# **Zero** Emissions Target

### **2019 ZERO EMISSIONS TARGET REPORT**

**Cruise Industry News** Zero Emissions Report

November 2018

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## Zero Emissions Target

ero emissions is the cruise industry's long term ambition, both for water and air, and not only at sea, but also in port.

It may have started with wastewater discharge regulations being introduced in Alaska and the Baltic some 20 years ago, followed by air emissions restrictions in ports on the West Coast, leading to the first installations of shorepower and testing of scrubbers.

Since 2015, so-called SOx Emission Control Areas established by the IMO have restricted the sulfur content in marine fuels used to 0.1 percent, and by 2020 IMO regulations puts a global sulfur cap at 0.5 percent for marine fuels (outside of ECAs), compared to a 3.5 percent limit today, which has been in effect since 2012; it was 4.5 percent before that.

In order to comply, ships will have to operate on the low sulfur fuel or, if running on heavy fuel oil, use exhaust gas cleaning equipment (scrubbers), or alternative fuels, including LNG.

New ships also have to comply with IMO Tier III NOx restrictions in ECA areas and Tier II everywhere else.

Next comes the 2020 and 2025 Energy Efficiency Design Index requirements that new ships must be 20 percent and 30 percent more energy efficient, respectively, than a 2015 baseline.

New ships are well on their way to meeting these targets already, resulting from more energy efficient powerplants, HVAC systems, lighting, galleys, hull forms and hull lubrication, and more, in addition to energy management plans and more efficient operations. Advanced wastewater treatment systems clean the discharges into the sea. New developments also promise to turn garbage into energy that can be burned as fuel rather than being incinerated and going up the funnel.

At the same time, port communities are becoming more concerned about air emissions from cruise ships when in port. Norwegian authorities have gone as far as to declare that their heritage fjords, that are popular with cruise ships, shall be emission free by 2025.

Longer term, the IMO has set 2050 as the target date for a 50 percent reduction in CO2 emissions from a 2008 baseline and that will require more than low sulfur fuel and scrubbers.

Thus, the cruise industry is actively engaged in developing technologies and fuels to reduce emissions both at sea and in port. So far, the focus is on LNG as the "next" fuel, but work is also underway advancing fuel cell and energy storage technologies and fuels such as hydrogen, methanol and ammonia for ship applications, as well as solar and wind power.

The path to zero emissions ships may be long, but the technology insiders are confident the industry will get there. ■

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### <u>Cruise Industry News</u>

The new and innovative LNG-fueled AlDAnova under the lights at Meyer Werft in Papenburg, Germany.

## New Carnival LNG Ships to Drive Fuel Efficiency

ith 11 LNG-fueled ships on order, Carnival Corporation has the largest orderbook of green ships in the cruise industry.

Later this year, the company's German brand, AIDA Cruises, will make history when the new 183,900-ton AIDAnova becomes the first cruise ship in the world to be powered by LNG while both at sea and in port. "AIDAnova is also significantly more efficient," said Arnold Donald, CEO, on the company's third quarter earnings call.

"In fact, she is over 20% more unit cost efficient and over 35% more fuel efficient than the AIDA fleet average, which bodes well for returns in the future," he said.

During the quarter, we completed contracts for two more next generation

ships powered by LNG both for our Princess brand to be delivered in 2023 and 2025, bringing the total number of ships on order fully powered by LNG to 11."

Orders for LNG ships cover the AIDA, Princess, Costa, P&O and Carnival brands. ■



# **'Paying** Off'

Gooday, about 30 percent of our fuel has had the sulfur removed before we buy it and given the success of our AEP (advanced emission purification – scrubbers) systems, we believe that this 30 percent figure will not change materially even after the 2020 date," said Richard Fain, chairman of Royal Caribbean Cruises, on the company's second quarter earnings call, commenting on the 2020 IMO regulations.

" In fact, for various technical reasons, many observers believe that the new regulations could actually reduce our fuel costs once the regulations come into force," he continued. You will see continued growth in our market fueled by increased capacity and the excitement surrounding such high profile ships.

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"Of course, it's required a massive investment in these AEP systems, but that investment is paying off in both fuel costs and environmental benefits.

"I shouldn't leave this topic of fuel without mentioning our energy conservation efforts because we are enormously proud of the work our teams have done and continue to do to find ways to reduce our energy consumption. We already have the lowest levels in our industry and have partnered with the World Wildlife Fund to improve it even further. While AEP systems and other such measures are good, the best way to reduce our environmental footprint is to use less energy in the first place."

Scrubber installation ready for the Grand

Princess

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# **IMO** 2020

tarting on January 2020, the International Maritime Organization's (IMO) new rules for sulfur emissions will come into force worldwide. The limit for sulfur in fuel oil used onboard ships operating outside designated emission control areas will be reduced to 0.5%.

### THREE WAYS TO COMPLY:

Install a Scrubber - an exhaust gas cleaning system will reduce emissions from the smokestack, enabling ships to meet IMO 2020 regulations while still burning HFO. Scrubbers are said to cost about \$1.5 million each. Installation takes place during drydocking, and on older ships, could cause stability concerns.

Burn MGO - marine gas oil is a low sulfur fuel already widely used in emissions control areas. MGO costs more than HFO and prices are expected to rise significantly in 2020 as demand spikes. Of 20,000 ocean-going ships, only 3,000 to 4,000 are projected to have scrubbers by 2020, which will change fuel buying dynamics.

The 5,200-guest AIDAnova

MGO may be more expensive and in short supply come early 2020

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LNG - a handful of cruise ships and container ships will be LNG-powered by 2020, with the clean burning gas meeting IMO requirements. Supply chain issues remain the biggest challenge

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# Taking Initiative

E very summer Norwegian news outlets focus on air pollution from cruise ships, particularly in ports where an inversion layer creates a very visible ceiling of smoke.

Taking a lead industry role to tackle the issue has been Carnival Corporation. "We have had discussions with a number of ports about installing cold ironing equipment, but the recent effort by Enova to fund shorepower in a number of ports unfortunately does not cover cruise ships," commented Tom Strang, senior vice president of maritime affairs for Carnival. Enova, a Norwegian government agency providing public funding for cold ironing installations, claims that funding shorepower for cruise ships is too costly, considering the power requirement and the limited seasonal use. It has instead thrown the challenge back to the cruise industry, with Enova's CEO stating that it is the cruise lines' responsibility to clean up their own business.

So far Enova has funded installations to the tune of nearly half a billion NOK and has issued an invitation for more applications.

#### Bellona

"Combine this with coverage of overcrowding in some of the most popular destinations, we decided to become more active and encourage the ports, the local communities and the infrastructure providers to get more actively engaged," continued Strang.

"Although we have a very good relationship with the ports, from time to time it is clear that our message is not getting out there."

Thus Carnival has forged a relationship with Norway's Bellona, an environmental group working internationally. "We found that we share many of the same objectives, to promote the use of clean technology, find sustainable ways to reduce emissions, and at the same time maintaining our ability to carry out our business in a clean fashion.

"As such we have set some targets together, like zero emissions in port and in pristine areas, which seems to us a good way to kick start and accelerate discussions that are already going on in Norway."

Bellona may also be expected to play a role on the public funding side, as most ports do not have the financial resources to pay for installations.

#### **TV Coverage**

In a TV interview this summer, Stein Kruse, CEO and president of Holland America Line Group, told a Norwegian reporter that the company would be willing to put money on the table for shorepower installations.

Also on Norwegian TV and responding to criticism, the port director for Oslo, Ingvar Mathisen, said that the port was only responsible for 5 percent of the CO2 emissions generated in the city, and that cruise ships in turn are responsible for only 4 percent of the port's emissions.

While Oslo provides shorepower for Color Line's cruise ferries, Strang commented that Carnival has not been successful in its discussions with the port.

A more typical TV report from another port claimed that one ship can

#### ZERO EMISSIONS TARGET

generate the same emissions in a day as 13,000 diesel-powered cars.

#### **Slow Start**

Said Strang: "We have to have discussions, we want to help the ports find ways of solving the issue, and we can share the experience we have from the United States."

So far in Europe only Hamburg and Kristiansand have shorepower for cruise ships, while an installation in Livorno has not been functional due to "automation issues," according to Strang.

As for Kiel announcing plans to install shorepower, he said: "That was a result of us telling them we wanted shorepower and how can we make that happen."

With more than 100 ships running on liquid fuels in the Carnival fleet, he said shorepower will be relevant for many years to come.

Thirty-nine ships in the Carnival fleet are fitted for shorepower, according to Strang, while more ships have the cabling in place.

"We have led the way," he added, "but found it very difficult to get ports to make commitments. Although today there is a lot more pressure from communities on local operators and ports to clean up their act."

Each ship needs from 5 MW to 12 MW in port, depending on the size of the vessel. Ship installations tend to run around \$1 million, while the recent shoreside installation in Kristiansand was budgeted at about NOK 40 million (about \$5 million) through EU funding.

#### **Other solutions**

A second-best solution is to burn LNG while in port; it has significantly less emissions than fuel oils.

Strang said Carnival is also looking at battery and fuel cell technologies, while making sure its ships reduce the hotel load to a minimum in port, running one instead of two engines, for example.

He described the efforts as part of the pathway to success: meaning eventually zero emissions.

# Thinking Differently



There is no single "best" solution for the most energy efficient and green ship going forward, according to Andreas Ullrich, global market leader, passenger ships and ferries at Bureau Veritas. Instead, he defined medium-term solutions being scrubbers, catalysts (SCRs) and LNG, and longer term with batteries and fuel cells, possibly combined with LNG-fueled engines.

"We also have to think differently," he said. "Today, powerplants consist of main engines generating energy in one or two spaces, but in the future there may be more decentralized arrangements, maybe smaller energy storage units positioned around the ship, supplying different consumers, supported by an excellent energy management system."

Ullrich continued: "LNG is currently the best option to reduce emissions, but it is a fossil fuel, and eventually we need to change to synthetic fuels, or fuels produced from renewables. We can also create energy from wind and solar power. "In the longer term, hydrogen may also be used as a fuel, if we can find solutions to transport and store it aboard. There is research underway to combine hydrogen with liquids, transforming hydrogen to a liquid form for transportation."

Hydrogen would most likely be for fuel cells, but may also have application in turbines, according to Ullrich.

He added that some cruise lines are testing small-scale applications of fuel cells to see if the technology is reliable and can deliver what is expected.

"If somebody starts, it will be a big push for the technology. This is what happened with LNG."

Meanwhile, energy storage systems are curtailed by high costs and low capacity, according to Ullrich, who added that if the price goes down and capacity goes up, they could be an attractive solution.

New technologies are mostly being considered for newbuilds, but older ships can also be retrofitted to some extent, he said, including scrubbers and SCRs to comply with emissions regulations.

"I think the cruise industry is taking huge steps forward to become both greener and more efficient, but one has to understand that it takes time to develop new technologies. We have ships on order now for 2027 deliveries. They are designed with existing technologies, but I think owners would be willing to make changes, if new technologies were to become available. They want their ships to sail for at least 20 years and even more, and by 2050 IMO regulations call for a 50 percent drop in CO2 emissions."

As for a zero emission ship, Ullrich said: "I am sure it will happen, but I am not sure when. Our over-riding goal must be zero emissions for both air and water."

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### Cruise Industry News



# >Energy Solutions

hanging its name to MAN Energy Solutions earlier this year means that MAN is now strategically focused on comprehensive powerplant solutions, including exhaust gas treatment systems, technology for LNG-fueled applications, and hybrid solutions with energy conversion and storage systems, and related automation systems, according to Sokrates Tolgos, head of cruise sales and tendering, MAN.

"We are going from being a pure engine and turbo machinery company to a systems supplier," Tolgos said.

"We have taken the first steps already with our acquisition of the marine fuel gas storage and supply systems of former Cryo of Sweden, and we have entered into a partnership with Canada's AKA, which is an electric solutions provider."

#### **Engine Series**

Tolgos said that today MAN is delivering the whole technology range of powerplants and systems from heavy fuel oil to LNG.

System offerings include the 48 engine series with common rail (CR) injection technology for big cruise ships operating on oil-based fuels, as well as the 45/60 CR, which was announced last year, and the 32/44 CR series for smaller ships.

For LNG-fueled ships MAN offers the

51/60 and the 35/44 dual fuel engines for large and smaller vessels, respectively.

"Considering the typical operating profile of cruise vessels, the application of our ECOMAP technology on CR engines can reduce fuel consumption by an additional 1 to 2 percent," Tolgos noted.

"The 45/60 CR engines are more sophisticated so the capital expense is higher, but the payback comes from reduced fuel consumption."

He explained how common rail and ECOMAP can be used to adapt each engine's performance characteristics, optimizing the fuel economy of the powerplant.

Common rail and ECOMAP are features for liquid fuel engines, while a gas injection system will be used for dual fuel engines.

#### LNG vs. Liquid Fuels

Big newbuilds are looking in the LNG direction, Tolgos said, but a large percentage of smaller ships are still looking toward liquid fuel.

He explained: "The feasibility of using LNG as a fuel has much to do with the size of the vessel.

"When you go from big to small, the power demand does not decrease at the same rate, and the autonomy range does not decrease. That means that the LNG



fuel tanks become relatively larger the smaller the vessel becomes.

"For that reason, we have had projects that started with LNG but changed to liquid fuel."

#### Solutions

In terms of future powerplant solutions, Tolgos said cruise lines have different options, including traditional diesel engines running on HFO and using scrubbers and catalysts (SCRs) to meet environmental regulations; MGO and catalysts; or LNG. However, LNG-fueled ships might still need catalysts as they also carry MGO as back-up fuel, although the system will not be active when running on LNG.

In addition, he said that oil companies have promised to supply new fuel types within the 0.5 percent sulfur cap required globally by 2020, but the question is how much the new fuel will cost. Tolgos' expectation is that a new blended fuel will be more like a diesel-fuel than a residual fuel, hence refinery economics will drive the cost up to be closer to distillate than residual fuel.

Compatibility of these new fuel types with existing engines is another factor that must be considered to safeguard reliable operation of the plant.

Meanwhile, he added, many experts are expecting to see HFO prices drop significantly against diesel/distillate type fuels in 2020 when the sulfur cap is introduced.

Tolgos said that he definitely expects cruise ships to meet Phase 3 of the EEDI (Energy Efficiency Index) in 2025. "We have more efficient engines, which in

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The 45/60 CR engines are more sophisticated so the capital expense is higher, but the payback comes from reduced fuel consumption.

combination with other factors, such as more efficient hull design, reduced energy consumption by various consumers, like HVAC and lighting, will help cruise ships comply."

### Lifecycle Cost

"The number of installed engines and cylinders are not only related to the vessel size and speed, but also to hotel load requirements and efficient engine loads, redundancy and safe return to port," Tolgos said. "For ships below 50,000 tons, it would be difficult to find space for more than four main engines, but larger ships tend to have from four to six engines. Looking at it from a lifecycle cost perspective, I would say that five to six main engines are the best solution."

While offering liquid fuel engines, LNG derivatives, and also researching energy storage systems, Tolgos said the next evolution may be fuel cells, especially if LNG can be used in fuel cells. This would also offer a completely new perspective on how to utilize space in future ship designs as fuel cells, in principle, enable the design of decentralized onboard generation of energy and power.

# Industry Is Leading the Way

he global shipping fleet can look at the cruise industry to lead the way for more energy efficient ships" said Ginger Garte, environmental and sustainability director, Americas Marine & Offshore, Lloyd's Register.

"The cruise lines are not waiting for regulations, but moving ahead, implementing fuel saving technologies and testing new technologies that are promising efficiencies. Although they can be small, they all add up."

Garte continued: "The cruise industry recognized more than a decade ago that climate change would be the biggest issue facing maritime industries. And they are tackling it in a multitude of ways, from advancing exhaust gas cleaning systems to looking at alternative fuels that are effective in meeting sulfur requirements.

"The biggest cruise companies are investing in both scrubbers and LNG. Although LNG may be a temporary measure, restricted by lack of bunkering capabilities around the world, and not reaching the level needed to decarbonize.

"By 2030, the industry will need a heavier lift, like methanol as a fuel, fuel cells or other solutions that are not currently available."

Looking at how the cruise industry has been performing historically, Garte said it has been very competitive in terms of energy efficiency.

Efforts include redesigning vessels for better hull hydrodynamics including air lubrication, welds around sea chests and coatings, as well as better aerodynamics for the superstructure.

"By reducing the friction between the hull and the water, we have verified that air lubrication can reduce fuel consumption by up to 5 percent," she said, "and consequently air emissions."



Monitoring performance ship-wide from the advanced engine control room aboard the Carnival Vista, which carries LR's ECO Notation.

Even casual dining venues contribute by eliminating table cloths, that in turn saves on water for washing. In addition, the latest generation of washing machines use 65 percent less water, according to Garte, who also noted better energy management of galleys, more efficient ice makers and dish washers.

Also critical is how the ships are operated, significant fuel savings and reduced emissions can be gained by just-in-time arrivals, trim optimization, weather routing and more.

"All energy efficiency programs are looked at and improved for every newbuild," Garte said.

The latest generation of newbuilds are up to 20 percent more efficient than the previous generation and thus the cruise lines are well on their way to meet the 2025 Phase 3 requirement of the Energy Efficiency Index stipulating that new ships must be 30 percent more efficient compared to a 2015 baseline.

And in order to reach the IMO target of 50 percent reduction of CO2 by 2050, Garte said the first zero emission will have to enter service around 2030.

Meanwhile, Carnival Corporation stated in its 2017 sustainability report that it has achieved a 26.3 percent reduction in CO2 emissions, three years ahead of its 2020 deadline.

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Increasing energy efficiencies and reducing emissions require a combination of an optimized powerplant and other energy consumers aboard, in addition to ship operations, including navigation and itinerary planning, according to Vesa Marttinen, director of cruise, ferry and superyachts at Wärtsilä, a major powerplant and systems supplier to the cruise industry.

He underscored that many variables play important roles, starting with the propulsion and hotel consumers.

To help minimize fuel consumption and consequently emissions, he added that fuel consumption, energy usage and other operating data must be shared between the vessel, the shoreside marine department and the engine and equipment suppliers.

### **Fuel Options**

Another aspect is the fuel; and power generation can use HFO in combination with scrubbers to meet emission requirements, or MGO, or LNG. In addition, oil companies are developing low-sulfur HFO to meet future emission requirements. Furthermore, Marttinen said that Wärtsilä, has been running tests with methanol, while also doing development work with batteries and fuel cells.

"The combustion engine itself has seen huge improvements over the past 100 years," he added, "and continues to improve step by step. The question now becomes how much effort it will take to achieve the next steps, and if the end-user is willing to pay the price, or if we can achieve similar gains doing something else with lower capital costs. In the end, the customer must justify the business case.

"Yet, it is our role as a technology company to continue to push forward."

#### **Powerplants**

What is the ideal powerplant today? "Let me answer this way," Marttinen said. "From what we have seen in the past, the steam engine was introduced 200 years ago, but it took 80 years before steam surpassed sails, so we can also assume it will take some time before LNG surpasses current fuels. Also forcing change and development is that the IMO is requiring a 50 percent reduction in greenhouse gases by 2050 and eventually going to zero.

"Meanwhile, LNG is a perfect bridge. It is available in multiple locations, and in the Caribbean, for example, if you look at island energy needs, LNG can also play a key role in generating energy ashore."

Hybrid solutions are also entering the picture, according to Marttinen, with powerplant configurations that include batteries or fuel cells. He noted that testing of fuel cells on ships already started more than 10 years ago.

"Technology, however, is only an enabler for operations," he explained. "You need to look at both the machinery and operations to get the total picture."

#### Zero Emissions?

Will there be a zero emissions ship in the future? "One day," answered Marttinen, "and it will be the result of multiple developments."

Meanwhile, new versions of older technologies are also being tried, such as rotor sails, which he said are 100 years old, but are now being optimized with new materials and computers. He said

#### ZERO EMISSIONS TARGET



he can also envision using wind turbines to generate power while in port.

"The key is to use technology to improve the assets and the operations, and while this usually involves the next generation of vessels, much can also be done with existing ships.

"Every time we reduce energy consumption we reduce greenhouse gases.

"The trend has been that ferries are usually first to implement new technologies and then cruise ships."

Marttinen also expects to see more actors getting involved in terms of port operations and vessel traffic control.

"You can say that sustainable operations start with the equipment on the ship, then you have the operation of the ship, the operation of the fleet, and also the operation of ports. Future ports may also have their own powerplants, using different sources of energy, and selling electricity to the ships.

"There are many different avenues moving forward."

#### Development

"We have been sort of vegetating in the marine leisure market," Marttinen continued. "We have these assets that go 20 knots, but is that needed? What if we could have zero emissions and go at 10 knots from port to port? Does a ship have to call at a port every day? What about every other day? The cruise lines would also generate more onboard revenue. In addition, if passengers are sourced in homeports and nearby areas with no flights, the operation would be even more sustainable.

"Developing assets and operations is what it is all about, and this is where we can give a helping hand."

# Ongoing **Debate**



orway's Kristiansand is the second European port to offer shorepower to cruise ships after its 16 MW installation came on line in September, thanks to an EU grant.

The only other European port offering shorepower is Hamburg, at its Altona Terminal, while Livorno expects to be operational by the end of the year.

A spokesperson for the Port of Hamburg said that preparations were underway for a feasibility study to install shorepower at all the cruise terminals. She also said that the port was in discussions with MSC and other cruise lines for shorepower and LNG bunkering.

In addition, Kiel has announced that it is planning a shorepower installation at its Ostseekai terminal for cruise ships.

Meanwhile, AIDA Cruises also has a hybrid solution, with the AIDAperla and AIDAprima running on LNG supplied by truck while in port in Hamburg, Rotterdam, Le Havre, Southampton and Zeebrugge, as well as in Barcelona for the AIDAprima, and in Madeira during the winter. According to AIDA, Marseille, Civitavecchia and Kiel are also preparing to supply LNG for the dual fuel ships, while the line is in the discussion stage with Palma de Mallorca.

### Cruise Industry News



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#### **Exclusive Club**

The only other operating shorepower installations for cruise ships are in the United States and Canada – on the West Coast in Juneau, Long Beach, Los Angeles, San Diego, San Francisco, Seattle and Vancouver and on the East Coast in Montreal, Halifax and New York's Brooklyn terminal.

Additional shorepower facilities in North America and Europe are dedicated to ferries, container ships, tugboats, fishing vessels and offshore vessels and rigs.

Longer term, Peter Castberg Knudsen of PowerCon, the Danish company that has installed the facility in Kristiansand, said he envisions shorepower to supply hotel consumption aboard when cruise ships are in port throughout Europe and also for charging applications for battery installations.

Also on a broad European scale, socalled Trans-European Transportation Network core ports will need to provide alternative infrastructure such as shorepower before the end of 2025, according to EU regulations, Castberg Knudsen said, unless there is no demand and the costs are disproportionate to the benefits.

He added that cruise ports in Europe have so far been reluctant to install shorepower due to the high investment cost combined with relatively low usage in addition to many ships not having the equipment to connect.



According to MedCruise, Livorno and Varna have shorepower installations for cruise ships, and Marseille for ferries.

Giovanni Spadoni, technical and commercial director for the Port of Livorno, said that its installation has been tested on a naval vessel, and the port is in the process of verifying whether Holland America Line ships can plug in. He said he expects the plant to be fully operational by the end of the year.

In China, Shenzhen has a shorepower installation for cruise ships, while other projects are reported to be underway at Wusong in Shanghai and Qingdao in Shangdong, according to Cavotec, a supplier of shorepower cable management systems.

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Hydro Powe

Down Under, the Ports of Auckland announced last year that they would pursue plans for shorepower. However, CLIA Australia countered that a key strategy of the cruise lines is the adoption of exhaust gas cleaning technology, which in combination with cleaner fuels, will mean that the usefulness of shorepower will decline over time.



### Funding

Kristiansand has been able to install shorepower thanks to a 4 million euro grant from the EU.

Hamburg's installation was financed partially by the EU and the City of Hamburg.

In North America, Los Angeles paid for its own installation. A spokesperson said that the port is recovering the investment through a passenger head tax and that the cruise lines pay for the electricity they use.

For San Diego, a spokesperson said the system was paid for by a combination of grant funding and money from the port's capital improvement program.

Carnival Corporation funded the installation cost in Seattle.

San Francisco, which completed its installation in 2010, was able to take advantage of state grants that were no longer available once California made shorepower mandatory in 2014.

For the Brooklyn Cruise Terminal, a spokesperson for the New York City Economic Development Corporation said the \$15 million spend on the onshore infrastructure was funded with about \$12 million from the port authority and nearly \$3 million from the Environmental Protection Agency. In Vancouver, the federal and provincial governments funded two-thirds of the installation, while Holland America Line, Princess Cruises and the port authority funded the other third.

A spokesperson said that the original \$9 million investment made in 2009 will be fully amortized by the end of the year (2018).

In Montreal and Halifax a combination of funding from the federal and provincial governments, as well as the port authorities, paid for the installations.

The project costs were estimated at \$10 million and \$11 million, respectively.

### **Cost Effective?**

Other cruise ports in Norway have applied for grants from Enova, a Norwegian government agency working to improve energy efficiencies and reduce emissions, but have been turned down, because the agency considers cruise ship usage to be seasonal and not cost effective.

This is partially because of the relatively low investment for supplying 1 to 2 MW of power compared to a system for a cruise ship at 16 MW.

The Kristiansand installation is 16 MW, 6.6-11 kV, 50-60 Hz. It was originally intended for Copenhagen, but for unknown reasons, that city pulled out of the project.

Ferries, coastal vessel traffic, fishing vessels and oil rigs in port for maintenance have been favored, said Jan Kjetil Paulsen, senior adviser on shipping at the Bellona Foundation, an environmental organization based in Norway.

Hurtigruten commented that it needs to stay in port for more than 45 minutes for a shore connection to make sense, which would eliminate many of its ports of call. It also noted that Bergen is the only port where it can presently use shorepower. Not all of its ships can plug in yet, however, with shipboard installations to be completed by 2021 or earlier, according to a spokesperson.

Enova recently awarded NOK 51 million in grants to 11 Norwegian ports, financing up to 75 percent of the installation cost of shorepower.

The agency has since issued another invitation for grant applications with a

late September deadline, while also announcing plans for yet another invitation in January 2019 with a March 2019 deadline.

So far, the agency has awarded half a billion NOK in grants for shorepower installations.

#### **Pollution Issues**

Paulsen said that the issue with cruise ships is local pollution when ships are in port, and that today there is an acute need to improve the air quality. LNG will help by reducing emissions and so will new ships that have to comply with the latest IMO requirements, compared to older ships that may be exempted.

Where clean (hydroelectric) power is not available, Castberg Knudsen's ideas include using wind turbines to compete with fossil fuels in terms of producing electricity at the lowest cost that can even make a shore system profitable, he said, without external funding.

Paulsen added that even with coalfired powerplants, it makes sense to move the emissions away from the populated port area, and that it is easier to clean the emissions from one powerplant rather than several ships.

#### **Public Reaction**

Meanwhile, some cruise ports are facing negative public reaction on heavy traffic days due to the visible exhaust that can literally "cover" a town or a fjord.

In Norway, one local politician even exposed himself to passengers as a form of protest.

The Norwegian government has recently announced that it will make its World Heritage fjords zero emissions zones by 2026, including Geiranger, a popular cruise destination.

That may mean that these fjords will be off limits to large cruise ships unless they can come up with new power solutions very quickly, according to Bellona's Paulsen.

He added that it is in the interest of the industry and the ports to reduce emissions. What tourist would pay to visit destinations covered by clouds of exhaust, he asked. ■



Cruise Line: CARNIVAL Ship: HORIZON Tonnage: 135,000 Capacity: 4,000 Yard: FINCANTIERI

Cruise Line: ROYAL CARIBBEAN Ship: SYMPHONY Tonnage: 227,625 Capacity: 5,400 Yard: CHANTIERS



Cruise Line: NORWEGIAN Ship: BLISS Tonnage: 164,600 Capacity: 5,200 Yard: MEYER





Cruise Line: TUI Ship: MEIN SCHIFF 1 Tonnage: 110,000 Capacity: 2,900 Yard: MEYER TURKU





### Cruise Industry News



## Staying Agile



Jan Meyer, CEO

lue and orange coveralls and bright yellow hardhats

strolled across Meyer Turku's vast campus one recent afternoon. An abnormal string of sunny days had all of Finland in a jolly mood. With TUI Cruises' new 111,500-ton Mein Schiff 2 about to touch water for the first time and Costa's Smeralda laying in semi-constructed sections nearby, Meyer Turku CEO Jan Meyer had to be smiling too.

While an orderbook stretching into 2024 is good news, the seventh-generation shipbuilder sees it as a call to action, not a time to get comfortable.

"We have good times now and some stability, but we really need to use these good times to prepare for the future," Meyer said. "We have to look at ourselves and find ways to improve things. We cannot sit still, because our competitors – our state-owned competitors in France, Italy and China – are certainly not sitting still."

The Meyer pledge – to improve the family business for the next generation to inherit – requires long-term planning: Grow when the climate is right and be ready for harsher conditions.

A new 120-meter crane went online this summer. The monstrous blue staple-shaped tower on wheels can lift 1,200 tons – twice that of the yard's previous crane.

#### Ramp Up

The plan for Meyer Turku is aggressive and somewhat audacious. When Meyer Werft took control in 2014, the yard could complete a single 100,000-ton ship every year, with about 5,000 employees working. In 2016 and 2017 that increased to 7,000 employees able to build 150,000 tons a year.

Currently, the 2018 and 2019 capacity projects 9,000 employees able to complete 180,000 tons a year. Moving forward, Meyer Turku wants to add 6,000 more employees by 2021, so 15,000 workers could build a 190,000-ton ship every 10 months.

The ultimate goal is that by 2022, when Royal Caribbean's first Icon ship is

built, the yard will have capacity to construct 190,000 tons every eight months, with 17,000 employees pitching in.

The obvious hitch to hiring all these people is not only do they need to be skilled, they also need to speak the yard's operating language, Finnish – one of the world's less common tongues. To meet these goals the yard has undertaken a massing staffing outreach, retraining internal workers displaced by robotics, as well as attracting new talent.

The yard has an agreement with the government to re-educate the unemployed to be welders. After a six-month training course, there is a standing job offer from the yard.

The school also has transfer-of-skills trainings where architects and engineers from the residential home construction sector can be retrained to design and build ships. The training extends to suppliers and subcontractors wanting to train their people.

The staffing uptick is part of the yard's 200 million euro investment in infrastructure improvements, new technologies, and an expanded design team that will reduce reliance on outside contractors. That said, Meyer praised his supplier and contractor network.

#### Reliability

About 800 subcontractor companies work on each ship, so many that the city of Turku is considering zoning an industrial park outside the shipyard for them. If it's built, Meyer would see his subcontractors each day when bicycling in to work from the city center.

"We are a big economic factor," he said of the relationship with the city.

The Meyer family, who started their shipbuilding dynasty in 1795, found something of a kindred spirit in the Finnish yard. Founded in 1737 as Fithie/Åbo Gamla Skeppswarf, the Turku shipyard consolidated, merged, or changed ownership at least 25 times before Meyer Werft's purchase. The roots are deep and wide, encompassing a broad network and impressive longevity.

"When we came to Turku we found a very unique way of working together as a cluster has been developed," Mey-

### <u>Cruise Industry News</u>

#### ZERO EMISSIONS TARGET



We have to look at ourselves and find ways to improve things. We cannot sit still because our competitors – our state-owned competitors in France, Italy, and China – are certainly not sitting still.

er recalled. "Sometimes I get questions, like, why did you choose Finland to help a shipyard, why did you not choose Norway or Denmark or Sweden or somewhere. Actually, that's not the point. The point is here we have a heritage of 200 years we can build on. We cannot sleep on it but we can build on it. And that's important. That's the kind of starting advantage that is unique to us and not our competitors. We can use it. And also, we are permitted to improve this collaboration and really bring this supplier collaboration to the next level. We also need to try as best we can to get long-term visibility. We want to get the orders ready so they can plan from the supplier side. Also, with this sort of longterm visibility we can develop processes and build teams."

The cruise industry is always excited about innovation: efficiency, maneuverability, amenities, environmental sustainability, visually pleasing spaces, etc. While these things are important, so too is reliability. If, late in the process of building a ship, there is uncertainty that a design or concept will work, the customer has every right to be disappointed. "This kind of thing is unacceptable," Meyer said.

"What's often overlooked is the aspect of reliability. That is something we should maybe focus more on in cruise-ship building. That is a real value," Meyer said. "This reliability, aside from our ability to offer a competitive package, innovation and a reasonable price, is an important factor in why we have an orderbook going into 2024."

Meyer said it's difficult to discuss innovations because his cruise line customers almost always want to be the first to reveal what's new. It's easier to discuss the process.

"It's about finding solutions. Design-

ing and building a ship is all about finding the best compromise for contradictory requirements," Meyer said. "Cruise-ship building is a lot about collaboration. So we have cooperation with our customer's architects. The customer has a concept for a restaurant. What they want to serve there. How they want to utilize the space. And of course they don't want to see any pillars whatsoever. For us, pillars are very good for the steel structure, but not very good for internal visibility. So we need to find a good compromise between these contradictory aims."

He gave the example of Mein Schiff's 50-meter wide diamond-shaped window structure. The glass wall at the aft of the ship needed to be stable but without cumbersome, view-blocking support pieces. Furthermore, the ship will twist ever so slightly because of propulsion and waves. "Even if there was a shift of just a few millimeters the stress on the windows would be enormous."

Meyer's design team had to perform an engineering feat. Through rigorous computer modeling and testing they were able to predict vibrations. They were able to remove most of the pillars, allow for stress reduction on the windows, and at the same time keep the room quiet and scenic.

"The ability to predict it allows us to tell the architect, 'Okay, we can remove that pillar.' And so it's visually appealing and still serves as a quiet space. And, of course, we need to do it together with a turn-key outfitter that's working in the aft part of the ship and is actually building it. And then it all needs to fit on the timeline," Meyer said. Building the same class of ship several times gives Meyer's team a chance to experiment and perfect designs. "It allows us to try out our computer models. The computer helps a lot, but does it reflect reality? That's the important question."

Revamping the shipyard by ramping up staffing and tonnage building capabilities, all while remaining innovative and price competitive – all in a five-year window – is similar to how Meyer described Mein Schiff's giant glass diamond windows.

"It looks simple. That's how it should be. But it's actually difficult to implement."

### Cruise Industry News

## The Hydrogen Alternative

n order to reach IMO's 2050 goal of 50 percent CO2 reduction in emissions from shipping, Tomas Tronstad, managing director at Hyon, said he sees two solutions: Batteries for ferries and short-sea operators; fuel cells and hydrogen for larger powerplant installations, like cruise ships.

"I expect the shipping fleet to look very different in 2050," he said, "and I don't expect to see the ships that are sailing today.

"Future ships may be larger because they will need bigger tanks to accommodate new fuels, such as hydrogen, methanol and perhaps ammonia, NH3, which has no carbon content."

#### **Ferries First**

Based in Norway, Tronstad said there are many hydrogen-fueled ferry projects as the Norwegian authorities have begun to stipulate zero emission vessels in certain areas, and are requiring hydrogen as Future ships may be larger because they will need bigger tanks to accommodate new fuels, such as hydrogen, methanol and perhaps ammonia, NH3, which has no carbon content.

a way of stimulating the development of the hydrogen industry in the country.

Hydrogen-run fuel cells are common on buses and trucks, he said, with the hydrogen stored in pressurized tanks.

Since hydrogen is very light, the tanks are pressurized at 700 bar containing 5 kilos of gas giving an average car a range of some 500 km. He said the tank size was comparable to a standard gas tank. Hyon is a joint venture between Nel Hydrogen, Hexagon Composites and Powercell of Sweden, thus offering a one-stop hydrogen and fuel cell solution, targeting marine industries, including cruise lines.

#### **Green Potential**

There are generally two ways to produce hydrogen today, Tronstad explained, with water (HO2) or natural gas (CH4) being the raw materials.

While using natural gas will mean CO2 emissions from the production; using power from renewable sources to split water in an electrolysis process means no CO2 and the resulting hydrogen can be considered renewable.

"NEL, only participates in projects based on renewable energy sources," Tronstad added.

He said hydrogen can be considered a "difficult" gas, as it is very light and has very small molecules, but taking that into

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When you pay for power, you are also paying for the grid, for the infrastructure. We will produce hydrogen using renewable energy, but not from the grid. We will produce the hydrogen where the power is being generated, and then transport the hydrogen to where it will be used. This will reduce costs significantly.

account, it is not difficult to design safe systems. He said that hydrogen is very predictable gas and does not pose any greater risks than gasoline or diesel fuel.

Thus, Hyon has received approval-in-principle from DNV-GL for its module-based fuel cell solutions, adapted for maritime use. The approval builds on the MS-100 hydrogen PEM (Proton Exchange Membrane) fuel cell system from Power-Cell for general application in ships.

The approval covers smaller modules of just a few hundred kilowatts to multi-megawatt units.

#### **PEM Fuel Cells**

Tronstad explained that PEM fuel cells are the standard already used in motor vehicles. He described them as very dynamic, operating effectively at different loads.

"At PowerCell/Hyon we have developed the world's lightest and most compact marine fuel cell solutions," he said. "So the fuel cells should not be a showstopper for large hydrogen cruise vessels."

What needs to be done next is to provide bunkering opportunities and to bring down costs. Explained Tronstad: "When you pay for power, you are also paying for the grid, for the infrastructure. We will produce hydrogen using renewable energy, but not from the grid. We will produce the hydrogen where the power is being generated, and then transport the hydrogen to where it will be used. This will reduce costs significantly."

Meanwhile, in the United States Nikola Motor Company is rolling out infrastructure for hydrogen production and filling stations (from Nel) for trucks. Maritime bunkering stations may be next.

The AIDAnova will be powered by dual-fuel powerplants from Caterpillar Mak.

## LNG vs. **Liquid Fuels**

deal powerplant solutions depend on operational profiles and areas of operation, according to John Shock, responsible for the cruise and ferry market for Caterpillar Mak.

"LNG is a very good solution," he continued, "and we are seeing both the cruise and ferry markets moving faster to LNG than other shipping segments. The progress has been huge, but gas is still not universally available, it carries higher capital costs and has some different performance characteristics that shipowners nevertheless are able to offset against better environmental performance."

When the first LNG-fueled cruise ship, the AIDAnova, enters service later this fall, she will have Caterpillar Mak engines and related systems, as will a sister ship slated for 2021 delivery, in addition to two LNG-fueled ships for Costa Crociere.

### **Proven Engines**

"The most proven powerplants remains the diesel engine running on MGO or with catalysts (SCRs) with HFO, Shock continued.

When Holland America Line's Nieuw Statendam enters service in November, she will feature a diesel electric Caterpillar Mak powerplant.

Shock said today's generation of diesel engines are very efficient and that fur-

Every cruise operator is hyper-focused on every aspect of the environmental impact of their operation from bilge water to wastewater, air emissions.

ther gains would most likely be small and incremental, and that more efficiencies would come from systems and operating procedures.

"The diesel engine can be more efficient," he said, "but we are restrained by emissions. Most of the modifications we do to the engines to reduce emissions, make them less efficient.

"We have been able to run our highspeed engines more efficiently at a higher emission level because the SCRs are so effective that we meet the IMO III requirement at the stack. The engine is 2 to 3 percent more efficient and by increasing the efficiency we are offsetting the cost of the urea (in the SCR system)."

As for scrubbers, Shock described the technology as transitional. "Scrubbers are improving and maturing," he said, "but many operators I talk to are not yet sold that they are reliable, cost effective and long-term viable. One issue is how to deal with the waste of closed-loop systems.

"Every cruise operator is hyper-focused on every aspect of the environmental impact of their operation from bilge water to wastewater, air emissions."

**AIDA**nova

#### **Data Analytics**

Caterpillar Mak is also focused on the digital realm, according to Shock. "Our data analytics system captures data that allows the shipowner to operate the engines more efficiently, minimizing fuel consumption, making sure that energy is being produced efficiently as well, and schedule optimized, condition-based maintenance.

"We also have an advisory power management system, which is a multi-engine optimizer, managing different loading on several engines at the same time.

"It (environmental regulations and technology development) is not going to stop," Shock said. "By 2050, the IMO is requiring a 50 percent reduction in greenhouse emissions."

As to whether a powerplant can become totally carbon neutral, he said: "As long as we operate on carbon-based fuels, I do not see how we can become carbon neutral. Today, LNG and methanol start out as natural gas, and if you are consuming energy to create fuels, even though the emission properties may be substantially better, you cannot get to zero emissions.

"It may eventually take new alternative fuels, energy storage or energy conversion systems and different technologies like fuel cells. To get to zero emissions, we are going to have to go the way of renewables."

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### Cruise Industry News



ith the AIDAnova slated to start regular service in the Canary Islands in December, Carnival Corporation has been working on the LNG bunkering processes and procedures not only for the new AIDA, but also for the Costa and Carnival ships that will follow.

Carnival has contracted Shell to supply AIDA and Costa with LNG in Northern and Southern Europe and Carnival in South Florida. A bunkering solution for P&O's new ships, which will also be LNG-fueled, was in the discussion stage in late May, according to Tom Strang, senior vice president of maritime affairs.

#### **Bunker Vessels**

Strang explained that the first bunkering of the AIDAnova will be done in Emshaven, under the responsibility of the Meyer shipyard, in conjunction with the delivery. The next bunkering is scheduled for Rotterdam, after which the ship will bunker in the Canary Islands, starting in early December.

"Because of the volume we are going to consume, LNG will be supplied by a bunker vessel," he continued. "Shell already has a bunker vessel, the Cardissa, based out of Rotterdam, and has another vessel under contract that is currently being adapted to bunkering.

"There are only six bunkering vessels for LNG in the world of which two will be dedicated to our trade going forward."

A barge is under construction for bunkering in South Florida that will be ready by the first quarter of 2020.

The LNG capacity of the new cruise ships will be 3,620 cubic meters in three tanks, Strang said. "The typical maximum bunkering load we can take will be just over 3,000 cubic meters, which should take from six to 10 hours, a little bit longer than traditional bunkering, but not significantly so."

The ships will be dual fuel, meaning they will also carry MGO onboard as a pilot fuel and to satisfy the safe return to port requirements.

#### **Approvals**

In order to bunker, Shell needs approval permits in every port, Strang explained. He described it as a complex process where Shell has to run risk and hazard assessments together with the ports and authorities, unlike bunkering HFO or MGO that do not require a similar approval process.

"Typically, specific solutions have to be

developed for each port because the rules and regulations related to getting certification are different; there is no consistent or internationally agreed standard at this the present time," he noted.

For bunkering in Rotterdam, for example, Strang said that much work has been done to develop procedures and processes as well as risk and hazard models with the cruise terminal in the center of the city. With the work nearly completed at press time, Strang said he saw no issues and that discussions were underway with a number of ports to get bunkering permits in place.

"If you move out of Northern Europe, it (LNG bunkering) becomes more challenging and that is why we have to start working early, but we are already seeing development, like in Spanish ports with smaller bunkering vessels. We are also seeing more companies selecting LNG as a fuel post 2020 and as that happens we will see the bunkering options develop faster."

#### Protocol

"As part of the process we have gone through with Shell we have developed a very specific bunkering protocol," Strang said.

"We are still discussing a safety distance, but typically a 25 meter horizontal safety zone is common. Vertically, with all the dispersions modeling that has been done, we have never had a situation where LNG has entered into the ship through any of the openings in the side. That being said, we are also taking into account what may be happening on open decks so we will have procedures making sure we are always safe."

The cruise line's class society must approve the procedures as must the class society for the bunkering vessel along with the port and local authorities, before permits are granted.

Strang added: "If we had waited until the infrastructure was there before placing orders we would only now be thinking about possible orders. We took the view that this is the best fuel available for environmental performance and a number of other reasons, and then we entered into partnerships to build the infrastructure when and where we need it." ■

ZERO EMISSIONS TARGET

Starting the hull assembly of the Color Hybrid in Poland this spring, from left: Krzysztof Kulczycki, co-owner of the CRIST shipyard; Trond Kleivdal, CEO of Color Line; and Gunvor Ulstein, CEO of the Ulstein Group.

## Building Largest Hybrid Vessel

hen the Color Hybrid launches service in the second half of 2019, the ferry will become the largest hybrid plug-in vessel. At approximately 528 feet in length, she will be able to accommodate 2,000 passengers and up to 500 cars, sailing between Sandefjord, Norway, and Strømstad, Sweden.

Norway's Color Line, which also runs cruise ferries between Norway and Germany in addition to other ferries, contracted the newbuild with the Ulstein Yard, which is assembling the hull at the CRIST shipyard in Gdynia, Poland, before towing her to Ulsteinvik in Norway in October for completion.

Explained Jan Helge Pile, senior vice president of technical and marine: "Our hybrid vessel is diesel mechanical and electrical mechanical. We run the diesel engines when crossing the Oslofjord, while switching to battery power going into and out of Sandefjord, and connecting to shorepower while alongside."

While Color Line now operates a conventional ferry on the same route, Sandefjord has stipulated new environmental regulations for the port, offering preferential pier space to vessels offering the lowest air and sound emissions among other requirements.

The Color Hybrid will have four main engines, compared to the traditional solution of four main engines and four auxiliary engines, according to Pile. In addition will be lithium ion batteries rated at 5 MWh. There will be four battery packs, with a combined weight estimated at 60 to 70 tons, in two separate battery rooms. The battery pack and related systems are supplied by Siemens. The ship will also have a heat recovery system.

"We turn the engines off about 3.2 nautical miles from Sandefjord and switch to battery power," Pile said. "Once we are alongside and moored, we switch to shorepower for the ferry and to recharge our batteries. The power source is renewable, it is hydroelectric. However, if there should be a power failure, we can recharge the batteries during the crossing.

"We stay overnight, although during the day we do a 50-minute turnaround.

"When we leave, we disconnect from shorepower and sail on battery power for 3.2 nautical miles, which takes about 25 minutes. Then we turn the engines back on. They run on MGO.

"It is a seamless transition," he added.

Not only will the Color Hybrid's turns and overnight stay in Sandefjord be without emissions, they will also be quiet, with no engine sounds disturbing the residential housing adjacent to the port.

### Cruise Industry News

## LNG ORDERBOOK

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The P&O lona is due for a 2020 delivery.

Cost(1) Sailing Delivery **CRUISE LINE** Ship Tonnage Capacity Yard Year **AIDA CRUISES** AIDAnova \$950 5.200 TBA 183.900 Meyer December 2018 \$950 183.900 5.200 2019 COSTA CRUISES Smeralda Meyer Turku | Europe October Ν CARNIVAL Unnamed \$950 183.900 5.000 Meyer Turku TBA TBA 2020 G **P&O CRUISES** Unnamed \$950 183.900 TBA TBA 2020 5.200 Meyer \$950 **AIDA CRUISES** Unnamed 183.900 5.400 Meyer TBA 2021 Spring **VIKING OCEAN** TBD TBD TBD VARD TBD Q2 2021 Unnamed S PONANT Unnamed \$324 30.000 270 VARD World Q2 2021 Н **COSTA CRUISES** Unnamed \$950 183.900 5.200 Meyer Turku TBA TBA 2021 TBA DISNEY Unnamed \$900 140.000 2.500 Meyer TBA 2021 **ROYAL CARIBBEAN** Unnamed \$1.100 200.000 5.000 Mever Turku TBA Q2 2022 D TBD TBD TBD VARD TBD Q2 2022 **VIKING OCEAN** Unnamed CARNIVAL Unnamed \$950 183.900 5.000 Meyer Turku TBA TBA 2022 S DISNEY Unnamed \$900 140.000 2.500 Meyer TBA TBA 2022 **MSC CRUISES** Unnamed \$1.200 200.000 5.400 Chantiers TBA TBA 2022 **P&O CRUISES** Unnamed \$950 183.900 5.200 Meyer TBA TBA 2022 Ω **AIDA CRUISES** Unnamed \$950 183.900 5.400 Meyer TBA Spring 2023 Ν \$900 2.500 TBA DISNEY Unnamed 140.000 Meyer TBA 2023 **MSC CRUISES** Unnamed \$1.000 177.100 4.888 STX France TBA TBA 2023 \$1.000 175.000 2023 PRINCESS Unnamed 4300 Fincantieri TBA TBA 0 5.000 TBA Q2 2024 **ROYAL CARIBBEAN** Unnamed \$1.100 200.000 Meyer Turku R \$1.200 200.000 TBA 2024 **MSC CRUISES** Unnamed 5.400 Chantiers TBA \$950 161.000 2024 Unnamed 4.000 Fincantieri TBA TBA TUI D \$1.200 200.000 5.400 TBA TBA 2025 **MSC CRUISES** Unnamed Chantiers Ε PRINCESS Unnamed \$1.000 175.000 4300 Fincantieri TBA TBA 2025 R **MSC CRUISES** Unnamed \$1.200 200.000 5.400 Chantiers TBA TBA 2026 TBA Unnamed \$950 161.000 4.000 Fincantieri TBA 2026 TUI

(1) IN MILLIONS

ZERO EMISSIONS TARGET

# Turbine **Power**

s the LNG story evolves and cruise ships also get larger, the benefits of the gas turbines become even more attractive, according to Mark Lipton, director of commercial applications engineering for GE's Marine Solutions.

"Bigger tanks for LNG will favor the smaller footprint of the turbines," he said, "and when the power demand also goes up for the larger ships, we can fulfill that in much less space than you need for diesel engines. If you think 100 MW, that will take a lot of diesel engines, but only two gas turbines. Our value story gets stronger and stronger.

"There is also talk of expanding the ECA zones for NOx emissions, and that would also play in our favor. While diesels do well on LNG, they need exhaust treatment for liquid fuels, which means more space and costs. The turbine meets ECA requirements with LNG or MGO without any exhaust treatment."

### **17 Cruise Ships**

Today, there are 17 cruise ships with GE turbines, eight are fitted with COG-ES (COmbined Gas Turbine Electric and Steam) systems and nine with CODLAG (COmbined Diesel Electric And Gas) systems.

As turbines need to run at higher loads to be efficient, Lipton said he can envision a future hybrid low emissions solution with turbines running on LNG combined with fuel cells.

"We are partnering with fuel cell suppliers and developing relationships," he said.

As for GE's LM2500 family of turbines, which was rated at 17 MW when it was first introduced on a naval vessel in 1969, it is now rated at more than 35 MW and is also more efficient.

"We have improved the power and efficiency," he said, "while also extending service intervals. Turbines usually run for up to 50,000 hours before major overhauls, and we have seen turbines running If you think 100 MW, that will take a lot of diesel engines, but only two gas turbines. Our value story gets stronger and stronger.

up to 200,000 hours before being retired. In terms of reliability, I think the cruise lines are very happy with us."

#### **Power Density**

The key to running a turbine efficiently is to operate at high loads, but that means more power than needed when a ship is in port. Hence the combination with a diesel engine is needed when the power demand is less, or in the future, with fuel cells. At less than 50 percent load, the efficiency curve of the turbine dips below that of the diesel engine, as much as 10 percent.

With turbines seeming to be the powerplant of choice for navies around the world, Lipton said that is because naval vessels usually have a much higher top speed design – all above 30 knots. Hence, the power density of the turbine is ideal for naval applications.

For large cruise ships, Lipton said that two gas turbines in separate engine rooms would provide enough power and redundancies to satisfy the safe return to port requirement, also noting the space saving features of the relatively small turbines.

As an example, Lipton explained that

despite the larger tanks on container ships running on LNG, turbines could provide so much space savings that the ships could actually carry more containers than before.

### Dual Fuel, Hybrid and Tomatoes

As for dual fuel applications, Lipton mentioned the Buquebus ferry sailing between Buenos Aires and Montevideo. It operates its turbines on LNG while at sea and on MGO in the harbor and alongside, according to Argentinean regulations. He said the switchover is automatic.

"GE turbines have run on gas for more than 45 years," he added."We know how to do this. We also have a powerplant installation in Norwalk, California, that operates a turbine in combination with batteries, feeding into the grid for the local utility company."

Further reduced emissions and even zero emissions can also be achieved by carbon capture and trading systems, according to Lipton. He noted a powerplant in Colorado where the carbon dioxide from the turbine plant is used in greenhouses to grow tomatoes.

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