only on the maximum power demand of the ship, but also on its specific operational profile (i.e. how much power for how long, mode of operation, etc.). The time factor also enters the equation, and the dimensioning approach evolves from power-based to energy-based. And an optimal balance between engine power and energy storage leads to a more compact design which requires fewer cylinders running at a higher efficiency loading rate. This of course reduces maintenance costs in the long term.

In its Diesel-mechanical version, Wärtsilä HY uses two separate key components: an internal combustion engine and an electric motor/generator, the latter being connected to the electrical grid (hence to the energy storage system). These components work in synergy with each other allowing for instant load-taking, green mode, start&stop, peak shaving, power boost, hence more redundancy, higher safety, less engine running hours and higher efficiency. All these features can be obtained with even more ease in the Diesel-electric version, where the combustion engine can directly generate electrical power through a generator.

Furthermore, the EMS is finely tuned to the vessel's design and operational profile throughout its lifecycle. This guarantees that every specific ship is designed and operated in the best possible way, according to the actual operating profile.

Generally, hybrid power systems improve fuel efficiency and reduce emissions quite simply because batteries are used to do some of the heavy lifting instead of diesel engines. In the case of Wärtsilä HY, the package is

optimised for specific operating profiles be they tugs, ferries or dredgers allowing ship operators to attain efficient power management, flexible layout solutions, and reduced noise and vibration, among other benefits.

The advantages

With the Wärtsilä HY onboard, directed by the EMS, a tug for example can sail out of a densely populated port in 'green mode,' i.e. powered exclusively by the batteries, and then assisting operations can be carried out with the diesel engines on and the batteries then cover all the load peaks and power instantaneously. The air quality impact of shipping in populated areas is thus reduced.

Another finesse of Wärtsilä HY is the cold-systems start-up, which essentially does away with the need to wait for the engines to warm-up prior to operations. This is instead overcome by the energy storage system leading to instant ship readiness. This instant availability of energy stored in the batteries is also a safety measure. This stable and efficient engine loading is due to the EMS peak shaving function where load fluctuations are absorbed.

With the Start & Stop functionality, at low loads, the power is supplied exclusively by the energy storage system until it reaches a pre-set minimum state of charge. At this point the engine is automatically activated, providing power to the ship and simultaneously re-charging the energy storage system.

Central to all of these advantages is an increase in operational efficiency, which in turn reduces fuel consumption and emissions.

In fact, in "green" mode, there are zero emissions, while in all modes – from start-up to full power output – the operation is free of visible smoke, thanks to a new Wärtsilä patent-pending procedure. Additionally, the reduced engine operating time lowers the maintenance requirements because the engines are running fewer hours in total.

The Wärtsilä HY also comes with entire system certification.

To summarize, Wärtsilä has leveraged its

technological leadership in both engines and electrical & automation systems to set a new industry benchmark in marine hybrid propulsion. Through combining its unique range of in-house competences, Wärtsilä has turned a complex system into an innovative single product that delivers unrivalled and guaranteed performance. The module is tailor-designed for individual vessel market segments and can be optimized for specific operating profiles, thanks to EMS. And with Wärtsilä as a single supplier for all this, performance is guaranteed. ●



Faster, easier, and safer together with robots

AUTHOR: Thessa Lageman

In a recent one-month pilot Wärtsilä ran with logistics company DHL, four small freight robots carried plastic bins and carton boxes in Wärtsilä's Central Distribution Centre (CDC) in Kampen, the Netherlands. The outcome was so positive that the robots are here to stay!

The warehouse staff normally carry the boxes themselves or use a pallet truck, but now they placed them on the robot shelves and pushed a button on the robot's touchscreen. The material transport robots then set off on their pre-defined route to their destination in the CDC. Here, DHL operates some of the warehouse activities, like goods reception, picking, and packing.

The floor space of the distribution centre in Kampen, a small Dutch town 90 kilometres northeast of Amsterdam, is

37,000 square metres, and it stocks over 80,000 unique parts, with some 27 million different pieces. Last year, over 100,000 deliveries were shipped from this CDC to more than 180 different countries. On an average, this means 35 trucks departed each day.

Even though the storages are already fully automated, there are still quite a high number of manual boxes and pallet movements between the various work stations. This is why further automation



seemed a logical step in the CDC. Innovation and robotics are essential for Wärtsilä, and are one of the key points in the partnership with DHL.

Teija Tikkala, Manager of IT Service Management in Wärtsilä Global Logistics Services, Parts Delivery, says now is the right time to start using robotics. "It's no longer a massive investment. The costs are getting more realistic and implementation is easy. There is also more technology related to smart autonomous machines available and the developments go fast."

Small mobile freight robot

The aim of the pilot was to explore the options of using the latest technology innovations in the warehouse's daily operations, she explains. "Wärtsilä and DHL also wanted greater insight into the added value of robotics in a storage environment and into the interaction between robots and employees."

Fetch Robotics, a California-based company, provided the *hmishelf25*-type robots. These small models have a loading capacity of 75 kilograms and can cover a

distance of two metres per second. The robots navigate using a 270-degree laser scanner combined with a 3D camera. For visualisation, the robot projects a blue light two metres in front of the robot.

Smooth interaction with humans

Before the pilot was launched, the staff received information about the robots – for example, how they move and what load they can carry. The Information Corner was set up to share details about the robots and progress of the pilot.

Early involvement of the staff is important, Tikkala emphasises. People had a lot of questions and also concerns about the robots and how robots would impact their daily work. "They also had a lot of great ideas how we should utilise the robots in the warehouse. So we arranged an idea contest and then selected the pilot use cases from those ideas."

The use of robots results in more rewarding responsibilities and tasks, she explains. The robots relieve the warehouse operators from physically strenuous work and, based on pilot findings, more than 30

kilometres of walking in the warehouse in Kampen each day.

"Carrying boxes from A to B is not a really valuable task. Instead, employees can concentrate on other jobs," Tikkala says. She adds: "Some of the warehouse operators will become a 'robot key user' and also configure new tasks for the robots."

User friendly

All in all, Tikkala believes, most employees were pleased with the robots. "People like how easy it is to use them." There was no need for complicated programming, for example. Also, only minimal warehouse changes were needed: floor striping to mark the robot's parking and charging spots.

The pilot is regarded as a success for a number of other reasons too, she explains. The stock availability has increased, having more continuous material flow has reduced some buffers, and thus efficiency and productivity have improved. "And of course we are proud to be part of this kind of new innovations and the positive publicity this has brought to Wärtsilä."

The company has now decided to



purchase three robots to support the operation within the CDC in Kampen. There are no plans yet to use them in other locations, but Tikkala thinks this is likely in the future.

Wi-Fi connection

Naturally, a few lessons were learned during the pilot and some things will be done differently next time. “One of the challenges was the blind spot in our Wi-Fi network, which made the robots stop or return to the

docking station,” recalls Tikkala. An efficient set-up and operation requires a Wi-Fi connection with sufficient range.

The robots are intelligent. They recognise their locations and surroundings, and can differentiate between dynamic and static obstacles, enabling evasive action for working safely with and around people. Apparently it is even safer to work with robots than without them. “Robots have built-in sensors that recognise movements, which the pallet trucks don’t have,” Tikkala says.

Robot dance

Initially the robots had some difficulties seeing certain objects, like the reflective stripes on the DHL global standard safety jackets. “The 3D camera got confused by the highly reflective vests and saw ‘speeding ghosts’. The result was that the robot had difficulties to navigate through what looked like an empty space for us.”

During the grand opening of the pilot, with dozens of visitors wearing a reflective safety vest, the robots suddenly became disoriented.

An hour later the cause was found. “The software has been adjusted, and the robots recognise the vests now,” Tikkala smiles.

On another occasion, two robots faced each other on their way to the charging unit to reload. When the nine-hour battery life ends, the robots independently make their way there. “They were programmed to avoid contact and started a sort of dance around each other,” says Tikkala. “It looked quite funny.”

She adds: “This can of course happen, if

robots are used for the same task or running on the same path, so you can program them to know who goes first.”

Larger and more complex

Over the coming months, the trial will continue in Kampen to further improve productivity, quality, and safety. “For the first pilot we selected fairly simple tasks and routes,” says Tikkala. “Now we can extend the route, and add more complex itineraries.”

There are also plans to experiment with

other robot types and technologies. “We’re thinking of investigating larger robots like the *freight500*, for instance, which can carry more and heavier parts.”

Early next year, Wärtsilä plans to start a pilot with drones, which could be equipped with a camera to calculate stock and gather other information.

“Like we did in this first pilot, we will also gather the ideas for using drones from our personnel. People have a lot of good ideas,” says Tikkala enthusiastically. ●