DNV·GL

FERRY AND RO-RO UPDATE

2018

- Regulatory update
- World's largest short-sea ro-ro
- Electrification in Norway
- Hydrogen ferry

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Cover photo: aenfotografi.no/Brødrene AA

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DEAR READER,

The shipping world is undergoing dramatic changes: the environmental agenda is forcing all of us to rethink ship propulsion and develop entirely new concepts. At the same time, digitalization and smart technologies are opening up new opportunities to streamline ship operation and management. The ferry segment is in a unique position to pioneer such developments: with relatively small ship sizes operating on short, precisely defined routes, typically in placid waters, conditions are ideal for trying out advanced technologies such as battery power and automation – for the benefit of the rest of the shipping industry.

This issue of FERRY AND RO-RO UPDATE is full of inspiring reports about the state of the art in ferry and ro-ro shipbuilding. Read about the "twin sisters", two new, record-sized ro-ro vessels incorporating technology from deep-sea vessels to take efficiency and flexibility to the next level. With the LNG-ready class notation, they will be able to switch to LNG as soon as bunkering infrastructure is available and LNG prices are attractive; many believe this will be the case in the foreseeable future.

Our compact, yet detailed environmental outlook goes through all the recent, upcoming and potential future rules and regulations facing our industry. What all this means for future engine types and fuel options is the subject of our summary of the current state of scientific and market research. A case study gives a concrete example of what these options could mean for a PCTC.

Advances in battery technology, Norway's successful electrification of local sea transport and the country's rapidly growing fleet of green ferries send an encouraging message into the world: the energy transition is progressing rapidly! Even hydrogen as a ship fuel is now the subject of a joint development project. International cooperation between manufacturers, governments and shipping companies is powering the ascent of hybrid power systems on larger vessels, and DNV GL has played a key role in bringing the stakeholders together and ensuring the safety and reliability of the electrical systems.

With unrivalled expertise and deep involvement in research and development activities, DNV GL is in a unique position to guide the way into the age of eco-friendly shipping. We look forward to seeing you at the Interferry Conference in Cancún!

Enjoy reading!

FERRY AND RO-RO UPDATE

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UNPRECEDENTED SIZE AND FLEXIBILITY

After the first year of operation, *Celine* has fully met her owner's expectations. She and her sister vessel *Delphine* incorporate state-of-the-art technology from other ship types and are LNG-ready.

In a growing network of routes now extending from Norway to Portugal, supersized vessels like *Celine* make economic sense.

A few years ago the Luxembourg-based company CLdN Ro-Ro made a decision to build the world's two largest short-sea ro-ro vessels. But setting a new size record to impress the shipping world was not the objective.

"The reasons behind this project were very simple, really," says Gary Walker, Director of CLdN. "First of all, we operate in the very competitive North Sea market, and larger vessels bring down the unit price. Second, we are covering longer distances than before, and bigger vessels work better on long hauls."

CLdN have expanded their route network from Zeebrugge, Rotterdam, London and Killingholme, into Sweden, Ireland, Denmark, Portugal, and now Santander in Spain. "Ordering newbuilds always gives us the option to take advantage of advances in technology and design, but the larger vessels also made it possible to transfer the best of deep-sea technology to ro-ro," Walker points out. Examples are new developments in thrusters, rudders and engines.

Learning new tricks

At 74,000 gross tonnes *Celine* and *Delphine* are 235 metres in length, and offer a capacity of 8,000 lane-metres. "We had to tailor these vessels to fit exactly to their surroundings, and they are practically as big as they can get. But thanks to the advanced design and technology, these ships are still very manoeuvrable, in spite of their very large dimensions," Walker confirms. The exterior dimensions were not the only challenges the new ships presented for CLdN, he adds. Embracing new technologies across the board meant that the engine room staff had to adapt to operating two-stroke engines rather than the four-stroke units typical for the rest of the fleet.

Electrical engineers met challenges too, having to move from low to medium voltage, and operating shaft generators at variable rotational speeds with frequency converters, rather than constant-speed engines. There were changes in operations as well, with larger volumes and more decks demanding more complex loading and unloading procedures, and better coordination and efficiency in port.

Despite the challenges, Walker is clear that experience with the big twins has met or exceeded expectations so far. "We are almost one year in with *Celine*, and she is exactly what we hoped she would be." The same goes for *Delphine*, he says, in operation since February 2018. "There are always some teething problems with new ventures, but overall it has gone very well. The biggest gamble was size, but any concerns we had have gone away."

"Using LNG as fuel is becoming more and more realistic. A lot depends on the pricing of fuel oil against LNG, but my gut feeling is that the horizon is near."

Gary Walker, Director of CLdN

Up next: LNG

The twins also represent CLdN's first gas-ready vessels, meaning they are ready for conversion to LNG when the time is right. Class partner DNV GL has been instrumental in guiding them into these new waters using their Gas Ready notation. "The relationship with DNV GL is good overall, and cooperation has gone very smoothly. They assisted with the gas drawings to prepare the ships for LNG, and they were very helpful in clarifying the rules."

Bas Veerman, BeNeLux Business Development Manager for Maritime at DNV GL, adds that the Gas Ready class notation has several levels and corresponding requirements. "The minimum level confirms that the vessel complies with rules for LNG-fuelled ship design and the main engine can be converted to gas or dual-fuel operation, or is dual-fuel ready. Optional levels may indicate different preparations of the ship for later conversion, such as certification and installation of parts of the LNG fuel system."

Gas-ready is more than a hypothetical case for CLdN, Walker assures. "It's not a case of 'whether', but rather of 'when'," he states. "Using LNG as fuel is becoming more and more realistic. A lot depends on the pricing of fuel oil against LNG, but my gut feeling is that the horizon is near. We are using very-low-sulphur fuel for the present, but the target fuel is LNG."

Better, not just bigger

Celine and *Delphine* have been widely publicized as the largest of their kind in the world, and Gary Walker assures that CLdN appreciates the attention their innovation has received. But, he maintains, it's about more than just big ships. "We designed these two with the ultimate flexibility for our types of cargoes on the longer routes. They have the ability to switch from 100 per cent dedicated cargo to any degree of cargo mix, from cars to double-stacked containers to project cargo. That flexibility is paying off. The combination of increased size and future-proofing these big ships for different cargoes has worked very well."

The next CLdN vessels in the pipeline are 217 metres in length with 5,400 lane-metres, ostensibly representing fewer challenges than their big sisters. So why didn't they start small, rather than take the big leap? "Our next ships are dimensioned for shorter-haul trade, but with the same technology and design advances, so they should be even easier to bring on line. We might have started with the smaller ships and moved on from there, but for various reasons the decision was made to order the larger ships first. Looking back, we took the hard road and it has paid off." **KG**

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Photos: DNV GL, CLdN, Stedman Photography

Increased capacity and flexibility enable *Delphine* and her sister ship to transport not only vehicles but also containers and project cargo.

Tonnage 74,000 GT

Length overall 235 m

Capacity 8,000 lane metres

TOWARDS ZERO EMISSIONS: ENVIRONMENTAL OUTLOOK

While the world is struggling to live up to its commitment to limit climate emissions, new data indicate that climate change may be more severe and occur more rapidly than anticipated earlier. IMO is looking for ways to make shipping climate-neutral over the next decades. DNV GL gives an overview of the status of the discussion and potential future measures.

When the Paris Agreement was adopted in 2015 in response to the increasing signs of global climate change, shipping and aviation were not included. Instead, IMO and ICAO were asked to come up with greenhouse gas (GHG) emission reduction schemes of their own. At MEPC 72, IMO adopted a strategy to reduce emissions from shipping. This aims to reduce total emissions from shipping by at least 50 per cent by 2050, and to reduce the average carbon intensity by at least 40 per cent by 2030 while aiming for 70 per cent in 2050, all figures compared to 2008. The ultimate vision of IMO is to phase out greenhouse gas emissions entirely at the earliest time possible within this century. This initial strategy will be reviewed in 2023 based on information gathered from the IMO Data Collection System (DCS) as well as a fourth IMO GHG study to be undertaken in 2019.

As it must be assumed that global shipping activity will continue to grow towards 2050, the 50 per cent emission reduction target is quite ambitious and will most likely require widespread uptake of zero-carbon fuels in addition to other energy efficiency measures. However, there are no zero-carbon fuels available today. A concerted research and development effort is needed not only to develop such fuels but also to make them available in the required volumes.

To implement its ambitious strategy IMO must develop new policy measures and regulations. The strategy contains a long list of options, such as strengthening

IMO is looking for strategies to eliminate greenhouse gas emissions from ships by 2100.

the energy efficiency design index (EEDI), applying operational indicators, reducing speeds, rolling out market-based measures, or developing zero-carbon fuels. Work on an action plan to kick-start the development of appropriate measures will start this autumn.

While limited immediate impact on ships is to be expected, the efforts required to reach the long-term goals must be built over the coming years, with a real impact starting to materialize in the 2020s. In a long-term perspective, DNV GL expects this strategy to fundamentally change the way ships are designed and operated.

More information on low-carbon shipping and alternative fuels is available at **www.dnvgl.com/low-carbon-shipping** and **www.dnvgl.com/alternative-fuel.**

CO_2 data collection in the EU and at IMO

In the EU, regulations for monitoring, reporting and verification (MRV) of CO_2 emissions have entered into force, requiring all ships above 5,000 GT sailing to or from European ports to report CO_2 emissions, cargo data and average energy efficiency. 2018 is the first year of reporting, with data being published annually by the EU as of mid-2019.

One purpose behind the EU MRV regulations was to encourage IMO to work on a similar mechanism with global coverage. The EU regulation itself contains a provision for a review aimed at alignment with a future international system, if in place. It is therefore significant that IMO has adopted a global mechanism for mandatory monitoring, reporting and verification of fuel consumption data for all ships of 5,000 GT and above. The scheme, known as the IMO Data Collection System (DCS) on fuel consumption, will have 2019 as its first year of operation.

The IMO DCS differs from the EU MRV in several important aspects, including the confidentiality of data, the calculation of efficiency metrics, and the requirements for data verification. While these are all issues where the EU has a strong preference for the requirements of its own system, the European Commission has nevertheless initiated a formal review process aimed at aligning the EU MRV with the IMO DCS. There are encouraging signs of a legislative proposal to be published in 2018, though it is expected to be challenging and likely time-consuming for the commission, the parliament and the council to come to an agreement. DNV GL believes that full alignment is unlikely, and that the industry must expect to cater to both reporting regimes for the foreseeable future.

More information on EU MRV and IMO DCS is available at **www.dnvgl.com/mrv** and **www.dnvgl.com/dcs.**

SO_x regulations

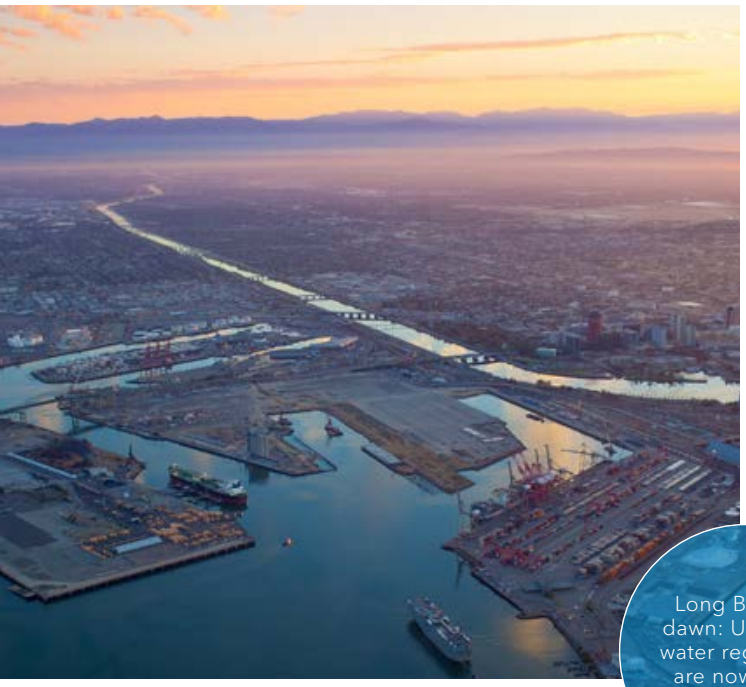
IMO has agreed that the 0.5% global sulphur cap will be implemented from 1 January 2020. The decision is final and will not be subject to renegotiation, which gives certainty to the maritime and bunker industries. There were intense discussions on both the practicalities of implementation and on how to ensure robust enforcement and a level playing field. IMO is continuing to discuss implementation and supporting measures on a priority basis and held an intersessional meeting dedicated to the topic in July.

The EU's CO_2 monitoring, reporting and verification (MRV) scheme is in effect as of 2018.

A series of guiding documents are expected to be published after completion at MEPC 73 (Oct. 2018) and MEPC 74 (May 2019). Ship operators will have to choose their preferred compliance strategy, a decision with far-reaching operational and financial implications. There is no one-size-fits-all solution on the table; scrubbers and LNG are both realistic options, but most vessels are expected to default to using 0.5% marine gas oil (MGO) and blends, at least initially. Local availability issues and price volatility are expected to result from the dramatic change of the fuel demand situation as of 1 January 2020, and the number of non-compliance cases, especially because of insufficient tank cleaning at bunker facilities and on board ships, is likely to be rather high during a transitional period.

Enforcement remains a critical concern, especially on the high seas. Contrary to emission control areas (ECAs), where enforcement is up to the respective port state, monitoring of operations on the high seas is the responsibility of the flag state. Legitimate questions are being asked about the readiness of all flag states to provide uniform and robust enforcement to ensure a level playing field around the globe. To some extent alleviating the enforcement issue, IMO at MEPC 72 agreed to establish a ban on the carriage of non-compliant fuels for all ships without scrubbers. This ban is considered certain to be adopted at MEPC 73 and will then take effect in March 2020. Ships without scrubbers will still be allowed to carry non-compliant fuel as cargo.

Moving to regional and domestic matters, it should be noted that in the EU the Water Framework Directive is imposing restrictions on the discharge of scrubber water. Belgium and Germany have prohibited the discharge of scrubber water in most areas, thereby limiting the operability of open-loop scrubbers. >



Long Beach at dawn: US ballast water regulations are now being fully enforced.

> Similar restrictions apply in some US coastal waters, e.g. off Connecticut.

In Asia, China's regulations for domestic SECA-like requirements are being rolled out in the sea areas outside Hong Kong / Guangzhou and Shanghai as well as in the Bohai Sea. China is taking a staged approach, initially requiring a 0.5% maximum sulphur content in fuel burned in key ports in these areas, gradually expanding the coverage to finally apply fully to all fuels used in these sea areas from 2019 onwards. China has furthermore recently announced its intent to expand the original three areas to a full 12 NM zone along its entire coastline from January 2019. Conceivably the allowable sulphur content will be tightened to 0.1% as early as 2020, and China may eventually submit a formal ECA application to IMO. In our view a formal IMO ECA application would carry with it a real possibility of coverage being extended to include further parts of Chinese sea areas.

More information is available at **dnvgl.com/maritime/publications/global-sulphur-cap-2020.html.**

NO_x regulations

The NO_x Tier III requirements have entered into force in the North American ECAs for ships constructed on or after 1 January 2016. Anyone constructing a ship today needs to consider whether operation in the North American ECAs will be part of the operational pattern, whether upon delivery or at any time in the future. If so, NO_x control technology will be required on board. When choosing an NO_x control technology operators should consider how they intend to ensure compliance with the 2020 sulphur cap to avoid system integration issues.

With respect to upcoming regulations, IMO has agreed to apply NO_x Tier III requirements to ships constructed on or after 1 January 2021 when operating in the North Sea and Baltic Sea ECAs. There are presently no indications of plans for additional NO_x Tier III areas.

China has recently announced that vessels imported after 1 September 2018 for domestic traffic will be required to adhere to Tier II requirements irrespective of construction dates. China is also considering expanding the Tier II requirements to cover all vessels in domestic trade, possibly in mid-2021.

Ballast water management

The Ballast Water Management (BWM) Convention entered into force on 8 September 2017, more than 27 years after the start of negotiations, and 13 years after its adoption in 2004. The implementation schedules was revised at MEPC 71 in July 2017. Briefly put, every ship in international trade will be obliged to comply at some point between 8 September 2017 and 8 September 2024. For ships from 400 GT upwards, the compliance date is linked to the renewal of the International Oil Pollution Prevention certificate, while ships below 400 GT must comply by 8 September 2024. By that date the entire world fleet must be in compliance.

In the US, the domestic ballast water management regulations entered into force in 2013. New ships were to comply upon delivery, while existing ships were to comply by the first scheduled dry-docking after 1 January 2014 or 2016, depending on ballast water capacity. USCG type approval is required for ballast water treatment systems; as of 26 July 2018 nine such approvals had been granted, with ten more in the approval pipeline. The USCG's previously liberal extension policy granting deferred installation dates to more than 12,500 ships due to the unavailability of approved systems has changed since the first type approvals were issued. Presently the USCG is very restrictive on granting extensions and this policy is likely to tighten further. In practical terms, operators should now plan their installation dates based on the compliance dates in the regulation and not gamble on receiving an extension.

For more information on ballast water-related topics please visit **dnvgl.com/bwm.**

Emerging issues

There are a number of new environmental regulations under consideration at IMO as well as in various countries. They cover a broad range of topics, such as plastic pollution from ships, the impact of noise on cetaceans, particle emissions, hull biofouling, and a ban on heavy fuel oil in the Arctic. The discussions are at various stages; New Zealand, for example, introduced biofouling regulations in May this year. The noise issue is primarily a concern of a few isolated stakeholders, while plastics and an Arctic HFO ban are under consideration at IMO. Nevertheless, most if not all of these topics are likely to be the subject of further domestic or international regulations sooner or later during the next decade. **EN**

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Photos: DNV GL, Courtesy of the Port of Long Beach

THE FUEL CHALLENGE IN SHIPPING

Public pressure on the shipping industry to reduce greenhouse gas and other emissions is increasing, and port cities demand an end to air pollution from visiting vessels. The shipping community is responding but finding that any long-term solutions require thorough evaluation.

Download the white paper from **dnvgl.com/alternative-fuel**

In April 2018 IMO resolved to reduce total emissions from shipping by at least 50 per cent by the year 2050 compared to 2008, and to cut the average carbon intensity by at least 40 per cent per unit of transport by 2030, aiming for a up to 70 per cent reduction by 2050. Greenhouse gas (GHS) emissions are to be phased out entirely within this century. This tentative goal will be reviewed in 2023 based on information gathered from the IMO Data Collection System (DCS) and a fourth IMO GHG study planned for 2019.

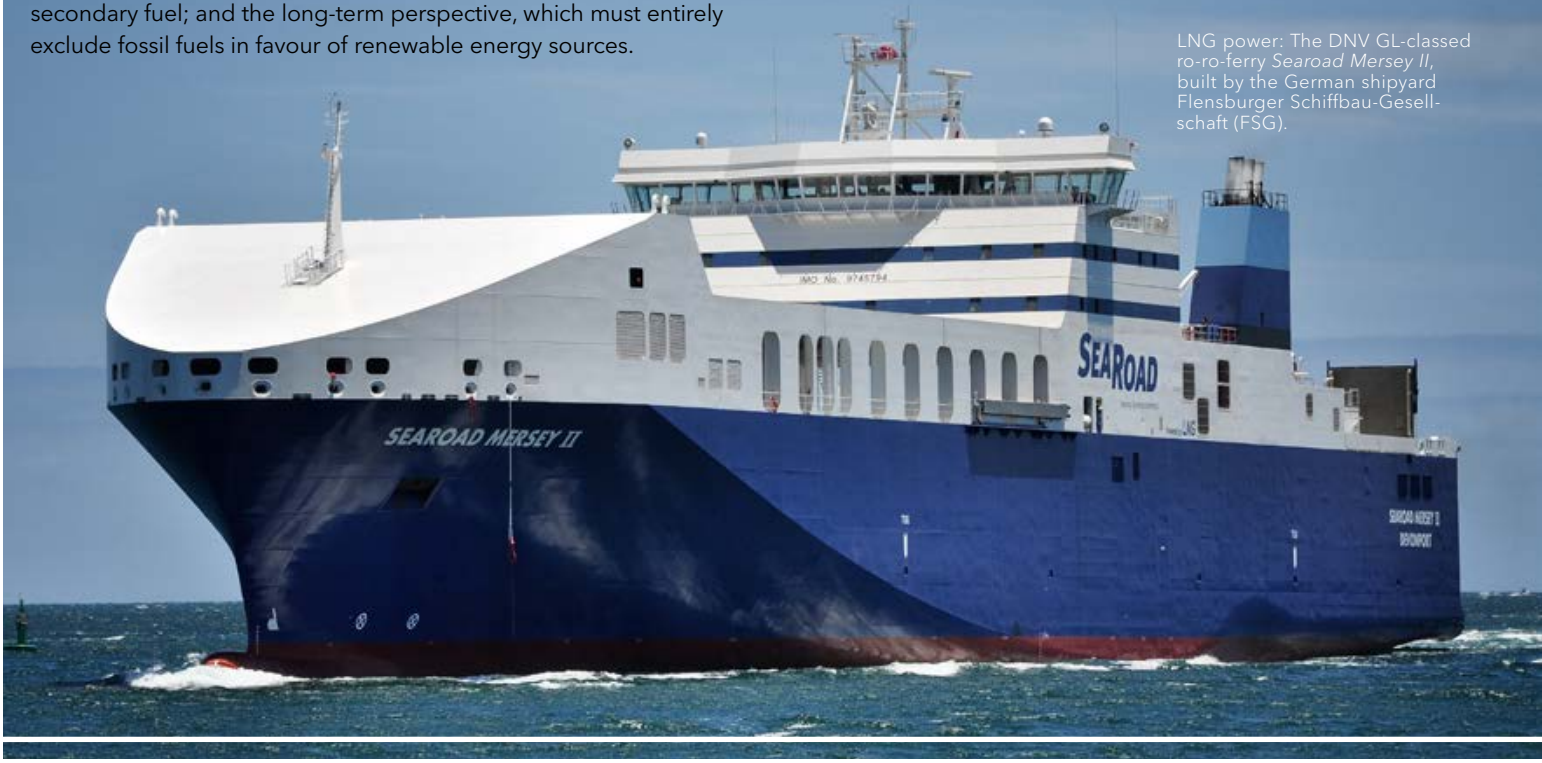
To meet these goals the industry will need new, eco-friendly, carbon-neutral energy sources and propulsion concepts. IMO wants to encourage the development of these resources through suitable policies and regulations, from strengthening the EEDI and applying operational indicators to requiring speed reductions and introducing market-based measures. Work on an action plan will begin this autumn.

Planning newbuilds with all this in mind means making the right choices now. There are two different time horizons to consider: for ships being built today which still use fossil fuels as a primary or secondary fuel; and the long-term perspective, which must entirely exclude fossil fuels in favour of renewable energy sources.

DNV GL has conducted in-depth studies into all current and potential future energy sources and propulsion technologies suitable for ships under technical and economic aspects. During the transitional decades following the entry into force of the 2020 sulphur cap, emissions of sulphur oxides (SO_x), nitrous oxides (NO_x), particulate matter as well as CO_2 and other greenhouse gases must meet tightening restrictions imposed by IMO and other bodies. Compliance can be achieved by optimizing a ship's operational efficiency through design measures, operational measures, and supporting technologies such as fuel cells, batteries, rotor sails, intelligent power management systems et cetera. The long-term perspective – a world without dependence on fossil fuels – points towards synthetic fuels produced from renewable sources.

New low-sulphur fuels

New, low-sulphur-compliant blended fuels (0.5% S) will be available in the market from 2020. It is expected that a varying range of products will be available in different parts of the world, >



LNG power: The DNV GL-classed ro-ro-ferry *Searoad Mersey II*, built by the German shipyard Flensburger Schiffbau-Gesellschaft (FSG).

Photo: SeaRoad Holdings

> depending on local refinery technology and crude oil quality. These fuels may prove to have different compositions from current HFO, hence predicting their compatibility with other fuel batches may be a challenge. It is expected that precautions with regards to fuel storage and mixing will be necessary. The ISO 8217 Fuel Standard working group is currently working on selecting testing methods for fuel stability and compatibility. A draft standard should be available in autumn 2019, with publication of the updated standard expected in 2022. Some initial samples of blended fuels are expected to become available later this year, which will allow all stakeholders to gain experience in using them. As DNV GL's PERFECt ship concept study has demonstrated, the well-known combined cycle gas and steam turbine technology might be a viable solution for ships in the power range above 30 megawatts once low-sulphur fuels are widely in use.

Feasible alternative options

Among the alternative ship fuels being discussed to substitute conventional fuels, DNV GL has identified LNG, LPG, methanol, biofuels and hydrogen as the most promising options. Currently about one third of LNG-fuelled vessels are ferries and ro-ro/ro-pax vessels. About 24 newbuilds from these segments designed for using LNG are currently on order.

New technologies with reasonable potential for application in low-carbon shipping include battery systems, fuel cell systems and wind-assisted propulsion. The biggest hurdles for other alternative ship fuels and propulsion technologies are unrelated to whatever it takes to apply current engine and gas turbine technology. In conjunction with the low-emission fuels named above they are readily available or can be developed without substantial effort. Fuel cell technology in combination with various fuels can achieve efficiencies equal to or better than those of current propulsion systems. However, fuel cell applications for ships are still in their infancy. The most advanced developments are those related to the DNV GL-supported e4ships lighthouse project in Germany, with Meyer Werft and ThyssenKrupp Marine Systems leading the initiatives for seagoing vessels. Wind-assisted propulsion likewise has a certain potential to reduce fuel consumption, especially on slow ships, but the business case remains challenging.

Batteries used for energy storage, while not a primary energy source, have major potential for ships running on short distances, or as supplementary energy sources on board any ship if used to increase the efficiency of the propulsion system. To date, hybrid battery solutions have been mostly confined to smaller car ferries and on shorter ferry routes, such as *Vision of The Fjords*, which operates in Nærøyfjord, Norway. Her recently delivered sister vessel *Future of the Fjords* is powered by electric motors (see page 18).

Where to go from here

The primary challenges associated with alternative fuels in shipping result from environmental considerations, availability of sufficient fuel quantities, fuel costs, and the rules of the IMO IGF Code. Environmental and price challenges continue to drive the interest in alternative ship fuels, but the number of realistic candidates remains small. After LNG has overcome the hurdles of international legislation, methanol and biofuels will follow suit very soon; the development of rules for LPG and hydrogen within the scope of the IGF Code will take considerably longer. Yet, the foreseeable volume requirements for shipping could in principle be met by all fuel alternatives mentioned above over the coming years. But a major rise in demand would without doubt require massive investments in production capacity, except LNG, which could be made available in quantities exceeding the currently forecasted demand.

Without government action in the form of tax breaks or subsidies, renewable fuels will find it difficult to compete with the prices of conventional fossil fuels. LNG and LPG are the only fossil fuels capable of achieving a reasonable CO_2 reduction in the next five to ten years. "CO_2-neutral" shipping seems possible only with fuels produced from renewable sources. If the shipping sector resorts to synthetic fuels produced from hydrogen and CO_2 using renewable energy, the resulting alternative fuels will be liquefied methane (which is very similar to LNG) and diesel-like fuels. **GW**

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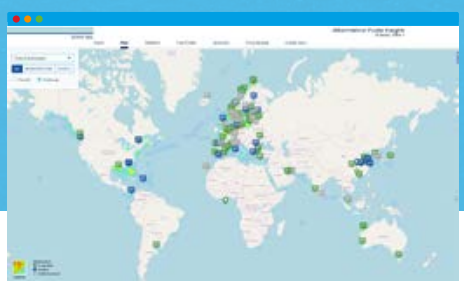
ALTERNATIVE FUELS INSIGHT (AFI) PLATFORM

To encourage the uptake of alternative fuels, DNV GL has developed a new online platform that will provide reliable and comprehensive market and bunkering information. Similar to the successful LNGi site, the Alternative Fuels Insight (AFI) platform gives detailed, visual insight into existing and planned bunkering opportunities along with up-to-date statistics on the uptake of alternative fuels and fleet status. The AFI platform is accessible for free through the Veracity marketplace. Initial features include:

- Interactive map of bunkering infrastructure for LNG and methanol (coming soon) with detailed project data
- Statistics on ship uptake for LNG, LPG, scrubbers, batteries and methanol
- Encyclopedia with information on alternative fuels needed for well-informed decision-making
- Interactive fuel finder with interfaces for sending fuel requests and establishing contact with fuel suppliers



A world map of current bunkering opportunities for alternative fuels is a key feature of the AFI platform:
dnvgl.com/AFI

GAUGING THE COST OF LNG

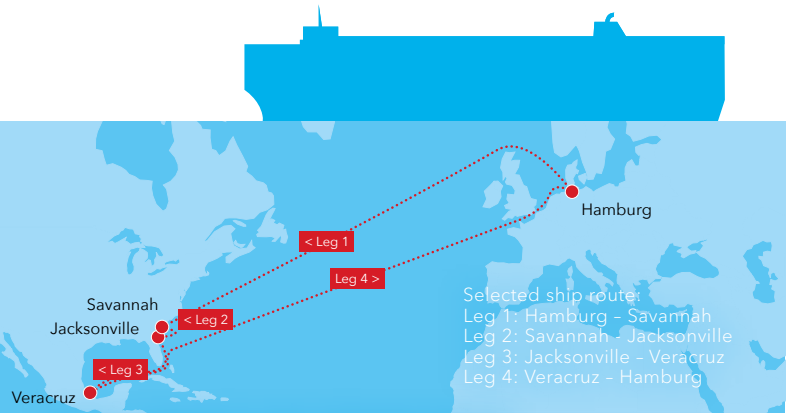
In a feasibility study, DNV GL has attempted to calculate the business case for an LNG-fuelled pure car and truck carrier operating between Europe and North America. Various scenarios are conceivable.

As the shipping industry enters a new age of strict environmental regulations, owners must choose a fuel that will be compliant and financially supportable. DNV GL's feasibility study assumes a pure car and truck carrier (PCTC) operating between Hamburg, the US and Mexico. Two LNG engine and tank configurations optimized for 16 and 18 knots were compared with a conventional engine with a scrubber system in terms of total capital and operational expenditures (CAPEX, OPEX). The calculations factored in all costs associated with either type of propulsion system and are based on current market prices of equipment.

A number of factors that can have a significant impact on the final results remain unpredictable, including the development of fuel prices, which will depend on demand as well as potential political measures. The study therefore considered various but not all conceivable price scenarios. While low-sulphur fuel oil (LSFO) will likely be the most expensive compliance option, the cost performance of LNG ranges between LSFO and HFO, depending on the assumed LNG market price. In the most favourable scenario, LNG approximates the cost of the scrubber-equipped ship, especially so in the 18-knot example. However, it should be noted that LNG offers additional benefits in terms of particulate matter and CO_2 emissions. DNV GL therefore included calculations of potential savings under an assumed CO_2 taxation or trading scheme, which would further improve the feasibility of LNG (see table on right).

Additional considerations

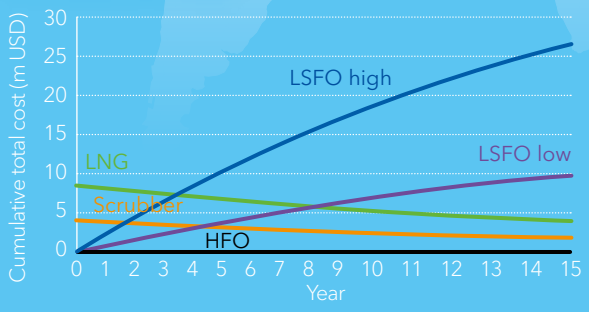
The DNV GL study may thus serve as a high-level basis for continued discussion only. While its assumptions are believed to be balanced and reasonable, there can be no guarantee that unexpected events or political decisions will not change the scenario significantly. The difference between LNG and the scrubber option is small, and LNG is believed to pose lower general risks and be the most future-proof option currently available. Options for further reduction of the LNG CAPEX include more frequent bunkering in favour of smaller tanks, which would also reduce the loss of cargo space. Risks associated with scrubbers relate to sludge disposal, restrictions applying to open-loop systems, and maintenance; additional investments for NO_x Tier III compliance should be kept in mind, as well. DNV GL offers more specific and accurate calculations for particular ships and operating patterns.



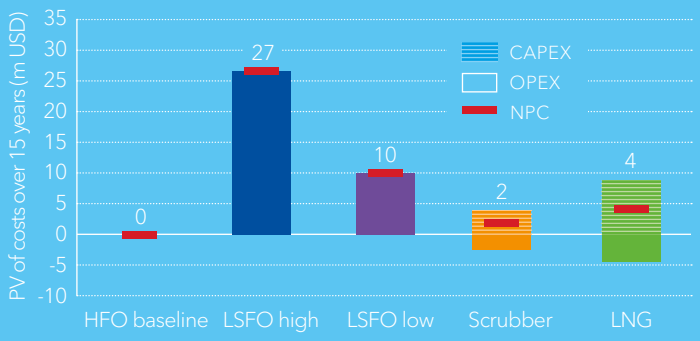
VESSEL SPECIFICS AND TRADING ROUTE

Length overall: 200 m
dwt: 20,000 t
CEU: 8,500 t
Cruising speed:
16 kn (low), 18 kn (high)

Engine – Case 1 (speed: 16 kn):
MAN 5S60ME-C8.5 (11,900 kW)
Engine – Case 2 (speed: 18 kn):
MAN 7S60ME C8.5 (16,350 kW)



Net present value (NPV) of cumulative added cost (million USD). The HFO scenario represents today's cost of operation, and is used as a baseline.



In the 15-year scenario shown, the investment in scrubber is somewhat more advantageous than in LNG on the basis of cash values.

Scenario	16 knots		18 knots	
	CO_2 emissions (ton/year)	Tax (m USD/year)	CO_2 emissions (ton/year)	Tax (m USD/year)
Fuel oil (HFO, MGO, LSFO)	23,700	0.7–3.6	38,100	1.1–5.7
Scrubber	24,200	0.7–3.6	38,900	1.2–5.8
LNG	17,800	0.5–2.7	28,600	0.9–4.3
LNG savings vs scrubber	6,400	0.2–1.0	10,300	0.3–1.5
NPV savings for LNG 2025–2035		1.1–5.3		1.7–8.5

The introduction of a CO_2 tax for shipping is one possible measure which the IMO or individual nations can implement to support the IMO GHG strategy. A wide span of taxes was tested to understand what this could mean. Such a tax is expected from 2025–2030 at the earliest.

Photos: DNV GL, SeaRoad Holdings

SOMEONE HAS TO GO FIRST

As the world's leader in marine battery solutions, Norway is working to become the first country to electrify coastal transportation. And while there is still a long road ahead, Norway has a genuine advantage: A network of stakeholders working together to make it happen.

Increasing public concerns about the environment have led to a growing sense of urgency for Norway's government and industry to act to slow climate change and improve air quality along its 2,650 km coastline. And with Norwegian domestic shipping contributing about nine per cent of Norway's total carbon dioxide (CO_2) emissions, 34 per cent of its nitrogen oxide (NO_x) emissions and 25 per cent of its sulphur oxide (SO_x) emissions, shipping has been identified as a key part of the clean air challenge.

Mandate to act

According to Sveinung Oftedal, Specialist Director for Norway's Department for Marine Management and Pollution Control, Norway is in a unique position to take the lead on zero emissions coastal shipping. "Norwegians prize the natural beauty of their country and many rely on ocean industries for their livelihood, so it is easy to understand why Norwegian politicians take actions towards green shipping," he says. "Second, Norway has one of the world's most complete maritime clusters in the world, so we have the technology. And finally, Norway has the resources to help incentivize stakeholders to create public-private partnerships to accelerate our transition to clean energy."

Oftedal acknowledges that like many big industrial shifts, innovation often follows regulation. "In addition to establishing our own domestic goals, Norway has worked closely with the UN, IMO and the EU which all share our commitment to reducing emissions," he says. "For example, as signatories to the Gothenburg Protocol, Norway has agreed to reduce emissions of SO_x by 59 per cent, NO_x by 42 per cent, ammonia (NH_3) by six per cent, volatile organic compounds (VOCs) by 28 per cent and particulate matter (PM) by 22 per cent. To meet some of these targets, we have to look at shipping."

Public-private cooperation

Rather than simply announcing new regulations and hoping for the best, the government has reached out to the private sector. In 2008, the Ministry of Climate and Environment announced an agreement with 18 of Norway's largest business organizations to create the NO_x Fund, established to help finance cost-effective emissions reductions. Companies can also apply for grants from Enova, another Ministry initiative which makes public resources available for investments in green solutions. Other programmes, such as Innovation Norway and the Norwegian Research Council's ENERGIX programme, provide funding for research, including renewable energy and efficient energy systems.

Fjord1's *Fannefjord* was converted into an LNG battery hybrid in 2016.

The long fjords of Hordaland in western Norway will be the home waters of new battery-powered ferries built by Havyard.

The government has also signalled its focus on coastal shipping. In January 2015, the Minister of Trade and Industry Monica Mæland and State Secretary for Climate and Environment Lars Andreas Lunde signed a declaration of cooperation with key players in the Norwegian coastal shipping industry. Known as the Green Coastal Programme, the initiative (developed in cooperation with DNV GL) establishes a partnership between private and public authorities to implement the government's maritime and port strategy.

Norwegian shipping companies have long been recognized as pioneers in developing green technologies. For example, Norwegian owners were among the first to develop hybrid gas-fuelled vessels and are leading the development of hydrogen-powered vessels. But for many short-sea operators, batteries are the future. Battery solutions not only drastically cut emissions in ports and at sea, but they can be charged using Norway's domestic energy grid, which is derived from clean, renewable hydropower. It is perhaps no surprise that of the 250 battery hybrid vessels either sailing or on order, about 40 per cent are Norwegian.

"It is a mistake to assume owners are dragging their feet. In fact, the development of new technology is moving so fast, government agencies sometimes struggle to keep up."

Arild Austrheim, Head of Newbuildings, Fjord1

First movers

While the Green Coastal Programme applies to all types of tonnage, the first movers have been the ferry operators, who compete for routes administered by both federal and municipal agencies. According to Arild Austrheim, Head of Newbuildings for Fjord1, Norway's leading ferry operator, the tendering process requires that operators invest in low or zero emissions vessels. "There are about 116 ferry routes in Norway, so to compete for these contracts, we have to show that we are committed to reducing emissions," he says. "That's why all the ferries in our 25-vessel newbuilding programme are electric."

Austrheim acknowledges that regulations are the primary driver for change, but he notes that it is the industry's willingness to develop and embrace new technologies that will make the difference. "In 2010, Fjord1 launched the *Fannefjord*, an LNG hybrid ferry which we converted into an LNG battery hybrid in 2016, so we already have a strong track record for trying out new systems," he says. "It is a mistake to assume owners are dragging their feet. In fact, the development of new technology is moving so fast, government agencies sometimes struggle to keep up."

Ground zero

By some estimates, the marine battery market will double by 2020, when about 80 per cent of new based coastal vessels will include some form of battery operation. Halvard Hauso, Executive >

"Most of this development is occurring in Norway, but we see demand for battery systems rising all over the world – especially in Asia."

Jens Hjorteset, Product Manager Energy Storage Systems, Rolls-Royce

> Vice President Sales & Marketing for Corvus, a Norwegian-Canadian-based battery manufacturer, says that his company is scaling up to meet demand. "We are in the process upgrading to semi-automated battery manufacturing in Canada, and have announced the construction of a fully-automated battery factory and research centre in Bergen," he says. "We already have a long track record of providing battery solutions to ferries and offshore supply vessels, and are now seeing demand rise in all kinds of shipping segments. But the largest growth potential for us in Norway is cruise, ro-pax ferries and ro-ro ferries."

Hauso says that while this demand is related to meeting domestic emissions reduction targets, the company's decision to invest in Bergen had more to do with being part of one of the world's most advanced and dynamic maritime clusters. "Norway is the place to be for battery technology," he says. "Working so closely with global leaders in marine battery solutions helps drive competition and innovation. For example, in less than two years, we have managed to cut the size and cost of our latest battery in half, without losing any storage capacity."

Export potential

Other key players in the development of marine battery solutions are systems integrators such as Siemens, ABB, Wärtsilä and Rolls-Royce – all companies with a strong presence in Norway. Jens Hjorteset, Product Manager Energy Storage Systems at Rolls-Royce, says the company has been delivering complete energy management systems since 2010. "We have and will continue to work with other battery manufacturers, but we also identified market demand for complete systems," he says. "Recently, we partnered with Color Line, Norled and the Norwegian Coastal Administration shipping company to develop SAVe Energy, a modular, liquid-cooled battery system that can be scaled according to a vessel's energy and power requirements."

While designed for ro-pax ferries, Hjorteset notes that the SAVe Energy system can be applied to a wide variety of marine applications, including cruise vessels and multi-purpose vessels. "Most of this development is occurring in Norway, but we see demand for battery systems rising all over the world – especially in Asia," he says. "Domestically, our business is driven by regulation, but winning contracts overseas will require that we make a stronger business case for electrified marine transport."

The role of class

As with any type of tonnage, the responsibility making sure these new technologies are safe and reliable falls to class societies. But according to Sondre Henningsgård, Discipline Leader & Digital Head in Maritime Advisory at DNV GL, they play a special role. "In addition to issuing type approvals and verification services, DNV GL is active in bringing different stakeholders together," he says. "For example, my colleague Narve Mjøs currently serves as Programme Director for the Green Coastal Programme and DNV GL is a member of NCE Maritime CleanTech, a research centre devoted to developing clean energy solutions, located south of Bergen. DNV GL is also involved in a number of joint industry projects to foster development."

Henningsgård himself serves as the Managing Director for the Maritime Battery Forum. Established in 2014 the Forum brings together a broad range of stakeholders to solve common challenges. "While the pace of development in battery technology, including

Oldie but goldie: *Ampere*, the world's first fully electric car ferry, was delivered in 2014.

GAME CHANGER

The world's first electric-powered car ferry, *Ampere*, was built by the Norwegian shipyard Fjellstrand in cooperation with Siemens and Corvus for Norwegian ferry operator Norled. The ferry, which generates zero emissions and minimum sound, was delivered in October 2014 and began commercial operations in May 2015.

SAVe Energy is a battery system which can be applied to a wide variety of marine applications.

The keel for the world's largest hybrid ferry – project name Color Hybrid – was laid in April 2018. Shipping company Color Line plans the first operation in June 2019 on the route from Sandefjord to Strømstad.

recycling or repurposing old batteries, and onboard power management systems has exceeded expectations, shore-based infrastructure remains a challenge," he says. "At the same time, most of the projects we are seeing are hybrids with engines and batteries, where the battery helps optimize the way the machinery is used."

Henningsgård adds that because port facilities are managed locally, owners face different conditions depending on where they operate. While some ports are working with owners to install charging stations, there are many discussions about technical standards, where to build shore-based infrastructure and who pays for what. And in some areas, local electrical grids may not be prepared to provide adequate power, creating another potential roadblock.

More needs to be done

Jan Kjetil Paulsen, Senior Advisor for Bellona (a Norwegian NGO), is encouraged by Norway's commitment to zero emissions coastal shipping but he believes more needs to be done to accelerate the country's green shift. "The electrification of ferries, sightseeing vessels and coastal fishing boats will make an impact, but these vessels usually operate on fixed, point-to-point routes or have a limited operation area and represent only a small fraction of Norway's coastal shipping fleet," he says. "Owners of other types of tonnage, such as coastal bulk carriers, fishing trawlers, container ships and tankers, are responsible for most of Norway's coastal emissions but may not have the resources or the right incentives to assume the high CAPEX costs required to convert to battery hybrid solutions."

Like many in the industry, Paulsen is concerned that without a coordinated strategy and sufficient funding for shore-based infrastructure, upgrading local electrical grids and introducing common standards for shore power charging stations, the domestic shipping industry may not be able to contribute its fair share to the defined national targets for reduced emissions. "The technology for zero emission shipping is evolving very quickly, but the lack of in-port infrastructure required to supply renewable energy in various forms remains an obstacle for rolling out this technology in a scale that will make an impact," he says. "This is not an issue for ferry operators on fixed eight to ten-year contracts, but for other types of tonnage, it is a genuine concern."

While the number of Norwegian ports offering (or are planning to offer) shore power for electrified ships is growing every year, Paulsen says there is still no coordinated national strategy to build out the infrastructure. "The reason Norway has more electric cars per capita than any other nation is because the government got behind efforts to build charging stations along Norway's road networks," he says. "While ship electrification is more complex, this same approach should be applied to ports."

Good timing

Despite these challenges, Norway's green shift in coastal shipping comes at a good time. Because of a slowdown in the offshore industry, Norwegian shipyards have the capacity to take orders for electric and hybrid-powered tonnage, and with more and more countries seeking to lower coastal emissions, Norway's world-leading expertise in marine battery technology may attract more overseas business, creating jobs.

For example, in May of this year, US-based Washington State Ferries announced plans to convert its three largest vessels from running on diesel fuel to electric power. To provide support, DNV GL recently brought representatives from the Norwegian Maritime Authority, Norway's Maritime CleanTech cluster, the Norwegian Embassy and the Confederation of Norwegian Enterprises to Seattle to meet with Washington State officials to share their experience in maritime battery technology and shoreside charging.

Time will tell if Norway can achieve its ambitious coastal emissions reduction targets. But as a "first mover" in marine battery technology, some worry that without more government support, Norway may miss its opportunity to industrialize its technological advantage, as it has in the offshore industry. But for now at least, Norway is racing ahead – as cleanly and quietly as an electric car. **AW**

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POWER AHEAD WITH HYDROGEN FERRIES

With one of the world's most extensive ferry systems and a wealth of clean hydropower, Norway has determined to take a pioneering position in hydrogen-fuelled ferries.

The Norwegian government is supporting a wide range of interconnected hydrogen fuel activities involving players ranging from the Norwegian Maritime Authority (NMA), the Directorate for Civil Protection (DSB) and the Norwegian Public Roads Administration (NPRA), to DNV GL, shipyards and shipowners.

With the backing of the government, the NPRA established a project in 2017 with the ultimate goal of building and operating a hydrogen-electric ferry on the Hjelmeland–Nesvik route on the southwest coast. The project aims to develop and implement hydrogen technology in order to achieve zero emissions on ferry routes not suitable for full-electric operation.

"The ambition for the project is to take zero-emission technology a big step further. It will require considerable development work to bunker and operate a vessel with hydrogen. We expect the transfer value to other maritime segments to be significant," Public Roads Director Terje Moe Gustavsen stated recently.

Camilla Røhme, project manager for development contracts for hydrogen-electric ferries in the NPRA, acknowledged the high level of cooperation in the project: "We are impressed at the hard work and dedication of the regulatory, technical and business stakeholders. The NMA and the DSB established robust guidelines for marine hydrogen early on, and the industry responded quickly and professionally. That cooperation makes it possible for this and other projects to look beyond the pilot stage, and begin developing long-term solutions for society."

From fossil to renewable

A second remarkable project, called HYBRIDShip, was initiated by Fiskerstrand Holding AS in 2016 and aims to convert an existing diesel-powered ferry to hydrogen. Fiskerstrand was granted support through PILOT-E, a financing tool from the Research Council of Norway, Innovation Norway and Enova.

HYBRIDShip stands for "Hydrogen and Battery Technology for Innovative Drives in Ships". "The goal of the HYBRIDShip pilot project is a hybrid-powered ferry to start operation in 2020," said Group CEO of Fiskerstrand, Rolf Fiskerstrand, when the project was launched. The main propulsion will be powered by hydrogen and fuel cells, supplemented with batteries, for ferries and ultimately larger vessels. "Our PILOT-E funding comes from a programme for zero-emission solutions in the marine industry, but Fiskerstrand also wants to lead this new technology. We believe it will be an important market in the near future," Fiskerstrand said in a 2017 interview with NauticExpo magazine.

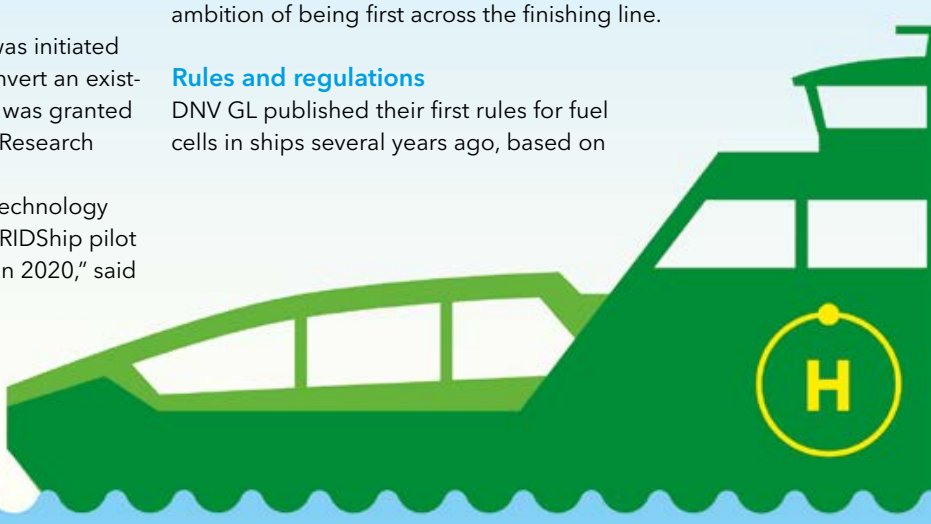
By focusing on a specific ship design, the project will also strengthen the NMA's approval process for the use of hydrogen as fuel in maritime transport, according to the NMA reports. The same effect can be expected for DNV GL's class rules.

"We are pleased that the Norwegian Maritime Authority is increasingly involved at an early stage in innovative projects," said NMA Director General of Shipping and Navigation, Olav Akselsen, in a recent press release. "This means that we are better prepared in those cases where the new technology is not covered by current regulations. But we also understand that the industry is increasingly looking at the NMA as an important partner in the development of new solutions."

By employing hydrogen-powered propulsion, both the NPRA and HYBRIDShip projects ultimately aim to make zero-emission technology feasible for routes that are too long for pure electric propulsion. Once the technology is refined on shorter routes, the plan is to expand into longer and more demanding trips and larger vessel types. In an interesting twist, both projects have the ambition of being first across the finishing line.

Rules and regulations

DNV GL published their first rules for fuel cells in ships several years ago, based on



The Norwegian Public Roads Administration supports a wide range of projects developing zero-emission sea transport.

"We are impressed at the hard work and dedication of the regulatory, technical and business stakeholders."

Camilla Røhme, project manager in the Norwegian Public Roads Administration

"It will require considerable development work to bunker and operate a vessel with hydrogen."

Terje Moe Gustavsen, Director of Norwegian Public Roads Administration

experience gained in the recently completed FellowSHIP project. An updated version was launched in January 2018. The rules are linked to relevant codes and standards for other industries with a longer hydrogen history. "There are still regulatory gaps related to the storage of hydrogen, but the International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code) that entered into force in January 2017 was an important milestone, as it is a mandatory code," says Gerd Petra Haugom, Principal Consultant, Environmental Advisory at DNV GL – Maritime.

The IGF Code opens up for applying a specifically defined "Alternative Design Approach" for approval of hydrogen fuel storage and fuel supply systems. The experiences gained with LNG and other low-flashpoint fuels provide valuable insights into the process of obtaining the approvals required before new hydrogen ships can receive approval from the NMA.

DNV GL has also worked closely with the European Maritime Safety Agency on the EMSA Study on the Use of Fuel Cells in Shipping, under the agreement of the European Commission and in support of EU Member States. According to EMSA, the study includes a technology and regulatory review, identifying gaps to be closed, the selection of the most promising fuel cell technologies for shipping, and a generic safety assessment where the selected technologies are evaluated according to risk and safety aspects in generic ship design applications.

Photos: DNV GL, Statens vegvesen

Fast-forward future?

One key challenge for the future will be to mature the infrastructure for delivering hydrogen where and when it is needed, but starting with ferries sailing on fixed routes simplifies logistical requirements greatly, and allows stakeholders to begin logging valuable experience.

Learning can also be shared across segments, as Gerd Petra Haugom notes: "For someone who worked with early projects for hydrogen vehicles and infrastructure, it is exciting to witness the growing interest for hydrogen in maritime. I really hope we might have a similar situation for hydrogen as we have seen with batteries over the last years. Back in 2015, when the first battery ferry was set in operation, hardly anybody believed the battery market could grow as fast as it has."

She has no doubt about hydrogen's potential to help clean up the maritime emissions picture. "There is a lot of good work being done in Norway and internationally, with many exciting projects to develop technologies that actually can make it possible to meet ambitious emission reduction targets. The Norwegian government has also provided critical support to help these first projects gain momentum and show the way for others to follow. With so many forces coming together, these targets now appear to be within reach." **KG**

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BRINGING THE FUTURE TO LIFE

A bold new step towards a greener transport infrastructure, *Future of The Fjords* is the result of a brilliant new concept combined with proven expertise and a can-do mindset.

A voyage on board *Future of The Fjords* is like no other. As the ship's catamaran hull slices through the crystal waters of Sognefjord, towering rock walls with 1,000 m peaks seemingly close in to embrace the vessel, nearly blocking out the sun. The only sound is the collective gasps of passengers marvelling at the pristine UNESCO World Heritage-listed landscape as this striking, 42 m long carbon fibre ship brings them closer to nature than ever before – with zero noise, zero emissions and the ultimate fjord experience.

Realizing ambitions

Launched in May this year, *Future of The Fjords* is a game changer for the passenger vessel segment. Sharing the zigzag design of her sister ship *Vision of The Fjords*, which mirrors the twisting mountain paths they sail alongside, *Future* replaces her sibling's dual-fuel solution with all-electric propulsion to ensure efficient, silent and environmentally responsible operation on the itinerary between Flåm and Gudvangen. An innovative charging solution enables her to gently bleed power from the local grid network, while also, uniquely, taking on sewage to ensure zero emissions to water.

It is, says Rolf A. Sandvik, CEO of shipowner The Fjords, a complete package that both serves and preserves the fragile beauty around the small hamlet of Flåm in West Norway.

"It has long been my ambition, and the ambition of our company's progressive owners, Flåm AS and Norway's largest ferry operator Fjord1, to launch a new breed of vessel that creates a blueprint for truly sustainable, responsible and memorable passenger transport," explains the former cruise ship captain from the deck of his sparkling new craft. "*Vision of The Fjords* marked

the start of that journey, with its diesel-electric propulsion system and a hull designed to minimize wake-induced shoreline erosion. But *Future of The Fjords* symbolizes the fulfilment of a dream. She offers an experience that immerses our passengers into the sensations of the fjord without impacting upon the natural beauty that brings them here. In that respect this craft is almost a portal, or a platform, to access the landscape, rather than a traditional 'ship'. She is, quite simply, the Future."

A new paradigm

The DNV GL-classed light craft, designed and built by Norway's Brødrene Aa, has the capacity to take 400 passengers on the 90-minute trip from Flåm to Gudvangen, passing through the spectacular World Heritage-listed Nærøyfjord. *Future* and *Vision* are the only ships serving the area that operate year round, with nearly 700 round trips per annum, exposing tourists from all over the world to the serenity of autumn and winter as well as spring and summer's dazzling array of colours. The design of these ships allows passengers of all mobility to literally climb over their hulls as if they were pathways, while those inside can get almost as close to nature thanks to comfortable panoramic lounges. An unforgettable experience, but that is only half the story, Sandvik is keen to stress.

"In terms of operation we want this to be a new paradigm for the industry," he states. "A demonstration of what can be achieved with the determination, investment and ambition to operate responsibly and sustainably. Not to mention the expertise of DNV GL and the technical ability of the yard and suppliers: This project shows how owners can pool unique competencies to tailor solutions that deliver optimal results for all stakeholders."

Batteries on board enable the ship to operate without compromising its pristine marine environment.

"It has long been my ambition, and the ambition of our company's progressive owners, Flåm AS and Norway's largest ferry operator Fjord1, to launch a new breed of vessel that creates a blueprint for truly sustainable, responsible and memorable passenger transport."

Rolf A. Sandvik, CEO of The Fjords

A bold new step towards a greener transport infrastructure, *Future of The Fjords* is the result of a brilliant new concept combined with proven expertise and a can-do mindset.

Photos: Brødrene Aa, DNV GL, The Fjords

Certifying excellence

DNV GL has been working with The Fjords since 2015, initially collaborating on the *Vision of The Fjords* project before moving on to *Future of The Fjords* in 2017. Principal Engineer Sverre Eriksen was a central member of a DNV GL team that oversaw all aspects of vessel verification, certifying everything from the original design drawings through to construction and all elements of onboard machinery.

Eriksen, a battery expert and an architect of DNV GL's class rules for battery-driven vessels, was charged with a key responsibility. "My focus was electrical," he explains. "There are hundreds, if not thousands, of diesel-electric vessels in operation, but very few all-electric, so this is an emerging area that demands proven expertise. All project stakeholders have to know that the batteries are installed correctly, safely and will operate as expected. For example, battery capacity and monitoring are key. The vessel can't afford to "black out" in the middle of the fjord, so we need to have a system in place to collect capacity and charging data to ensure the captain can see exactly how many nautical miles he can travel. If you think about your laptop, as it ages it may say the battery is 100 per cent charged but then only lasts an hour. We can't have this situation with a vessel, so safeguards and >

The Powerdock in Gudvangen provides the required charging capacity of 2.4MWh with the help of batteries.

MAIN PARTICULARS – *FUTURE OF THE FJORDS*

- Length: 42 m
- Width: 15 m
- Materials: Carbon fibre sandwich
- Seats: 400
- Class: DNV GL light craft
- El-motor: 2×450 kW
- Propeller: CPP propeller
- Battery pack: 1,800 kWh
- Speed: 16 kn

> systems have to be in place to ensure reliable, safe and efficient operation."

He continues: "As a leader in the field of verifying this increasingly in-demand vessel type, we are here to offer expertise, hands-on assistance and operational peace of mind. It's been a really exciting journey, with a client who is genuinely breaking the mould within their niche segment."

Charging innovation

Future of The Fjords electric propulsion is delivered by two 450 kW motors enabling cruising speeds of 16 knots, which require a charging capacity of 2.4 MWh when the ship docks in Gudvangen. However, as Sandvik explains, initial conversations with local energy supplier Aurland Energiverk were far from promising in this regard.

"We had a meeting with Brødrene Aa and Aurland in which they explained they could only offer a charging capacity of 1.2 MWh through the grid, half what the vessel requires. So we needed a completely new, innovative approach to bring the electric concept to life."

"It was then that the yard suggested that Westcon, the battery supplier, could provide a battery bank that could be sited shoreside and charge slowly throughout the day. This would allow it to top up energy capacity without any disruptive, and expensive, power surges. I then asked if it would be possible to somehow float the unit. My thinking here was both flexibility and cost, as it would negate the need for expensive land-based infrastructure while giving us the freedom to move the vessel, and the charging solution, when required," says Sandvik.

At this point the next trailblazing idea emerged. The floating "Powerdock" concept, as it would be christened, was innovative enough, but what if it could solve another pressing environmental problem? "At present every other vessel operating on these stunning waterways simply dumps its sewage into the water," Sandvik laments. "There are currently no regulations governing this for domestic trade. But we wanted to do things differently. That made me think: 'could this charging solution also operate as a storage unit for black water?' So I suggested it."

Electrifying ideas

The designers at Brødrene Aa got to work. What they came up with was a 40 m long, 5 m wide floating dock containing battery packs capable of charging the vessel in just 20 minutes. Constructed from carbon fibre composite, and designed to complement the ship's style, the dock also features storage room for on-board consumables, a diesel tank for *Vision* and a 20 m³ tank for receiving grey and black water, which is then taken to the on-shore sewage treatment plant. "Thus, the sewage problem is solved," Sandvik smiles with satisfaction, "giving us the greenest passenger vessel in Norway and helping us preserve the integrity of our beautiful fjords."

But it doesn't stop there. Sandvik believes the Powerdock has the potential to unlock green transport on land as well as on the water in any remote area where there is a need for electric ferries but no grid infrastructure to support them.

"Why stop at using the Powerdock for vessels?" he muses. "Here we have a solution that any form of electric transport can simply plug into without exerting strain on the grid. For example, electric cars, motorbikes or buses could utilize it – it can literally become a local green transport hub, one that is cost effective, efficient and easy to install. In this way, together with the new benchmark it sets for responsible maritime operations, we see the potential impact of *Future of The Fjords* extending far beyond this beautiful landscape around us."

The Fjords are now planning for the next stage of their fleet renewal programme. DNV GL is on board to help Sandvik continue this breathtaking voyage. ■ **AJ**

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Photo: Brødrene Aa

DIGITAL DEFENCE

As owners act to fortify their ships and shore-side operations against cyberrisk in the face of evolving threats and imminent regulation, DNV GL has expanded its services to cover control systems, software, procedures and human factors.

Although the notion of a ship in the middle of the ocean being disabled by a software malfunction or by hackers was initially greeted with considerable scepticism and denial, a spate of incidents, including most notably an attack that disrupted operations at Cosco, has transformed attitudes. Today the maritime industry acknowledges the potential dangers and is taking steps to address cyberrisk at various levels.

Cybersecurity is a moving target. Threats continue to grow in reach and complexity, with new vulnerabilities discovered on a seemingly daily basis. In the space of a few years, hacks and security breaches have jumped from being an exceptional event confined to a special breed of technology companies to becoming a fact of life impacting everyone. No industry is immune.

Cybersecurity was considered a minor issue by the shipping industry for a long time. Recent events have changed that.

While in earlier decades office IT systems were the predominant target, these days more incidents are affecting operational technology (OT) – the programmable control systems responsible for operating machinery. The trend reflects the growing complexity of such systems and a general increase in connectivity, which in turn increases the attack surface of a vessel.

This increase is borne out in the statistics: The number of attacks on OT in 2016 was double that of the preceding year and quadruple the 2013 level. So whereas before it was mostly a company's finances and reputation that were at risk, now the threat has escalated to confront the safety of life, property and the environment. The stakes are much higher. For this reason cybersecurity must now be considered an integral part of overall safety management in shipping.

Risky job

Managing cyber risk is ultimately not different to managing any other risk, remarks Patrick Rossi, DNV GL's Maritime Cyber Security Service Manager. "The equipment and terminology may be unfamiliar and somewhat daunting but the approach is fundamentally the same as, say, preparing for and carrying out hot work modifying a vessel's structure."

Software changes, for example, should not be done on a whim, which can often happen on ships. Because IT engineers don't frequently visit vessels, when they do come aboard to update the ECDIS or set up the latest version of a maintenance management application, the temptation is to be helpful. They click to install a new service pack and a backlog of other app updates. Nine times out of ten, this is fine. But occasionally it can disrupt settings elsewhere on the system. Moreover, the consequences won't become apparent until long after the engineer has left and the ship has set sail.

Instead updates should be carefully planned, tested, approved and recorded. They should be categorized as minor or major to ensure personnel with the appropriate authority can approve them. This, Rossi says, is virtually identical to the process for gaining approval prior to carrying out welding.

Lessons learned from NotPetya

If there was one positive outcome of the NotPetya ransomware attack on Maersk last year, reasons Rossi, it was awakening owners and operators to the fact that cyberthreats are not hypothetical. "Today there is much greater awareness of the real-world implications and acceptance that cyberrisk has to be tackled."

However, shipowners and operators are at different stages on the learning curve in formulating a response, he observes. "Some are bewildered by the scale of the problem and don't know where to begin; others have introduced some countermeasures but are uncertain whether they've covered everything they need to cover." >

Software installations and updates should be left to an IT expert, following thorough testing.

Photos: DamienGeso - stock.adobe.com, DNV GL

> In its role as a classification society DNV GL has adapted and expanded its cybersecurity services to assist owners and operators in protecting their assets against evolving threats and ensuring their safeguards satisfy new industry rules and regulations.

DNV GL now provides services for educating and raising the awareness of all stakeholders both on shore and at sea; assessing and implementing defensive and reactive countermeasures; and monitoring and reviewing the effectiveness and robustness of barriers with an emphasis on continuous improvement.

These services are purposely designed to be non-system specific so as to work equally for conventional IT and industry-specific operational technology, which is important when systems are interlinked. This also avoids obsolescence. While the consequences of an OT outage are likely to be more serious, they can often be traced back to a weakness in IT systems, particularly if they originate from an external source.

Practical advice

In September 2016, DNV GL published a Recommended Practice (RP) to educate shipowners and operators on how to deal with cyberrisk. "It was designed to demystify a subject the industry was still getting to grips with. We took care to write it in a maritime language and context."

The focus was on practical steps, stresses Rossi. "Most advice coming from industry bodies at the time, while produced with noble intentions, was very high-level. Our idea was to close the gap between theoretical concepts and the real world." For example, DNV GL's RP accounts for common constraints such as limited budget and resource availability. The core approach is to identify weaknesses, assess their severity, then prioritize the most serious ones. The RP has been released as a free resource.

The next step for vessel operators would be to carry out a cybersecurity assessment. DNV GL can support this by sending interdisciplinary teams to help onshore and offshore personnel identify and address specific business risks.

"While operators typically understand the written guidance, translating those principles into action is sometimes more challenging," notes Rossi. This collaboration results in a highly methodical approach to developing effective risk mitigation procedures that mesh neatly with the operator's structure and working practices. Apart from closing cybersecurity gaps by technical means, this appraisal also considers system management and the human factor.

Once countermeasures and a new risk management regime have been implemented, they can be followed up and qualified by penetration testing. "Testing the robustness of barriers is essential to ensure that assets are secure and nothing has been overlooked," explains Rossi. In this process, authorized "white-hat" hackers do their best to compromise the IT and OT defences to validate that safeguards work as they should and risks have been eliminated.

Life cycle management

DNV GL also provides third-party verification of cybersecurity requirements throughout the newbuild project life cycle. "Our

Today's complex networks and interlinked applications have increased exposure to cyberthreats considerably.

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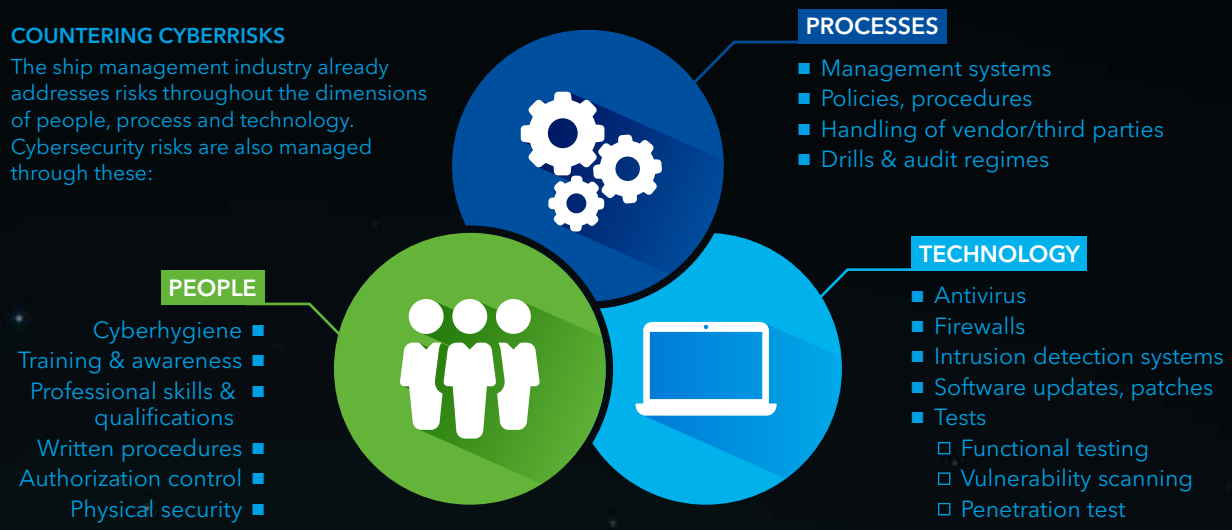

cybersecurity team recently worked with a major cruise line on devising a process for embedding cyber resilience from the very beginning of the vessel design phase," reports Rossi.

This was accomplished by introducing defined risk handling and accommodating procedures to all stakeholders in the project – not only the owner and yard but also the vendors. Incorporating technology and systems from third-party suppliers unavoidably adds complexity to a project and, from a cybersecurity perspective, increases potential exposure to malevolent actors. Meanwhile, shipyards are as much on the learning curve as vessel owners.

"For a large, sophisticated vessel like a cruise ship, which is dependent on technology for both operational and hotel needs, collaboration is absolutely critical," Rossi stresses. "Cyberrisks are multifaceted. The response has to mirror that. Everyone has to be involved in the conversation, because, as the saying goes, a chain is only as strong as its weakest link."

The feedback from the project, he notes, was overwhelmingly positive. "Tackling cybersecurity right from the beginning of a vessel's life cycle enables stakeholders to take a proactive, rather than reactive, approach to the problem. It provides more opportunities to insert barriers."

Based on these advisory services, DNV GL has developed its first class notations covering cyber resilience. The Cyber Secure notations have three qualifiers: Basic, Advanced and "+". Basic is primarily intended for ships in operation; Advanced is designed to be applied throughout the newbuilding process. The '+' qualifier is available for systems not covered by the scopes of Basic and Advanced.

The human element

Of course, cybersecurity is not just a matter of firewalls and antivirus software. Up to 90 per cent of incidents are attributed to human behaviour. Phishing and social engineering, unintentional downloads of malware etc. remain common issues. At the same time, most crews and onshore staff are not taught how to respond to cyberattacks or major technology failure and consequently fail to contain the damage.

DNV GL has therefore expanded its options for training through its Maritime Academy. Courses cover cybersecurity from both management and technical angles and even include lessons in hacking to give participants an insight into how cyberattackers operate. Additional new tools incorporate friendly phishing campaigns and simulations of other social engineering techniques as well as features for assessing staff alertness so customers can fine-tune the level and frequency of cyber awareness training.

DNV GL can help vessel operators combine traditional IT security best-practices with an in-depth understanding of maritime operations and industrial automated control systems. DNV GL understands the importance of tackling and integrating the human factor when devising and implementing a cyberrisk management strategy because ultimately, it is people who drive our industry. ■ KT

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