Committee on Transportation and Infrastructure
U.S. House of Representatives
Washington DC 20515

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January 10, 2020

SUMMARY OF SUBJECT MATTER

TO: Members, Subcommittee on Coast Guard and Maritime Transportation
FROM: Staff, Subcommittee on Coast Guard and Maritime Transportation
RE: Hearing on "The Path to a Carbon-Free Maritime Industry: Investments and Innovation"

PURPOSE

The Subcommittee on Coast Guard and Maritime Transportation will meet on Tuesday, January 14, 2020, at 10:00 a.m. in 2167 Rayburn House Office Building to survey new developments in sustainable shipping technologies and international emissions standards established to decarbonize the maritime industry. The Subcommittee will hear from Maersk Line, the Washington State Department of Commerce, ABB Marine and Ports, Chamber of Shipping of America, and the World Shipping Council about innovations in zero-emission vessel (ZEV) design, research and infrastructure needs, and strategic opportunities for American maritime commerce.

BACKGROUND

Emissions and the Maritime Industry

The International Maritime Organization (IMO) has set the stage for a massive decarbonization of the shipping industry. On its own, today's international shipping industry accounts for over 1 billion tons of emissions per year, 3% of total global of sulfur oxides (SO_x), nitrogen oxide (NO_x), particulate matter (PM), and carbon dioxide (CO_2) emissions.[1] If international shipping were a country, it would rank as the 6^{th} largest polluting actor on the planet; shipping emissions contributed to 1,200 early

[1] Olmer et al., Greenhouse Gas Emissions from Global Shipping, 2013–2015, The International Council On Clean Transportation, 2017; Heitmann N, Khalilian S, Accounting for carbon dioxide emissions from international shipping. Burden sharing under different UNFCCC allocation options and regime scenarios. Mar Policy 35:682–69, 2011.

deaths in the United States last year alone.[2] SO_x are known to be harmful to human health, causing respiratory symptoms and cardiovascular and lung disease, with concentrated impacts in communities adjacent to ports.[3] In the atmosphere, SO_x can exacerbate radiative forcing and global climate change, leading to acid rain, harming crops, forests and aquatic species, and contributing to the acidification of the oceans.[4]

The IMO has established increasingly stringent greenhouse gas emissions reductions from the 2008 baseline: a 40% reduction by 2030, and a 70% reduction by 2050 regardless of trade growth, with full decarbonization shortly after.[5] The IMO Energy Efficiency Design Index requires all newly built ships built from 2013 onwards to meet mandatory reduction targets, increasing in stringency every five years up until 2030, which is currently incompatible with a continued long-term use of fossil fuels by commercial shipping.[6] While demand for seaborne trade is projected to grow by 39% through 2050, and energy-efficiency measures, hull and machinery improvements, and speed reduction are readily available to reduce vessel emissions, carbon-neutral fuels will need to grow 30-40% to meet world fleet energy needs by 2050, in addition to improving energy efficiency, to achieve IMO greenhouse gas ambitions.[7]

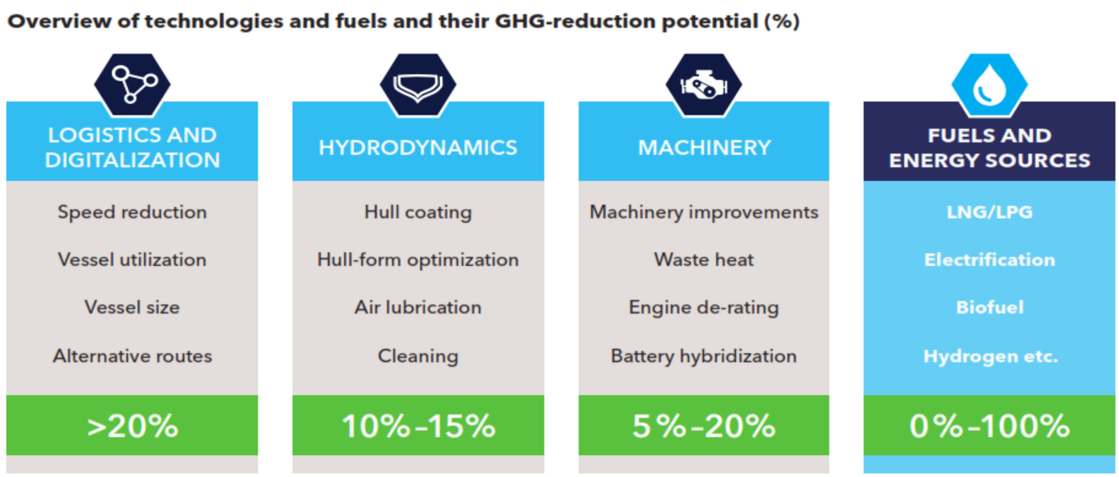

Figure 1- Available methods to reduce vessel emissions by percentage of global emissions mitigated. DNV GL 2019.

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[2] Schlanger, Zoe, If shipping were a country, it would be the world's sixth-biggest greenhouse gas emitter, World Economic Forum, 2018; Anenberg et al., A Global Snapshot of the Air Pollution-Related Health Impacts of Transportation Sector Emissions in 2010 and 2015, The International Council On Clean Transportation, 2019.
[3] Bhandarkar, S., Vehicular Pollution, Their Effect on Human Health and Mitigation Measures, Vehicle Engineering, Vol. 1 Issue 2, June 2013; Jiang et al., Air pollution and chronic airway diseases: what should people know and do?, Journal of Thoracic Disease Vol. 8 Issue 1: E31–E40, January 2016; Bailey et al., Pollution prevention at ports: clearing the air, Environmental Impact Assessment Review, Vol. 24, Issues 7–8, October–November 2004, Pages 749-77.
[4] Perhac, R.M. (1992) Acid Rain Encyclopedia of Physical Science and Technology. Vol. 1. Academic Press, London; Peterson, M., The effects of air pollution and acid rain on fish, wildlife, and their habitats, U.S. Department of the Interior, Fish and Wildlife Service, Office of Biological Services, 80/40.3, 1982; Prinn et al., Effects of air pollution control on climate: results from an integrated global systems model, from Human Induced Climate Change: an Interdisciplinary Assessment, Cambridge University Press, UK, 2007.
[5] International Maritime Organization, IMO Action to Reduce Greenhouse Gas Emissions from International Shipping, IMO 2019.
[6] Nishatabbas et al., The implementation of technical energy efficiency and CO2 emission reduction measures in shipping, Ocean Engineering, Vol. 139, 2017: 184-197; DNV GL, Maritime Forecast to 2050 Energy Transition Outlook 2019.
[7] DNV GL, Maritime Forecast to 2050 Energy Transition Outlook 2019, page 15.

To accommodate the IMO emission caps, fossil fuel-based marine fuels (such as Heavy Fuel Oil, Low Sulphur Heavy Fuel Oil, Marine Diesel Oil and Liquefied Natural Gas) will need to comprise a small share of the total fuel mix in 2050.[8] Additionally, by 2025, the IMO will require all new ships be 30% more energy efficient than those built in 2014.[9] The international fleet has made substantial improvements in vessel design, emission scrubbing technologies, and fuel efficiency to mitigate emissions, but to reach the goals established by the IMO shipping companies will need to invest in new vessels, alternative fuels, shore and supply infrastructure, and logistics facilities.

Ships are highly capital-intensive assets with typical operating lives of 20 to 30 years. With the ratification of new emissions standards by the IMO, therefore, shipping companies must consider zero-carbon fuels and associated technologies now in order to meet established deadlines. Vessels coming online after 2030 will need to ZEVs or very low emission vessels in order to assure they can operate for their full expected commercial life, which would extend to the period after 2025 in which fleetwide emissions would be drastically reduced.

Federal Participation at the IMO

The United States' Maritime Administration's (MARAD) Office of Environment and Compliance has played an important role in international maritime environmental policy development for several years, serving as a member and active participant of the US delegation for the IMO and, more recently, as a technical chair and working group members in the International Standards Organization. In this role, MARAD collaborates with the international maritime industry to establish ship and marine technology standards that can improve environmental impacts.

MARAD works with the US Coast Guard, Environmental Protection Agency, the US Navy, and the State Department in preparing proposed regulations related to emission reductions through performance-based standards. Pollutants of concern under Annex VI include nitrogen oxides, sulfur oxides, and particulates from marine vessels.[10] In October 2008, Annex VI was amended to allow for development of Emission Control Areas (ECAs) by 2015.[11] The ECA system, which establishes tighter regional emission standards for engine emissions and fuel quality in most coastal waters up to 200 nautical miles from the coasts of the continental United States and large portions around Alaska and Hawaii, has been found to be a cost-effective, reliable means of reducing air pollution and improving public health.[12] The North American ECA has been in effect since 2015, restricting emissions within the designated control area to 0.10% sulfur content.[13] Starting January 2020, the IMO expanded the 0.5% limit for sulfur content to ships operating outside designated ECAs.[14]

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[8] Ibid.

[9] Chestney. N. IMO agrees on stricter efficiency targets for some ships, Reuters, May 2019, Accessed January 9 2020.

[10] International Maritime Organization, Prevention of Air Pollution from Ships, online, see (Reg. 4, 13, 14, 15, 16, and 18), Accessed Jan 9 2020.

[11] Ibid.

[12] Environmental Protection Agency, Proposal to Designate an Emission Control Area for Nitrogen Oxides, Sulfur Oxides and Particulate Matter Technical Support Document, Assessment and Standards Division, Office of Transportation and Air Quality, EPA-420-R-09-007, April 2009.

[13] International Maritime Organization, North American emission control area comes into effect on 1 August 2012, online, Accessed Jan 9 2020.

[14] Ibid.

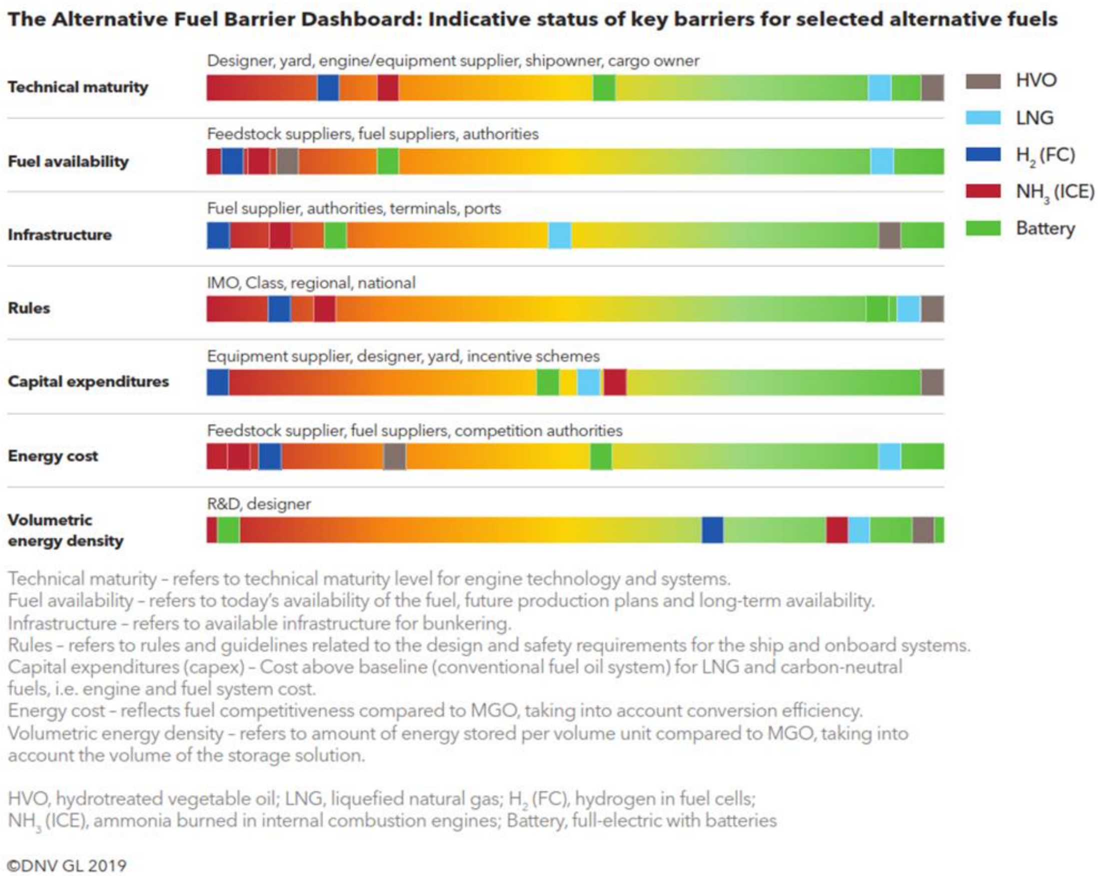

Figure 2 --Alternative fuel are variably accessibility and ready for deployment, many still lacking the necessary infrastructure and availability to be considered viable by operators. Fuel sources (identified by color on the key to the right), are ranked by technology maturity along a scale from low maturity (red) to high maturity (green). Source: DNV GL 2019.

Alternative Fuel Technologies

Existing technologies and fuels deployed to meet the US ECA and early IMO emissions caps include scrubbers, a mechanical treatment of high sulfur fuels to remove sulfur from the exhaust of the vessel, and low sulfur fuels like LNG, which remains price-competitive with distillate fuels and requires limited installation of additional processing technology. Alternative technologies under consideration by operators to meet the new IMO emissions caps include hydrogen, ammonia, methanol, and electricity. The technical applicability and commercial viability of alternative fuels and power sources will vary greatly for different ship types and trades, like deep-sea vessels or short-sea shipping operators.

For most alternative fuels and power sources, technical applicability and commercial viability will vary greatly for different ship types and trades. Deep-sea shipping comprises large ocean-going ships, and a large proportion of their energy consumption relates to propulsion of the ship at steady speed over long distances. These vessels are today driven by two-stroke combustion engines, which are highly efficient for propulsion and maximize the space available for cargo through the use of energy-dense fuel. Short-sea vessels, travelling shorter distances and with variable power demands make electric or hybrid-electric power systems (including diesel/gas electric) more efficient than traditional mechanical drives. The wide range of engine load profiles in the short-sea fleet increases flexibility for using energy from batteries, fuel cells and waste heat as well as renewable sources (e.g. solar, wind, waves) available onshore

The primary energy sources considered to produce existing alternative fuels like hydrogen, ammonia, methanol, gas oil and electricity include: natural gas with capture and storage for hydrogen and ammonia, biomass and algae for methanol and gas, and renewable electricity for hydrogen and batteries. Hybridization and electrification can deliver emission savings regardless of the type of fuel used to generate electricity. To develop, prove, scale and commercialize ZEVs, operators are establishing collaborative joint ventures with fuel technology companies, equipment manufacturers and energy developers from other industrial sectors outside of shipping. The U.S. Department of Energy's Water Office, MARAD's Marine Environmental Technical Assistance office, and U.S. Coast Guard have initiated conversations about the availability and viability of new fuels for use in the maritime industry.

Alternative Vessel Designs

Cargo ships, like cars, vary widely in performance and design. In addition to retrofitting existing ships, compliant vessels can be efficiently designed and built to meet the new emissions standards.[15] New vessel designs including battery electric propulsion, wind propulsion, hydrodynamic designs, internal engine modifications, humid air motors, and other internal engineering adjustments are no longer theoretical design options for shipowners. Rotor sails, for example, can reduce a ship's fuel use by 5-20%.[16] Norsepower in Finland, Ladeas in Norway, Mitsui O.S.K. Lines, Ltd. and NYK Line in Japan, have acquired detailed design contracts for wind-assisted propulsion ship designs; some projects have operational wind-assisted vessels on the water today.[17] For existing vessels, third-party operators can assess vessel efficiency based on each ship's design specifications and engine type, helping shipping companies lower their bunker fuel bills and to reduce emissions associated with moving goods around the world.[18]

Example: Zero Emission Research Vessel – Sandia National Laboratories partnered with the Scripps Institution of Oceanography, the naval architect firm Glosten and the class society DNV GL to assess the technical, regulatory and economic feasibility of a hydrogen fuel-cell coastal research vessel. Feasibility was found for a 10-knot vessel with 2400 nautical mile range, able to perform 14 Scripps science missions, refueled with liquid hydrogen at 4 different ports of call along the U.S. west coast. No "show-stopping" issues were identified by either DNV GL or the United States Coast Guard. This work was funded by the Maritime Administration (MARAD) within the U.S. Department of Transportation. Source: Sandia National Laboratories.

[15] Environmental Protection Agency, Proposal to Designate an Emission Control Area for Nitrogen Oxides, Sulfur Oxides and Particulate Matter Technical Support Document, Assessment and Standards Division, Office of Transportation and Air Quality, EPA-420-R-09-007, April 2009.
[16] Kornei, K., Spinning metal sails could slash fuel consumption, emissions on cargo ships, Science, September 2017.
[17] Gallucci, M, Dreamboats, Grist, October 21, 2019. Accessed January 5th 2020.
[18] Gallucci, M., Shipping industry takes a page from bitcoin to clean up its act, Grist, Feb 21, 2019. Accessed January 5th 2020.

Example: Full Port Electrification at the Georgia Ports Authority – Port of Savannah is piloting four electric rubber-tired gantry cranes, which use 95 percent less fuel than their diesel-powered counterparts by only using diesel when moving between container rows. GPA also replaced its 27 diesel ship-to-shore cranes with electrified cranes that recharge themselves as they lower containers, producing enough energy to power themselves for 18 minutes of each operating hour. These newly adopted technologies provide solution for both GPA and surrounding communities: GPA saves money, since electric cranes cost 85 percent less to operate, and communities benefit from reduced pollution. Source: Georgia Ports Authority.

Shore Power and Electrification

Cold ironing, also known shore-to-ship power or alternative marine power, is the process of providing shoreside electrical power to a ship at berth while its main and auxiliary engines are turned off. With this process, emergency equipment, refrigeration, cooling, heating, lighting, and other equipment are still able to receive continuous electrical power, while the ship loads or unloads its cargo. Cold ironing requires semi-standardized electrical port and vessel infrastructure, conduits and safety systems to ensure personnel safety and continuous power transfer, and sufficient electrical capacity at the port.

Electrification of port infrastructure and at-berth vessels has been demonstrated to significantly reduce per vessel emission reductions for NO_x, particulate matter and CO_2 emissions, including reductions in noise pollution.[19] Establishing emission control requirements for ports and terminals have been implemented at the state and local level in California to mitigate localized emissions impacts and reduce long-term operating costs.[20] Because cold ironing requires upgrades to ships and shore-side port infrastructure, shore power is most feasible for frequently calling ships, and may be cost-prohibitive for infrequent callers; industry analysts cite a lack of national legislation, tax exemptions on shoreside electricity, and a reduced price differential between bunker fuel and electricity costs as barriers to global implementation.[21] Marine fuels are currently globally tax exempt, providing an additional incentive to use diesel fuels for shore power.[22]

Example: Maritime Hydrogen Fuel Cell Project – The Maritime Hydrogen Fuel Cell (MarFC) project is testing the feasibility of hydrogen-fuel-cell-powered generators as an alternative to diesel generators to provide clean power in port operations. Co-funded by the U.S. Department of Energy's Fuel Cell Technologies Office and the U.S. Department of Transportation's Maritime Administration, MarFC completed a six-month deployment at the Port of Honolulu. Other Barge-Mounted Hydrogen Fuel Cell for Vessel Cold-Ironing were found to be able to power container ships at berth at the Port of Tacoma and/or Seattle, powering tugs at anchorage near the Port of Oakland, and powering refrigerated containers on-board Hawaiian inter-island transport barges. Port of Seattle, the Suisun Bay Reserve Fleet, the California Maritime Academy, and an excursion vessel on the Ohio River have other demonstration projects. Source: Sandia National Laboratories.

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[19] Office of Transportation Air Quality, National Port Strategy Assessment: Reducing Air Pollution and Greenhouse Gases at U.S. Ports, Environmental Protection Agency, EPA-420-R-16-011, September 2016. Local governments in California have had success with reducing localized vessel emissions through At-Berth regulations in 2007 and 2009. Recent regulation requires a fleet operator to reduce at-berth oxides of nitrogen (NOx) and particulate matter (PM) emissions from its vessels' auxiliary engines in port by at least 80% by 2020.
[20] JD Supra, CARB Continues Roll-Out to Reduce Emissions from Vessels in California Ports and Targets Ride-Hailing Vehicle Greenhouse Gas Emissions; Update on AB 617, California Air and Climate Vol. 11, November 2019; Office of Transportation Air Quality, National Port Strategy Assessment: Reducing Air Pollution and Greenhouse Gases at U.S. Ports, Environmental Protection Agency, EPA-420-R-16-011, September 2016.
[21] Sukharenko, D., Shore power lacks global investment, tax exemptions, Journal of Commerce online, accessed December 20th 2019.
[22] Hiene, D. and Gade, S., Unilaterally removing implicit subsidies for maritime Fuels: A mechanism to unilaterally tax maritime emissions while satisfying extraterritoriality, tax competition and political constraints. Int Econ Econ Policy (2018) 15:523–545.

Challenges for the Maritime Industry:

1. **Availability**: New technologies and fuels require sufficient supply chains and safety infrastructure in whatever ports they intend to visit in the United States or abroad for each category of alternative fuel. LNG, for example, is available globally and in large volumes, but limited bunkering infrastructure has directed LNG-fueled vessels to ports that can ensure access to that fuel.

2. **Safety**: The new properties and qualities of alternative low emissions fuels may pose different safety challenges for vessel and port operators and which may result in changes to regulatory and enforcement capacity in the Environmental Protection Agency and the U.S. Coast Guard. For example, the significantly higher buoyancy of hydrogen compared to natural gas means that hazardous zones defined in current maritime safety codes for natural gas may be inaccurate if applied to hydrogen. Operators, regulators, and crew will need to adjust to vessel operations to safely accommodate new fuel sources.

3. **Enforcement**: Limited compliance and enforcement of the 2020 sulfur cap, emission reduction measures, and at-berth emissions regulations will undermine the efficacy of these programs. For example, from 2014-2016, one liner did not meet operational time limits for diesel use for at least half of its visits to the Port of Los Angeles Long Beach.[23]

4. **Limitations of Electrification**: The potential for electricity in the maritime sector is currently limited to short-sea and in-port operations. Maersk is testing battery power at sea to utilize excess energy generated at off-peak hours to operate large container vessels.[24]

5. **Research and Development**: Eight global shipping associations have submitted a plan to the IMO for a fuel tax dedicated to helping eliminate CO^2 emissions from international shipping.[25] The tax would generate funds of about $5 billion over a 10-year period, which the association deems necessary to achieve the IMO's 2050 emission reduction targets.[26]

[23] California Air Resources Board, California Air Resources Board settles with COSCO Container Lines Co., Ltd., for $965,000, California Air Resource Board, December 2019.

[24] Maersk Intl., Maersk to pilot a battery system to improve power production, Press Release, November 2019.

[25] Those associations include BIMCO, Cruise Lines International Association, Intercargo, Interferry, International Chamber of Shipping, Intertanko, International Parcel Tankers' Association and the World Shipping Council. The Maritime Executive, Fuel Tax Proposed to Fund $5 Billion R&D Plan, December 18 2019, Accessed Jan 9 2020.

[26] The Maritime Executive, Fuel Tax Proposed to Fund $5 Billion R&D Plan, January 2020

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