Committee on Transportation and Infrastructure
U.S. House of Representatives
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April 12, 2021

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 "Practical Steps Toward a Carbon-Free Maritime Industry: Updates on Fuels, Ports, and Technology"

PURPOSE

The Subcommittee on Coast Guard and Maritime Transportation will hold a hearing on Thursday, April 15, 2021, at 11:00 a.m. EDT to examine emissions output from vessels and ports, and the future of zero emissions technology. The hearing will take place in 2167 Rayburn House Office Building and via Zoom. The Subcommittee will hear testimony from Glosten, International Council on Clean Transportation, Maersk, the Port of Hueneme, and World Shipping Council.

BACKGROUND

Maritime Emissions

Maritime transportation is vital to the world economy. With over 80 percent of global trade by volume carried onboard ships and handled by seaports worldwide, the importance of maritime transportation for trade cannot be overemphasized.[1] In order to meet the stringent demands of shippers and compete on a worldwide playing field, shipping companies have traditionally relied on cheap and readily available fuels, often including fossil fuels such as bunker fuel. As a result of fossil fuel consumption, shipping accounts for 3 percent of the world's carbon emissions and if shipping were a country, the sector would be the world's sixth-largest emitter.[2]

For nearly 100 years, ships have run on cheap bunker fuel. When burned, bunker fuel emits large amounts of carbon dioxide (CO_2) as well as black carbon, a fine particulate that can absorb a

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[1] United Nations Conference on Trade and Development. "Review of Maritime Transport 2017." https://unctad.org/system/files/official-document/rmt2017_en.pdf. Accessed on April 5, 2021.
[2] Bloomberg. "Huge Container Ships' Biggest Problem Is Emissions." https://www.bloomberg.com/opinion/articles/2021-03-30/huge-container-ships-biggest-problem-is-emissions. Accessed on April 5, 2021.

million times the incoming solar energy as CO_2.[3] Black carbon accounts for 21 percent of CO_2-equivalent emissions from ships, making it the second most important driver of the shipping industry's climate impacts after CO_2.[4] Currently there are no regulations controlling black carbon emissions from shipping.[5]

At current growth rates, shipping could represent about 10 percent of global greenhouse gas (GHG) emissions by 2050.[6] The Third International Maritime Organization (IMO) GHG Study, completed in 2014, estimated that for the period 2007-2012, shipping emitted about 1,000 megatons of CO_2 per year, equaling approximately 3.1 percent of annual global CO_2 emissions.[7]

Vessel fuel efficiency has not kept pace with other modes of transportation. Ships built in the first decade of the 2000s were, on average, less fuel-efficient than those built in the 1990s, according to the first CE Delft study on the historical development of the design efficiency of new ships.[8] On average new ships built in 2013, such as bulk carriers, tankers, and container ships, were 10 percent less fuel-efficient than those built a quarter of a century ago.[9] These findings contradict the shipping industry's narrative that it has been constantly improving its environmental performance.[10] CO_2 emissions grew to 1,056 million tons in 2018 versus 962 million tons in 2012, the study showed.[11] According to the International Council on Clean Transportation (ICCT), the growth of shipping is outpacing efficiency improvements and by 2050, emissions from the industry are projected to be up to 130 percent higher than 2008 levels. Improvements in fuel efficiency have slowed since 2015, with annual improvements of only 1 to 2 percent.[12]

Within the shipping sector investments in the research, development, and deployment of zero emission technologies may put the sector on a sustainable path towards achieving carbon reductions. The IMO has set a goal of reducing carbon emissions from ships to 50 percent below 2008 levels by 2050, and groups like the Getting to Zero Coalition and "Blue Sky" Maritime Coalition have brought together companies and organizations across the maritime sector to achieve this goal. In fact, many shipping companies have adopted their own ambitious goals for reducing their operational carbon footprint.[13]

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[3] Bloomberg. "Huge Container Ships' Biggest Problem Is Emissions." https://www.bloomberg.com/opinion/articles/2021-03-30/huge-container-ships-biggest-problem-is-emissions. Accessed on April 5, 2021.
[4] Transport & Environment. "Shipping and climate change." https://www.transportenvironment.org/what-we-do/shipping-and-environment/shipping-and-climate-change. Accessed April 5, 2021.
[5] *Id.*
[6] *Id.*
[7] International Maritime Organization. "Third IMO GHG Study 2014: Final report." https://www.imo.org/en/OurWork/Environment/Pages/Greenhouse-Gas-Studies-2014.aspx. Accessed April 5, 2021.
[8] *Id.*
[9] Transport & Environment. "Shipping and climate change." https://www.transportenvironment.org/what-we-do/shipping-and-environment/shipping-and-climate-change. Accessed April 5, 2021.
[10] *Id.*
[11] Reuters. "Shipping's share of global carbon emissions increases." https://www.reuters.com/article/us-shipping-environment-imo/shippings-share-of-global-carbon-emissions-increases-idUSKCN2502AY. Accessed April 5, 2021.
[12] *Id.*
[13] Bloomberg. "Huge Container Ships' Biggest Problem Is Emissions." https://www.bloomberg.com/opinion/articles/2021-03-30/huge-container-ships-biggest-problem-is-emissions. Accessed on April 5, 2021.

Port Infrastructure

The most immediate reduction in emissions will come from investment in port infrastructure. Shore-side power (i.e., shore power) allows ships to shut off their engines when berthed in port and connect to the electricity grid to reduce local air pollution and GHG emissions.[14] Shore power infrastructure varies by ship type but is being implemented worldwide. Unlike other technologies for which research and development are still underway, this technology exists and is available to ports for immediate adoption.[15] For vessels such as tankers, cruise ships, and roll-on/roll-off (i.e., ro-ro) vessels that commonly berth at the same dock and do not use cranes, shore-side connection is easier. At container terminals where vessels do not always dock at the same position, there is a need for more connection points.[16] These variables present challenges to ports and create a need for worldwide shore power consistency and standards.

A major benefit of using shore power is the improvement in local air quality.[17] Emissions at berth are replaced by emissions from electricity generation elsewhere that provides the shore power; emissions from electricity generation are usually lower and occur further from population centers.[18] Reducing harmful emissions at ports would also mitigate the public health impacts associated with port operations, which disproportionately affect low-income communities and people of color.[19]

However, the installation of shore power technology at ports can lead to a drain on local electrical systems and a substantial increase in electricity demand. Some ports are exploring the use of microgrids to establish electrical security and demand stability. Microgrids provide a way for ports to minimize the use of diesel generators, their common form of power backup, and can allow for the integration of renewable energy technology to decrease the overall emissions. A primary hurdle to integrating shore power and microgrid technologies is the upfront costs, which can cost millions of dollars and require significant resources from port and marine terminals. For example, the Port of Los Angeles invested $27 million on a microgrid project in 2018, which required financial assistance in the form of state grants.[20]

Beyond the capacity demand for shore power plug-in will be the need for refueling infrastructure as new, lower emission fuels are adopted. Fuel sources such as green hydrogen present unique carbon zero emissions possibilities, though there is a lack of refueling infrastructure in place for maritime uses.[21] This presents a challenge in which shipping companies may wish to build vessels

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[14] The Conversation. "How shipping ports can become more sustainable." https://theconversation.com/how-shippingports-can-become-more-sustainable-156483. Accessed April 5, 2021.
[15] *Id.*
[16] International Council on Clean Transportation. "Costs and Benefits of Shore Power at The Port of Shenzhen." https://theicct.org/sites/default/files/publications/ICCT-WCtr_ShorePower_201512a.pdf. Accessed April 5, 2021.
[17] *Id.*
[18] *Id.*
[19] Ocean Conservancy. "Economic Recovery and a Zero-Emission Shipping Sector: A Roadmap for Federal Investment." Page 1.
[20] "Enabling Smart Ports Through the Integration of Microgrids: A Two-Stage Stochastic Programming Approach" http://www.ie.uh.edu/sites/ie/files/faculty/glim/SPMicrogrid_Elsevier-AE-2019.pdf. Accessed April 6, 2021.
[21] DNV. "Building a marine supply infrastructure as part of a future hydrogen society." https://www.dnv.com/expert-story/maritime-impact/Building-a-marine-supply-infrastructure-as-part-of-a-future-hydrogen-society.html. Accessed April 9, 2021.

that operate on a new fuel source, but cannot refuel due to the lack of infrastructure; conversely, the opposite could occur where a port may wish to invest in the refueling infrastructure but lack consumer demand for utilization.

Alternative Fuels

The IMO has established increasingly stringent targets for CO_2 emissions reductions in international shipping from the 2008 baseline: a 40 percent reduction by 2030, and a 70 percent reduction by 2050 regardless of trade growth, with full decarbonization shortly thereafter.[22] The IMO Energy Efficiency Design Index requires all ships built after 2013 to meet mandatory reductions with progressive targets every five years up until 2030, which is currently incompatible with continued long-term use of fossil fuels by commercial shipping.[23] While demand for seaborne trade is projected to grow by 39 percent through 2050, energy-efficiency measures, hull and machinery improvements, and speed reduction are readily available to reduce vessel emissions; however, the use of carbon-neutral fuels will need to grow 30-40 percent to meet world fleet energy needs by 2050 to achieve IMO greenhouse gas ambitions.[24] According to the Global Maritime Forum and is demonstrated by figure 1 below, zero emissions adoptions need to be at 5 percent of the market share by 2030 to reach full decarbonization by 2050.[25] Slow adoption of zero emissions technology is anticipated at first but is expected to grow substantially as cost decreases and availability increases.[26]

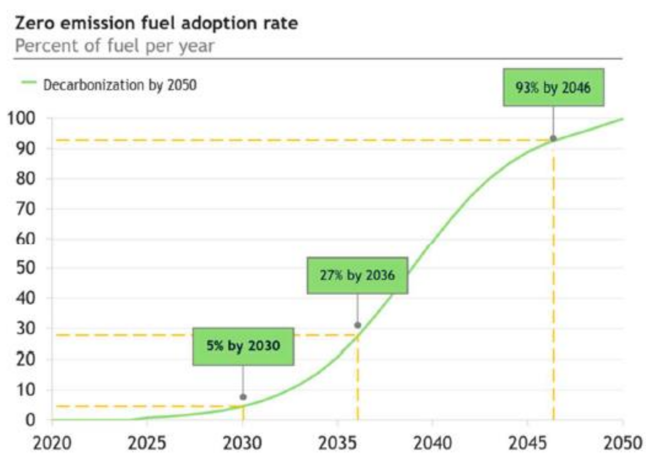

Figure 1- Global Maritime Forum. "Zero Emission Fuel Adoption Rate" available at https://www.globalmaritimeforum.org/news/five-percent-zero-emission-fuels-by-2030-needed-for-paris-aligned-shipping-decarbonization

22 International Maritime Organization. "IMO Action to Reduce Greenhouse Gas Emissions from International Shipping." IMO 2019.

23 Nishatabbas et al. "The implementation of technical energy efficiency and CO2 emission reduction measures in shipping." Ocean Engineering, Vol. 139, 2017: 184-197, https://www.sciencedirect.com/science/article/pii/S0029801817302160?via%3Dihub. Accessed April 6, 2021; DNV GL, "Maritime Forecast to 2050 Energy Transition Outlook 2019." https://eto.dnv.com/2018/download. Accessed April 6, 2021.

24 DNV GL. "Maritime Forecast to 2050 Energy Transition Outlook 2019." page 15. https://eto.dnv.com/2018/download. Accessed April 6, 2021.

25 Global Maritime Forum. "Zero Emission Fuel Adoption Rate." https://www.globalmaritimeforum.org/news/five-percent-zero-emission-fuels-by-2030-needed-for-paris-aligned-shipping-decarbonization. Accessed April 8, 2021.

26 *Id.*

Additionally, by 2025, the IMO will require all new ships to be 30 percent more energy efficient than those built in 2014.[27] The international fleet has made substantial improvements to 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 20-30 years.[28] As such, and with the ratification of new emissions standards by the IMO, shipping companies must consider zero-carbon fuels and associated technologies now to meet established deadlines. Vessels coming online after 2030 will need to be zero-emission vessels (ZEVs) or very low emission vessels to assure they can operate for their full expected commercial life. 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 coastwise shipping operators.[29]

International Shipping

International, oceangoing vessels will need different fuel sources and technologies than inland and coastal vessels due to their size and the length of their voyage. Further, cargo ships vary widely in performance and design. In addition to retrofitting existing ships, compliant vessels can be designed efficiently and built to meet the new emissions standards. 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 options for shipowners. Rotor sails, for example, can reduce a ship's fuel use by 5-20 percent.[30] 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; some projects already have operational wind-assisted vessels on the water today.[31] For existing vessels, operators can assess vessel efficiency based on each ship's design specifications and engine type, helping to lower their fuel costs and reduce emissions associated with moving goods around the world.[32]

Starting January 2020, the IMO placed a global upper limit of 0.5 percent (reduced from 3.5 percent) on the Sulfur content of marine fuel.[33] Known as "IMO 2020," the reduced limit is

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[27] Reuters. Chestney. N. "IMO agrees on stricter efficiency targets for some ships." May 2019. https://www.reuters.com/article/us-imo-shipping-efficiency/imo-agrees-on-stricter-efficiency-targets-for-some-ships-idUSKCN1SN2BV. Accessed April 6, 2021.

[28] Journal of Physics. IOP Conference Series: Materials Science and Engineering. "Maritime vessel obsolescence, life cycle cost and design service life." https://iopscience.iop.org/article/10.1088/1757-899X/95/1/012067/pdf. Accessed April 8, 2021.

[29] DNV. "Alternative Fuel Technologies can Bridge the Gap." https://eto.dnv.com/2019/Maritime/alternative-fuels. Accessed April 9, 2021.

[30] Kornei, K. "Spinning metal sails could slash fuel consumption, emissions on cargo ships." Science. https://www.sciencemag.org/news/2017/09/spinning-metal-sails-could-slash-fuel-consumption-emissions-cargo-ships. September 2017. Accessed April 6, 2021.

[31] Grist. Gallucci, M. "Dreamboats." October 21, 2019. https://grist.org/fix/dream-ships-could-turn-the-tide-for-trans-ocean-shipping/. Accessed April 6, 2021.

[32] Grist. Gallucci, M. "Shipping industry takes a page from bitcoin to clean up its act." https://grist.org/article/shipping-industry-takes-a-page-from-bitcoin-to-clean-up-its-act/. Accessed April 6, 2021.

[33] International Maritime Organization. "IMO 2020 - cleaner shipping for cleaner air." https://www.imo.org/en/MediaCentre/PressBriefings/Pages/34-IMO-2020-sulphur-limit-.aspx#:~:text=and%20the%20environment.-

mandatory for all ships operating outside certain designated Emission Control Areas where the limit previously was 0.1 percent.[34] Existing technologies and fuels deployed to meet IMO 2020 and other emissions caps include scrubbers, a mechanical treatment of high sulfur fuels to remove sulfur from the exhaust of the vessel, and switching to low sulfur fuels like liquified natural gas (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. Another concern that arises from the use of these fuels is the availability, supply, and potential impacts on consumer prices of the increased demand for source material.

Importantly however, LNG does not deliver the emissions reductions required by the IMO's initial GHG strategy, and its consumption could actually worsen the shipping industry's climate impacts.[35] Over a 100-year time frame, the maximum life cycle GHG benefit of LNG is a 15 percent reduction compared with other bunker fuels, and this is only if ships use a high-pressure injection dual fuel (HPDF) engine and if upstream methane emissions are well-controlled.[36] There are concerns that continued investment in LNG infrastructure on ships and on shore might make the transition to low-carbon and zero-carbon fuels in the future more difficult.[37] Over a 20-year time period, methane traps 86 times more heat than the same amount of CO_2.[38] Depending upon the state of engine technology, LNG-fueled ships might become less viable if GHG limits are established well before 2050. Concerns about such GHG limits might lead to a decrease in orders of LNG-powered ships over time.

Companies like Maersk are leading initiatives to develop carbon neutral vessels by 2023.[39] These vessels would run on fuels such as biofuels or methanol. While these fuels do emit carbon, it is derived from plant material, which first pulls carbon out of the atmosphere during photosynthesis and the equivalent amount of carbon is released during usage.[40] This would not add any new CO_2 to the atmosphere, like fossil-based fuels do, but does not reach the zero-emission mark and still places emission burdens on port adjacent communities.[41]

Hydrogen is a potential energy carrier that can potentially supplement traditional fuel sources or complement electricity on vessels. When produced from electricity, these fuels are called electro or e-fuels and include ammonia, methanol, formic acid, synthetic methane (SNG), or higher hydrocarbon synthetic fuels (syn-fuel).[42] Currently, hydrogen is predominantly used as feedstock for

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,From%201%20January%202020%20the%20global%20upper%20limit%20on%20the,the%20limit%20is%20already%200.10%25. Accessed April 6, 2021.

34 *Id*.

35 *Id.*

36 International Council on Clean Transportation. "The climate implications of using LNG as a marine fuel." https://theicct.org/publications/climate-impacts-LNG-marine-fuel-2020. Accessed April 5, 2021.

37 *Id.*

38 *Id.*

39 Maersk. "A.P. Moller - Maersk will operate the world's first carbon neutral liner vessel by 2023 – seven years ahead of schedule." https://www.maersk.com/news/articles/2021/02/17/maersk-first-carbon-neutral-liner-vessel-by-2023. Accessed April 9, 2021.

40 International Council on Clean Transportation. "The potential of liquid biofuels in reducing ship emissions." https://theicct.org/sites/default/files/publications/Marine-biofuels-sept2020.pdf. Accessed April 9, 2021.

41 *Id.*

42 DNV. "10 transitions to turn ports into decarbonization hubs." https://www.dnv.com/power-renewables/themes/green-ports/index.html. Accessed April 5, 2021.

the chemical and petro-chemical industries and produced from natural gas through steam reforming or partial oxidation (blue hydrogen if combined with carbon capture and storage). Hydrogen has great potential to decarbonize industrial processes and facilitate the energy transition as it can also be produced from renewable electricity, termed "green hydrogen".[43] Some ports are natural hubs for connecting offshore wind given their often-close proximity to wind farms, and therefore have easy access to abundant renewable electricity, which can be converted to green hydrogen through electrolysis. The economic competitiveness of green hydrogen will likely require investments in both ports and vessels.

U.S. Domestic Shipping

Coastwise vessels, traveling shorter distances and with variable power demands relative to international shipping vessels, 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 coastwise fleet increases flexibility for battery storage, fuel cells and waste heat, as well as renewable sources (e.g. solar, wind, waves).

Electrification of the domestic industry will be enabled by a massive deployment of additional renewable energy source capacity, the associated grid and storage infrastructure, green hydrogen production, electric boilers, and heat pumps. Electrification of vessels could result in a 50 percent decrease of fossil cargo (oil, gas, LNG). Companies have worked with state and local entities on electrification conversion projects— for example, Glosten partnered with the state of Alabama to convert the historic Gee's Bend Ferry into the first all-electric passenger/car ferry[44] in the United States. These projects have demonstrated the applicability to the coastwise fleet, but hurdles still exist for electric vessels that need more powerful systems and operate in locations without the necessary infrastructure. This could have a significant impact on the surrounding industry, improve the local electricity grid, and support utility services and other electricity production facilities should the proper investments in infrastructure to support these projects be made.[45]

To develop, prove, scale, and commercialize electrification, 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,[46] the Maritime Administration's Marine Environmental Technical Assistance office,[47] and the U.S. Coast

[43] University of Houston. "Advancing Sustainable Low-Carbon Energy through Convergence." https://uh.edu/uh-energy/research/ccme/advancing-sustainable-low-carbon-energy/adv-sus-low-carbon-energy-convergence. Accessed April 9, 2021.
[44] Glosten. "The Nation's First All-Electric Vehicle Ferry" https://glosten.com/sectors/the-nations-first-all-electric-vehicle-ferry/. Accessed April 9, 2021.
[45] DNV. "10 transitions to turn ports into decarbonization hubs." https://www.dnv.com/power-renewables/themes/green-ports/index.html. Page 21. Accessed April 5, 2021.
[46] Department of Energy. "DOE Shows Fuel Cells Used in Maritime Applications Can Increase Efficiency by 30%." https://www.energy.gov/eere/fuelcells/articles/doe-shows-fuel-cells-used-maritime-applications-can-increase-efficiency-30. Accessed April 9, 2021.
[47] Maritime Administration. Maritime Environmental and Technical Assistance (META) Program. https://www.maritime.dot.gov/innovation/meta/maritime-environmental-and-technical-assistance-meta-program. Accessed on April 9, 2021.

Guard[48] have initiated conversations about the availability and viability of new fuels and energy sources for use throughout the maritime industry.

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[48] United States Coast Guard. "Energy Management Performance." https://www.dcms.uscg.mil/Our-Organization/Assistant-Commandant-for-Engineering-Logistics-CG-4-/Program-Offices/Energy-Management/. Accessed April 9, 2021.