PRACTICAL STEPS TOWARD A CARBON-FREE MARITIME INDUSTRY: UPDATES ON FUELS, PORTS, AND TECHNOLOGY

(117–12)

REMOTE HEARING

BEFORE THE

SUBCOMMITTEE ON
COAST GUARD AND MARITIME TRANSPORTATION

OF THE

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TRANSPORTATION AND
INFRASTRUCTURE
HOUSE OF REPRESENTATIVES

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

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Chairman

Katherine W. Dedrick, Staff Director

Sam Graves
Ranking Member

Paul J. Sass, Republican Staff Director

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 (CO2) as well as black carbon, a fine particulate that can absorb a million times the incoming solar energy as CO2.[3] Black carbon accounts for 21 percent of CO2-equivalent emissions from ships, making it the second most important driver of the shipping industry's climate impacts after

[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.

[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.

CO2.[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 CO2 per year, equaling approximately 3.1 percent of annual global CO2 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] CO2 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]

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.

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[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.

[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.

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 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 CO2 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]

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[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.

[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.*

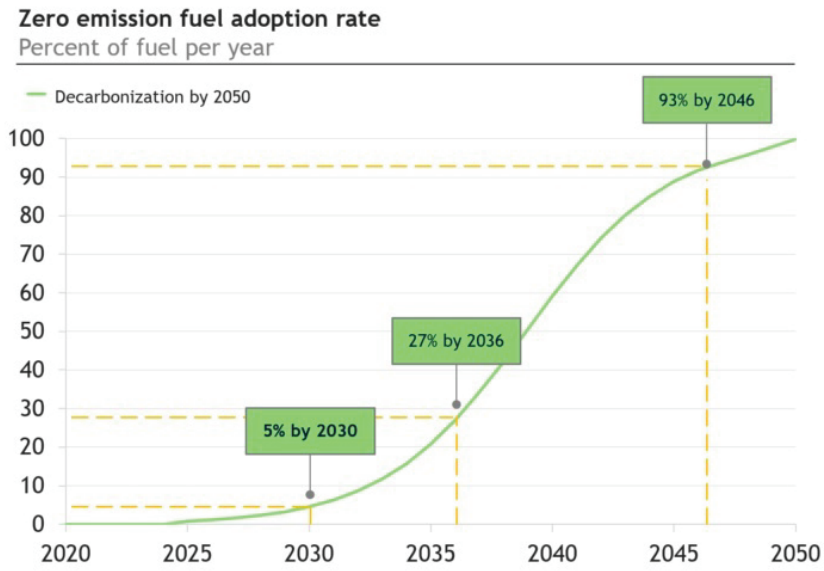

Figure 1—Global Maritime Forum. ''Zero Emission Fuel Adoption Rate'' available at https://www.globalmaritimeforum.org/news/five-percent-zero-emission-fuels-by-2030-needed-for-paris-aligned-shipping-decarbonization

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 per-

[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.

cent.[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 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 liquefied 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 CO2.[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 CO2 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,

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[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.-,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.*

synthetic methane (SNG), or higher hydrocarbon synthetic fuels (syn-fuel).[42] Currently, hydrogen is predominantly used as feedstock for the chemical and petrochemical 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 Guard[48] have initiated conversations about the availability and viability of new fuels and energy sources for use throughout the maritime industry.

WITNESS LIST

- Mr. John Butler, President and Chief Executive Officer, World Shipping Council
- Ms. Kristin Decas, Chief Executive Officer and Port Director, The Port of Hueneme
- Mr. Morgan Fanberg, P.E., President, Glosten
- Dr. Lee Kindberg, Director of Environment & Sustainability, Maersk
- Dr. Dan Rutherford, Program Director and Regional Lead, International Council on Clean Transportation

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[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.

[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.

[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.

PRACTICAL STEPS TOWARD A CARBON-FREE MARITIME INDUSTRY: UPDATES ON FUELS, PORTS, AND TECHNOLOGY

THURSDAY, APRIL 15, 2021

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON COAST GUARD AND
MARITIME TRANSPORTATION,
COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE,
Washington, DC.

The subcommittee met, pursuant to call, at 11:04 a.m. in 2167 Rayburn House Office Building and via Zoom, Hon. Salud O. Carbajal (Chair of the subcommittee) presiding.

Members present in person: Mr. Carbajal, Mr. DeFazio, Mr. Larsen, Mr. Gibbs, Mr. Weber, and Ms. Malliotakis.

Members present remotely: Mr. Auchincloss, Mr. Lowenthal, Ms. Brownley, and Mr. Van Drew.

Mr. CARBAJAL. The subcommittee will come to order.

I ask unanimous consent that the chair be authorized to declare a recess at any time during today's hearing.

Without objection, so ordered.

I also ask unanimous consent that Members not on the subcommittee be permitted to sit with the subcommittee at today's hearing and ask questions.

Without objection, so ordered.

For Members participating remotely, please let committee staff know as soon as possible if you are experiencing connectivity issues or technical problems.

To avoid any inadvertent background noise, I request that every Member please keep their microphones muted when not seeking recognition to speak. Should I hear any inadvertent background noise, I will request that the Member please mute their microphone. And finally, to insert a document into the record, please have your staff email it to DocumentsT&I@mail.house.gov.

With that, we will commence our hearing.

Good morning and welcome to today's Coast Guard and Maritime Transportation Subcommittee hearing on practical steps toward a carbon-free maritime industry. Today we will examine the progress towards eliminating carbon emissions in the maritime industry, and how Congress can support these efforts.

This work is crucial to mitigating the effects of climate change. Without decisive action in the maritime industry and elsewhere, we are going to experience severe impacts on our way of life from sea level rise, flooding, and more frequent extreme weather events.

Climate change is one of the most important challenges of our time. As we seek solutions, we must capitalize on the opportunity to promote American innovation and bolster the American workforce. Burning fossil fuels in the maritime industry and elsewhere results in emissions of greenhouse gases and other pollutants that are harmful to human health. Greenhouse gases also absorb and trap heat in our atmosphere, which has led to shifts in regional climate patterns that have consequences for our food and water systems, public and private infrastructure, and national security.

The science is crystal clear: We are vulnerable to climate changes due to human actions. Over the past 171 years, human activities have raised atmospheric concentrations of carbon dioxide by 48 percent above pre-industrial levels found in 1850. The last time the atmospheric carbon dioxide amounts were this high was more than 3 million years ago—let me say that again: more than 3 million years ago—when the temperature was 3.6 to 5.4 degrees higher than during the pre-industrial era, and sea level was 50 to 80 feet higher than today.

Unfortunately, many of the worst air pollution problems can occur in our communities comprised of minority populations. Port communities are directly exposed to nitrous oxide, sulfur dioxide, and particulate matter, and have some of the country's highest asthma rates. Many of these citizens make up our maritime and longshore workforce, so their health is not only a moral issue, but also a public good for sustaining maritime commerce.

Commerce by sea is cleaner and safer than transportation by land, and we should do everything possible to encourage more waterborne transportation. But traditional maritime fuel emits harmful greenhouse gases, contributing to global and regional climate change. International shipping accounts for 3 percent of the world's carbon emissions, and if it were a country, the sector would be the world's sixth largest emitter.

The International Maritime Organization has set an ambitious goal of reducing carbon dioxide emissions by 50 percent before 2050, which is not possible unless the industry takes immediate and aggressive action. But that is not enough. Maritime carbon emissions must be eliminated if we are to avoid the most devastating impacts of climate change.

While the challenge can seem daunting, we must recognize and capitalize on the opportunity for American industry to innovate and lead the pack. If we develop new forms of energy generation, we can also create jobs for the American people. We are already seeing positive steps taken by ports, vessel owners, shipyards, academic institutions, and State and local governments, such as the Santa Barbara Air Pollution Control District in the central coast of California, which I represent.

The Air Pollution Control District has developed a vessel speed reduction program, "Protecting Blue Whales and Blue Skies," that has not only cut carbon emissions, but has reduced noise pollution in our local waterways, and avoided vessel strikes with local marine mammals. I know Representative Lowenthal had a lot to do with these efforts in his area, as well, in the Port of Long Beach and the Long Beach region.

I am convinced that, if we think outside the box, we can bolster our maritime industry, create new jobs, and position America as a leader in maritime technologies. I look forward to hearing from our expert witnesses on ways to reach our ambitious emissions goals, while stimulating the U.S. economy and domestic job growth.

[Mr. Carbajal's prepared statement follows:]

Prepared Statement of Hon. Salud O. Carbajal, a Representative in Congress from the State of California, and Chair, Subcommittee on Coast Guard and Maritime Transportation

Good morning, and welcome to today's Coast Guard and Maritime Transportation Subcommittee hearing on "Practical Steps Toward a Carbon-Free Maritime Industry." Today, we will examine the progress toward eliminating carbon emissions in the maritime industry, and how Congress can be supportive. This work is crucial to mitigating the effects of climate change. Without decisive action in the maritime industry and elsewhere, we are going to experience severe impacts on our way of life from sea-level rise, flooding, and extreme weather events.

Climate change is the most important challenge of our time. As we seek solutions, we must capitalize on the opportunity to promote American innovation and bolster the American workforce.

Burning fossil fuels in the maritime industry and elsewhere results in the emission of greenhouse gases and other air pollutants that are harmful to human health. Greenhouse gases also absorb and trap heat in our atmosphere, which has led to shifts in regional climate patterns that have consequences for our food and water systems, public and private infrastructure, and national security. The science is crystal clear, we are vulnerable to climate changes due to human actions.

Over the past 171 years, human activities have raised atmospheric concentrations of carbon dioxide by 48% above pre-industrial levels found in 1850. The last time the atmospheric carbon dioxide amounts were this high was more than 3 million years ago, when temperature was 3.6 to 5.4 degrees higher than during the pre-industrial era, and sea level was 50 to 80 feet higher than today.

Unfortunately, many of the worst air pollution problems occur in communities comprised of minority populations. Port communities are directly exposed to nitrous oxide, sulfur dioxide, and particulate matter, and have some of the country's highest asthma rates. Many of these citizens make up our maritime and longshore workforce, so their health is not only a moral issue but also a public good for sustaining maritime commerce.

Commerce by sea is cleaner and safer than transportation by land, and we should do everything possible to encourage more waterborne transportation, but traditional maritime fuel emits harmful greenhouse gases contributing to global and regional climate change. International shipping accounts for 3 percent of the world's carbon emissions, and if it were a country, the sector would be the world's sixth-largest emitter.

The International Maritime Organization has set an ambitious goal of reducing carbon dioxide emissions by 50 percent before 2050, but that is not possible unless the industry takes immediate and aggressive action. But that is not enough. Maritime carbon emissions must be eliminated if we are to avoid the most devastating impacts of climate change. While the challenge can seem daunting, we must recognize and capitalize on the opportunity for American industry to innovate and lead the pack. If we develop new forms of energy generation, we can create jobs for American workers.

We are already seeing positive steps taken by ports, vessel owners, shipyards, academic institutions, and state and local governments such as the Santa Barbara Air Pollution Control District in California's 24th Congressional District. The Air Pollution Control District has developed a vessel speed reduction program that has not only cut carbon emissions but has reduced noise pollution in our local waterways and avoided vessel strikes with local marine mammals. I am convinced that if we think outside the box, we can bolster our maritime industry, create new jobs, and position America as the leader in maritime technologies.

I look forward to hearing from our expert witnesses on ways to reach our ambitious emissions goals while stimulating the U.S. economy and domestic job growth.

Mr. CARBAJAL. I ask unanimous consent to insert a statement from the Ocean Conservancy into the hearing record.

Without objection?

Without objection, so be it.

[The information follows:]

Letter of April 14, 2021, from Daniel Hubbell, Shipping Emissions Campaign Manager, Ocean Conservancy, Submitted for the Record by Hon. Salud O. Carbajal

APRIL 14, 2021.

Hon. SALUD CARBAJAL,
Chair,
Subcommittee on Coast Guard and Maritime Transportation, House Committee on Transportation and Infrastructure, 2165 Rayburn House Office Building, Washington, DC 20515.

Hon. BOB GIBBS,
Ranking Member,
Subcommittee on Coast Guard and Maritime Transportation, House Committee on Transportation and Infrastructure, 2165 Rayburn House Office Building, Washington, DC 20515.

DEAR CHAIR CARBAJAL AND RANKING MEMBER GIBBS,

Ocean Conservancy would like to thank the Subcommittee on Coast Guard and Maritime Transportation for holding this important hearing on emissions from the maritime industry, entitled *Practical Steps Toward a Carbon-Free Maritime Industry: Updates on Fuels, Ports and Technology*. Emissions from shipping and ports demands urgent action, and we are encouraged to see this Committee's consideration of the issue. Our nation's ports and the shipping sector are both directly impacted by climate change and a large contributor to air pollutants and global greenhouse gas emissions, which impact air quality, our climate, and our economy. Efforts to decarbonize domestic ports and make the United States a leader in the global transition to zero emission shipping must be part of the solution to ensure a clean energy future, create jobs and boost the economy. As you hear from other expert witnesses and consider infrastructure investments and policy solutions to move us towards a decarbonized maritime industry, we would like to take the opportunity to add our recommendations to the record for today's hearing.

Over 80% of the world's trade by volume is carried on oceangoing vessels, and America's ports are the key points of access for this trade. In a given day, billions of dollars' worth of goods flow through our ports, supporting the employment of nearly 31 million Americans in 2018.[1] The ships that we rely on to deliver our goods to port are responsible for an estimated 2.9% of global carbon dioxide emissions[2], and emissions from the sector are expected to rise by as much as 130% by 2050.[3] In order to protect livelihoods, human health, and our ocean, we cannot afford to delay this industry's transition to a clean future. A zero-emission future for the sector is possible, but significant investment will be needed for research and development to build out true zero emission fuels, port infrastructure such as shore power, and retrofits and construction of vessels. While this transition is an ambitious undertaking, it is feasible, fiscally responsible and urgently necessary. If shipping were decarbonized by 2050, it could yield an estimated net benefit of $1.2–9.1 trillion to the global economy, or roughly $84–637 billion for the United States alone.[4]

In addition to economic benefits, decarbonizing the shipping sector and our ports has direct impacts on air quality. Ports, at-berth vessels and supporting equipment such as trucks are often major producers of air pollution, disproportionately affect-

[1] American Association of Port Authorities (2019). 2018 National Economic Impact of the U.S. Coastal Port System: Executive Summary. Available at: https://www.aapa-ports.org/advocating/PRdetail.aspx?itemnumber=22306

[2] Saul, J. (2020). Shipping's share of global carbon emissions increases. Reuters. Available at: https://www.reuters.com/article/us-shipping-environment-imo/shippings-share-of-global-carbon-emissions-increases-idUSKCN2502AY

[3] Ibid.

[4] Michelin, M., et al. 2020. "Opportunities for Ocean-Climate Action in the United States." Report. San Francisco, CA: CEA Consulting. Available online at: www.oursharedseas.com/oceanclimateaction.

ing lower income communities and communities of color.[5] In California alone, the California Air Resources Board (CARB) estimates that ports and goods movement are responsible for 3,700 premature deaths each year.[6] Solutions such as installing onshore power for ships to utilize at-berth, rather than burning fuel in their own engines alongside the dock, serves the dual purpose of reducing carbon emissions and improving air quality.

There are a number of recommendations relevant to this Committee outlined in Ocean Conservancy's recently-published report, entitled *All Aboard! How the Biden-Harris Administration Can Help Ships Kick Fossil Fuels*. As this Committee advances an infrastructure package and considers policy solutions to decarbonize the shipping sector and our nation's ports, we would like to highlight the recommendations below:

1. *Increase funding for existing programs that can fund zero-emission research & development, port infrastructure projects, and construction and retrofitting of ships*. This includes the following:
   a. Funding for the *Port Infrastructure Development Program (PIDP)* with prioritization for green port infrastructure that reduces greenhouse gas emissions, including shore power, and replacement of polluting equipment.
   b. Funding for federal financing through *MARAD's Title XI* to provide retrofits to existing vessels, including upgrades to enable vessels to accept shore power, and provide for new construction of zero-emission vessels.
   c. Funding for *MARAD's Maritime Environmental and Technical Assistance (META) Program*. The program has demonstrated success with carrying out projects that support research, demonstration and development of emerging technologies and initiatives to improve environmental sustainability of the maritime sector. Increasing funding would allow the program to support additional research into zero-emission vessels, fuel cell applications for ships and ports, port electrification, and energy efficiency.
2. *Set federal clean ship standards* with identified, progressive targets for decarbonization of 50% by 2025, 80% by 2030 and 100% by 2035.
3. *Support new grant programs through proposals such as the Climate Smart Ports Act (CSPA)*, which would add a $1 billion per year fund dedicated to improving sustainability in America's ports. Reaching zero-emission targets and preparing ports for zero-emission ships will require significant investment. The EPA, working with the Department of Transportation, should establish a new fund and grant program to jumpstart the zero-emission transition at American ports.
4. *Leverage the Marine Highway Program to establish a domestic zero-emission Marine Highway corridor*. This would encourage uptake of zero-emission technologies for shipping and ports while at the same time relieving congestion and emissions on interstate highways.
5. *Encourage the Department of Transportation to collaborate with the Department of Energy* to accelerate the research, development, and deployment of zero emission fuels for shipping, including through ARPA–E and the creation of an Advanced Technologies Loan Program for zero-emission shipping.
6. *Support collaboration across ports*. In the long term, collective investment by multiple ports could open the possibility of zero emission short sea shipping by U.S. flagged ships.
7. *Allow for the procurement of low and zero-emission vessels for Maritime Training Institutes* to ensure mariners can develop the necessary skills to safely operate these ships.
8. *Require port emission inventories*. U.S. ports are not currently required to conduct an annual inventory of air pollutants or greenhouse gases. Uniform reporting of emissions is needed to set and track compliance with zero-emission targets.
9. *Establish a short-term Zero Port Pollution Tax*. While public dollars are necessary and appropriate for many infrastructure projects, American taxpayers alone should not bear the burden. A Zero Port Pollution Fund could support zero-emission vessel development and green port infrastructure through a tax on deadly criteria pollutants (NOx, SOx, and black carbon, the most dangerous component of particulate matter), as well as greenhouse gases (notably CO2 and CH4).
10. *Establish an Environmental Justice Ports Advisory Commission* or ports and shipping working group within the White House Environmental Justice Advi-

[5] EPA (2017). Shore Power Technology Assessment. EPA–420–R–17–004. Available at: https://www.epa.gov/ports-initiative/shore-power-technology-assessment-us-ports

[6] Michelin et al. 2020

sory Council to prioritize frontline community perspectives in port and shipping policy decisions.

Our nation's ports and shipping sector have a critical role to play in our transition to a clean energy future, and Ocean Conservancy stands ready to work with this Committee and the administration to make zero-emission shipping and ports a reality. We encourage you to engage all stakeholders in this crucial area of the ocean economy, including frontline communities, as you consider our national infrastructure needs.

Sincerely,

DANIEL HUBBELL,
Shipping Emissions Campaign Manager, Ocean Conservancy.

cc: The Honorable Peter DeFazio, Chair, House Committee on Transportation and Infrastructure
The Honorable Sam Graves, Ranking Member, House Committee on Transportation and Infrastructure

Mr. CARBAJAL. With that, I now call on the ranking member of the subcommittee, Mr. Gibbs, for an opening statement.

Mr. GIBBS. Thank you, Mr. Chairman.

In 2018, the International Maritime Organization issued its initial strategy on the reduction of greenhouse gas emissions from shipping, and a revised strategy is due in 2023.

Industry has responded by beginning to develop, test, and use new fuels and new technologies. I look forward to hearing today what the costs are of the industrywide recapitalization that decarbonization will require, and who will bear the cost.

I am also interested in if these changes will be done in line with planned vessel replacements.

I am also interested in which technologies and fuels show promise for which sectors, and whether the witnesses expect multiple technologies and fuels to be used in the future, instead of a single fuel.

In the past, wind-powered vessels were succeeded by coal, which was succeeded by bunker fuel. It appears the next transition may be to an array of fuels and technologies, rather than the linear movement from a single dominant fuel to a different single dominant fuel.

In addition to decarbonizing vessel fuel, efforts to reduce air emissions are also underway at ports. Again, I am interested in the status and cost of these efforts.

While the IMO has set goals for vessel emission standards, what are the goals for reductions of emissions standards at our ports? Will ocean carriers and ultimately U.S. importers and exporters bear these costs?

I look forward to what today's witnesses have to tell us about methods, costs, and any efficiencies to be gained through efforts to decarbonize vessel and port operations.

[Mr. Gibbs' prepared statement follows:]

Prepared Statement of Hon. Bob Gibbs, a Representative in Congress from the State of Ohio, and Ranking Member, Subcommittee on Coast Guard and Maritime Transportation

Thank you, Chair Carbajal, for holding this hearing today.

In 2018, the International Maritime Organization issued its initial strategy on the reduction of greenhouse gas emissions from shipping, and a revised strategy is due

in 2023. Industry has responded by beginning to develop, test, and use new fuels and new technologies.

I look forward to hearing today what the costs are of the industry-wide recapitalization that decarbonization will require and who will bear that cost. I'm also interested if these changes will be done in line with planned vessel replacements.

I am also interested in which technologies and fuels show promise for which sectors, and whether the witnesses expect multiple technologies and fuels to be used in the future instead of a single fuel. In the past, sail was succeeded by coal, which was succeeded by bunker fuel. It appears the next transition may be to an array of fuels and technologies rather than the linear movement from a single dominant fuel to a different single dominant fuel.

In addition to decarbonizing vessel fuel, efforts to reduce air emissions are also underway at ports. Again, I am interested in the status and costs of those efforts. While IMO has set goals for vessel emission standards, what are the goals for reductions of emissions standards at ports? Will ocean carriers and ultimately U.S. importers and exporters bear these costs?

I look forward to what today's witnesses have to tell us about methods, costs, and any efficiencies to be gained through efforts to decarbonize vessel and ports operations.

Mr. GIBBS. Again, Mr. Chairman, I yield back.

Mr. CARBAJAL. Thank you, Mr. Gibbs.

Now I would like to recognize Chairman DeFazio.

Mr. DEFAZIO. Thank you, Mr. Chairman. I appreciate your having this hearing on this really interesting and important topic. I think I have tasked every subcommittee to look at ways to reduce carbon emissions within their jurisdiction, and this is an important contribution to that effort.

With COVID–19 disrupting global cargo, the role of the maritime industry has become more apparent to many more people over the last year—and then, of course, the high publicity with the blockage of the Suez Canal by *Ever Given*.

I think now that folks are becoming aware that the majority of everything they consume is involved in maritime transportation, that they will be a little more focused on the industry in the future. And I think this gives us an opportunity to begin to deal with the industry's carbon pollution.

They are already moving away from the dirty bunker fuels under an international agreement. They are already the most fuel-efficient way, per ton, to move freight. But there are possibilities to move much more in a direction to reduce their carbon emissions. They are 3 percent of the world's industrial emissions now, and could be 10 percent by 2050 without significant changes.

There is a lot of interesting research going on. There is a company in my State called Element One, and their technology utilizes seawater—the most, I guess, plentiful thing on Earth—and methanol to produce hydrogen, to run hydrogen fuel cells, and run a hydrogen fuel-cell ship. This has tremendous potential. Fifty percent carbon reduction, if you use standard methanol, and, obviously, carbon neutral if you use a renewable methanol.

Our ports, as the chairman mentioned, coming from southern California, they are already hard at work to try and eliminate carbon pollution in the ports with the drayage trucks, with the equipment that moves containers around, and other operations. They are looking at electrification. It is capital intensive. And I am sure that our international competitors are going to be subsidizing this, and I think there is a role for the Federal Government to be involved.

There are many steps that we could take: grant funding for ports looking to add shoreside power hookups for vessels to run on electricity while they are at dock, to purchase electric cargo handling equipment, and to construct microgrids that integrate clean energy sources which could involve offshore wind or tidal power or wave power, given the situation of our particular ports.

We want to be the innovator in these areas, we want to lead the world, and we want to begin to export these technologies, just like we used to lead the world in so many things before. That is also part of the President's plan: to restore our international competitiveness instead of being a country that is totally dependent upon imports; to be again as someone who is more focused on exporting technology and creating jobs here at home.

I think there are a lot of opportunities here for long-lasting, middle-class jobs: longshore mariners, shipbuilders—an industry that we need, is essential, as a maritime nation. And with these new technologies, we could be leading the world.

There is no one-size-fits-all for this. Today in the hearing, we will hear of a number of different approaches. And I appreciate, again, the opportunity to become educated more on the subject.

Thank you, Mr. Chairman.

[Mr. DeFazio's prepared statement follows:]

Prepared Statement of Hon. Peter A. DeFazio, a Representative in Congress from the State of Oregon, and Chair, Committee on Transportation and Infrastructure

Thank you, Chair Carbajal, and thank you for having a hearing on the important topic of reducing emissions and decarbonizing the maritime industry.

This hearing builds upon our efforts across all modes of transportation to reduce carbon emissions in order to address climate change. This hearing comes at a crucial time as we aim towards Building Back Better, creating American jobs, and becoming global leaders in new technologies.

With the COVID–19 pandemic disrupting global cargo movements, the role of the maritime industry is front and center. Between the EVER GIVEN's blockage of the Suez Canal and the major backlog on the West Coast, the American public is newly aware of the importance of the maritime supply chain. I hope that this presents an opportunity to discuss the industry's greenhouse gas emissions and practical ways to reduce them.

Climate change is real and we're already starting to see the consequences. The international maritime industry accounts for 3 percent of the world's carbon emissions with the potential to grow to 10 percent by 2050 if significant changes are not made. The maritime industry cannot afford to waste any time; we must decarbonize now.

We often hear of electric vehicles or revitalizing our energy grid, but what most fail to realize is the potential that exists within our maritime infrastructure. Industry is already hard at work researching and developing vessel infrastructure for the alternative fuels of the future, such as hydrogen, ammonia, methanol, and battery power.

Some American companies, such as Element One in my home state of Oregon, are developing new technologies to utilize hydrogen fuel cells aboard ships using seawater and methanol—this technology is now available at various re-fueling hubs across the country and world.

Ports are building out and investing in critical shore-side infrastructure to electrify their operations, and states are providing some financial aid to help cover the upfront costs. Projects such as these are capital-intensive and in their infancy, so federal investment may be necessary. I have no doubt that our foreign competitors will be subsidizing their maritime industries.

The Biden administration is prioritizing emissions reduction across transportation sectors, and international agreements are setting targets for maritime carbon emissions reduction by 2050. But now is not the time for us to take the back seat; Con-

gress needs to implement strong and progressive measures to reach the goal of a fully decarbonized maritime industry.

There are many steps we can take to support this vital work. For instance, we can increase grant funding for ports looking to add shore-side power hookups for vessels to run on electricity, to purchase electric cargo handling equipment, and to construct microgrids that integrate clean energy sources such as offshore wind.

We must identify ways to position the United States as a leader in new technologies across the transportation sector. Doing so will create lasting, middle class jobs for longshore workers, mariners, and shipbuilders as well as jobs associated with the research, development, and maintenance of new technologies.

Today, I am excited to hear from an excellent panel of folks who are leading the charge on decarbonizing the maritime industry. There is no one size fits all, and we know there will be different solutions for different maritime problems. That's why it is our job to support a wide array of practical yet progressive steps as we steer the shipping industry toward a decarbonized future. And while we will hear some success stories today, I want to remind us all that there is still much more to be done to reach the goal of zero carbon emissions.

Mr. CARBAJAL. Thank you, Chairman DeFazio. I would now like to welcome the witnesses on our panel.

First we have Mr. John Butler, president and chief executive officer of World Shipping Council.

Second we have Ms. Kristin Decas, chief executive officer and port director, the Port of Hueneme.

Next we have Mr. Morgan Fanberg, president of Glosten.

Next we have Dr. Lee Kindberg, director of environment and sustainability with Maersk.

Last we have Dr. Dan Rutherford, program director and regional lead for International Council on Clean Transportation.

Thank you for being here today, and I look forward to hearing your testimony.

Before we begin I would like to turn it over and recognize my colleague, Representative Julia Brownley, who represents the district to the south of my district, to say a few words about Ms. Decas and the Port of Hueneme, which I also adopt as partially my port, because they are right on the border of her district and my district.

And with that, Representative Brownley.

Ms. BROWNLEY. Well, thank you, Mr. Chairman, for allowing me to be here this morning to introduce Kristin Decas, a constituent of mine and the CEO and port director of the Oxnard Harbor District and Port of Hueneme and Ventura County.

You could not have chosen a better witness for today's hearing, which is appropriately entitled, "Practical Steps Toward a Carbon-Free Maritime Industry: Updates on Fuels, Ports, and Technology." Without a doubt, Ms. Decas is one of the Nation's leading experts in what our Nation's ports are doing to address the threats posed by the climate crisis.

Ms. Decas has been instrumental in working to strengthen the Port of Hueneme's commitment to staying on the leading edge of environmental stewardship. Through her extraordinary leadership, the Port of Hueneme became the first port in California to earn the Green Marine certification in 2017. This is a voluntary industry program that looks at multiple environmental performance indicators at ports, including air emissions, prevention of spills and leakages, community impacts, and environmental leadership.

Under her stewardship, the port has installed plug-in power systems for ships that come into the port, so that they can turn off their diesel engines and reduce carbon emissions. The port is also

proactively developing its Port of Hueneme Reducing Emissions, Supporting Health Clean Air Plan, in partnership with our local air quality regulatory agency, the Ventura County Air Pollution Control District.

This port has also implemented new technologies and best practices, including a new zero-waste policy, phasing in high-mast LED lighting to reduce energy use and light pollution, overhauling a harbor patrol boat to reduce emissions, switching to compostable supplies, and hosting zero-waste events, and a lot more.

The port has been dogged in their pursuit of new grant opportunities to help the port build greener infrastructure and procure zero-emission cargo handling equipment. And Congress has a critical role to play to ensure our ports have access to necessary Federal resources to help them transition towards a cleaner, greener future.

And I was delighted to have the chairman of the full committee, Peter DeFazio, visit the Port of Hueneme. And as the Port of Hueneme's Representative in Congress, along with our subcommittee chair here today, I could not be more proud of the work that is being done by the port commissioners and by Ms. Decas and her team of talented professionals to keep our local port clean and green. And I am very proud to be here today to introduce all of you to a wonderful leader, and my constituent, Ms. Kristin Decas.

Thank you, Mr. Chairman, for the opportunity, and I yield back.

Mr. CARBAJAL. Thank you, Representative Brownley. Let me just say I grew up in Oxnard, breathing a lot of those emissions. So I am grateful for the port becoming the greenest port in the Nation, and helping alleviate the public health concerns that are associated sometimes with some of our ports and neighboring communities.

With that, we will proceed to our witnesses.

Without objection, our witnesses' full statements will be included in the record.

Since your written testimony has been made a part of the record, the subcommittee requests that you please limit your oral testimony to 5 minutes.

Mr. Butler, you may proceed.

TESTIMONY OF JOHN W. BUTLER, PRESIDENT AND CHIEF EXECUTIVE OFFICER, WORLD SHIPPING COUNCIL; KRISTIN DECAS, CHIEF EXECUTIVE OFFICER AND PORT DIRECTOR, PORT OF HUENEME–OXNARD HARBOR DISTRICT; MORGAN M. FANBERG, P.E., PRESIDENT, GLOSTEN, INC.; B. LEE KINDBERG, PH.D., GCB.D, HEAD OF ENVIRONMENT AND SUSTAINABILITY–NORTH AMERICA, MAERSK; AND DAN RUTHERFORD, PH.D., MARINE AND AVIATION PROGRAM DIRECTOR, INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Mr. BUTLER. Chairman Carbajal, Ranking Member Gibbs, full committee Chairman DeFazio, members of the subcommittee, thank you for the opportunity to testify today. I am John Butler, president and CEO of the World Shipping Council.

Our members provide 90 percent of global containership capacity, and offer a significant percentage of the world's vehicle carrier fleet.

VOICE. The timer——

Mr. CARBAJAL. Please proceed. Sorry about that.

Mr. BUTLER. The subcommittee's focus today on practical solutions to decarbonization of shipping is right on point. We face a huge challenge.

Over the coming decades, we need to convert the world's international fleet to low- or no-carbon fuels and associated technologies, and we have to do that in a way that does not undermine the essential transportation services that make the global economy function. I would like to emphasize two points today.

My first point is that, although there are some promising low- and zero-carbon fuels and technologies under consideration, we simply do not yet know which of these options will end up being viable for the long haul. This is not a matter of simply picking an available fuel and getting on with it.

The fact is that all of the future fuels under consideration have significant issues that have to be overcome in terms of safety, energy density, life cycle, carbon profile, and other challenges. In order to reach a point where investment capital will flow to create fuel production and delivery infrastructure for alternative fuels, we need much greater technological certainty about what fuels and technologies will turn out to be truly sustainable, from an operational, safety, environmental, and economic perspective.

To get that technological and investment certainty, we must accelerate the necessary research and development now. Current R&D efforts are fragmented, and dedicated funding and global scale are missing. To address that R&D gap, the shipping industry in December of 2019 proposed that the International Maritime Organization create the International Maritime Research and Development Board, or IMRB.

The IMRB would be a research coordination and funding effort paid for by industry that would deploy $5 billion over 10 years to identify alternative fuels and move them towards commercial viability. That proposal has now been cosponsored by 10 IMO member countries, along with the entire shipping industry, and the latest version of that very detailed proposal is attached to my written testimony.

United States research institutions would be well placed to participate in the work funded by the IMRB, and there will be collateral clean air and technology development benefits beyond GHG reduction that would come from the work that the IMRB can do. We strongly urge the United States to back this proposal when it is next discussed in the IMO in June of this year.

My second and final point is that it is critical for the United States to engage actively both at the IMO and with other nations. Decisions are being made today that will affect the industry and the country's international trade for the foreseeable future, and we have to get this right.

One threat to a global solution is that the European Union is proposing to apply its internal carbon pricing scheme to ships operating far beyond EU waters. That raises trade and sovereignty concerns, and it threatens to undermine the ability of the IMO to implement a global solution. That EU proposal will be released in more detail probably in June of this year, and it is worth the attention of the United States Government.

I thank you for your time, and I look forward to your questions. [Mr. Butler's prepared statement follows:]

Prepared Statement of John W. Butler, President and Chief Executive Officer, World Shipping Council

1. INTRODUCTION: THE WORLD SHIPPING COUNCIL AND THE LINER SHIPPING INDUSTRY

Chairman Carbajal, Ranking Member Gibbs, and Members of the Subcommittee, thank you for the invitation to testify today. My name is John Butler. I am President and CEO of the World Shipping Council [1] ("WSC" or the "Council"). WSC is a non-profit trade association whose goal is to provide a coordinated voice for the liner shipping industry in its work with policymakers, the public, and other industry groups with an interest in international transportation.

WSC members comprise an industry that has invested hundreds of billions of dollars in the vessels, equipment, and marine terminals that are in worldwide operation today. Approximately 1,200 ocean-going liner vessels, mostly containerships, make more than 28,000 calls at ports in the United States during a given year—almost 80 vessel calls a day. This industry provides American importers and exporters with door-to-door delivery service for almost any commodity to and from roughly 190 countries. Approximately 35 million TEU [2] of containerized cargo are currently imported into or exported from the United States each year. The container shipping industry is one of the most important facilitators of the nation's growth and ongoing economic activity. Ocean shipping is also—by far—the most fuel-efficient form of transportation on the planet.

Provided below for the subcommittee's consideration are a discussion of the industry's efforts to transition to zero or near-zero emission fuels and a description of the industry proposal to establish an International Maritime Research and Development Board (IMRB) and International Maritime Research Fund (IMRF) to accelerate the research and development work needed to create the technologies that are critical for ships to use low and zero-carbon fuels. WSC staff would welcome the opportunity to discuss these subjects further with subcommittee Members or staff.

2. REDUCING GREENHOUSE GAS (GHG) EMISSIONS AND THE TECHNOLOGICAL CHALLENGE OF TRANSFORMING THE GLOBAL FLEET

The Subcommittee's interest in reducing GHG emissions shipping is indeed timely. The issue of reducing GHG emissions is today the single largest issue under consideration by the International Maritime Organization (IMO), the specialized United Nations body that regulates international shipping and in which the U.S. plays an active role.

International ocean shipping, including all sectors (container, bulk, tanker, etc.), carries over 80% of the world's international trade and generates between 2–3% of global CO2 emissions. In 2018, the IMO adopted a resolution that set two goals for GHG reductions from shipping. The first goal is a 40% increase in overall fleet efficiency by 2030. The second goal is a 50% reduction in absolute emissions by 2050 (versus a 2008 baseline), with emissions to be reduced to zero or near zero as soon as possible after 2050.

It will likely be possible to meet the IMO's 2030 GHG goal through a combination of the mandatory 'Energy Efficiency Design Index' requirements for new ships that became effective in 2013, and new efficiency regulations covering the existing fleet that are expected to be adopted by the IMO in 2020. The existence of a highly competitive liner shipping market, the fact that fuel is the biggest variable cost for vessel operators, and increasing societal and customer requirements to reduce emissions provide vessel operators with powerful incentives to make their operations as efficient as possible and will help reach that goal.

While the IMO's 2030 GHG goal can be met by operational and design modifications applicable to a fleet that remains fossil-fuel based, *the 2050 reduction goal, and the move thereafter to a zero or near-zero GHG emission status for ocean shipping, cannot be met by an industry that uses fossil fuels as its propulsion base.*

[1] A complete list of WSC members and more information about the Council can be found at www.worldshipping.org.

[2] A TEU is a twenty-foot equivalent unit. Most containers are 40 feet in length and equal 2 TEUs.

In order to meet these ambitious 2050 and beyond goals, it is imperative that new fuels and related propulsion, fuel storage, and fuel infrastructure systems are engineered and deployed. Moreover, the transformation in the fuels used by ocean-going vessels must begin in the near future in order for the change-over to occur in time to meet the IMO's deadlines. This is because ocean vessels have a commercial lifespan of 20–25 years, which means that investment decisions made today will be with us for a generation. Therefore, we must act now to develop new fuels and related technologies if we are to avoid locking in fossil-fuel based vessels for a period that extends beyond the 2050 target date for the most drastic GHG reductions.

The challenge the industry faces is that while there are promising possibilities for the fuels of the future, none of the candidate fuels available today can be used to power large ships serving trans-oceanic routes. Hydrogen, ammonia, and other fuels have been identified as potential replacements for fossil fuels in marine applications, but these fuels present safety, storage, handling, and production challenges that must be overcome before they are practically and safely available for widespread use. There may also be additional zero GHG emission options that have not yet received the same level of examination.

Vessels that sail across oceans must obviously carry their fuel with them, and that means fuels must be safe to handle and carry, must be energy-dense so that they do not displace too much cargo space, and must be widely available. All of these criteria represent technical challenges that will require substantial effort and engineering expertise to resolve. The solutions to these challenges will not simply appear by themselves.

3. The Proposal for an International Maritime Research and Development Board

To address these challenges, WSC and all of the world's major shipping organizations[3] in December of 2019, submitted to the IMO a comprehensive proposal to coordinate and fund the research, development, and demonstration work necessary to decarbonize shipping. Last month, an updated version of that proposal, now also cosponsored by ten IMO member states, was submitted to the IMO. A copy of the updated proposal, which will be discussed at the IMO's Marine Environment Protection Committee (MEPC) meeting in June 2021, is attached as Exhibit A. The proposal would set up an International Maritime Research and Development Board (IMRB) that would manage a $5–6 billion industry-funded research and development (R&D) effort over a 10 to 12-year period to identify the fuels and related technologies of the future that will be needed to meet the IMO's aggressive decarbonization goals. The shipping industry would fund this R&D effort through mandatory contributions to the International Maritime Research and Development Fund (IMRF) via a proposed per ton contribution of GHG emissions to generate approximately $500 million per year. To track GHG emissions and contributions, the IMRB and IMRF would employ a fuel oil data collection system already established by IMO.

The critical importance of this R&D effort cannot be overstated. Without this industry funding of $5–$6 billion to accelerate R&D, there is no apparent technological pathway that would allow the industry to reach the IMO 2050 and beyond GHG targets. Put simply, the research and development will not occur on its own; it requires a coordinated "push" in the form of a well-funded and comprehensive international effort.

Moreover, increased technological certainty that comes from the IMRB R&D will provide increased investment certainty as it becomes clear which near-zero and zero GHG emissions technologies will be worth investing in the long term. Creating such technologies, which provide practicable alternatives to fossil-fuel based propulsion, are also essential for market-based measures such as carbon pricing to work. Carbon pricing is designed to motivate the industry to change behavior to cleaner technologies by adding a cost to the continued use of fossil fuels. But carbon pricing can only function if alternatives to fossil fuels are practically available at commercial scale. Without such fuels and related technologies, market-based measures such as carbon pricing only add cost without reducing emissions.

The IMRB proposal is at an advanced level of development, including detailed organizational plans, a viable funding mechanism, and proposed amendments to MARPOL Annex VI to provide the legal vehicle for the program. There is no other existing proposal in the world that can deliver the necessary research and development work in the time that we have to get this work done. Any further delay in doing that work will increase technological and investment uncertainty and make

[3] See page 1 of Exhibit A for the list of co-sponsors.

the process of decarbonization more expensive, with increased risk of stranded investment. The United States' support for the IMRB proposal at the June MEPC meeting will be critical to its approval and success. *We therefore encourage the U.S. Congress to urge the Administration to communicate its support for IMRB at the upcoming IMO MEPC meeting and at other international engagements on climate change*.

4. DISCUSSION OF THE IMRB PROPOSAL

As mentioned above, the baseline facts that the international shipping industry faces with respect to GHG reduction may be summarized as follows:

- The 174 member countries that participate in the IMO have already set ambitious goals and deadlines for reductions in GHGs from shipping.
- The most ambitious of the IMO's GHG reduction targets *cannot* be met by a global vessel fleet that relies primarily or even substantially on fossil fuels.
- Although there are promising fuels and related technologies that may be practically applicable to trans-oceanic vessels at some point in the future, there are no low carbon or zero-carbon fuel/propulsion systems available today that can be used by large trans-oceanic vessels.
- Because ocean-going vessels are long-lived assets (20–25 years), we must move as quickly as possible to develop and deploy low-carbon and zero-carbon propulsion systems and fuels to avoid stranded assets and delays in implementing next generation technologies.

As the industry evaluated this set of facts, it became clear that an essential component in meeting the IMO's deadlines for reducing GHGs from international shipping is to create and support a dedicated research and development effort to identify and deploy practical application technologies that can replace fossil fuel propulsion for large ships. It also became apparent that, although there are a number of R&D efforts underway around the world, many of these are focused on short-sea applications or are not of a size and scale to be able to develop global solutions within the required timeline. Our focus therefore turned to the question of how the IMO could be used as the organizing body to create and sustain an R&D effort that could deliver the required solutions.

The IMO is the only body in the world that is capable of bringing together the elements that are necessary for the successful creation and maintenance of an R&D effort of the size necessary to produce results within the time required. This is the case for several reasons:

- The IMO is the only existing body with the reach to coordinate a global R&D effort focused on commercial maritime transport.
- Any global R&D effort must have a mandatory industry financial contribution mechanism in order to generate necessary funding, avoid free riders, and maintain a level commercial playing field.
- In order to implement a sustainable funding mechanism, any effective industry-wide R&D program will need to have access to the IMO's fuel consumption database, as well as a defined communication procedure with flag states, both of which the IMO already has in place.

Once we determined that the magnitude of the challenge and the need for quick action required a substantial and sustained R&D effort to identify and develop the propulsion systems of the future, and we determined that the IMO was the right body to organize that effort, we began crafting a proposal to the IMO that describes how this critical R&D work can be undertaken and funded. After a period of over two years during which we consulted with IMO member states, environmental groups, technical experts, academics, and other industry groups, on December 18, 2019, WSC and seven other international shipping organizations submitted to the IMO an initial proposal to create the IMRB. IMO considered this proposal and asked for comments on specific questions raised by Member States.

On March 10, 2021, WSC and ten IMO member states and industry co-sponsors submitted a detailed and expanded IMRB proposal to IMO. The revised proposal is to be considered at upcoming meetings of IMO's Marine Environmental Protection Committee (MEPC) in June and November. A copy of the March 10, 2021 submission is attached to this testimony as Exhibit A.

Boiled down to its essence, the IMRB's decarbonization R&D effort would be a global, targeted grant program funded by a mandatory contribution based on each ton of vessel GHG emissions. The IMRB proposal is detailed and addresses a number of issues regarding the purposes and management of the IMRB that will have to be considered in order for the proposed R&D structure and effort to yield the necessary results. Among the issues addressed by the proposal are:

1) R&D objectives of the IMRB;

2) Funding of the IMRB, including a structure that ensures that all funds are delivered directly to the IMRB, with no involvement of member country tax authorities;
3) Governance of the IMRB, balancing high-level IMO oversight with the need for an independent, knowledgeable board of directors and professional staff that is nimble and adaptable in deploying the assets of the IMRB to obtain effective R&D results;
4) Management of grants and contracts;
5) Provisions on conflict of interest;
6) Treatment of intellectual property generated through research efforts, balancing the need to incentivize participation by qualified experts, companies, and institutions with the need for the results of IMRB-funded research to be made broadly available in order to encourage competition in developing next-generation fuels and supporting technologies; and,
7) Dissolution of the IMRB upon completion of its work.

The IMRB proposal, if adopted by the IMO, would substantially accelerate and increase the scope of R&D work that is essential to decarbonizing shipping. That research is not occurring today on a schedule or a scale that will yield results in time to meet the schedule set by the IMO or at the speed increasingly demanded by society at large, and there is no indication that any one company or any one country would be willing or able to undertake such a research effort on its own. Luckily, we have in the IMO an existing international organization with global participation that is already deeply involved in the issue of decarbonizing shipping. All that is required in order to bring this powerful R&D tool into being is the political will to consider and adopt the IMRB proposal.

We are optimistic that, as more IMO member states understand the IMRB proposal, the more they will support it. In addition to the fact that this is the only proposal currently before the IMO that seeks to directly implement decarbonization through research and engineering solutions, making this industry-funded investment in R&D makes business and policy sense. The alternatives to finding technological solutions that allow the ocean transportation industry to ultimately eliminate its carbon emissions are to either reduce the transportation services that support world trade or to continue on a path of increasingly burdensome and low-yielding regulations of a fossil-fuel powered industry. Neither of those outcomes—artificially constraining trade or chasing ineffective regulation—is desirable. Finding non-fossil-fuel solutions will allow international ocean shipping to continue to grow to serve expanding world trade, thus providing a sustainable path for both climate and economy. It is possible to de-couple trade and GHG emissions, and for the former to grow while the latter declines.

5. The Looming Concern of European Union Unilateral GHG Regulation

Even as the IMO continues to work on global solutions, the European Union (EU) is unilaterally seeking to extend its own Emissions Trading System (ETS) to the global shipping sector by imposing extraterritorial GHG regulations on the last voyage leg into the EU, and the first voyage leg out of the EU, for all ships that arrive at or depart from EU ports[4]. The EU's GHG rules would, for example, apply to all vessels, including U.S. owned and/or flagged vessels operating within U.S. jurisdictional waters and on the high seas if those vessels also called at EU ports directly from U.S. ports.

The EU's effort is in sharp contrast to the IMO's multilateral effort and has the potential not only to upset the IMO's role as the regulator of international shipping, but also to open the door for additional nation states to impose their own unique GHG regulations on global ocean carriers that call at their ports. Such approaches would create an impossible patchwork of GHG regulations applicable to ships carrying U.S. and international commerce to jurisdictions around the globe. WSC's paper examining the potential impacts of an EU ETS is attached as Exhibit B[5]. It

[4] European Parliament 2019–2024, Amendments adopted by the European Parliament on 16 September 2020 on the proposal for a regulation of the European Parliament and of the Council amending Regulation (EU) 2015/757 in order to take appropriate account of the global data collection system for ship fuel oil consumption data (COM(2019)0038—C8–0043/2019—2019/0017(COD), (First reading) [European Parliament Amendments], available at: https://www.europarl.europa.eu/legislative-train/theme-environment-public-health-and-food-safety-envi/file-revision-of-the-eu-system-to-monitor-report-and-verify-co2-emissions-from-ships

[5] A copy of the WSC paper on the EU ETS is also available at: https://www.worldshipping.org/public-statements/regulatory-comments/WSC__EU__ETS__Discussion__Paper__10__September__2020__Final.pdf

is therefore critical for the IMO, with its global reach, to regulate GHG emissions from international shipping, and we encourage the United States to engage with the EU to limit application of its ETS scheme to intra-EU maritime transportation and to continue to support the IMO's efforts on maritime decarbonization.

6. Conclusion

International shipping is by far the most efficient means of cargo transportation on the planet, and advances in ship design, size, and operational strategies have allowed containerships, for example, to increase their efficiency by as much as 50% over the past decade. These are impressive advances, but the fact is that over time these advances will be overtaken by trade growth, and it is not possible in the long run to reach the world's decarbonization goals for shipping by continuing to burn fossil fuels.

Because we do not yet know what specific fuels and related technologies will replace fossil fuels, the next logical step is to do the research to answer that question and to make the next generation of fuels available for commercial deployment in the world's fleet. The IMRB proposal to the IMO provides the funding and the structure to make that essential R&D work happen, and we look forward to working with the IMO member states to bring the IMRB into existence. We would welcome the active support of the United States in this vital work to reduce global shipping's impact on climate change.

EXHIBIT A

"Reduction of GHG Emissions from Ships: Proposed Draft Amendments to MARPOL Annex VI," by the Marine Environment Protection Committee of the International Maritime Organization

[The 36-page document is retained in committee files and is available online at https://docs.house.gov/meetings/PW/PW07/20210415/111423/HHRG-117-PW07-Wstate-ButlerJ-20210415-SD001.pdf]

EXHIBIT B

"EU ETS Discussion Paper," September 10, 2020, by the World Shipping Council

[The 13-page document is retained in committee files and is available online at https://docs.house.gov/meetings/PW/PW07/20210415/111423/HHRG-117-PW07-Wstate-ButlerJ-20210415-SD001.pdf]

Mr. Carbajal. Thank you, Mr. Butler, you are right on time.

We will proceed next with Ms. Kristin Decas.

Ms. Decas. Good morning, Chairman Carbajal, Ranking Member Gibbs, and members of the subcommittee, and Congresswoman Brownley. My name is Kristin Decas, and I am CEO and port director of the Port of Hueneme in southern California. On behalf of my Board of Harbor Commissioners, I would like to express my appreciation for the opportunity to appear before the subcommittee today.

We are looking at a moment in history, where timely action by Congress promises to reshape the future of our Nation through Federal investment in transportation systems. Such an action will allow investments of taxpayer dollars to go where they are needed most: to the creation of family-sustaining jobs with higher-than-average wages for disadvantaged communities. The outcome will be the transformation of social equity, the advancement of a carbon-free transportation network, and growth in trade, ensuring our Nation is the most competitive in the world.

It is critical to note the importance ports have in driving local and regional economies. The total economic value generated by U.S. coastal ports totals $5.4 trillion, roughly 26 percent of GDP. U.S. port activity employs over 30.8 million Americans. Last year

the Port of Hueneme's trade with the world reached $10.85 billion, generating over $1.7 billion in economic impact, and creating over 15,800 trade-related jobs.

This profound economic stimulus does have an impact on our environment and community. And as with any negative, there is a cure and a pathway forward. California ports not only lead the Nation, but the world in environmental achievement. California ports are the only ports that require refrigerated cargo ships to electrify at berth, making them zero emission at port complexes. Collectively, California's 11 deepwater seaports realized emission reductions on the order of 80 percent in PM, 90 percent in SOx, and 50 percent in NOx.

At the Port of Hueneme, we more than live up to this legacy of environmental achievement and tradition. Since 2008, the port achieved an 85-percent reduction in diesel PM. In 2012, we completed a comprehensive environmental framework that sets goals in air quality, water quality, marine resources, soil and sediment, energy, and climate change. In 2014, we installed our shoreside power system to enable ships to plug in at berth. In partnership with Tesla, we installed five battery packs to purchase power at off-peak hours and store it for daytime use.

We are currently engineering and installing new electrical infrastructure to power hybrid electric mobile cranes, zero-emission trucks, and zero-emission yard tractors. Our board approved the purchase of the first two zero-emission, heavy-duty port trucks in Ventura County. These American-made, Kalmar battery-powered trucks will move containers of fresh produce around the port, while producing zero pollution.

I would now like to respectfully recommend the course of action Congress should take to propel the future of the goods movement industry to a sustainable and decarbonized transportation sector.

Assess and invest. Assess, and assess, and build the blueprint. Abraham Lincoln once said, "Give me six hours to chop down a tree, and I will spend the first four sharpening the ax." There needs to be a true understanding of all the complexities of a paradigm shift to decarbonization. This requires the development of a blueprint to effectively transition to a new fuel economy, which includes a nationwide feasibility and cost analysis.

For example, the capacity of our Nation's utility networks, infrastructure availability, and upgrade costs need to be fully evaluated and understood. At the Port of Hueneme, the forecasted cost for electric infrastructure is $28.5 million. This cost does not include the utility company's own infrastructure improvements that will be required, estimated to run $50-plus million.

Furthermore, the fees and building costs of retrofitting vessels and other private-sector assets need to be factored into the plan. The Port of Hueneme is one example of millions across the country where these dynamics need to be flushed out, and the roadmap defined, so the investments made by the Federal Government are well informed by true cost, science, and technological viability.

Invest. Invest in maritime and transportation infrastructure. For California ports alone, experts forecast the cost to replace current equipment with zero-emission or near-zero-emission equipment to exceed $23 billion and $35 billion to replace current equipment

with electrified, high-density equipment and supporting infrastructure, all prior to utility upgrades. So invest. Invest in a zero-emission future. Invest in a new alternative fuel economy. Invest in resilient infrastructure, and invest in a just transition. Infrastructure investments in places like the Port of Hueneme and Oxnard will foster positive social reform and racial equity.

In closing, California ports such as the Port of Hueneme are pioneers of testing, innovating, and taking on risk of implementing new technologies that lower emissions. As early adopters, California ports have expertise and best practices in what works. Today the Port of Hueneme is excited to partner with you to help prosper Federal action to assess and invest in our future.

Thank you for the opportunity to provide testimony.

[Ms. Decas' prepared statement follows:]

Prepared Statement of Kristin Decas, Chief Executive Officer and Port Director, Port of Hueneme–Oxnard Harbor District

Good morning Chairman Carbajal, Ranking Member Gibbs and members of the subcommittee. My name is Kristin Decas, and I am the Chief Executive Officer and Port Director of the Port of Hueneme–Oxnard Harbor District in Southern California.

On behalf of the President of the Board of Harbor Commissioners, Jason Hodge and my entire Board, I would like to express my appreciation for the opportunity to appear before this Subcommittee today to discuss the vital role ports play in our economy and the actions the Port of Hueneme is taking towards making our Port the greenest port in the country.

We are looking at a moment in history where timely action by Congress promises to reshape the future of our nation through federal investment in our ports, roads, bridges, rail, airports, and transit systems. Such action will ensure investments of taxpayer dollars go where they are needed most, to the creation of family sustaining jobs with higher-than-average wages for disadvantaged communities. The outcome will be the transformation of social and racial equity, the advancement of a carbon free transportation network and growth in trade, making our nation the most competitive in the world.

It is critical to note the importance ports have in driving local and regional economies by providing the gateway for delivery of goods and employment opportunities. According to Martin Associates, an internationally recognized economic and transportation consulting firm, prior to the outbreak of the COVID–19 pandemic the total economic value generated in terms of revenue to businesses, personal income and economic output at U.S. coastal ports accounts for $5.4 trillion, roughly 26 percent of GDP. This research also showed that over 30.8 million Americans are employed in jobs generated as a result of port activity. Ports also generate significant tax revenue, with $47.1 billion of direct, induced and indirect federal, state and local tax revenue created through the economic activity taking place at ports across the nation.

This profound economic stimulus does have an impact on our environment and community, and as with any negative, there is a cure and pathway forward. To deliver cargo from the dock to the consumer requires heavy equipment, which necessitates a significant use of energy to ensure efficient goods movement. This activity has led to historical environmental, social and racial equity issues for communities adjacent to ports, known as "sacrifice zones." Globally companies and nations are stepping up and pivoting to sustainable energy sources and zero emission equipment. The future of the US economy, which consumer consumption of goods is the main driver and over 90% of goods transit through Ports, relies on keeping pace with other global partners in technology and climate solutions. Federal investment is vital to implementing climate mitigation, sustaining existing jobs, driving new jobs in innovation and technology and accelerating the movement to a decarbonized transportation system. The Port of Hueneme is at the nexus of this movement and an excellent model of how federal investment in port complexes can foster economic prosperity, especially in underserved communities, and at the same time lead the effort toward a carbon free maritime industry.

For the purpose of background, the Port of Hueneme, an official US Port of Entry located within Ventura County, is the fourth largest California deep water cargo seaport and plays a crucial role in the vitality of the local, state and national economy. Naval Base Ventura County, a strategic military port, and the Port share the federal channel entrance and harbor. We have a rich history of partnership and joint use. The Port was initially built to support the agricultural sector in Ventura County. Today, Port of Hueneme serves as a top strategic auto and refrigerated cargo hub on the US West Coast, situated within sixty miles north of the Los Angeles metropolitan area, the largest population center on the West Coast with approximately 14 million people. Trade related businesses operating out of the Port make it the County's fourth largest employer and a leading economic force in the region.

As one of the state's strategic intermodal transportation ports, the Port provides the County with competitive advantages to attract private investment while creating family sustaining jobs. Last year Port of Hueneme's trade with the world reached a total of $10.85 billion in value. Exports totaled $1.22 billion and imports reached $9.64 billion. The $10.85 billion in annual cargo, generates over $1.7 billion in economic impact and creates over 15,800 trade related direct, induced, indirect, and influenced jobs. Annually, trade activity resulting from the Port currently yields on average $119 million in state, county and local tax revenues which support vital community services. The Port closed fiscal year 2020 with a recorded total of 1.62 million cargo tons translating to only a slight 1.8% decrease in overall Port volumes despite COVID–19 caused shipment slowdowns. Of note, the modest 1.8% loss in tonnage follows a record-breaking fiscal year 2019. During the ongoing congestion crisis facing larger ports, the Port of Hueneme serves as a resiliency hub handling citrus exports to Asia.

The Port of Hueneme has performed solidly even in times of economic slowdown. During the contraction of Ventura County's economic output between 2016 and 2017, according to a report by the Ventura County Civic Alliance, jobs at the Port grew 9.2% from 2015 to 2017, demonstrating the Port severing as a regional economic engine even when the rest of the economy was lagging. GDP data from the US Bureau of Economic Analysis shows that Ventura County's trade sector realized .4% growth compared to .2% in the state of California and .16% in Los Angeles County during this same period. The US Bureau of Economic Analysis measures local GDP performance by 12 major industry sectors. Ventura County's lowest performing sectors over the last decade include, "nondurable manufacturing" (biotech), and "Finance, Insurance, Real Estate and Leasing." The County sits deeply in the negative in these two areas, enough to stagnate the entire County's GDP. Ventura County fails to achieve a mark of "high performing" GDP growth in all 12 sectors. Furthermore, the County underperforms the nation's average in 8 of the 12 sectors. However, Ventura County outperforms the national average in the areas of natural resources, construction and trade. Over the last decade Ventura County finds itself in the bottom 20% of all Metropolitan Statical Areas nationally for GDP growth. The positive take away being Ventura County shows a solid, competitive base in trade. Federal investment in small to medium size ports in counties similar to Ventura throughout the nation will unquestionably foster compounded economic growth while addressing socioeconomic justice issues in communities hit the hardest by COVID–19 and recession.

The Port of Hueneme acknowledges that the future of the logistics and global supply chains will be dictated by the effective investment and transition to electric technology. The Port plays an essential role in the health and vitality of the local and regional economies and takes very seriously our responsibility as an active community partner and as an environmental steward. This builds community trust, buy-in and the social license to operate. In sharing the Port's environmental stewardship and community engagement efforts with you today, it is our intention to build the foundation for prioritizing ports in the federal infrastructure plan.

To bring context to where federal dollars can make a significant difference in the environmental movement toward decarbonization of the goods movement network, I will describe the environmental progress taking place at the Port of Hueneme and highlight the significant infrastructure needs requisite to a true transition to a zero emission port and supply chain. California ports not only lead the nation, but the world in environmental achievement. California ports are the only ports that require refrigerated cargo ships to electrify at berth, making them zero emission at port complexes. Collectively, California's eleven deep water seaports realized emission reductions on the order of 80% in particulate matter, 90% in SOx and 50% in NOx. This advancement sets the stage for all our nation's ports. California is paving the way toward decarbonization and our initiatives are a sound model for all US port terminals. The California and Port of Hueneme model can be scaled up based on need, proportion and/or access to resources.

At the Port of Hueneme, we more than live up to this legacy of environmental achievement and tradition on the global stage. In 2012, the Port completed a comprehensive Environmental Management Framework (EMF), that establishes both long and short-term goals and a vision of a sustainable green future. The EMF put forth evaluation strategies to monitor and track the Port's progress in each stated goal and creates key performance indicators (KPIs) to quantify results openly and transparently. The Port's environmental team implements, monitors, and evaluates environmental projects, in partnership with Port tenants, regulatory agencies, and the community. Specifically, the Port developed a set of environmental management goals in air quality, water quality, marine resources, soil and sediment, energy management and climate change adaptation.

With the adoption of the EMF, the Port has realized significant milestones in environmental progress. The Port is proactively developing its Port of Hueneme Reducing Emissions Supporting Health (PHRESH) Clean Air Plan in partnership with our local air quality regulatory agency, the Ventura County Air Pollution Control District (VCAPCD). This comprehensive plan will include:

- An assessment of the regulatory setting in which the Port operates;
- A detailed review of the Port's emissions inventory, including an assessment of possible emissions growth scenarios;
- The establishment of specific air quality goals for the Port for both criteria pollutants and greenhouse gases;
- A summary of our community involvement;
- An analyses of possible emissions control strategies and cost, and cost benefit analyses;
- Estimates of funding and implementation and resources needed; and
- The establishment of a Community Coalition to provide insights into the plan and provide an open and transparent outlet to share data with the community.

As part of PHRESH, the Port purchased and installed the only reference grade air quality monitors in South Oxnard at Haycox Elementary School. We have posted initial results in a power point presentation format delivered by our environmental manager. We are currently translating the presentation into Spanish and Mixteco (an indigenous language from Oaxaca, Mexico). Additionally, through this investment students will learn firsthand about air quality monitoring and about the importance of racial and environmental equity and access to clean air from Port staff members who come from their own community.

We have also made significant strides in deploying zero emission technology. In 2014 the Port installed a high-voltage, shore-side power system which allows ships to shut down traditional diesel fueled engines while berthed and plug in, substantially reducing ship born emissions at berth. Since 2008 the Port achieved an 85% reduction in diesel particulate matter emissions from our ships at berth. To feed power to the shoreside system, the Port in partnership with Tesla, installed five battery packs to purchase power at off-peak hours and store it for daytime use by vessel plug-in systems. We are currently engineering and installing new electrical infrastructure to power a new generation of electric, zero emission cargo handling equipment, including newly arrived hybrid electric mobile harbor cranes and zero emission trucks. In the third quarter of this year, we will be deploying our first zero emission yard tractors. To further our pursuit of the goal to decarbonize cargo operations and help bring cleaner air to our community, the Port of Hueneme's Board approved the purchase of the first two zero emission heavy duty Port trucks in Ventura County. These American made Kalmar battery powered trucks will help to move containers of fresh produce around the Port while producing zero pollution. The trucks are part of a project in conjunction with the Port of Los Angeles funded by the California Air Resources Board, that will also include the installation of power vaults to run the Port's cranes on electrical power and the use of a hydrogen fuel cell big rig truck. Furthermore, this investment will create opportunities for Port maintenance and union machinery mechanics to learn new skillsets and become pioneers in the transition to a zero-emission economy.

With environmental stewardship as a top priority, we have reached many additional historic benchmarks. We installed new cutting-edge LED lighting to significantly reduce energy use and associated emissions. The Port has developed and is implementing a zero-waste policy to reduce solid waste generation. The Port is dredging the harbor entrance and the sand is being deposited to support our local beaches and fight beach erosion. To protect the integrity of our water quality, we have a robust stormwater management plan and installed new stormwater filtering system. The port contracted a third-party auditor, Green Marine, a globally renowned environmental auditor to certify the Port's environmental agenda. Complimenting these successes, *the Port is committed* to forward-looking environmental and community initiatives including:

1. Industrial Operations Decarbonization: *The Port is committed* to a trucking and cargo handling equipment transition to zero emissions on and off Port, functioning as a regional leader in implementation of zero emission medium and heavy-duty equipment.
2. Jobs and Social Justice: *The Port is committed* to bringing economic equity to the region by providing employment opportunities for green jobs while pushing forward an agenda of transitioning Port equipment from diesel to less-polluting fuels of the future in collaboration with our community partners.
3. Education Initiatives for the Local Community: *The Port is committed* to providing new opportunities for the region and local community in STEM with an eco-maker space which has more than $3 million of high-tech equipment for access by local students, environmentalists and entrepreneurs to develop and test ideas and build projects.
4. Clean Truck Initiatives: *The Port is committed* to developing a clean trucking coalition in Oxnard and to seek funding for zero emission trucks and infrastructure.
5. PHRESH Air Quality Community Project—*The Port is committed* to launching a Clean Air Plan, Port of Hueneme Reducing Emissions Supporting Health (PHRESH), and to providing local air quality data to the community as a mechanism to empower local knowledge.
6. Green Jobs Training Program: *The Port is committed* to creating a green jobs training program in coordination with other workforce development groups including, LA Clean Tech Incubator, Ventura County Workforce Development Board, local labor unions, state universities (CSU-Channel Islands and Cal Poly San Los Obispo, UC Santa Barbara) as a catalyst to prosper local jobs vital to the future of our region.
7. Aquaculture Partnership: *The Port is committed* to partnering with entrepreneurs, scientists and other experts for the development of an aquaculture campus on Port to develop foods and jobs of the future for equitable, decarbonized food production.
8. Habitat Restoration: *The Port is committed* to partnering on the restoration of Ormond Beach, a local habitat that has suffered from superfund level pollution from a former smelter company, with community and stakeholders including, the City of Oxnard, City of Port Hueneme, Coastal Commission, Nature Conservancy to achieve habitat restoration, safe equitable access, and recreation and education opportunities.
9. Community Outreach and Development: *The Port is committed* to listening and communicating with community members about their needs and concerns and is constantly creating opportunities to leverage its relationships with its customers to reinvest locally with the intention of creating social capital.

I hope my testimony is a clear statement of the commitment by the Port of Hueneme's Board of Commissioners and staff to the continued advancement of decarbonization and environmental stewardship. I would now like to respectfully recommend the course of action Congress should take to propel the future of the goods movement industry. If the nation and you, our leaders, want a sustainable and decarbonized transportation sector, one of our largest sources of climate and air pollution, the stage must be set for cleaner vehicles, cleaner fuels, and active alternative transportation options, particularly for low-income and vulnerable communities around the nation. How do we get there? *ASSESS* and *INVEST*:

ASSESS—BUILD THE BLUEPRINT:

Abraham Lincoln once said, "Give me six hours to chop down a tree and I will spend the first four sharpening the axe." There needs to be a true understanding of all the complexities of a paradigm shift to decarbonization. This requires the development of a blueprint to effectively transition to a new fuel economy which includes a nationwide feasibility and cost analysis. For example, the capacity of our nation's utility networks, infrastructure availability and upgrade costs need to fully be evaluated and understood. At the Port of Hueneme, the forecasted cost for electric infrastructure is $28.5 million. This cost does not include the utility company's own infrastructure improvements that will be required, an upgrade from a 16.9 to a 66 kilo-volt power distribution system. This utility company infrastructure upgrade is necessary in order to provide enough power to the Port of Hueneme for its electrification projects and could run as high as $50+ million. The utility company has indicated that they are nearing maximum capacity and may not be able to support future high electrical capacity needs from the Port of Hueneme. Furthermore, the feasibility and costs of retrofitting vessels and other private sector assets needs to be factored into the plan. The Port of Hueneme is one of example of millions

across the country where these dynamics need to be flushed out and the road map defined, so the investments made by the federal government are well informed by true costs, science and technological viability.

INVEST—BUILD THE NEW ALTERNATIVE FUEL ECONOMY:

The goods movement industry turns to its leaders in Congress to appropriate the funds requisite to incentivizing a transition to a carbon free future. For the decade spanning 2018–2028, AAPA identified $20 billion in multimodal and rail access needs at ports. For California ports alone, the Pacific Merchant Shipping Association estimates costs to replace current equipment with zero emission or near-zero emission equipment to exceed $23 billion and $35 billion to replace current equipment with electrified high-density equipment and supporting infrastructure, all prior to utility upgrades. As populations shift, as cargo volumes grow, and as we continue to embrace e-commerce and direct to consumer shopping, federal investments at these magnitudes will be critical to ensuring the United States has a 21st century multimodal freight network that competes globally, delivers locally and runs on clean energy. *INVEST*:

- *INVEST in a multimodal freight network program as contained in H.R. 511, the National Multimodal Freight Network Improvement Act*
- *INVEST* in a Zero Emission Future: There are massive costs to the replacement and repowering every piece of equipment. Significant dollars are needed to provide funds for equipment replacement and infrastructure and to ensure the energy capacity exists to meet the full demands of the supply chain.
- *INVEST* in a New Alternative Fuel Economy: New alternative fuel infrastructure triggers vast costs and utilities complications; Federal funding for planning, engineering, permitting and construction are key to the transition.
- *INVEST* in Resilient Infrastructure: Congress needs to drive investment in our critical (e.g., grid) and natural (e.g., forests, soil) infrastructure to create a more resilient, inclusive, and sustainable economy.
- *INVEST* in a Just Transition—Invest in training and educational programs that create high quality job opportunities for our nation's emerging decarbonized economy, with a focus on renewable energy, circular economy, and water and energy efficiency, thereby seeding the pipeline for a green workforce and social equity.

To further expand on this last point, I would like to use the Port of Hueneme as example to demonstrate how investment in clean technology at ports results in a paradigm shift in the workforce for underserved communities. The cities of Oxnard and Port Hueneme are two communities adjacent to the Port of Hueneme. In Oxnard, 23.8% of the population lives in poverty and only 64.7% of residents have completed a high school education. Both the cities qualify as economically distressed areas under the Recovery Act based on their unemployment rates and per capita income being substantially less than the national average. Why is this so? Ventura County has traditionally been an agricultural hub for the harvesting of strawberries, lemons, celery, beets, and other crops. Given the nature of this history, most employment opportunities for minorities have come in the form of packing house labor or direct picking in the fields. Most of these jobs have been designated as unskilled labor and reserved for low-income Spanish speaking communities which are mostly categorized for immigrants of Mexican descent. Additionally, a recent influx of 20,000 Mixtec, indigenous immigrants from the Oaxaca region in Mexico, have brought the inclusion of a third language (Mixteco) which further adds to the language barriers and racial divide. In South Oxnard, which neighbors the Port of Hueneme, the neighborhood of Southwinds is home to upwards of 80% of the Mixteco indigenous groups which live in overcrowded conditions directly under the poverty rate.

Utilizing the Port and its longstanding job creating contributions to the region, it is therefore imperative that these barriers be addressed through intentional interventions that can help create access and mobility within the local job markets. Eliminating barriers to participation in the green technology and renewable energy economy of the future should be a key ingredient to the federal approach to infrastructure investment and expanding job opportunities for disadvantaged communities. The Port of Hueneme is actively working to link those in need of economic opportunities with the educational and employment resources which the Port engages with in its day-to-day cargo work. Connecting those in need with education to those with jobs will help alleviate the barriers which have historically kept the poor in a vicious cycle of less equal access to jobs, housing, and educational opportunities in "sacrifice zones." Federal investment in infrastructure and zero emission cargo handling equipment will bolster this job creation pipeline for the underserved.

In closing, California Ports such as the Port of Hueneme have been early adopters of green technology solutions. California Ports are the pioneers of testing, innovating and taking on the risk of implementing new technologies that lower emissions. As early adopters California ports have expertise on best practices and what works. The Port of Hueneme and our customers have spent over $50 million in the last 10 years on port related electric infrastructure improvements. We have a strong track record. Today the Port of Hueneme is excited to partner with you and to continue to serve as a role model for other U.S. Ports who are ultimately all going to be a part of the carbon free maritime industry. We stand ready to help prosper federal action to assess and invest in our future.

I thank you for the opportunity to provide testimony to the Committee about the Port of Hueneme's role in the national and southern California regional economies and importance of continuing environmental improvements in maritime goods movement and strengthening of the national economy.

Mr. CARBAJAL. Thank you, Ms. Decas. You were well ahead of your time, so thank you.

Next we will proceed to Mr. Morgan Fanberg.

Mr. FANBERG. Thank you, Chairman Carbajal, Ranking Member Gibbs, and subcommittee members, for the opportunity to speak with you today.

As a U.S.-based naval architecture firm, Glosten has been working to decarbonize the marine industry for more than a decade. Creating a carbon-free maritime industry is an unprecedented challenge that creates a unique opportunity for U.S. technology developers. However, foreign competition is better funded, and is currently leading the decarbonization technology race.

So how can the U.S. lead, when we have less than 3 percent of the world's oceangoing fleet? Well, we can make the greatest impact by focusing our decarbonization efforts on the U.S. domestic fleet, which is one of the world's largest, consisting of ferries, tugs, dredges, coastal tankers, and other vessels.

We need a national strategic initiative plan with a focused vision and an urgent timeline. MARAD and the Department of Energy are the agencies to lead these efforts. This plan should include the following three actions to accelerate U.S. progress.

First, DOE should increase port and terminal infrastructure funding for electric vessel charging and alternative fuel bunkering. Electrifying ships already comes at a premium. Therefore, adding cost for shoreside infrastructure will be quite difficult for private operators to fully bear without Government assistance. The benefits of electric harbor vessels cannot be realized without this infrastructure, much like the electric car industry cannot thrive without roadside charging stations. Likewise, bunkering alternative fuels can require specialized fueling infrastructure that will be difficult to scale without Government support.

Second, MARAD has the experience to bring together academia, Government, technology providers, and vessel operators. By funding consortiums such as Washington State's Maritime Blue, we can pilot, demonstrate, and commercialize carbon-neutral and carbon-zero technologies for our domestic fleet.

In the U.S. we have the needed resources from these following groups: universities and national labs for fundamental research into alternative fuels—hydrogen, ammonia, methanol, nuclear, green diesel, or other renewable fuels; industry partners, such as vessel operators, equipment suppliers, and naval architects to convert research into practical technologies that are ready for dem-

onstration and commercialization; and maritime academies, where we can use the new fleet of training vessels now under construction as platforms for testing and proving emerging technologies, while also preparing cadets and midshipmen for the future.

The third and final step in this plan is development of a streamlined regulatory process that encourages new technologies, provides certainty from design through construction, and prevents project time delays. This process is critical to the success of any U.S.-led effort.

We at Glosten are involved in several collaboration projects. Two that represent partnerships are, first, the Glosten and Bieker foil ferry. This is a modern composite hydrofoil, all-electric passenger ferry. It requires less than half of the installed power of a typical high-speed passenger catamaran. This project is a great example of the partnership that MARAD can foster. In our case, Washington State's Maritime Blue has brought our technology team together with local operators, ports, builders, and the classification agency, DNV.

Our cluster was recently awarded a $400,000 FTA grant to further the design, which is fantastic. However, by comparison, a U.K.-based developer of a competing design was awarded a $45 million Government grant to not only design, but also build and demonstrate their concept.

Second, as part of a MARAD-funded project, Glosten, Sandia National Laboratories, and Scripps Institution of Oceanography worked together to design a hydrogen-fueled coastal research vessel. The design proved the feasibility to build and operate a coastal research vessel powered solely by hydrogen fuel cells. This is a shovel-ready project requiring Federal funding for construction, so we can demonstrate the effectiveness of alternative fuel technology, not only for research vessels, but for other longer range coastal ships.

By comparison, the EU's Horizon 2020 program funded, through a $25 million grant, the construction of a Norwegian hydrogen-powered cargo vessel. It will be launched in 2024.

So in summary, the global maritime industry has not faced a more daunting challenge since vessels moved from sail power to steam. Action must be taken now to tackle the amount of scientific and engineering work required to move the industry to carbon-free in the next 25 to 30 years.

We have the key resources ready to meet this challenge. But if we delay, we will watch as foreign countries develop future technologies and equipment, fuels, and infrastructure. We have a great opportunity to showcase American leadership and ingenuity. But similar to so many of our Nation's historic challenges, no single entity can get us to our goals.

We need Government to partner with academia and private industry to develop, deploy, and demonstrate decarbonization technologies to achieve emission targets and position the United States as the global maritime leader.

Thank you.

[Mr. Fanberg's prepared statement follows:]

Prepared Statement of Morgan M. Fanberg, P.E., President, Glosten, Inc.

INTRODUCTION

Thank you, Chairman Carbajal, Ranking Member Gibbs, and subcommittee members for the opportunity to speak to you today. It is my honor to share my perspective on how our nation can be a leader in the challenge to decarbonize marine transportation.

Creating a carbon-free maritime industry is an unprecedented challenge that creates a unique opportunity for U.S. technology developers. If this is our goal, time is of the essence. We will soon lose to foreign competition that is better funded and better prepared to lead the maritime industry toward decarbonization.

As a U.S.-based naval architecture firm, Glosten has been working to decarbonize the marine industry because we believe this is one of the most important and impactful marine industry transformations of our time.

The U.S. domestic fleet as one of the world's largest, which in 2020 was comprised of 3,652 [1] self-propelled vessels of more than 100 gross tons. This is a highly varied fleet that includes passenger ferries operating in population centers such as New York City and San Francisco Bay, offshore supply vessels in the U.S. Gulf, tug and barge operations plying our inland waterway system, near-coastal tankers, containerships, and dredges keeping our shipping channels open.

The U.S. is a major maritime trading center with an opportunity to define and supply the necessary infrastructure to support a decarbonized fleet.

We believe the U.S. has the necessary academic, industrial, engineering, and marine operator resources necessary to meet the challenge facing our domestic fleet. We are at a point where we can either be late and adopt foreign technologies, or we can move quickly and lead the world.

Meeting the global maritime carbon reduction goals requires an aggressive shift from burning fossil fuels to low or zero-carbon fuels and the electrification of certain short-run vessels. Today, these non-fossil fuels do not exist at commercial scale, port infrastructure cannot handle future demands, and regulations applying to these future technologies do not exist.

STEPS TOWARD DECARBONIZATION

To reduce total greenhouse gas emissions from shipping by 50% by the year 2050, we will need to employ public-private partnerships. The immediate step is to develop a national strategic initiative with a clear vision, timeline, achievable metrics, and proper accountability.

The Maritime Administration (MARAD) and the Department of Energy (DOE) are the government agencies ready to lead these efforts by developing this strategic initiative plan and executing projects aimed at reaching our goals of decarbonization. These agencies need to lead this initiative by increasing targeted funding for research and development, infrastructure improvements, and design and demonstration projects.

The strategic initiative plan should include the following three actions to accelerate U.S. progress toward decarbonization:

1. The DOE should increase funding for port and terminal infrastructure projects targeting electric vessel charging and bunkering of zero carbon alternative fuel sources. Vessel electrification already comes at a premium; therefore, adding costs for shoreside infrastructure will be very difficult for private operators to fully bear without government assistance. The benefits of electric harbor vessels cannot be realized without this infrastructure, much like the electric car industry cannot thrive without roadside charging stations. Likewise, bunkering alternative fuels can require specialized fueling infrastructure that will be difficult to scale without government support.
2. MARAD should accelerate the path to commercialization for marine vessel decarbonization. Academia, government, and commercial entities must work together in close coordination to achieve successful pilot projects. Not only will this approach demonstrate the effectiveness of new innovations, but it will showcase the United States as a global leader in decarbonization and support the export, rather than import, of future maritime technology. These groups include:
   a. *Universities and National Labs* for fundamental research into alternative fuels. Advanced battery technology is already available for all-electric propul-

[1] Data search on UNCTAD STAT (12 April 2021) (https://unctadstat.unctad.org). Exported into a U.S. report.

sion on coastal vessels, but this technology is restricted to vessels operating on short routes or in other coastal water operations. To decarbonize vessels on longer duration routes, power systems will need to be fueled by hydrogen, ammonia, or other zero carbon and renewable fuels.

b. *Industry partners* that can convert research into practical technologies that are ready for demonstration and commercialization. This conversion will require marine equipment suppliers, naval architects, and marine vessel operators.

c. *Maritime academies* to leverage the new fleet of training vessels now under construction as platforms for testing and proving emerging technologies, such as hybrid and zero carbon fuel propulsion, and solar and wind capture, while also preparing cadets for the future.

3. Support and encourage the streamlining of the regulatory review and approval process for maritime decarbonization projects from design through construction. A streamlined regulatory process will help reduce costs to government and industry funded innovation projects without compromising safety or the environment.

WHAT GLOSTEN IS DOING

The following project examples require support to advance U.S. competitiveness in marine vessel decarbonization:

Foil Ferry

Glosten has partnered with Bieker Boats to form Foil Ferry, LLC. This new company's vision is to design and bring to market a modern, composite hydrofoil passenger ferry. This ferry requires less than half of the installed power of a typical, high-speed passenger catamaran and could utilize all-electric propulsion on applicable routes.

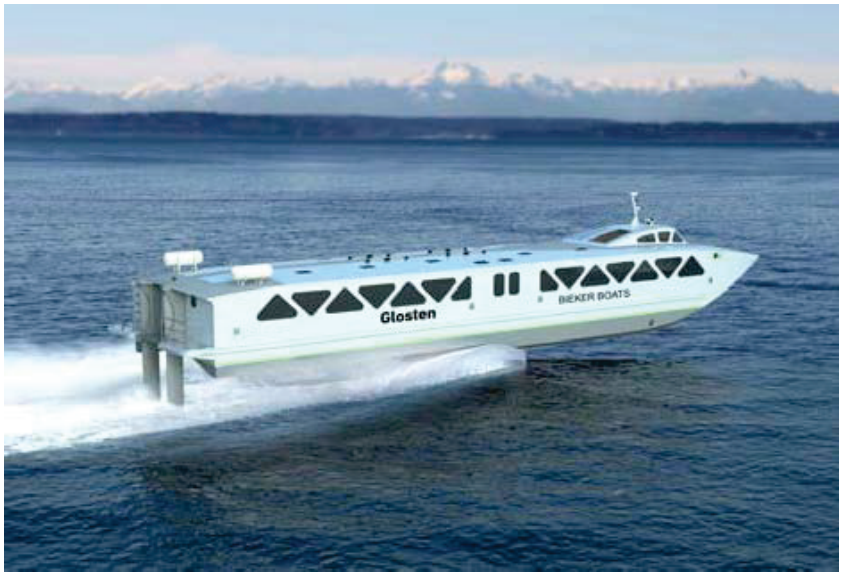


Figure 1—Foil Ferry Rendering

As part of the public-private Washington Maritime Blue Partnership, we were recently awarded a $372,910 USD Federal Transportation Administration grant to further this design. Once the design is complete, we will look for future grant funding to build a prototype vessel to showcase the technology with the aim of building vessels for future ferry system routes.

By comparison, a UK-based developer of a competing design was awarded a $45M USD government grant to complete and build their design [2].

[2] https://www.artemistechnologies.co.uk/en/technologies/news/23__Artemis-Technologies-to-build-zero-emissions-ferries-following-60M-funding

Zero-V

As part of a MARAD funded project, Glosten worked with partners Sandia National Laboratories and Scripps Institution of Oceanography to design a hydrogen fueled coastal research vessel that addressed the technical, regulatory, and economic feasibility challenges. This project assessed the benefits and determined the prospects for refueling such a vessel at expected points of call. The team determined it was feasible to design, build and operate a coastal research vessel powered solely by hydrogen fuel cells [3] [4].

Figure 2—*Zero-V* Research Vessel

This is an example of a shovel-ready project requiring federal funding to help demonstrate the effectiveness of alternative fuel technology, not only for research vessels, but other longer-range coastal vessels.

As one of several comparison examples, the European Union's Horizon 2020 program granted the Norwegian hydrogen cargo vessel *Topeka* $25M USD with an expected launch in 2024 [5].

Skagit County's Guemes Island Replacement Ferry

Washington State's Skagit County Public Works hired Glosten to develop a ferry design to replace their current 41-year-old diesel-powered vessel. An initial propulsion system selection showed favorable operational costs savings and a reduced life cycle cost with a battery electric propulsion system. With the Commissioners' decision to proceed with an electric ferry, Glosten developed the vessel design.

[3] https://energy.sandia.gov/wp-content/uploads/SAND2018-4664__Zero-V__Feasibility__Report__8.5x11__Spreads__FINALDRAFT__compress.pdf

[4] https://www.sciencedirect.com/science/article/abs/pii/S036031992032156X

[5] https://www.greencarcongress.com/2020/12/20201219-topeka.html

Figure 3—Skagit County All-Electric Ferry

The County Road Administration Board awarded Skagit County $7.5 million for the electric ferry project. An additional $1.5 million from Washington State Capital Fund has been awarded for shore charging infrastructure. The entire project is estimated to cost approximately $19.5 million. The County continues to seek funding through state and federal avenues to close the financial gap. Successful completion of this project with construction of this ferry will demonstrate the advances in technology for other ferry systems where routes could be served by battery-powered vessels.

CONCLUSION

In summary, the global maritime industry has not faced a more daunting challenge since vessels moved from sail power to steam. Action must be taken now to tackle the amount of scientific and engineering work required to move the industry to carbon-free in the next 25–30 years. We have the key resources ready to meet this challenge, but if we delay, we will watch as foreign countries develop future technologies in equipment, fuels, and infrastructure.

We have a great opportunity to showcase American leadership and ingenuity, but similar to so many of our nation's historic challenges, no single entity can get us to our goals. We need government to partner with academia and private industry to develop, deploy, and demonstrate decarbonization technologies to achieve emission targets and position the United States as the global maritime leader.

Mr. CARBAJAL. Thank you, Mr. Fanberg. Next we will go to Dr. Lee Kindberg.

Ms. KINDBERG. Thank you, Chairman Carbajal. And may I get a sound check?

Mr. CARBAJAL. We can hear you.

Ms. KINDBERG. Thank you. Thank you, Chairman Carbajal, Ranking Member Gibbs, Chairman DeFazio, and members of the committee. Thank you for the invitation to speak today. I am Lee Kindberg, and I am head of environment and sustainability for North America, for Maersk, a global logistics and container shipping company.

This is a really exciting time to be in shipping, as you have heard, a time of change that will transform the industry as much as containerization did in the 20th century. And ocean shipping is already the most energy-efficient way to move cargo long distances and has the lowest carbon footprint of any mode of transportation.

Those ships use very large diesel engines to move these mountains of cargo, and that generates greenhouse gases, primarily carbon dioxide, or carbon, and other pollutants.

Now, reducing those emissions requires both improving energy efficiency and new, carbon-neutral fuels and technologies. There are likely to be several winners, since there are several types of shipping. Our customers and other stakeholders need us to provide carbon-neutral shipping to enable them to meet their zero-carbon goals.

In December 2018, we made a commitment to do just that, to achieve carbon-neutral shipping by 2050 for our entire fleet. We also set 2030 goals for energy efficiency, and a goal of launching our first carbon-neutral vessel by 2030. At the time that really seemed like a moonshot goal. Today we see it as still a very challenging target, but clearly possible to reach. And I would like to report today on progress we are making on that. Since 2008 we have reduced our emissions by 47 percent per container moved. So this is an energy efficiency effort.

Today's customers are actually paying a premium for our carbon-neutral eco-delivery shipping service that is new just in the last year. It is small, but it is growing.

We are also already testing bio-based fuels, batteries, and other technologies on commercial vessels, and we are evaluating other fuels. And there is a table in the written statement that goes into details of some of those other fuels.

We are developing a new renewable fuel using ethanol and lignin from agricultural and forest wood wastes. This work is supported in part by several of our major customers. So, again, the support from our customers is critical.

In March of this year we announced that our first carbon-neutral container vessel would be operational by 2023, 7 years earlier than our 2030 commitment. This will be the world's first carbon-neutral liner vessel. This, and all of our new vessels, have been committed to be capable of using those new, carbon-neutral fuels. This particular vessel will be powered by green methanol, a fuel which is not available on this scale today.

The limited supply of fuels like green methanol is a bottleneck for decarbonizing the industry. We believe this commitment is the best way to kickstart the rapid scaling of carbon-neutral fuels, and also give us operational experience and provide a carbon-neutral product for our customers.

Now, the biggest challenges ahead are not just on the ships. The land-based industries and infrastructure must be there to supply those fuels and technologies at scale, and we have to do it sustainably, without jeopardizing food production, or forests.

Economic and policy systems must also adapt to support this transformation, and there will probably be more than one winner in the work to develop new fuels and energy sources, and likely competition between shipping and other industries to develop and purchase those fuels.

So what will it take to make this happen? Well-focused R&D, with collaboration across the industry, and with other related industries; alignment between national and international goals and metrics. The International Maritime Organization, the IMO, sets

the rules for international shipping, and is tightening the metrics and goals for vessel emissions, even as we speak.

And then measure what matters. For good decisionmaking and to avoid stranded assets, include the full set of greenhouse gases, both upstream and downstream impacts. And by that I mean the impact of fuel production, distribution, and use all count. You have to look at it from well to wake, and not just look at the stat gas emissions.

Requirements need to be clear, performance-based, enforced, and encourage early action, not penalize it. And both incentives and enforcement should be part of the future climate programs.

Ladies and gentlemen, this is an energy transformation. It is not a new fuel or a vessel modification. Huge changes to both vessel design and land-based infrastructures must happen to produce and distribute those new energy sources. And policies, metrics, and laws must adapt to enable that change.

So thank you for this opportunity to provide this progress report, and I will be happy to take any questions.

[Ms. Kindberg's prepared statement follows:]

Prepared Statement of B. Lee Kindberg, Ph.D., GCB.D, Head of Environment and Sustainability–North America, Maersk

Chairman Carbajal, Ranking Member Gibbs, and Members of the Subcommittee, thank you for the invitation to testify today.

Maersk is a world leader in logistics and has long been committed to environmental leadership. We are headquartered in Copenhagen Denmark and our North American Headquarters is in Florham Park, New Jersey. We operate over 700 container vessels globally under brands including Maersk, SeaLand, Hamburg Sud, and Svitzer ocean-going tugs. Here in the U.S., Maersk Line, Limited is the owner and operator of our U.S. Flag vessels and the largest participant in the U.S. Maritime Security Program. On the land side we have APM Terminals (our marine terminal operating arm), and other supply chain logistics facilities in the United States and globally.

We are committed to ensuring that our business practices are safe, responsible and transparent. This year the urgent priorities of the pandemic have kept us busy, however sustainability remains at the top of our agenda. We see increasing expectations from all stakeholders, and especially our customers, investors, governments and employees—expectations that we and our industry deliver more solutions, more visibility and more help in decarbonising supply chains. Our goals, strategies and progress are discussed in our annual Sustainability Reports, available on our website [1].

The shipping industry emits 2–3% of the world's anthropogenic CO2 and shipping is the only industry to have set global metrics and goals on energy efficiency, greenhouse gas emissions and other pollutants such as sulfur. These air emissions are produced by fuel consumption in our ships' very large diesel engines, and include both Greenhouse gases (GHG, primarily CO2, which is sometimes referred to as "carbon" or "carbon footprint") and criteria air pollutants (SOx, NOx, fine particles).

Maersk alone emits approx. 0.1% of global anthropogenic CO2, so decarbonization is a cornerstone in our sustainability strategy. Our first focus is on ocean transport, which is the source of 98% of our "Scope 1 emissions." Decarbonization goals will be extended to our marine terminals and other logistics services and transport modes over the coming years.

Reducing fuel consumption does reduce operating costs and also reduces emissions of both greenhouse gases and other pollutants. In the last twelve years Maersk has reduced our fuel consumed and related emissions by 47% per container moved. This energy efficiency improvement was achieved in three primary ways: new larger vessels, retrofits of our existing vessels, and improved operational and vessel manage-

[1] Maersk's annual Sustainability Reports are available on our website at https://www.Maersk.com/en/business/sustainability.

ment practices. Our Radical Retrofit program involved investing $1Billion over 5 years starting in 2015. We continue to mature, harden and implement the "Connected Vessel" digitalization project to connect our fleet digitally with our global operations coordination centers and enable real-time optimization to reduce fuel consumption and related emissions.

In December 2018 Maersk announced a goal of Net Zero Carbon Shipping by 2050. That commitment included launching our first zero carbon vessel by 2030 and continuing our energy efficiency work with a 2030 goal of a 60% reduction in emissions vs. 2008.

Just two years after setting that net zero ambition in December 2018, we find we have come further than we imagined possible at that time. In 2018, a 2050 net zero ambition for shipping was a moonshot goal. Today, we see it as a challenging target, but clearly possible to reach.

A prerequisite for Maersk to meet the Net Zero 2050 target is radical innovation in technologies and fuels. We have openly recognized the need for close collaboration with external stakeholders such as technology and fuel providers, researchers, investors, governmental officials and staffs, and especially our customers to meet the target. We plan significant future investments, including further energy efficiency work, alternative fuel development, and the technologies needed to build zero carbon vessels.

A First Carbon Neutral Vessel

In March of this year we announced that our first carbon neutral container vessel will be operational by 2023. This has been made possible by the advances in technology, our strategic commitment to sustainable practices and the active support of our partners and stakeholders. Powered by biomethanol or e-methanol, this feeder vessel will pilot an industry-first, scalable carbon neutral product. This is encouraged by the strong support and commitment by our customers to keep accelerating the full transition to decarbonisation.

This first vessel will give valuable operational experience, help accelerate our journey, demonstrate real demand to fuel suppliers, and provide a scalable, carbon neutral option for customers. We believe our commitment to put the world's first carbon neutral liner vessel in operation by 2023 is the best way to kick start the rapid scaling of the carbon neutral fuels needed, since the limited supply of green methanol is a bottleneck for decarbonising the industry.

Action on Zero emissions shipping

Maersk is already engaged in several innovation projects and is significantly scaling up our innovation efforts. Currently we have more than 50 engineers in our technical innovation departments who focus primarily on reducing fuel consumption, and we are hiring more as we speak to broaden our efforts. At this point we are not ruling out any technological options and the innovation work covers many areas including the following:

1. Continue our *cutting-edge fuel efficiency efforts* such as retrofitting existing vessels with new technologies and setting new standards on fuel efficiency when we order new vessels. Maersk does not purchase standard vessels; we always optimize designs, with close collaboration between our technical experts and the shipyards.
2. *Electrification*. We installed a major marine battery on a vessel in 2020 to learn how this technology might be useful on a vessel and to drive further development on the technology. We also now connect vessels to shore power in California and China, allowing us to operate in port without emissions.
3. *Research in new alternative fuels*. We have a range of programs exploring new marine fuels, including several programs related to biofuels. Examples include:
   - Biofuel-based ECO-Delivery: A pilot voyage with 4 major customers in April–May 2019 used renewable biofuel blends made from used cooking oils on an Asia-Europe roundtrip to prove applicability and test commercial opportunities. This successful trial led to a new carbon neutral shipping service called "ECO-Delivery," which has grown even more quickly than we had hoped and continues to attract new major shipping customers.
   - Lignin Ethanol Oil ("LEO") biofuel: Maersk, together with a coalition of U.S.-based and international customers and in collaboration with the University of Copenhagen, has establishing a new sustainability innovation project to develop a biofuel tailor-made for shipping (LEO). This biofuel does not exist today but has the potential to have significant positive impact on CO2 emissions as well as other air emissions from shipping.

The concept is to blend bio-based ethanol with the biopolymer lignin (a by-product of agriculture, paper making and wood-products production) to form a new relatively inexpensive biofuel with high energy content. The LEO biofuel should be a sustainable fuel meaning that it is: 1) Made from waste/by-products not competing with food uses—a 2nd generation biofuel, 2) Should be CO2 neutral, and 3) is economically feasible and price competitive with conventional fuels (or only small price premium). The current objectives of the LEO project are to confirm the feasibility of the fuel, test it on a vessel, and make it commercially feasible for uptake in the shipping industry.

- In the fall of 2020, the Maersk Mc-Kinney Moller Center for Zero Carbon Shipping was established by seven companies including Maersk, with the intent of accelerating development of the technologies and fuels needed to for carbon neutral shipping in the time frame needed.

THE NEED FOR STRONG REGULATIONS, GLOBAL STANDARDS AND ENFORCEMENT

Wise fuel choices depend on having global metrics and goals, and clear standards for how to measure, report and verify the full impact of fuels and operations. These metrics need to include the full suite of GHG—CO2, methane and nitrogen oxides—as well as the upstream and downstream impacts of fuel extraction, production, delivery and use. Global standards are strongly needed in this area to enable clear comparisons and impact assessments. And in this rapidly changing field, performance-based standards are needed rather than attempting to choose winners among the new fuels and technologies.

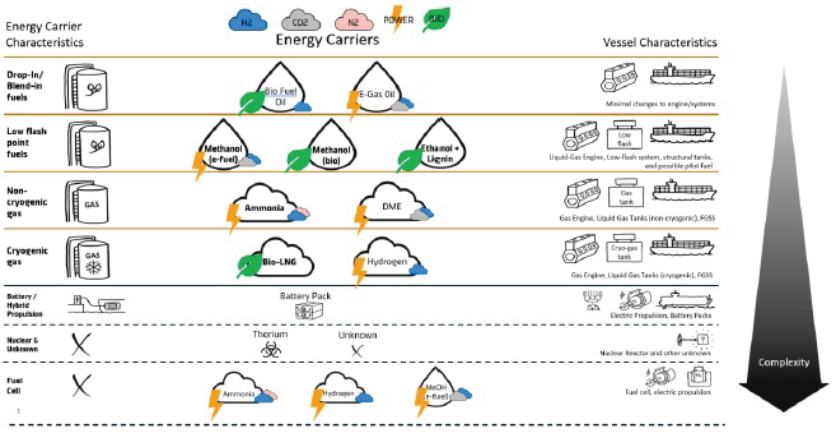
The importance of enforcement is illustrated by the recent implementation of IMO's 2020 fuel rule. As of January 2020, all ships were required to reduce their sulfur oxide emissions by over 80%. This was a major transition and the vast majority of the global fleet (including Maersk vessels) has complied by switching to more expensive low sulfur fuel. This comes at a very steep price; for Maersk alone, the additional bill was estimated to be around $2 billion per year. The very large potential savings by non-compliance show the importance of strong enforcement. For example, a vessel trading from Asia to Europe could "save" close to $750,000 USD per ship per voyage by ignoring the IMO2020 rules. Companies rely on good enforcement to provide the "level playing field" necessary for competitiveness and environmental progress.

The same strong enforcement concepts will need to be fundamental components of any climate-related programs. When developing climate programs at the national and international level it is of utmost importance that mechanisms are in place to ensure that international competition is not disrupted and that first movers are rewarded for early investments into emissions reducing technology.

In closing let me reiterate that the changes required to achieve carbon neutral shipping will not be easy or inexpensive, either on the vessel side or the land-based fuels infrastructures. However, we believe it can and must be done. Massive innovative solutions and fuel transformation will be required to produce and distribute entirely new energy sources. Regulatory changes and standards development are also needed on a global scale to enable this transformation.

Members of the Subcommittee, thank you again for the opportunity to discuss this important topic with you today. I will be happy to answer any questions.

POTENTIAL CARBON-NEUTRAL FUELS



Mr. CARBAJAL. Thank you, Dr. Kindberg.

Now we will go to Dr. Dan Rutherford.

Mr. RUTHERFORD. Good morning, Chairman Carbajal, Ranking Member Gibbs, Chairman DeFazio, Congresswoman Brownley, and other subcommittee members. I appreciate the opportunity to testify today on behalf of the International Council on Clean Transportation.

The ICCT is an independent, nonprofit research organization headquartered in Washington, DC, with offices in San Francisco, Berlin, Beijing, and São Paulo. ICCT employs a team of over 100 transportation experts that advise policymakers on how to improve the environmental performance of the transport sector.

Maritime shipping is a cornerstone of our modern economy, but it comes with impacts. Air pollution from shipping is linked to at least 64,000 premature deaths per year, globally, with the underprivileged and minority communities living near ports feeling the brunt of the impact. In 2018 global shipping emitted about 1 billion tons of carbon dioxide, or more than the German and Dutch economies combined.

Much work lies ahead if the sector is to meet the U.N. goal of cutting greenhouse gas emissions from international shipping by at least 50 percent from 2008 levels by 2050. To meet this goal, we will need zero-emission, deep-sea ships on the water by no later than 2030. Key technologies include battery-electric ships for near-port operations and short-sea shipping; hydrogen, which, in pressurized or cryogenic form can power fuel cells that are already available and scalable; and ammonia, which is gaining attention as an easy-to-store hydrogen carrier. These fuels can be generated from abundant renewable electricity with a negligible climate footprint.

Today we are already seeing fully battery-electric and fuel-cell zero-emission vessels, especially ferries and barges on short, dedicated routes. Infrastructure investments for fast charging for battery-electric ships can also support shore power to reduce at-port air pollution. We expect full-sized, deep-sea, zero-emission vessels

running on hydrogen fuel cells or burning renewable ammonia to be possible as soon as 2030. Hybrid or fully zero-emission regional cargo ships will be available even sooner. Technologies like wind-assisted propulsion and hull air lubrication will help reduce energy use and make zero-carbon fuels more competitive.

A word of caution: biofuels and liquefied natural gas are being used now, but neither is a reliable bridge to zero-emission vessels. Sustainable biofuel supply is limited, in demand by a variety of sectors, and must be generated from waste, and also not result in deforestation in order to be sustainable. LNG produces about 25 percent less CO2 when combusted. But due to methane leaks upstream during the production of LNG, and also downstream from the engine itself, LNG is often worse for the climate than conventional fuels after accounting for its full life-cycle emissions.

The coming transition to zero-emission shipping can be a win for the U.S. economy, the environment, and human health. Zero-emission vessels eliminate air pollution from the ships themselves, easing the health burdens of coastal and near-port communities. ZEVs avoid the water pollution generated by ships that use sulfur scrubbers. There are also quieter, and ZEVs will unlock new careers to develop advanced engines, fuel cells, batteries, and fuels.

The production and sale of zero-emission marine fuels in particular is a major opportunity for U.S. businesses. Today, the largest vessels visiting U.S. ports are often fueled abroad, not here at home. Producing zero-emission marine fuels like electricity, hydrogen, and ammonia domestically will provide new economic opportunities for Americans, while protecting vulnerable near-port communities.

So what actions can the U.S. Government take to support the ZEV transition? First, we need substantial investments to develop and deploy zero-emission vessels and fuels, along with supporting port electrification and infrastructure. U.S.-flagged Jones Act vessels, which operate shorter routes between regular ports, can be used to demonstrate and mature the technologies we will need for deep-sea ZEVs.

Second, the U.S. should work with key trading partners, including Canada, Mexico, the EU, and China, to establish zero-emission vessel corridors and associated infrastructure.

Finally, the U.S. should lead in negotiating ambitious international standards for larger ships at the International Maritime Organization. These actions can reduce climate and air pollution from shipping, improve the health and well-being of port communities, and help unlock new markets for zero-emission vessels and fuels.

Thank you for the opportunity to present today.

[Mr. Rutherford's prepared statement follows:]

Prepared Statement of Dan Rutherford, Ph.D., Marine and Aviation Program Director, International Council on Clean Transportation

My name is Dan Rutherford. I'm the program director for shipping and aviation at the International Council on Clean Transportation. The ICCT is an independent, non-profit research organization headquartered in Washington DC, with offices in San Francisco, Berlin, Beijing, and São Paulo. ICCT employs a team of over one

hundred transportation experts that advise policymakers on how to improve the environmental performance of the transport sector.

I appreciate the opportunity to testify today on behalf of the ICCT. Maritime shipping is a cornerstone of our modern economy, but it comes with impacts. Air pollution from shipping is linked to at least 64,000 premature deaths per year globally [1], with underprivileged and minority communities living near ports feeling the brunt of that impact. In 2018, global shipping emitting about a gigatonne of carbon dioxide (CO2), or more than the German and Dutch economies combined.[2] Much work lies ahead if the sector is to meet the United Nations' goal of cutting GHG emissions from international shipping by at least 50% from 2008 levels by 2050.[3]

To meet this goal, we'll need zero emission deep sea ships on the water by no later than 2030. Key technologies include battery electric ships for near-port operations and short sea shipping; hydrogen, which in pressured or cryogenic form can power fuel cells that are already available and scalable; and ammonia, which is gaining attention as an easy-to-store hydrogen carrier. These fuels can be generated from abundant renewable electricity with a negligible climate footprint.

Today, we're already seeing fully battery electric and fuel cell zero-emission vessels, especially ferries and barges on short, dedicated routes (Figure 1). Infrastructure investments for fast charging for battery electric ships can also support shore power to reduce at-port air pollution. We expect full-sized, deep-sea zero-emission vessels running on hydrogen fuel cells or burning renewable ammonia to be possible as soon as 2030. Hybrid or fully zero-emission regional cargo ships will be available even sooner. Technologies like wind-assisted propulsion and hull air lubrication will help reduce energy use and make zero carbon fuels more competitive.[4]

A word of caution: biofuels and liquefied natural gas (LNG) are being used now, but neither is a reliable bridge to zero-emission vessels. Sustainable biofuel supply is limited, in demand by a variety of sectors, must be generated from waste, and not result in deforestation in order to be sustainable.[5] LNG produces about 25% less CO2 when combusted but, due to methane leaks upstream during the production of LNG and downstream from the engine itself, LNG is often worse for the climate than conventional fuels after accounting for its full life-cycle emissions (Figure 2).[6]

The coming transition to zero emission shipping can be a win for the U.S. economy, the environment, and human health. Zero-emission vessels (ZEVs) eliminate air pollution from the ships themselves, easing the health burdens of coastal and near-port communities. ZEVs avoid the water pollution generated by ships that use sulfur scrubbers. They're also quieter. And zero-emission vessels will unlock new careers to develop advanced engines, fuel cells, batteries, and fuels.

The production and sale of zero emission marine fuels in particular is a major opportunity for U.S. businesses. Today, the largest vessels visiting U.S. ports are often fuelled abroad, not here at home (Figure 3). Producing zero emission marine fuels like electricity, hydrogen, and ammonia domestically will provide new economic opportunities for Americans (Figure 4) while protecting vulnerable near-port communities.

So, what actions can the U.S. government take to support the ZEV transition? First, we need substantial investments to develop and deploy zero-emission vessels and fuels, along with supporting port electrification and infrastructure. U.S. flagged "Jones Act" vessels, which operate shorter routes between regular ports, can be used to demonstrate and mature the technologies we'll need for deep sea ZEVs.

Second, the U.S. should work with key trading partners, including Canada, Mexico, the EU, and China, to establish zero-emission vessel corridors and the associated infrastructure. Finally, the U.S. should lead in negotiating ambitious international standards for larger ships at the International Maritime Organization. These actions can reduce climate and air pollution from shipping, improve the health and well-being of port communities, and help unlock new markets for zero-emission vessels and fuels.

Thank you for the opportunity to present today. I look forward to answering any questions the honorable members have for me.

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[1] Sofiev et al., 2018.
[2] Faber et al., 2020; Crippa et al., 2019.
[3] Rutherford & Comer, 2018.
[4] Comer et al., 2019.
[5] Zhou et al., 2020.
[6] Pavlenko et al., 2020.

SUPPLEMENTAL INFORMATION

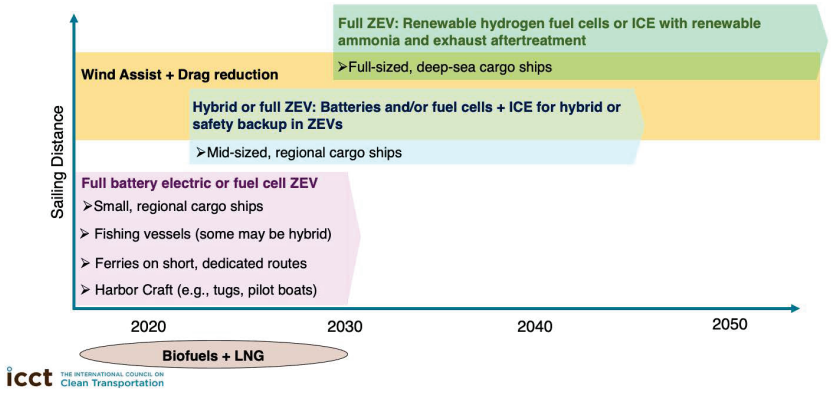

Figure 1: Technologies for zero emission shipping through 2050.

PRINCIPLES FOR ASSESSING ALTERNATIVE MARINE FUELS

Flexible, technology-neutral standards set a level playing field for innovation and enable industry to find least-cost ways to reduce emissions. ICCT research has identified three key principles when evaluating fuels to support zero emission shipping:

1. *CO2e not CO2*: Some fuels and energy sources are zero-CO2, but not zero CO2 equivalents (CO2e). For example, burning ammonia (NH3) in a marine engine will emit zero CO2, but could emit nitrous oxide (N2O), which has a global warming potential about 300 times that of CO2.
2. *GWP20 not solely GWP100*: Reducing pollutants with high 20-year global warming potential (GWP20), such as black carbon and methane, helps avoid additional near-term warming, which is essential for limiting warming to 1.5°C or well-below 2°C. GWP20 is a particularly useful metric for evaluating "bridge" fuels.
3. *Well-to-wake not tank-to-wake*: Consider the full life-cycle impacts of marine fuels and energy sources. Some fuels, such as hydrogen, are zero-emission when they are used, but they must be sourced from renewable energy, not fossil fuels, to be truly zero-emission.

Collectively, these three principles highlight that LNG is unlikely to be a suitable future fuel for shipping. LNG is mostly methane, a potent GHG that traps 86 to 87 times more heat in the atmosphere than the same amount of CO2 over a 20-year time period. Methane leakage during extraction, processing and transport, and methane slip when burned, means that using LNG is often worse for the climate than conventional fuels, particularly over shorter timescales. For example, the most popular LNG engine technology today emits up to 70% more lifecycle GHGs (20-year GWP) than the cleanest oil-based fuel (marine gas oil, MGO), as shown in Figure 2.[7]

[7] Pavlenko et al., 2020.

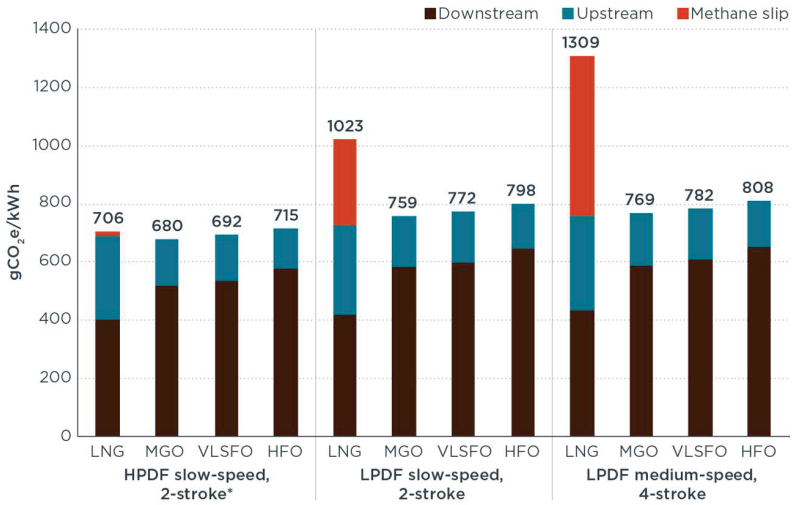

Figure 2: Lifecycle GHG emissions by engine and fuel type, 20-year GWP

CENTRALIZED VS. DISTRIBUTED MARINE FUEL PRODUCTION

The largest oceangoing vessels can operate up to 50,000 miles, enough to circumnavigate the Earth twice, before refueling. As a result, the current centralized fossil fuel bunkering system means that a relatively small number of ports, mostly foreign, dominate global marine bunker fuel sales (Figure 3). This is particularly true for Pacific bunker fuel sales, which are dominated by Asian ports.

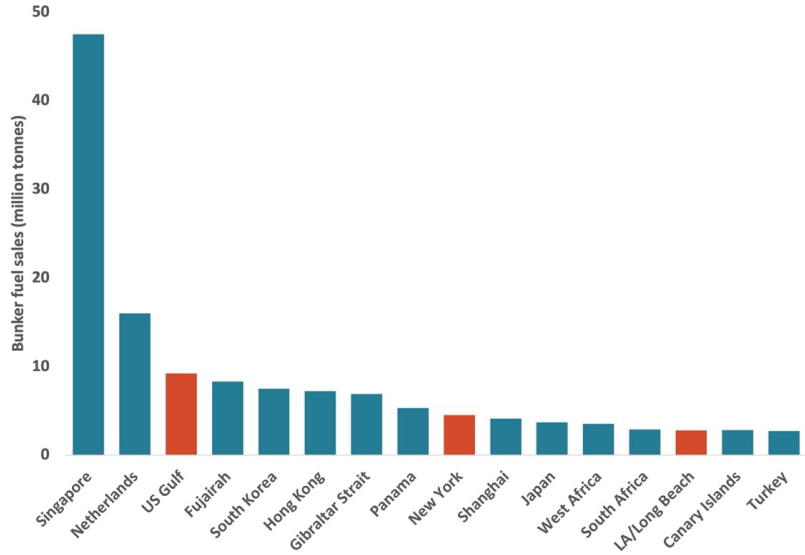

Figure 3: Marine bunker fuel sales in 16 busiest ports, 2019 (Source: Ship & Bunker)

In contrast, zero emission marine fuels like hydrogen and ammonia can be generated widely and, because of their lower energy density, are more likely to be sold and used near where they are produced. This is particularly true of renewable hydrogen. When my colleagues and I analyzed the potential for zero emission trans-

pacific container shipping, we found that shifting to liquid hydrogen could generate substantial new refueling demand at U.S. ports, particularly in Southern California. Furthermore, our work highlighted the potential for Aleutian Islands ports to serve as a new refueling stop between Asia and the West Coast of the United States if hydrogen refueling infrastructure is built there (Figure 4).[8]

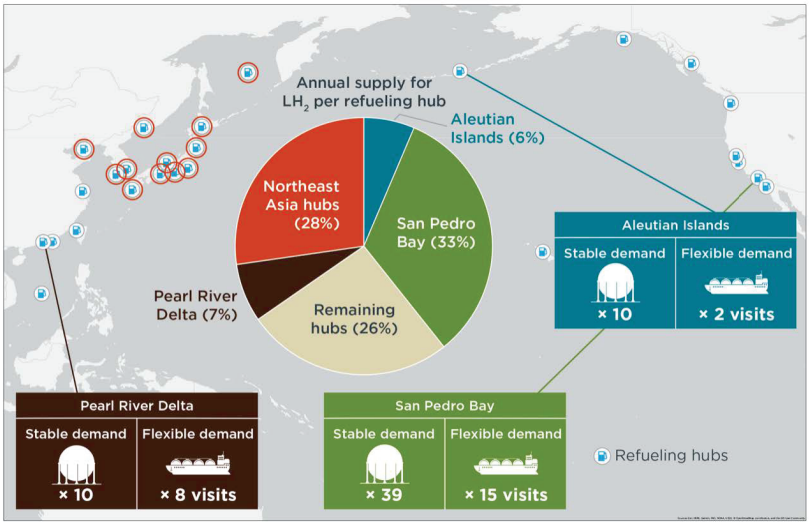

Figure 4: Hydrogen demand and refueling infrastructure for transpacific container ships.

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[8] Georgeff et al., 2020.

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Mr. CARBAJAL. Thank you, Dr. Rutherford.

With that, we will move on to Member questions. Each Member will be recognized for 5 minutes. And first we will start with Chairman DeFazio.

Mr. DEFAZIO. Thank you, Mr. Chairman.

First, to Dr. Kindberg, the biofuel that you are going to use, right now there is virtually no availability for that 2023 target. You are going to need it on both ends of a voyage, right? So I am just curious about the capability of supplying what we need to produce this.

Ms. KINDBERG. When I had an update on this—and thank you, Mr. Chairman—when I had an update on the fuel availability on this, I learned from our Maersk Oil Trading team that we were talking to something like 35 or 37 different suppliers of these fuels to start to ramp this up.

The first time you do something like this, it is going to take some effort. But we feel that this is a really important signal to send to these suppliers, that there will be a demand for these. Otherwise, you get into the chicken and the egg.

Mr. DEFAZIO. All right. And I was also intrigued by the bio-based ethanol with the polymer lignin. You want to tell me a little bit about that?

I mean, what is the advantage of adding the lignin? Does that make it a higher value fuel, or what? What is that?

Ms. KINDBERG. Well, lignin actually has the—it comes from agricultural waste. It is what makes plant stems stiff. So it is the second most common biopolymer in the world. It is available from paper mill effluence, all kinds of waste products. And you can mix it into an alcohol, a renewable alcohol, and come up with a fuel that has the potential to be more cost effective.

So as you know, one of the real costs with these new fuels, or one of the real challenges with these new fuels, is the cost. You are looking at something like double the cost, even for some of the fuels that are more readily available.

So I probably ought to stop there, but I am pretty passionate about this topic, so——

Mr. DEFAZIO. Well, no, no, I——

Ms. KINDBERG [continuing]. If you wanted to know more about it later, I am glad to have the conversation.

Mr. DEFAZIO. Well, I just will say, I mean, we have this issue with straw. My district is the largest producer of grass seed in the world. And for years they would torch the fields to get rid of pests, potential weeds, and things like that. When it stopped raining, finally, in Oregon, the skies would go dark, and we are all breathing smoke all summer. Finally, it has been substantially banned, but now there isn't the market for that straw. So I assume that straw would be a potential lignin source.

Ms. KINDBERG. I would assume so, too. I know that the gas that is used for making sorghum, for example, is a source of lignin.

Mr. DEFAZIO. OK, well, I am going to have to——

Ms. KINDBERG. So there could be all kinds of opportunities here, rather than just burning that stuff.

Mr. DEFAZIO. Yes. They are dealing with it in alternative ways, and trying to ship it places. But the market is not that adequate. So thanks.

And then to Mr. Fanberg, I have got to say, it sounded a little pessimistic, in terms of where we are vis-a-vis foreign competition in these areas. Do you want to be a little more specific about that, and what steps specifically we should take to begin to at least be partially competitive?

Mr. FANBERG. Well, so on the foreign competition, that one example I used about our foil ferry project, we do have stiff competition, and it is very well funded. This is where the industry is headed with passenger ferries and efficiency, when it comes to foil-bound ferries. So that was one example of a very well-funded foreign competitor in the U.K.

I didn't mean to sound overly pessimistic, because I do think that this meeting, and the action that is happening, not just from Glosten's point of view, but from other naval architects, is very encouraging, that we are working hard. But the funding source is our difficulty when it comes to demonstrating these new technologies. We have enough funding to get started, to do design work. But when it comes to actually demonstrating and putting something on the water, that is where the gap is.

Mr. DEFAZIO. So you mentioned potentially MARAD and DOE, correct?

Mr. FANBERG. Yes, that is true. Yes.

Mr. DEFAZIO. OK, we will have to pursue that, then. Thank you very much.

Thank you, Mr. Chairman.

Mr. FANBERG. Thank you for the question.

Mr. CARBAJAL. Thank you, Chairman DeFazio. Next we will go to Ranking Member Gibbs.

Mr. GIBBS. Thank you. Thank you, Mr. Chairman. Thank you to the witnesses for being here today.

The International Maritime Organization has set greenhouse gas reduction targets of 40 percent in 2030 and 50 percent in 2050 from the 2008 levels. The World Shipping Council says these targets can only be met if shipping moves from fossil fuels to low- or zero-carbon fuels that are not available today.

Mr. Butler, do you envision the industry will be able to convert existing vessels to the use of these new fuels?

And I guess, if so, at what cost to the shippers and consumers? And if not, will existing vessels be scrapped early, and at what cost, Mr. Butler?

Mr. BUTLER. Thank you, Congressman. A couple of points, just a clarification on the IMO 2030 goal. That 40 percent is an efficiency goal, as opposed to an absolute goal.

We do think that, with current efforts underway, we will be able to meet the 2030 goal with existing ships through additional efficiency gains. The 2050 goal of 50 percent is an absolute reduction. And in order to get that, given the growth in trade, we are absolutely going to have to move to low- and zero-carbon fuels, and that is going to be the energy transition that Dr. Rutherford and Dr. Kindberg are talking about.

In direct answer to your question about retrofitting existing vessels, there has been a lot of work already done on existing vessels in order to meet the requirements that we face in the immediate future. Whether or not existing vessels can be retrofitted to be essentially zero carbon will depend entirely on what technologies and fuels we end up using in the 2050 timeframe. And as I testified earlier, we simply don't know yet what those are going to be. We don't know what is going to come out on top.

And really, in order to answer your question, we have to do the research and development that I talked about, so that we know what technologies we are talking about.

Mr. GIBBS. So there is a lot of unknowns, obviously, because we don't know what the technologies or the fuels are going to be. So you don't know if it is going to be one single fuel, or multiple, different fuels. That is just all up in the air right now, right?

Mr. BUTLER. It is. I think, you know, I think for different ship types and different applications, we have already seen—and we have heard a bit today, for example—very short-sea and ferry applications. You can look at things like electrification, deep sea, transoceanic ships that have to carry their fuel for thousands and thousands of miles. Those solutions won't be there.

We will probably see multiple fuels, but you have to remember that ships move all over the planet. And so, having a consistent source of fuel, no matter what port you go to, is pretty critical. I think that, for the deep-sea fleet, ultimately, that will push us in the direction of a smaller number of fuels than we have for the coastal fleets.

Mr. GIBBS. Thank you.

Mr. Fanberg, you stated that the Department of Energy and MARAD should take the lead in developing decarbonized U.S. vessels. Since the U.S. Coast Guard inspects and documents such vessels, what role should the Coast Guard play in this process?

Mr. FANBERG. Thank you, Ranking Member Gibbs, for the question. Yes, the Coast Guard should actually take a very active role. As I mentioned in the three steps there in the strategic initiative plan, that third step was to coordinate with the Coast Guard to get ahead of these future technologies, and get regulations in place ahead of time, ahead of these projects that we put in place.

Timely regulatory review, timely new regulations are critical to any of the success of these projects that are coming.

Mr. GIBBS. Dr. Kindberg from Maersk, you talked about your feeder vessel being the first carbon-neutral container vessel. Was this vessel really a test bed for new technologies to be used later on your larger oceangoing ships?

And because you also commented about the cost of fuel being double, so what is the role of this new vessel you just talked about that would be available in a couple of years, you said?

Ms. KINDBERG. Well, this new vessel will be powered by green methanol. We are actually testing several technologies on commercial vessels today. For example, we have a battery being tested on the *Maersk Cape Coast*, and we have, actually, commercial use of biofuels on several vessels sailing out of Europe, because that is where that fuel is available.

So, yes, we are looking at test beds, but this vessel in particular is to give us some serious operating experience, particularly with a fuel that has a low flashpoint. In other words, it is more flammable than the typical bunker fuels that we are used to using.

Mr. GIBBS. I am out of time, so I yield back. Thank you.

Mr. CARBAJAL. Thank you, Ranking Member Gibbs. Now I will recognize myself, to be followed by each Member for an additional 5 minutes of questions.

With that, Ms. Decas, as I mentioned earlier, in my district the Santa Barbara County Air Pollution Control District has done some remarkable work with vessels on lowering speeds as they approach the coast and ports through the "Protecting Blue Whales and Blue Skies" program. This work has reduced emissions from vessels still burning fossil fuels and has had a positive impact on our local air quality.

Ms. Decas, can you talk about how your port has assisted in getting vessels to participate in reducing speeds, and how this, coupled with new emissions-reducing technology can help the port reduce overall emissions and improve air quality for the surrounding areas?

The public health burden of port emissions often falls on nearby disadvantaged communities of color. What work has the Port of Hueneme done to engage local communities to ensure their concerns are heard?

Ms. DECAS. OK, I will start with the first one, Blue Whales, Blue Skies. Our customers do actively participate in this program. We strongly encourage it, and several of them have received awards, and I will submit those awards to you so they can get into the congressional record.

We are looking in terms of clean air emissions, a variety of technologies. One is something called a sock. Well, not quite a sock, but it is a technology, a bonnet system where, if a vessel comes in, you will be able to cover the stack and capture emissions that way. That is something that is emerging as a new look, or a new opportunity for the industry in terms of capturing at-berth emissions.

In terms of the social equity piece, this is exactly right. Adjacent communities at ports are often considered to be sacrifice zones. Particularly in Port Hueneme, we have a very large minority population. If we can develop green types of technologies, there are two things that can happen. One, immediately you have the direct relief from environmental mitigation. And then two, you can also develop a pipeline and workforce development into these green technologies, and that is exactly what we are doing at the Port of Hueneme.

We are looking at ways to interface and get our populations the education that they need, so there is direct pipelines to new job and uplifting our social equity at the Port of Hueneme through workforce developments, local project labor agreements to hire local community players, and ensure apprentices in those types of things are happening so that we can really develop our workforce and uplift the economic health of our community, access to public healthcare, and all of that.

Mr. CARBAJAL. Thank you. And I appreciate you submitting that information for the record. And without objection, it will be submitted, regarding the awards that you referenced.

Ms. DECAS. Yes.

[The information follows:]

Letter of June 22, 2021, Regarding Port of Hueneme and the Vessel Speed Reduction Program, from Kristin Decas, Chief Executive Officer and Port Director, Port of Hueneme–Oxnard Harbor District, Submitted for the Record by Hon. Salud O. Carbajal

JUNE 22, 2021.

Hon. Congressman SALUD CARBAJAL,
2331 Rayburn HOB,
Washington, DC 20515.

DEAR CONGRESSMAN CARBAJAL,

Thank you for the honor and opportunity to testify on April 15, 2021 at the "*Practical Steps Toward a Carbon-Free Maritime Industry: Updates on Fuels, Ports, and Technology*" Coast Guard and Maritime Transportation Subcommittee hearing. I hope I offered insights that will help advance the decarbonization of the maritime industry and bring social equity to underserved communities. As part of my testimony, a question was raised specific to the work of the Port of Hueneme and the Vessel Speed Reduction Program (VSR), also known as the Blue Whales and Blue Skies Program. I committed to providing additional information for the record that highlights the efforts of our customers participating in this program and respectfully request this letter be accepted as my response.

For the purpose of background, the VSR program includes shipping lanes through the Santa Barbara Channel off the coast of Ventura and Santa Barbara Counties and encourages participating shipping lines to reduce their vessel speeds. Under the National Oceanographic and Atmospheric Administration (NOAA) program, participating vessel lines are awarded financial incentives based on the amount their vessels travel below 10 knots in the VSR zones. These reductions in vessel speed translate into lower ship emissions of pollutants and greenhouse gases, reduced risk of vessel strikes of whales, and reduced ship noise in the offshore environment. Below are some additional facts relative to VSR:

- Every year, container ships and auto carriers make thousands of transits in the shipping lanes in the Santa Barbara Channel region and along the California coast.
- These vessels are a significant source of air pollution and ship strikes on endangered blue, humpback, and fin whales.
- The VSR incentive program is a voluntary program where the Project partners ask vessel operators to slow down to a speed of 10 knots or less.
- Reducing air pollution and fatal strikes on endangered whales.

The Port of Hueneme recognizes that participation in this program is essential for the environment at multiple levels. In the last few years, Port customers have received multiple awards for their voluntary participation in the program. Port of Hueneme customer participation and award levels are outlined in the table below for your reference:

PORT OF HUENEME CUSTOMER PARTICIPATION AND VSR AWARDS EARNED

Hueneme Customers in VSR in Santa Barbara Channel

Year	Hueneme Carrier	Award Level
2016	Maersk	n/a
2017	Maersk	n/a
	NYK	n/a
	K Line	n/a
2018	Maersk	Silver
	NYK	Gold
	K Line	Gold
	Hyundai Glovis	Gold
2019	Maersk	Gold
	NYK	Gold
	K Line	Gold
	Hyundai Glovis	Silver
2020	Maersk	TBD
	WWL	Gold
	NYK	Gold
	K Line	Gold
	Hyundai Glovis	Gold

At the Port of Hueneme, we are excited to inform you that we are increasing our engagement with this program. In 2021 we will be undertaking a Memorandum of Understanding (MOU) with NOAA to work collaboratively to increase customer participation in the program and to more widely acknowledge the important work done by those participating customers. The important benefits including improved air quality for our community and the protection of maritime life such as rare cetaceans which call our local oceans home.

In closing, I would like to add a few additional highlights showing our commitment to addressing the growing concerns around sustainability and climate change. The Port of Hueneme was recognized as the greenest port by the United States Green Shipping Summit in 2017. In 2016, the Port of Hueneme was also the first port in the State of California to earn the prestigious Green Marine certification which is an onerous third-party audit and verification of sustainability practices by maritime facilities. The Port has continued to be re-certified by Green Marine annually since 2016. The Port of Hueneme moves over $10 billion in cargo, provides em-

ployment for 15,000 local citizens, and in the last decade has realized a 26% growth in cargo while reducing diesel emissions by more than 80%.

Sincerely,

KRISTIN DECAS,
CEO/Port Director, Port of Hueneme.

Mr. CARBAJAL. And as somebody who grew up in that area, I am very grateful for, again, the strides that the Port of Hueneme has made to ensure that there is a reduction of emissions, and that the public's health is protected. So thank you.

Mr. Rutherford, last week I introduced legislation that will double the authorization for the Maritime Environmental Technical Assistance program, or META, within the Maritime Administration. This program provides funding for research and development of new technologies, such as alternative fuel sources. Can you speak to the sort of research the META program has resulted in, and how this research has benefitted your work? And what more could we do to bolster that program?

Mr. RUTHERFORD. Thank you, Chairman Carbajal. The Maritime Environmental Technology Assistance program has been an important program, traditionally, in helping foster new technologies to support the maritime sector in the United States.

In particular, ICCT has, over the years, done a variety of research related to black carbon emissions from international shipping. Black carbon is the second most important climate forcer that is emitted from ships. It accounts for somewhere between 7 and 21 percent of the total greenhouse gas impact of shipping. And META, in fact, has funded some of that work, along with partners at the University of California in Riverside.

So that is, I think, one example of META work in this area that has been valuable over the years. I certainly think META will continue to have an important role in research and development in the sector in a variety of new opportunities that Morgan and other participants today have discussed.

So certainly, electrification of the maritime sector, investments in technologies like shore power, alternative fuel development, and a variety of other technologies need to be matured for deep-sea ships no later than 2030.

Mr. CARBAJAL. Thank you.

Mr. Fanberg, I represent a coastal district that has a large passenger and small vessel presence. Your company's work on electrification of ferries in Alabama is of great interest to me, and I can see how it might apply to other vessels in our domestic fleet. Do you see coastwise and domestic vessels, whether commercial or recreational, adopting this technology? And what can Congress do to help accelerate that shift?

Mr. FANBERG. Thank you, Chairman Carbajal, for the question, and thank you for recognizing our project in Alabama, the Gee's Bend Ferry. That was a great example of a retrofit, an existing ferry that was able to secure grant funding and convert from diesel to all electric.

So your question about transferring that to other entities, yes, absolutely. Obviously, depending on the route of the ferry or the small craft, it will depend greatly on that route and whether or not it is applicable for all-battery power. So there is no question that

there are so many other vessels, as they age out, and new construction projects start, that these vessels could be ripe for an all-electric propulsion system.

To encourage that, more projects like the Gee's Bend Ferry—in my State we are also working on a project up in Skagit County to replace a 41-year-old diesel-powered passenger and car ferry. That will be another project that, if we can get more funding, will be all electric. So, to encourage other municipalities and ferry systems and private operators to go all electric, we need more of those initial projects to showcase the technology and actually show that there is a reduction in maintenance costs and life-cycle costs when you can move from a diesel engine to a rotating electric motor. So very encouraging.

Mr. CARBAJAL. Thank you very much.

Next we will go to the distinguished gentleman from Long Beach, Representative Lowenthal.

Mr. LOWENTHAL. Thank you, Mr. Chairman, and I greatly appreciate your describing me, but I really also want to thank you, Chairman Carbajal, for your leadership in greening the maritime industry.

And I also want to thank the panel. Reducing maritime emissions is a really critical priority for the well-being of our planet, and can have a tremendous impact upon port communities such as—I represent the largest port complex in the Western Hemisphere, and that is the port I represent, the Port of Long Beach, which is part of the L.A.-Long Beach Port Complex. And so my port backs up right into the Port of L.A. It is really one large complex.

So my first question is really for Dr. Kindberg.

It is very exciting, Dr. Kindberg, your ability to launch a carbon-neutral vessel within 2 years, and you have already begun to talk a little bit about what are some of the issues in scaling up the technology. And so I have a two-part question.

One is, when am I going to see a carbon-neutral vessel at the Port of Long Beach? I am interested in your larger ships. And when am I going to see a carbon-neutral vessel there?

And then, the question is, what else do you need to do to have the industry move in this direction?

We have seen the progress that you are saying—the industry side, to have this carbon-neutral vessel within 2 years. What do you think is needed to ensure that these new shipping fuels, such as methanol, are pushed to markets so you can become competitive? What role can we play? Thank you.

Ms. KINDBERG. First, let me—Congressman Lowenthal, first let me thank you for your continued leadership to our industry, and your long-term involvement. It is always good to see you.

Mr. LOWENTHAL. Always good to see you, too.

Ms. KINDBERG. Yes, it is more difficult this way, isn't it?

I would say that, in terms of when, I would love to bring some of these bio-based fuel ships here today. And we are talking to various fuel suppliers and so forth, because, as you know, to be able to make those long trips we have to have fuel at both ends. So that is one of the things that we are talking to a number of people about, to get that fuel arranged, to be able to do the biofuels, which we can do in existing ships.

And then, for some of the new fuel ships, again, I would love to see them come here. Again, we are talking to fuel suppliers. We have to be able to arrange the needed renewable fuels. And I can get into more detail with you, if you are interested in more detail on that. But I won't take up all of your time with my enthusiasm here.

Mr. LOWENTHAL. Well, I was just wondering, what role do you think that the Federal Government and this committee, under the leadership of Representative Carbajal, can play in bringing these fuels to market?

Ms. KINDBERG. Well, I would have to say, first of all, engage actively in setting the international frameworks for the global industry. We need goals and frameworks that are future-proof, and those are being discussed right now. So the U.S. needs to play a very active role in those discussions.

And we need to establish mechanisms that encourage and reward early actors, and bring up the laggards, both the carrot and the stick.

And we need global mechanisms to develop those new fuels and make them available and affordable.

I also think the U.S. could leverage our R&D muscle and decades of experience in renewables to accelerate work on new fuels and energy systems, and the landside infrastructure to support them: the national labs, the universities. We have got tremendous research muscle here, and we could use it and address that challenge.

Mr. LOWENTHAL. Thank you. I have one question also following up on this to Mr. Rutherford, if I have time.

Mr. Rutherford, I am very pleased. I think it was in your written testimony, you talked about the possibility of hydrogen infrastructure in the San Pedro Bay. Well, that is the Ports of L.A.-Long Beach. Can you talk more about how we can develop and deploy this technology?

I have not heard very much discussion of hydrogen fuel cells. And maybe you can talk about that, or hydrogen infrastructure that would be needed to propel hydrogen as an alternative fuel.

Mr. RUTHERFORD. Thank you for the question, Congressman Lowenthal. I am a little bit concerned about the time. I am happy to provide more details for the record, but within my written testimony there are several links to studies that my organization have completed on this question. So I encourage you to review those, and I am happy to provide additional details for the record.

Mr. LOWENTHAL. Thank you. I will do that, also, and request that, Mr. Rutherford.

I believe, Ms.—I don't have in front of me——

Mr. CARBAJAL. I think you are out of time, Mr. Lowenthal. We are going to have a second round of questions, so you certainly——

Mr. LOWENTHAL. Thank you.

Mr. CARBAJAL [continuing]. You are welcome back. Thank you so much, Mr. Lowenthal.

With that we will go to the other distinguished gentleman from the State of Washington, Representative Larsen.

Mr. LARSEN. Thank you, Mr. Chairman.

Mr. Fanberg, you might not be surprised I am going to ask you some questions. Skagit County is in my district, and Guemes Is-

land Ferry is the project you are talking about with Skagit. What are the physics of an electric-powered ferry in a channel like the Guemes Channel, which has tidal currents running back and forth, compared to diesel power? And what are the challenges of physics on that?

Mr. FANBERG. The challenges—you are talking about an area that has some extreme currents. And so that was part of our project, was to look at the environmental aspects of going to all electric.

So when it comes to physics, it is, obviously, all about thrust and how quickly we can react in that channel, not only due to the environmental aspects, but also it is highly trafficked through that channel, as well, as you know.

So when it comes to the design, it is really about either matching what a diesel-powered vessel can do when it comes to maneuverability. We also can look at different types of propulsion, whether it is an azimuthing thruster that can move the vessel in any direction, or even the propeller design can go into some of the physics and the maneuverability aspects.

Mr. LARSEN. OK, so there are other design features you can incorporate in order to address any of the thrust challenges you get with electric versus the classic diesel.

Mr. FANBERG. Absolutely.

Mr. LARSEN. Yes. On that, Whatcom County, which is just north, has the ferry to Lummi Island, and they are looking at replacing their ferry, as well.

Mr. FANBERG. Right.

Mr. LARSEN. And you mentioned the funding issue. Just a note: in the INVEST in America bill last year, which was incorporated into the Moving Forward bill last year, we did include low- and no-emission ferry funding in that. And I will be pursuing that again this year, over the next couple of weeks, as we put together the infrastructure bill. So there are opportunities.

Our State ferry system is the largest, based on vehicles and passengers, as well. Those are, by scale, much larger ferries than, say, what we are looking at in Skagit County. And I don't know if you are involved with the State ferry system discussion on electric, I know that some other folks are. Again, getting to questions of scale, and thrust, and maneuverability, to make this a reality—that is where I am getting at, I want to make this reality—what do we need to be thinking about, when it comes to these larger platforms, compared to the smaller platforms you will see in Skagit?

Mr. FANBERG. Congressman Larsen, good question, and yes, we are involved in the Washington State ferry projects. You know, there are two avenues there. They are looking to convert, actually, the ferry that I take home every day, the existing vessel, another conversion project to all electric. And then the new class of ferries, one of those, the fifth of the class, is in development to be an all-electric ferry.

So the big issue when it comes to these longer routes—both of those will be all electric—it is that infrastructure problem, getting the power to the dock. We have a longer route. And if you don't have enough battery capacity to do a round trip, it is about getting

the infrastructure at both ends of the dock, so you can recharge rapidly to make your return trip. So that is the big challenge right there—the battery technology exists, the engineering power is there to convert the vessels or to design them. It comes down to infrastructure and making sure we have power where we need it.

Mr. LARSEN. Yes, and I don't mean to ask this facetiously, but just as a matter of scale, to go from Anacortes to Friday Harbor with stops in Orcas and Shaw—and I invite everyone to my district to do that, by the way, call me any time—does the battery need to be as big as the ferry to make that round trip, what is the scale?

Because you are not stopping, you don't get to stop. It is not really long enough. You land the ferry, you unload your load, you leave. Hopefully, all within 20 minutes.

Mr. FANBERG. Those ferries that are existing are large enough for the density of the battery. So again, battery technology has come a long way—the power you can get in a footprint now, compared to 10 years ago, where you probably physically couldn't get a battery on those vessels to make those routes. So the density and the technology has come a long way, where the ferry sizes that are existing up there, it shouldn't be a problem to get the right-sized battery.

Mr. LARSEN. Yes, OK. Well, again, I will, in my last 10 seconds, just remind folks we did put language in the Moving Forward Act, which was in the INVEST in America Act. We will be pursuing that again. My office will be pursuing that again as part of the American Jobs Plan.

Thank you, Mr. Chair.

Mr. CARBAJAL. Thank you, Mr. Larsen.

Now we are going to proceed with another round of questions for those Members that would like to ask additional questions. Each Member will be recognized for 5 additional minutes, and I will start with myself.

In your testimony, Dr. Kindberg, you say that Maersk is responsible for .1 percent of the global CO2 emissions. Most companies would not volunteer that information. You then proceed to explain Maersk's plan to exceed the IMO's goals on emissions. Why is Maersk seemingly going above and beyond the international standard?

Is there a business case to be made here?

Ms. KINDBERG. Well, first, of course, the right answer is that it is the right thing to do. So thanks for asking that question.

But also, it is very important that our customers provide us demand signals that this is indeed something that they want, that they need, and that they are expecting us to do. And we actually have customers who are paying a premium today to ship net-zero-carbon shipping. That is a change just in the last 2 years.

So we are really starting to see, I would have to say, a global change among cargo owners and shippers to really support some of these new investments.

Mr. CARBAJAL. Thank you.

Mr. Butler, what are the requirements that must be developed for non-carbon-based fuel delivery and storage?

Mr. BUTLER. Mr. Chairman, there are a lot of things that have to happen, seemingly all at once, but at the same time they have to happen, I think, in a certain order, just as a matter of logic.

I think, in answer to your question, when you think about, for example, storage and delivery, the first thing you have to figure out is, well, what is it that I am storing and delivering? So we have to look at what technologies can safely be placed on the ships.

And then you turn to the—probably in many ways—much more daunting question of, OK, how do we produce those fuels in a way that is itself low-carbon or no-carbon?

We have heard a lot of talk about electricity today. That is not going to work on big ships. But just to take that as an example, you can power a vessel with electricity, but if the electricity is being generated by a coal-fired powerplant, you haven't done a lot for greenhouse gas. So you do——

Mr. CARBAJAL. We lost your microphone, Mr. Butler.

Mr. BUTLER. Is it back now?

Mr. CARBAJAL. We can hear you, just a little fainter than before. Keep going, you are fine.

Mr. BUTLER. So, to get back to the direct answer to the question, first you need to know what the fuel is, and then you have to figure out what are the constraints on storage, reduction, and transportation of that fuel to make sure that it is available all the places that it has to be. So there is a series of steps that you have to take logically in order to answer that question.

Mr. CARBAJAL. Thank you very much.

And this is to all witnesses: While we understand that research and development is underway, which fuels are best suited for international shipping, coastwise shipping, small passenger vessels, and tugboats?

[Pause.]

VOICE. I guess I can go first.

Mr. CARBAJAL. Don't all at once, now.

[Laughter.]

Mr. FANBERG. If I could go first, Chairman Carbajal, I think, from my perspective as an engineer, you look at the technologies that are already in development and are already somewhat proven. So battery technology is, as you heard me mention, for more of the short routes when it comes to harbor craft and passenger ferries.

And then, of course, hydrogen is—it might not be the most ideal going forward, and there may be better fuels in the future. But right now it actually could be used, and very efficiently, and there is good fuel cell technology that could be powered by hydrogen. There could be future technology [inaudible] but right now those are the two technologies that are the most promising.

Mr. CARBAJAL. Thank you.

Anyone else?

Ms. DECAS. I will go. Chairman Carbajal, I will just say, from an infrastructure side, from the port's standpoint, not looking at vessel technology, the electric infrastructure is proven at ports. I will add, though, that there is one challenge, and one I think Congress should influence, is entry into—and incentivize entry into the market. There is only one producer of shoreside power system, a company called Cavotec.

So the ports in California compete for mechanics. There is really only one mechanic. So if our system goes down, there is only one mechanic that can come out, and we compete for that. So entry to market is really important, and encouraging R&D in these technologies.

And then, just in terms of our handling equipment, and other infrastructure development, we too are looking at hydrogen solutions as a potential, and hydrogen fuel cells to run port operations that would complement what the vessel industry is doing.

Mr. CARBAJAL. Thank you.

Why don't you conclude, Mr. Rutherford?

Mr. RUTHERFORD. Thank you, Chairman Carbajal, I very much agree with Morgan and Kristin on this.

To a first approximation, the problem is burning carbon fuels. So if you can move away from a fuel that contains carbon, and move towards a fuel that can support electrification of ships, starting with the ships near port and eventually branching out to the deep-sea ships, that is the ultimate long-term solution. So there we are talking about battery electric, hydrogen, and then some sort of hydrogen carrier, for example, ammonia or potentially green methanol.

Mr. CARBAJAL. Thank you.

And Ms. Kindberg, I see you wanted to say something. So in conclusion, if you could, conclude.

Ms. KINDBERG. Thank you. I just can tell you what we are working on for our big ships. We are focusing on biodiesel and biofuels, renewable alcohols, those lignin fuels that I mentioned, the lignin alcohol blends, and ammonia. The ammonia is a longer term option, due to safety and design considerations. So that is where we are really focusing. You have to have a really energy-dense fuel to be able to cross the Pacific.

Mr. CARBAJAL. Thank you.

Now, proceeding with the same complementary approach of all my colleagues, I will go to our distinguished ranking member from Ohio, Mr. Gibbs.

Mr. GIBBS. Thank you, Mr. Distinguished Chairman.

Mr. Butler, the organization, the World Shipping Council, proposes to establish an industry-funded International Maritime Research and Development Board and International Maritime Research Fund to accelerate the development of technologies to achieve low- and zero-carbon fuels. What happens if the industry-funded international research program is not established, and market-based measures are left to drive the industry to shift to cleaner fuel technologies, Mr. Butler?

Mr. BUTLER. Congressman Gibbs, I would rather focus on what happens if it is implemented. But to answer your question directly, without a well-funded, international, coordinated research and development effort, it is going to take the industry much longer to figure out what technologies are——

Mr. GIBBS. Can you speak up just a little bit? You are kind of fading away there.

Mr. BUTLER. Sure. Without that research and development activity, it is going to take the industry much longer to figure out which technologies and which fuels are going to be viable to allow us to

decarbonize. That translates into it takes us much longer to actually get the job done, and it also translates into a tremendous amount of investment uncertainty in the interim.

So it is really critical that we use this mechanism of the IMRB to jump-start the technological work. The sooner we do that, the sooner you see the private investment come off of the sidelines and go into building the infrastructure necessary to supply those fuels. So it is really a question of timing, and time is not on our side. So it is absolutely critical that we take this step.

Mr. GIBBS. Dr. Kindberg, one of your colleagues sits on the board of the World Shipping Council. And after hearing Mr. Butler's testimony, I noted that you were kind of silent in your testimony about the establishment of this International Maritime Research and Development Board and International Maritime Research Fund. Would you like to share your views on the establishment of this fund and development board?

Ms. KINDBERG. We absolutely support the proposal. There does need to be a way to coordinate this work globally. Without that coordination—and it is not just the funding, it is also the convening power of a body like this that could ensure that you can work together without jeopardizing antitrust considerations and things like that.

So this organization would do more than just handle the money, it would also convene and designate kinds of projects that would enable us to really accelerate this work, and perhaps avoid dead ends.

Mr. GIBBS. Thank you.

Dr. Rutherford, I was trying to understand on your figure 3 in your testimony. You have Singapore—it almost looks like they have a monopoly on refueling, or they move a lot more fuel than all the rest of the ports around the world. Was there something significant about that? Is Singapore so big that they move a lot of fuel?

Mr. RUTHERFORD. Thank you, Ranking Member Gibbs. Yes, Singapore definitely has advantages in terms of geography, and also economies of scale for selling shipping fuels.

One of the points I was trying to make with that figure is that, because of today's centralized fossil fuel bunkering system, it is possible for ports outside of the U.S. to capture most of the fuel sales markets. That is because ships today are designed to have huge operating ranges. The largest oceangoing vessels, containerships or tanker ships, they are capable of operating up to 50,000 miles without refueling. Just to put that into perspective, that is a long-enough distance to circumnavigate the world twice without refueling. As a result, those ships can refuel once in a major hub like Singapore, and then operate up to 90 days before refueling, back and forth to the United States, for example.

In contrast, some of these emerging zero-carbon fuels have a lower energy density. That means that there will need to be some minor operational or design changes to make them work. But it also means that the fuels can be generated and used closer to port, and that could create new business opportunities, for example, in the ports of southern California that Congressman Lowenthal was referencing earlier.

Mr. GIBBS. Thank you, and my time is up. I will just make one quick comment, Mr. Chairman. It seems like there might be a lot of opportunities on some of these new biofuels that we might be able to get market share for that.

Mr. CARBAJAL. Absolutely.

Mr. GIBBS. I just wanted to mention that. So thank you, I yield back.

Mr. CARBAJAL. Thank you, Ranking Member Gibbs. And next we will go to Representative Auchincloss.

Mr. AUCHINCLOSS. I would like to thank Chairman Carbajal for convening this timely and important hearing.

It is going to take a bold, all-of-Government approach to overcome the challenges of the climate crisis, and this hearing gives us the opportunity to delve into some aspects of that. And in my district, local colleges and businesses are already investing in the R&D necessary to strengthen the maritime workforce.

Dr. Kindberg, I am particularly happy to get to speak with you today, because Maersk has partnered with Bristol Community College in my district to train students in wind skills development as part of the college's National Offshore Wind Institute, NOWI.

Now, this year your company sold the world's first product tanker fit with wind propulsion technology to Norsepower Rotor Sails on board, and they showcased the drop in fuel consumption.

So my question is, is there the opportunity to take, at the nexus of offshore wind and wind propulsion technology, a workforce development approach that trains people like the students of Bristol Community College in the skills necessary to advance both of those industries?

Ms. KINDBERG. And I must confess that I am not familiar with the program at Bristol Community College, and I apologize for that. We do work with colleges around the world and are big believers in workforce development. There will be a whole new set of skills needed to both build and install these new technologies, and to maintain them, and to handle all these fueling systems. So there absolutely will be needs for workforce development to support all of these things.

Mr. AUCHINCLOSS. And do you think that there is—if you think of, like, a Venn diagram of the skills necessary to do offshore wind construction and maintenance and the skills necessary to do wind propulsion technology, how much of an overlap is there in terms of the programming that you would need for workforce development?

Ms. KINDBERG. You know, I am not that familiar with Maersk tankers. The Flettner rotors that they have actually been using, I have heard that they are getting good results. But I am not an expert on that one. I am happy to get you some information, if you need.

Mr. AUCHINCLOSS. I would be interested in that.

Mr. Fanberg, perhaps I could turn to you and get your thoughts on this. Some ports are natural hubs for connecting offshore wind, like the places in my district—Brayton Point, for example, in Somerset, Massachusetts. My district is right onshore of the greatest natural offshore wind resource, really, in the Western Hemisphere, and we are working hard to take advantage of that, in creating a cluster in southeastern Massachusetts devoted to offshore wind. Do

you see a nexus between offshore wind manufacturing, logistics, R&D, with wind propulsion for international shipping?

Mr. FANBERG. Thank you, Representative Auchincloss.

So the crossover between the wind energy and wind technology for vessels, there is a—first of all, supporting the offshore wind industry off the coast, the east coast, is going to be a very large boom for the whole maritime industry in general. So maybe there is no crossover between the skill set for installing wind turbines and the skill set for operating a vessel with—like Maersk with the Flettner rotor, but there certainly will be a crossover in the maritime industry when it comes to jobs, and the maritime industry together.

I don't necessarily see a crossover in the skill set for offshore wind and operating a vessel with Flettner rotors or other wind technology, except for the engineering side of things. I think, when it comes to the installation of offshore wind, certainly when we do deep-sea offshore wind, there is a crossover in skill set for naval architects to combine both of those technologies. So there is something there.

Mr. AUCHINCLOSS. That is helpful feedback, I appreciate that.

One of the things I expect Massachusetts will become a leader on is not just the installation, maintenance, operation, but also the latest R&D around this. Massachusetts is famous for its product development and putting the best minds to work on hard manufacturing problems. And I could see that there could be synergies between the best R&D for offshore wind and taking some of those learnings and applying them to wind propulsion. And I think Bristol Community College might be one of the leading centers of excellence for that.

Mr. Chair, I yield back the balance of my time.

Mr. CARBAJAL. Thank you, Representative Auchincloss. Next we will go to Representative Malliotakis.

Ms. MALLIOTAKIS. Thank you very much, Mr. Chairman. I just wanted to follow up on some of the questions of the ranking member regarding achieving targets for greenhouse gas reduction that has been set up by the International Maritime Organization.

In particular, I was wondering—and I guess this is a question for Mr. Butler—if you envision the industry being able to convert existing vessels to these new fuels. You touched on it slightly, but I am wondering what you would think the cost to shippers and consumers would be. And if they were to scrap existing vessels early, what would be the impact on that, as well?

And if you have any information or insight into the construction costs of new decarbonized vessels compared to the current vessels.

Mr. BUTLER. Congresswoman, thank you for the question. I will ask first whether you can hear me. I know there was a problem.

Ms. MALLIOTAKIS. Yes, we can.

Mr. BUTLER. OK, great. I mean, I am sorry to say that I can't give you very precise numbers about the cost of all of this, because we don't know quite yet what this is.

You know, I have spoken earlier, we don't know which fuels and their related technologies are going to end up being the long-haul investments that the industry makes for the deep-sea sector. And whether or not those technologies and fuels will be suitable for retrofit is similarly an open question.

I think it is safe to say that, at least in the short term, as we make this conversion, costs are going to go up. I think we need to be honest about that, and I really can't see a scenario where, at least based on what we know now, we have a no-cost transition. There will be cost. And that is one of the reasons that it is so absolutely critical that we avoid going down dead ends. And that means doing the research and development on the front end to figure out as early as possible which technologies are going to pan out.

Ms. MALLIOTAKIS. Thank you, I appreciate that. And certainly, looking at the economic impact of all this, I think, should be a priority before we go down this path.

And the second question I have, in recent conversations with the aviation industry, they had been talking about technology that they feel they could implement that would reduce fuel emissions. And this is a question for everyone, if you see that anything specific that you can share with us regarding possibly the same opportunities in the shipping and vessel industry.

Ms. KINDBERG. Well, shall I jump into that one first?

Ms. MALLIOTAKIS. Sure.

Ms. KINDBERG. And thank you for your question. I am not sure exactly which technology you are talking about in the aviation industry, but I can tell you that, over the last 5 years, we have done what we called our radical retrofit program to make dramatic energy efficiency improvements on about 100 of our vessels. And that program cost us $1 billion.

Ms. MALLIOTAKIS. Could you share a little more about some of the impact that has had, and how many vessels, and sort of the success that you have seen?

Ms. KINDBERG. In that particular case—well, some of the success—these are vessels that commonly call the United States. And let me give an example in southern California—sorry, we also do call Port Authority of New York, New Jersey. But the example in southern California is one I happen to know quite well, because we did a study with the ports and with Scripps Institution of Oceanography.

So not only did we improve energy efficiency of those vessels, we also reduced underwater radiated noise, which has an impact on the whales in Santa Barbara Channel and other places. So that happened to be a win-win. But we were just very fortunate to be able to have found that sweet spot. And we hope that underwater radiated noise and other environmental impacts can also be benefitted. So we really have to look at the whole picture, and not just greenhouse gases.

Ms. MALLIOTAKIS. OK.

Ms. DECAS. Congresswoman, to complement what Maersk is saying, we do take on one of their vessels, a liner service, once a week in the Port of Hueneme, and they religiously plug in their vessel at berth, and that has led to profound impacts on the environment locally, here in our community, 85 percent reductions from shoreside power systems. So that is a technology worth pursuing.

And I think, as the conversation moves forward around all these new fuels in the shipping industry, it is really important that ports are at the table, so they understand the infrastructure needs that are going to drive and coordinate with what is happening on the

vessel side, so we are not working in silos, building one infrastructure at the ports and a different infrastructure for the vessels. So that is going to be a very important part of the conversation.

Ms. MALLIOTAKIS. Thank you.

Does anyone have any comments on what the potential impact will be of establishing zero-emission refueling stations in American ports, both environmentally and economically?

Ms. DECAS. I will speak to that. I can tell that you—and Port of Hueneme is interesting. We had $4 million in our reserves when I started in 2012, when we were regulated, to build a $14 million system, and we got it done. So it takes innovation and creativity, and working with different partners and investment. And we got it all across the board from the State, from the EPA. We got a new market tax credit deal to help us build the infrastructure to scale that up. And the larger ports, L.A. and Long Beach, invested well over $100 million in infrastructure.

But again, the payoff has been in the return to the communities, in terms of really significant and tangible emission reductions. So it is a solid investment, but the ports can't bear those costs alone, that we do need the assistance and the subsidies coming from State and Federal Governments so that we can really transition and transform into a decarbonized transportation network. In my testimony I said it is going to be about $35 million in California alone to retrofit our ports to zero-emission electric technology.

Ms. MALLIOTAKIS. Thank you.

Mr. CARBAJAL. With that, that concludes our hearing for today.

I would like to thank each of the witnesses for their testimony today. I ask unanimous consent that the record of today's hearing remain open until such time as our witnesses have provided answers to any questions that may be submitted to them in writing.

I also ask unanimous consent that the record remain open for 15 days for any additional comments and information submitted by Members or witnesses to be included in the record of today's hearing.

Without objection, so ordered.

The subcommittee stands adjourned.

[Whereupon, at 12:41 p.m., the subcommittee was adjourned.]

SUBMISSIONS FOR THE RECORD

Prepared Statement of Hon. Sam Graves, a Representative in Congress from the State of Missouri, and Ranking Member, Committee on Transportation and Infrastructure

Thank you, Chair Carbajal and Ranking Member Gibbs, for holding this hearing today.

As my colleagues on this Committee know, everything in this country moves.

And as the current cargo surge has reminded us, 99 percent of everything moves at some point by water.

Many consumer goods and parts needed for U.S. manufacturing arrive by container vessels, and any added costs placed on ocean carriers may get offset by cost increases for consumers and manufacturers.

I would also note that today, U.S. agriculture exporters are being devastated by higher shipping costs related to the existing container shortages in many areas. We can see firsthand the need to keep shipping rates at reasonable levels.

Therefore, we have to be mindful of how any new requirements on industry will add to the cost of transporting goods. With that said, I look forward to hearing from our witnesses about how they see the future of shipping and efforts being made to reduce the maritime industry's impact on the environment.

Again, I thank the Chair, the Ranking Member, and the witnesses, and I yield back.

Statement of Jennifer States, Director for Blue Economy, DNV Energy and Maritime North America, Submitted for the Record by Hon. Bob Gibbs

I. INTRODUCTION

Chairman Carbajal, Ranking Member Gibbs, and Members of the Subcommittee, thank you for the opportunity to submit a statement for the record of the Subcommittee's recent hearing, *Practical Steps Toward a Carbon-Free Maritime Industry*. My name is Jennifer States, and I am the Director for Blue Economy with DNV.

DNV is the independent expert in risk management and quality assurance. Driven by our purpose to safeguard life, property, and the environment, we empower our customers and their stakeholders with facts and reliable insights to make critical decisions with confidence. As a trusted voice for many of the world's most successful organizations, we use our knowledge to advance safety and performance, set industry standards and benchmarks, and inspire and invent solutions to tackle global transformations.

In the maritime industry, DNV is the world's leading classification society and a recognized advisor. We enhance safety, quality, energy efficiency and environmental performance of the global shipping industry—across all vessel types and offshore structures.

In the energy industry, DNV provides assurance to the entire energy value chain through its advisory, monitoring, verification, and certification services. As the world's leading resource of independent energy experts and technical advisors, DNV helps industries and governments to navigate the many complex, interrelated transitions taking place globally and regionally. DNV is committed to realizing the goals of the Paris Agreement, and supports customers to transition faster to a deeply decarbonized energy system.

DNV was established in Norway in 1864 and has been operating in the United States for 123 years, since 1898. DNV USA is headquartered in Katy, Texas, and has 39 offices in 22 states, including major hubs in California, Ohio, and Pennsylvania. We employ 12,000 people worldwide (2,300 in the USA), and in 2020 generated global revenues of $2.4 billion ($500 million in the USA). DNV is wholly

owned by an independent foundation and invests five percent of its revenue in research and development.

Decarbonizing the maritime industry requires a multifaceted approach that includes ships (the energy end-user), ports and shoreside infrastructure (to service and deliver the energy that the ships will use), and collaborative, cross-sector innovation to develop effective solutions for the ecosystem. Our statement discusses each of these three facets, followed by a summary of DNV's five recommendations to the Subcommittee, which are:

1. Develop a national maritime decarbonization strategy.
2. Renew the aging U.S.-flag merchant fleet.
3. Prioritize research, development, demonstration, and deployment funding for decarbonizing ships, ports, and supporting infrastructure.
4. Improve the framework and funding mechanisms with regional maritime cluster organizations to implement collaborative demonstration projects.
5. Set a uniform regulatory framework for port greenhouse gas (GHG) emissions.

II. Reducing carbon emissions from ships

Shipping's main challenge over the current decade is to prepare for and start on a decarbonization pathway. Alternative carbon-neutral fuels are essential for achieving International Maritime Organization (IMO) greenhouse gas (GHG) emissions reduction goals in 2050, and the only practical way for shipping to achieve the ultimate vision of full decarbonization as soon as possible before 2100.

Shipping is experiencing increasing pressure to decarbonize its operations and to reduce emissions to air. Most notably, in April 2018 the IMO adopted an ambitious GHG emissions-reduction strategy for international shipping. Increasingly, we also see key stakeholders such as banks and cargo owners focusing on decarbonization, and legislation was introduced at the end of the 116th Congress to reduce/eliminate vessel emissions from ocean transportation (H.R. 8632, Ocean-Based Climate Solutions Act). All this points to a changing business environment for ships. It will shape the future fleet in important ways, particularly in the choice of fuels and technologies. This will likely impact costs, asset values and earning capacity more significantly than observed in the past.

In contrast to previous environmental requirements, meeting GHG targets requires fundamentally more challenging technological and operational changes for shipping. The challenges include a transition to new and alternative zero-carbon/carbon-neutral fuels and unconventional technologies. In addition, the energy efficiency of ships requires rethinking, with the uptake of proven energy-recovery and energy-efficiency technologies to be intensified. These challenges also place a new and stronger focus on system-level thinking and integration of all available technologies. While the industry has been discussing emissions reduction for many years, all the most likely solutions face challenges and barriers. Meanwhile, shipowners postpone investment in new ships for fear of ordering a vessel that will be unacceptable under future GHG regulations.

The decarbonization of shipping is part of a global transition across all industries towards greater use of renewable energy and less of fossil fuels. We have some ideas today on possible fuels for widespread adaptation in the decades to come, but cannot point to an entirely safe bet for the future at this point of time. In the 2019 edition of our Energy Transition Outlook, we predicted that carbon-neutral fuels will likely supply around 40% of the total energy for international shipping in mid-century if the IMO's ambitions for reducing GHGs are to be achieved. The type and the pace of future regulations have an important role to play here, together with the future global energy mix, as well as fuel price and infrastructure development.

An increasing number of studies consider ways shipping could decarbonize, developing scenarios for the transition from conventional to zero-carbon or carbon-neutral fuels, along with technical and operational energy optimization. The zero-carbon/carbon-neutral fuels will need producing from three primary energy sources; sustainably provided biomass, renewable electricity, or fossil fuels with carbon capture and storage (CCS). Decarbonization could be especially challenging in the deep-sea segment, which generates 80% of the global fleet's CO2 emissions.

U.S. Government commitment

Subsequent to the Subcommittee's hearing, the Honorable John Kerry, the U.S. Special Presidential Envoy on Climate Change, announced on 20 April 2021 that President Biden is committed to achieving low to zero emissions from shipping by no later than 2050 and has recommitted the U.S. to discussions, debate and decisions at the IMO on GHG controls for international shipping.

DNV welcomes and supports the U.S. Government's commitment of working with countries in the IMO. DNV recommends the United States develop a national action plan to reduce GHG emissions from international shipping, and thus align with the IMO's Marine Environment Protection Committee (MEPC) 75 resolution urging Member States to develop and update a voluntary National Action Plan (NAP).

In addition to a national action plan for the U.S. international fleet, DNV recommends the United States also develop a maritime decarbonization strategy for the its domestic fleet by working across relevant agencies and with industry engagement. Based on DNV's international experience supporting governments with the development of their domestic maritime decarbonization strategies, public-private partnerships have successfully accelerated actionable goals. Some examples are:

- Washington Maritime Blue, USA: A cluster alliance launched by Washington State, committed to the development of maritime business, technology, and practices that promote a sustainable future contributing to economic growth, ecological health, and thriving communities. Discussed further in Section IV, below.
- Green Shipping Program, Norway: A public-private partnership program supporting the Norwegian Maritime Cluster's GHG initiatives to gather the maritime industry and escalate investment in green shipping.
- Maritime Decarbonization Center, Singapore: Foundation Det Norske Veritas—which owns DNV Group—has teamed up with the Maritime and Port Authority of Singapore (MPA) and five other industry leaders to establish a maritime decarbonization center in Singapore, supported by contributions from the founding members totaling $90 million. The center's mission is to catalyze and facilitate decarbonization in the maritime sector.
- E4ships, Germany: promoting the use of fuel-cell systems and electric fuels in shipping.
- Vancouver Maritime Centre for Climate, Canada: an industry-led initiative with support from the Government of Canada, dedicated to accelerating the transition to a zero emissions shipping industry in British Columbia.

Near-term actions benefitting decarbonization of shipping

There are several near-term measures that can be taken to benefit decarbonization of the U.S. fleet. These measures also generate opportunities beyond decarbonization, including the creation of jobs in the maritime industry, in the American shipbuilding industry and in the related supply chains.

To support near-term carbon reduction of the U.S. fleet, DNV recommends an increase of the existing funding to the Federal Ship Financing Program (MARAD Title XI) and the establishment of a priority for new ships that reduce their GHG emissions to federal and international levels. This is the primary financing mechanism for U.S. shipbuilding. With an average age of 24.5 years for the U.S. flag fleet compared to 13.3 years for the international fleet, the renewal of the U.S. flag fleet will contribute significantly towards the U.S. and IMO 2030 and 2050 GHG reduction goals. Expanding the use of Capital Construction Funds (CCFs) or Construction Reserve Funds (CRFs), which provide deferred tax treatment on private capital used for shipbuilding/repair, could also increase the amount of private investment.

In November 2020, the IMO introduced an Energy Efficiency Existing Ship Index (EEXI) when it approved amendments to MARPOL Annex VI at its MEPC 75 session. Subject to adoption at IMO's MEPC 76 in June this year, the requirements will enter into force in 2023. The EEXI will apply to all existing vessels above 400 gross tons and falling under MARPOL Annex VI. Guidelines on calculations, surveys, and verification of the EEXI will follow and be finalized at MEPC 76. Nevertheless, as the EEXI is the extension to existing ships of the newbuilding-related Energy Efficiency Design Index (EEDI), most procedures will be the same as for the EEDI (which has been applicable since early 2015), with some adaptions regarding limited access to design data. DNV findings show that some shipowners, including those of U.S.-flag ships engaged in international trade, may have challenges to meet the intended requirements. Therefore, these ships' urgent replacement will also benefit the decarbonization of the U.S. fleet.

DNV also recommends that emissions reduction become a part of the selection criteria for funding/financing opportunities at federal agencies such as the Departments of Energy, Transportation, Commerce, Interior, and Homeland Security, and at independent agencies such as the EPA. The emissions reductions should be validated by U.S. shipowners and shipyards associations, plus MARAD, at a minimum. There are similar international programs that can be referenced, such as:

- Poseidon Principles launched in 2019 by three global shipping banks to provide a framework for integrating climate considerations into lending decisions that promote decarbonization of international shipping. Today, 24 leading banks,

jointly representing approximately $175 billion in shipping finance, have aligned in commitment to the Poseidon Principles.
- Sea Cargo Charter was born from inside the Poseidon Principles to provide a global framework for aligning chartering activities with responsible environmental behavior to promote international shipping's decarbonization. Today, 20 major ship charterers are signatories.

Promotion of alternative fuels and technologies to support decarbonization of shipping

The future fuel and technology picture for the shipping industry is complex and getting more so. In the 2020 edition of our Maritime Forecast to 2050, DNV set out three decarbonization pathways forward and a detailed library of 30 scenarios we hope will enhance shipowners' ability to navigate technological, regulatory and market uncertainty due to decarbonization—and maintain their vessels' competitiveness, profitability and value over time.

Our key messages are worth repeating here:

1. Over the next decade the shipping industry needs to start rolling out the next-generation ships running on carbon-neutral fuels. This will require accelerated technology development, large-scale pilot projects for deep-sea vessels and safety standards development.
2. A clear and robust regulatory framework must be in place to ensure the global availability of large volumes of carbon-neutral fuels; to enable their safe transportation, storage and use; and, to incentivize their uptake by ocean carriers while retaining a level playing field in the ocean transportation marketplace.
3. Picking the wrong fuel solution today can lead to a significant competitive disadvantage. Managing decarbonization risks is critical to protecting a vessel's future value, profitability and competitiveness, and for shipowners to ensure that their ships are on an acceptable GHG emission trajectory.

To help ship owners and other maritime stakeholders monitor the global uptake of alternative fuels and assess the best options for their own vessels, DNV developed the Alternative Fuels Insight (AFI) platform. AFI provides a complete overview on developments of alternative fuels and technologies, covering both investments on ships and in bunkering infrastructure. A core aim is to improve clarity for a range of stakeholders allowing them to make informed decisions. It will assist ship owners in selecting a fuel for the vessels they order today and in coming years, and also fuel suppliers weighing up investment in new bunkering infrastructure. Maritime authorities will benefit from increased transparency, while equipment suppliers can gather intelligence for product development strategies.

The U.S. Government can assist through promoting research, demonstration, and development of emerging technologies. The Maritime Administration (MARAD) does this through its Maritime Environmental and Technical Assistance (META) Program, with which it is funding several projects on alternative fuels (e.g., biofuels, LNG, methanol) and alternative energy (e.g., battery for auxiliary power and for hybrid use, fuel cells) to support decarbonization. Some examples are:

- SF-Breeze, a zero-emission, hydrogen fuel cell, high-speed passenger ferry, and establishment of a hydrogen refueling capability in San Francisco Bay, and
- Zero-V, a zero-emission, hydrogen fuel cell, coastal research vessel.

DNV recommends that MARAD META funding be expanded substantially to accelerate research and development into alternative fuels and alternative energy to support maritime decarbonization.

III. Ports and shoreside infrastructure to support decarbonizing ships

While using low- to no-emissions fuels is crucial for the decarbonization of maritime transportation, decarbonizing the maritime industry also requires attention to ports and shore-side operations. Low- and zero-emissions fuels are still in the development stage, and strides have been made in electric ships, but the current U.S. and global fleet is still powered largely by petroleum fuel oils. For vessel owner/operators to make the transition to alternative energy and fuels, the availability of charging and fueling infrastructure at port facilities is critical. New business models that work for ports, their tenants and utilities are needed to enable the capital-intensive infrastructure to be built. In addition, as these technologies mature, it will still take time to retrofit or rebuild the fleet so that it is powered by low- or zero-emissions fuels.

One near-term solution is to reduce emissions at ports. There needs to be an increase in spending for Research, Development and Demonstration (RD&D) for maritime energy technologies and fuels. In this regard, the EPA's Diesel Emissions Reduction Act (DERA) funding can be expanded building new and retrofitting existing

vessels, as well as a priority set for port projects. DOE's EERE and ARPA–E should make maritime and ports a strategic priority, and increased funding should be used to support RD&D of novel low- and zero-carbon fuels and technologies that can scale in production and volume to help the maritime industry decarbonize rapidly. RD&D topics of interest include port operations and infrastructure, vessel hull design, energy sources and carriers (hydrogen, biofuels ammonia, batteries, marine renewable energy, etc.), vessel operations and energy efficiency, and exhaust treatment.

As a major contributor to carbon emissions, ports and their users offer many largely untapped ways to reduce greenhouse gas emissions throughout their operations. In addition, reducing or eliminating carbon emissions in ports is beneficial to all stakeholders beyond the maritime industry; local communities can reap the benefit of cleaner air and fewer health impacts, a revitalized neighborhood surrounding the port, and job creation as necessary infrastructure is built.

DNV's recent report, *Ports: Green Gateways to Europe*, outlined ten green transitions that would significantly reduce carbon emissions at and near ports. Three transitions stand out as solutions that would make a significant impact in reducing carbon emissions at ports: electrification of port-connected activities, including cold ironing and drayage trucks; uniform regulations at the federal level specifying carbon emission reduction standards and other related regulations; and integrating offshore wind transmission infrastructure into ports. In addition, integrating energy efficiency measures such as LED lighting can bring an overall reduction of the carbon footprint of ports. Last summer, DNV issued a series of white papers focused on North American waterfront decarbonization opportunities including shore power, drayage trucks and tugs.[1]

However, the decarbonization of the electricity supply is a necessary step to reaching low- or no-emissions operations for ports. Fortunately, the current trajectory of the integration of renewables into the grid is accelerating across the United States. DNV's Energy Transition Outlook predicts that generation from solar PV and wind will dominate the generation mix, reaching about 45 percent total by 2050. With goals put forward by the Biden Administration recently, this percentage could dramatically increase.

To balance electricity supply and demand, especially as more renewable energy comes on-line, the grid must have system flexibility, which can be provided by a mix of supply- and demand-side options, including flexible conventional generation, curtailment of renewable generation, new transmission, and more responsive loads.

Port decarbonization

DNV recommends incentivizing and funding the electrification of port operations to the largest extent possible, particularly cold ironing and drayage trucks. Electrification of port operations offers multiple benefits: decarbonization of port operations and reduction in emissions impacts for the nearshore communities, economic development opportunities for the local community for as new infrastructure is constructed, and new or increased revenue streams for utilities as loads from ports grow. There are obstacles that need to be overcome, and individual ports are hard pressed to achieve electrification without support and involvement from federal, state, and local governments. The single most important factor for achieving low- or zero-carbon emissions operations via electrification is ensuring that the electricity supply is primarily from renewable generation sources. As mentioned above, the Administration's goal to reach a carbon emission free electric sector by 2035 will accelerate the availability of clean energy.

Electrifying specific areas of port operations, cold ironing when ships are at berth and drayage trucks that move cargo, and improved access to charging and alternative fueling for harbor craft and other vessels would make the largest impact on decarbonizing port operations. However, each require large investments by utilities, ports and industry, and greater funding is required to enable larger adoption of these practices. Each operation also has specific considerations to make them more readily feasible for both ports and, in the case of cold ironing and alternative energy/fuel bunkering, ship operators.

Mandating cold ironing while at berth, as is required in California, can reduce the quantity of carbon emissions significantly—NOx emissions can be reduced by 30 percent and particulate matter by 65 percent per call. The overall reduction in greenhouse gas (GHG) emissions depends on the local generation mix, but the average is about 36 percent. From a strictly environmental standpoint, cold ironing is an effective way to reduce GHG in ports significantly, especially if the local generation mix is primarily renewables. However, the capital cost is about $2 million to

[1] The waterfront decarbonization white papers are available from DNV at https://www.dnv.com/services/waterfront-decarbonization-192317.

$10 million per berth, and, depending on the design of the ship and the berth, may not work in all situations. However, innovative approaches to shore power that are currently in development, such as mobile fuel cells powered by hydrogen, that can adapt to a variety of ships at berth, can help to address this issue. Additionally, the utility itself needs to be able both supply the power that the ship needs, and to manage large and somewhat intermittent loads as ships come and go in the port.

While ports can serve as the hosts for fueling and charging infrastructure, utilities are critical in providing decarbonized energy options. Utilities like Tacoma Power are leading the way in offering special tariff structures for shore power and for electro-fuel generation such as hydrogen. Going into effect April 1, 2021, this first in the nation electrofuel tariff is designed for industrial producers of electrofuels to take Tacoma Power's carbon-free electricity and produce hydrogen or hydrogen-rich compounds that can be used to store electricity for later use.

As described in my testimony to the House Committee on Science, Space, and Technology on July 17, 2020, an example of utility leadership in this space is our Joint Innovation Project for growing a "Maritime Hydrogen Ecosystem through Formic Acid Storage Pathways."[2] This is a cooperative pilot project for mobile shore power that is being developed between the utility, ports, industry and national labs that can demonstrate how to make, store, move and use hydrogen and liquid hydrogen carriers (such as formic acid). These new technologies and the system-based approach to solving the business case challenges offer promise for scaling production of hydrogen for future maritime uses.

Drayage trucks in ports are commonly fueled by diesel engines. Electrifying this equipment can further reduce carbon emissions in ports. Battery electric and hydrogen fuel-cell trucks can virtually eliminate NOx and particulate matter and can decrease carbon emissions by about 60 percent. But, as with cold ironing, capital costs, which include drayage truck purchase and charging infrastructure, can be a barrier.

Ports can also play a key role in enabling fueling/charging infrastructure for low-zero emissions alternatives for vessels and shoreside operations. This requires a coordinated planning and capital investment approach to find new hybrid public-private funding solutions and business models that can work across utilities, industry and ports. The Port of Seattle is leading the way in developing their Waterfront Clean Energy Strategy in partnership with their utility, Seattle City Light, as well as key port stakeholders from industry and the near-shore community. DNV is supporting the Port of Seattle by providing expertise in energy planning, engineering and project facilitation.

Ports as a gateway to offshore wind

To ensure that electrifying port operations has the most impact, the electricity supply must also be decarbonized. Options like microgrids that combine on-site renewables generation from solar PV with storage are viable and can mitigate the effects of the large loads ships at berth may have on the grid. However, the rapid growth of offshore wind generation on the East Coast presents an opportunity to integrate offshore wind infrastructure into ports. Many ports are heading in this direction now, e.g., the Port of Virginia, Bedford, MA and others. We applaud the statement by Secretary of Transportation Buttigieg to look favorably at ports with offshore wind infrastructure for the Port Infrastructure Development Program (PIDP) now open for funding. DNV recommends finding funding and incentives to help ports integrate offshore wind transmission infrastructure into their current footprints. Because ports are already industrialized areas, adding this infrastructure enables the preservation of less-developed areas of the shore. It also can solve the problem of access to renewable energy; by portioning off some of the electricity generated by offshore wind via a substation the port could readily use this energy for shore-side operations.

Energy efficiency programs

Port operations also include those that are typical of any commercial and industrial undertaking, with lighting, heating and cooling for buildings, refrigerated storage, and other functions that typically use electricity to operate. These functions also provide opportunities to reduce carbon emissions. DNV recommends that the federal government creates pathways for port-specific energy efficiency programs to be implemented in cooperation with local utilities. San Diego Gas & Electric currently offers a port-specific program that can be used as a model. Including incentives and funding for electrification, as well as more common efficiency measures

[2] *From Lab to Market: Accelerating Our Progress Toward Economic Recovery and a Clean Energy Future, Hearings before the Subcommittee on Energy of the House Committee on Science, Space, and Technology*. 116th Cong. (2020). Testimony of Jennifer States.

to address energy use from lighting and buildings can also reduce the overall carbon footprint of ports and port operations.

https://www.mytpu.org/tacoma-power-announces-the-nations-first-electrofuel-tariff/-:~:text=Tacoma%20Power%20owns%20renewable%2C%20carbon,are%20from%20carbon%2Dfree%20sources.&text=The%20electrofuel%20tariff%20was%20approved,into%20effect%20April%201%2C%202021

Regulatory framework for uniform carbon emission standards

Given the expanse and diversity of U.S. coastal areas, it is inevitable that each port's emissions are regulated by different localized standards. While all ports must comply to federal Clean Air Act standards, those that operate in states that have fewer state and local regulations may operate at a competitive advantage. Ship owners must also contend with different needs for different ports, e.g. cold ironing requirements in California but not elsewhere, adding complexity to an already complex operation. DNV recommends a uniform regulatory framework for port greenhouse gas emissions to provide consistency across all ports, and to accelerate port decarbonization across the country. These regulations should address all port operations, including harbor craft (which emit the majority of carbon in port operations), decarbonizing electricity supply, and addressing and mitigating emissions from drayage trucks and other related transportation operations.

As a significant contributor to carbon emissions, the decarbonization of ports operations is urgently required to mitigate the maritime industry's overall contribution to GHG emissions, especially as low- and zero-emissions fuels are far on the horizon. It also requires that the maritime industry work with other stakeholders—utilities, technology companies, the government, and local communities—to ensure that is both feasible and equitable. Championing new technologies and strategies to address global challenges like decarbonized and flexible cold ironing can create new jobs, improve local communities, and place the U.S. at the forefront of the energy transition in the maritime sector.

IV. Cross-sector innovation to develop effective solutions

Decarbonizing the maritime industry requires a multifaceted approach that includes ships (the energy end-user), ports and utilities for the shoreside infrastructure (to deliver the energy that the ships will use), and collaborative, cross-sector innovation to develop effective solutions. How can we foster an environment that brings together all these key players to accelerate clean energy innovations for maritime emissions reductions? I have seen first-hand how a collaborative organization coupled with government support can make all the difference in bringing players together to work towards a common vision and implement maritime innovation projects.

In addition to my role at DNV, I serve as Project Director for Washington Maritime Blue. This Maritime Blue Cluster organization, launched in 2018 by Governor Jay Inslee, has brought diverse players together across the quadruple helix of government, industry, research, and community organizations to: first, agree on a common vision for values that focus on competitiveness and sustainability; And second, to work together in an independent, collaborative organization to meet new regulatory, economic, and innovation challenges. Getting ahead of the curve in addressing challenges also means the companies involved can turn challenges into a competitive advantage and growth opportunity for our local industries.

Washington Maritime Blue is a non-profit cluster organization that is a partnership between public entities, private industry, community organizations and research institutions which is charged with implementing Washington State's Strategy for the Blue Economy [3]. Through Joint Innovation Projects (JIPs), incubator and accelerator programs, workforce development programs, and much more they cultivate collaboration as a key factor for the triple bottom line values of the blue economy: economic growth, healthy ecosystems, and thriving communities. DNV has been working with Maritime Blue since its initial conception to foster creativity across entities and find ways to take innovative ideas from drawing board to implementation. Maritime Blue's JIPs are driving development of new solutions in our region and demonstrating how we can work together to accelerate this maritime energy transition.

In his testimony to the Subcommittee for this hearing, Glosten President Morgan Fanberg described the Zero Emissions Fast Foil Ferry project being led by Washington Maritime Blue. This is a great collaboration example that brings together the

[3] *Washington State's Strategy for the Blue Economy*, Washington State Department of Commerce & DNV GL (2019).

key capabilities needed to demonstrate our leadership in zero-emission maritime transportation. But the lack of public funding available to build and demonstrate innovative vessels such as this puts U.S. companies at a disadvantage over global competitors. Washington Maritime Blue and the JIP team was fortunate to secure grant funding for advancing the design work from the Federal Transit Administration's Accelerating Innovative Mobility (AIM) funding opportunity. The team is also providing local public and private match funding to leverage the Federal investments. The Foil Ferry is the only maritime project selected for an AIM award, as the program is structured with a focus on land-based public transit. There was not an aligned opportunity under MARAD that could provide funding for this project at the time. Nor is there currently public funding available for the next step in building the demonstration vessel. Representative Larsen mentioned during this hearing re-introducing legislation to create a low and zero emission passenger ferry program in the Moving Forward Act, H.R. 2, 116th Cong. (2020). Chairman Carbajal mentioned plans to introduce legislation to double funding for MARAD's Maritime Environmental and Technical Assistance (META) program. DNV supports these proposals, which could serve as a conduit for providing funding opportunities for accelerating leading maritime transportation technologies such as the Fast Foil Ferry project.

It is also essential to bring together the ports, utilities, and industry for planning the infrastructure needed to enable clean energy and fueling options for zero emissions. As described above, DNV and Washington Maritime Blue are supporting the Port of Seattle in their Waterfront Clean Energy Strategic Plan that brings together these key players to facilitate cross-industry planning. Clean energy planning processes such as these can bring together the necessary stakeholders to understand each other's value propositions and find new business models to enable implementation.

Collaborative infrastructure planning and implementation is critical to the energy transition. The Federal government can support this with funding for implementing projects such as MARAD's Port Infrastructure Development Program (PIDP). But currently, only ports are eligible, and the infrastructure that can be funded is limited to projects that will improve the safety, efficiency, or reliability of the movement of goods into, out of, around, or within a port. Funding programs such as the PIDP could be better utilized to support rapid decarbonization of the maritime industry by requiring applicants to indicate in their grant applications how their project contributes to measurable emissions reduction. Or expanding the types of project to explicitly include energy and fueling infrastructure and making emissions reductions part of the grant selection criteria. In some ways, the PIDP and other federal grant programs are too stove-piped to achieve these objectives and we recommend that the GAO study how these programs could best be used to have a cross-sector approach to reducing GHG emissions.

In addition to Washington Maritime Blue, there are new collaborations being launched to that will work across sectors in North America to advance zero-emissions vessel and shoreside infrastructure projects. The Blue Sky Maritime Coalition (the Coalition) is a non-profit, strategic alliance formed to accelerate the transition of waterborne transportation in the United States and Canada toward net-zero greenhouse gas emissions. The Coalition brings together industry, community, government, academia and other stakeholders across the waterborne transportation value chain to action projects that remove barriers to accelerating development, encourage innovation, and promote policies in support of zero emissions.

These types of collaboration are key to advancing the maritime projects for maritime energy transitions. But public funding that is structured to support such efforts is critically needed. Organization funding for operations is needed for these collaborations and cluster organizations. Funding is needed for projects such as zero-emission vessels and shoreside infrastructure. This includes funding for planning, feasibility and demonstration phases. Funding should be structured with multi-entity eligibility. For the new charging and fueling infrastructure that is needed, the project could be led by ports, utilities, industry, or non-profit consortiums. More flexibility is needed to enable the partnerships for making the business cases work.

Washington Maritime Blue and the Blue Sky Maritime Coalition are leading the way in developing collaborative, cross-sector innovations to deliver effective maritime emission reduction solutions. But leadership is needed at the Federal level to deliver a carbon-free maritime industry. Although Special Presidential Envoy John Kerry recently announced that the U.S. is committing to work with countries at the IMO to achieve zero-emissions from international shipping , this commitment does not fully address the U.S. domestic fleet or shore-side emissions challenges that especially impact our near-port and disadvantaged communities.

We need a U.S. Maritime Decarbonization Strategy and goals that create the roadmap for funding and regulatory actions. The strategy should: identify core challenges in meeting international targets; prioritize the challenges based on climate, national defense, economic interests, and environmental justice needs; set national goals for maritime emissions reduction that address these prioritized challenges; specify how each agency can contribute to the goals; and how the respective agencies will work with the private sector. The goals should be jointly developed by DOE, MARAD, EPA, and the USCG, with support from other agencies, industry and nonprofits.

V. RECOMMENDATIONS

In closing, DNV offers the Subcommittee the following recommendations as practical steps towards a carbon-free maritime industry.

1. *Develop a national maritime decarbonization strategy*. This strategy should include both a National Action Plan to reduce GHG emissions from U.S. ships in international trade (in alignment with the IMO MEPC 75 resolution on national action plans), and a maritime decarbonization strategy for U.S. ships in domestic service.
2. *Renew the aging U.S.-flag fleet*. The advanced age of the U.S. fleet makes renewal a more cost efficient and effective decarbonization strategy for many vessels. To support decarbonization through renewal of the U.S.-flag fleet, we recommend increasing the existing funding to the Federal Ship Financing Program (MARAD Title XI), with priority given to ships that incorporate effective decarbonization strategies.
3. *Prioritize research, development, demonstration, and deployment funding for decarbonizing ships, ports, and supporting infrastructure*.
   a. *Increase R&D spending on maritime fuels and energy technologies*. The U.S. Department of Energy's EERE and ARPA–E should make maritime a strategic priority, in alignment with the interagency strategy. In addition, EERE, ARPA–E and MARAD should increase funding for maritime energy R&D to a combined total of at least $60 million annually. This funding should be used to support R&D of novel low and zero-carbon fuels and energy technologies that can scale in commercial production and volume to help the maritime industry decarbonize rapidly. R&D topics of interest include port operations and infrastructure, vessel hull design, energy sources and carriers (hydrogen, biofuels ammonia, batteries, marine renewable energy, etc.), vessel operations and energy efficiency, and exhaust treatment.
   b. *Review and expand existing decarbonization programs*. There are several Federal grants and funding programs that are addressing air pollution, such as the EPA's DERA program. These programs should be expanded to specifically include maritime in their scope where applicable. Additionally, maritime emissions reduction and environmental justice components of these programs and grants should be strengthened. The application process for these grants should be reviewed to ensure that the forms are not unnecessarily onerous or complicated and that the funds are available to all types of business, both large and small, and equally distributed among all geographic regions.
   c. *Increase incentives and funding to decarbonize port operations*. Decarbonization efforts should include electrification of port operations to the largest extent possible, particularly the cold ironing of ships and the electrification of drayage trucks. To ensure that electrifying port operations has the most impact, energy efficiency needs to be improved and the electricity supply decarbonized. The federal government should create pathways for port-specific energy efficiency programs to be implemented by local utilities and provide ports incentives to integrate offshore wind transmission infrastructure into their current footprints.
   d. *Make emissions reduction mandatory in grant and funding selection criteria*. There are many existing Federal programs that provide financial support for port infrastructure, ship construction, or maintenance and retrofits (e.g., for the PIDP, BUILD and Small Shipyard Grants). These mechanisms should be better utilized to support rapid decarbonization of the maritime industry by requiring applicants to indicate in their funding applications how their project contributes to measurable emissions reduction. Existing programs should be reviewed and modified as necessary to include emissions reduction and environmental justice in the selection criteria of awardees. This increased incentive will hasten the adoption of low- or zero-emission technologies and/or fuels.

4. *Improve the framework and funding mechanisms with regional maritime cluster organizations to implement collaborative demonstration projects*. The Federal government should support maritime cluster organizations, incubators, accelerators, and other innovation hubs that foster entrepreneurs and startups focused on maritime decarbonization. Since 2015 the cumulative number of incubators, accelerators, and other innovation hubs globally that were founded to support maritime startups has more than tripled as of 2020. These organizations are inherently regional in their respective scopes and work directly with the local communities to create new businesses and jobs. Federal support could come from the U.S. Department of Commerce and MARAD.
5. *Set a uniform regulatory framework for port GHG emissions*. This framework should provide consistency across all ports and address all aspects of port operations, including harbor craft, electricity supply, and emissions from drayage trucks and other related transportation operations.

In addition to the above five priority recommendations, we offer one further suggestion: to *Green the Federal Fleet*. The U.S. Government owns thousands of ships and boats which are operated by the Navy, Coast Guard, Army Corps of Engineers, National Park Service, NOAA, and others. The Navy alone is responsible for more than 30% of all U.S. Government fuel consumption. The U.S. Government should lead the maritime industry by example. Where possible these vessels should be retrofitted to use non-fossil fuels or be used as test and demonstration platforms for new low- and zero-carbon fuels and technologies to help with technology de-risking. The training vessels currently being built for the state maritime academies (National Security Multi-Mission Vessels or NSMVs) are excellent opportunities. Additionally, selection criteria for the acquisition of Federal vessels should be weighted to favor vessels that reduce or eliminate the need for fossil-fuels.

Mr. Chairman, Ranking Member Gibbs, and Members of the Subcommittee, thank you for this opportunity to share with you DNV's experience, insights, and recommendations for practical steps that the U.S. Government can take to decarbonize the maritime industry. We welcome continued dialogue with you and your staff on this most important topic.

APPENDIX

QUESTION FROM HON. ALAN S. LOWENTHAL TO DAN RUTHERFORD, PH.D., MARINE AND AVIATION PROGRAM DIRECTOR, INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Question 1. During the hearing you began to speak about the possibility of hydrogen infrastructure in the Port of Los Angeles, Long Beach but did not have the chance to finish. Please provide your response and include details on how this technology is best developed and deployed. What is necessary to effectively build up the infrastructure needed to propel hydrogen as an alternative fuel?

ANSWER. Thank you for the opportunity to provide supplemental information. Hydrogen is an energy carrier that can be produced in a variety of ways, including by splitting water using renewable electricity ("green hydrogen"). Subsequent processing can generate compressed hydrogen (CH2) or liquefied hydrogen (LH2). Each has its advantages and disadvantages as an energy carrier. Liquid hydrogen is cooled and cryogenically stored, is more energy dense, but requires significant energy for liquefaction and storage. Compressed hydrogen can be stored at room temperature under high pressure but is less energy dense and requires more storage space onboard a vessel.

When used on a ship, hydrogen generates no pollution (only water) if used in a fuel cell and can also be burned in specialized diesel engines. Fuel cells can be powered by either liquid or compressed hydrogen. We envision hydrogen being first adopted by harbor craft, tugs, and ferries as a compressed fuel, transitioning to short-range cargo carrying ships using either compressed or liquefied hydrogen. Fuel cells are the most likely propulsion technique, with a prototype 3.2 MW fuel cell under development today. Larger, oceangoing vessels will require liquid hydrogen to achieve transoceanic ranges. Marine engine manufacturers are working to commercial diesel engines capable of burning hydrogen and ammonia, an easy-to-store hydrogen carrier that is already commonly used as agricultural fertilizer.

In contrast to fossil fuel bunkering, which is dominated by a few ports worldwide, hydrogen is more likely to be generated, sold, and used in a distributed fashion given its lower energy density. That's because, as a more difficult to store fuel, oceangoing vessels would need to shift from a strategy of fueling once every 90 days for a 30,000 mile plus range using heavy fuel oil (HFO) towards a strategy of refueling at each major port they visit. This creates a business opportunity for US ports, which are responsible for 14.5% of maritime trade by mass (UNCTAD, 2020; ITA, n.d.) but capture only 7% of bunker fuel sales (Ship & Bunker, 2021). For container ships, Georgeff et al. (2020) predicts that the San Pedro Bay Ports of Los Angeles and Long Beach (PoLA and PoLB) could become the dominant Pacific Rim ports for LH2 sales. Ports on Alaska's Aleutian Islands could also become important refueling locations for transpacific ships powered by renewable hydrogen.

Regarding steps to support hydrogen use in shipping, fully developing a green LH2 bunkering infrastructure at the PoLA and PoLB will require significant planning, infrastructure investments, and policy support. It would include local hydrogen generation capacity, including excess renewable wind and solar electricity and dedicated hydrolyzers to generate hydrogen; port storage, initially in the form of 2,500 cubic meter cryogenic spherical tanks but eventually larger flat-bottom tanks; at-berth bunkering infrastructure to support stable demand; and dedicated barges for ship-to-ship bunkering to meet seasonable and/or flexible demand. See Georgeff et al. (2020) and Mao (2020) for further details.

Expanded leadership is needed from the U.S. to support zero carbon fuels in shipping to combat climate change, reduce air pollution impacting vulnerable near-port communities, and to support American jobs. A recent (March 2021) compilation of zero emission shipping demonstration projects (Fahnestock & Bingham, 2021) highlights the need for action. In that Global Maritime Forum report, 106 discrete demonstration projects for hydrogen ships and fuel are highlighted, followed in impor-

tance by projects to develop ammonia as a fuel for larger ships. Only three projects in North American were identified.

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