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THE PATH TO A CARBON-FREE MARITIME INDUSTRY: INVESTMENTS AND INNOVATION

(116–48)

HEARING

BEFORE THE

SUBCOMMITTEE ON
COAST GUARD AND MARITIME TRANSPORTATION

OF THE

COMMITTEE ON
TRANSPORTATION AND
INFRASTRUCTURE
HOUSE OF REPRESENTATIVES

ONE HUNDRED SIXTEENTH CONGRESS

SECOND SESSION

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CONTENTS

Page

Summary of Subject Matter v

STATEMENTS OF MEMBERS OF THE COMMITTEE

Hon. Sean Patrick Maloney, a Representative in Congress from the State of New York, and Chairman, Subcommittee on Coast Guard and Maritime Transportation:
- Opening statement 1
- Prepared statement 2

Hon. Bob Gibbs, a Representative in Congress from the State of Ohio, and Ranking Member, Subcommittee on Coast Guard and Maritime Transportation:
- Opening statement 3
- Prepared statement 3

Hon. Peter A. DeFazio, a Representative in Congress from the State of Oregon, and Chairman, Committee on Transportation and Infrastructure, prepared statement 63

Hon. Sam Graves, a Representative in Congress from the State of Missouri, and Ranking Member, Committee on Transportation and Infrastructure, prepared statement 64

WITNESSES

Joshua Berger, Governor's Maritime Sector Lead, Washington State Department of Commerce:
- Oral statement 4
- Prepared statement 6

John W. Butler, President and Chief Executive Officer, World Shipping Council:
- Oral statement 11
- Prepared statement 12

B. Lee Kindberg, Ph.D., Head of Environment and Sustainability–North America, Maersk:
- Oral statement 15
- Prepared statement 17

Peter Bryn, Technical Solutions Manager–North America, ABB Marine and Ports:
- Oral statement 19
- Prepared statement 20

Kathy Metcalf, President and Chief Executive Officer, Chamber of Shipping of America:
- Oral statement 33
- Prepared statement 34

SUBMISSIONS FOR THE RECORD

Submissions for the Record by Hon. Sean Patrick Maloney:
- Letter of January 14, 2020, from David Bolduc, Executive Director, Green Marine 64
- Letter of January 14, 2020, from Daniel Hubbell, Shipping Emissions Campaign Manager, Ocean Conservancy 66
- Letter of January 13, 2020, from Bruce Appelgate, Associate Director, Scripps Institution of Oceanography 69
- Letter of January 14, 2020, from Jesse N. Marquez, Executive Director, Coalition For A Safe Environment 70

Page

APPENDIX

Questions to Joshua Berger, Governor's Maritime Sector Lead, Washington State Department of Commerce, from:
Hon. Peter A. DeFazio 77
Hon. Anthony G. Brown 80
Questions to John W. Butler, President and Chief Executive Officer, World Shipping Council, from:
Hon. Peter A. DeFazio 81
Hon. Anthony G. Brown 84
Questions to B. Lee Kindberg, Ph.D., Head of Environment and Sustainability–North America, Maersk, from:
Hon. Peter A. DeFazio 84
Hon. Anthony G. Brown 85
Hon. Carol D. Miller 86
Questions to Peter Bryn, Technical Solutions Manager–North America, ABB Marine and Ports, from:
Hon. Peter A. DeFazio 86
Hon. Anthony G. Brown 87
Foreword to Responses from Kathy Metcalf, President and Chief Executive Officer, Chamber of Shipping of America 88
Questions to Kathy Metcalf from:
Hon. Peter A. DeFazio 89
Hon. Anthony G. Brown 91
Hon. Carol D. Miller 92

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JANUARY 10, 2020

SUMMARY OF SUBJECT MATTER

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

PURPOSE

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

BACKGROUND

EMISSIONS AND THE MARITIME INDUSTRY

The International Maritime Organization (IMO) has set the stage for a massive decarbonization of the shipping industry. On its own, today's international shipping industry accounts for over 1 billion tons of emissions per year, 3 percent of total global of sulfur oxides (SOx), nitrogen oxide (NOx), particulate matter (PM), and carbon dioxide (CO2) emissions.[1] If international shipping were a country, it would rank as the 6th largest polluting actor on the planet; shipping emissions contributed to 1,200 early deaths in the United States last year alone.[2] SOx are known to be harmful to human health, causing respiratory symptoms and cardiovascular and lung disease, with concentrated impacts in communities adjacent to ports.[3] In the

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

[2] Schlanger, Zoe, If shipping were a country, it would be the world's sixth-biggest greenhouse gas emitter, World Economic Forum, 2018; Anenberg et al., A Global Snapshot of the Air Pollution-Related Health Impacts of Transportation Sector Emissions in 2010 and 2015, The International Council On Clean Transportation, 2019.

[3] Bhandarkar, S., Vehicular Pollution, Their Effect on Human Health and Mitigation Measures, Vehicle Engineering, Vol. 1 Issue 2, June 2013; Jiang et al., Air pollution and chronic airway diseases: what should people know and do?, Journal of Thoracic Disease Vol. 8 Issue 1:

Continued

atmosphere, SOx can exacerbate radiative forcing and global climate change, leading to acid rain, harming crops, forests and aquatic species, and contributing to the acidification of the oceans.[4]

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

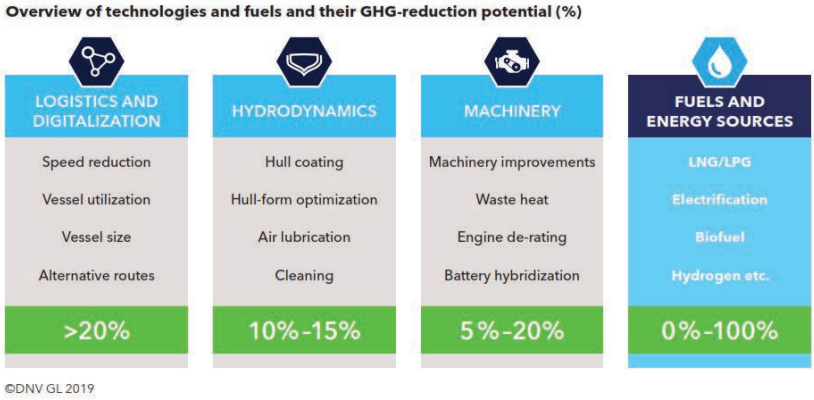


Figure 1—Available methods to reduce vessel emissions by percentage of global emissions mitigated. DNV GL 2019.

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

Ships are highly capital-intensive assets with typical operating lives of 20 to 30 years. With the ratification of new emissions standards by the IMO, therefore, shipping companies must consider zero-carbon fuels and associated technologies now in order to meet established deadlines. Vessels coming online after 2030 will need to

E31–E40, January 2016; Bailey et al., Pollution prevention at ports: clearing the air, Environmental Impact Assessment Review, Vol. 24, Issues 7–8, October-November 2004, Pages 749–77.

[4] Perhac, R.M. (1992) Acid Rain Encyclopedia of Physical Science and Technology. Vol. 1. Academic Press, London; Peterson, M., The effects of air pollution and acid rain on fish, wildlife, and their habitats, U.S. Department of the Interior, Fish and Wildlife Service, Office of Biological Services, 80/40.3, 1982; Prinn et al., Effects of air pollution control on climate: results from an integrated global systems model, from Human Induced Climate Change: an Interdisciplinary Assessment, Cambridge University Press, UK, 2007.

[5] International Maritime Organization, IMO Action to Reduce Greenhouse Gas Emissions from International Shipping, IMO 2019.

[6] Nishatabbas et al., The implementation of technical energy efficiency and CO2 emission reduction measures in shipping, Ocean Engineering, Vol. 139, 2017: 184–197; DNV GL, Maritime Forecast to 2050 Energy Transition Outlook 2019.

[7] DNV GL, Maritime Forecast to 2050 Energy Transition Outlook 2019, page 15.

[8] Ibid.

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

ZEVs or very low emission vessels in order to assure they can operate for their full expected commercial life, which would extend to the period after 2025 in which fleetwide emissions would be drastically reduced.

FEDERAL PARTICIPATION AT THE IMO

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

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

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

[11] Ibid.

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

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

[14] Ibid.

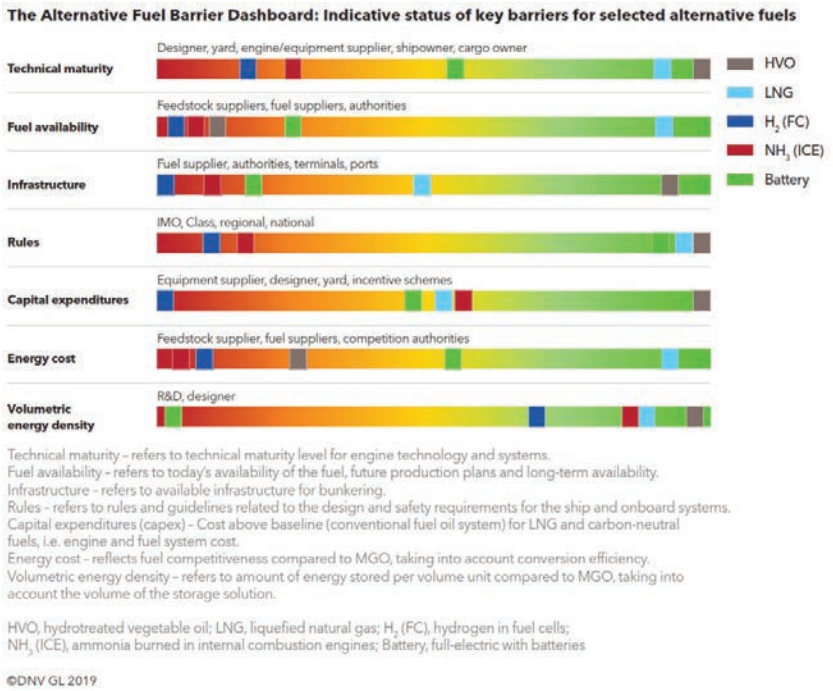


Figure 2—Alternative fuel are variably accessibility and ready for deployment, many still lacking the necessary infrastructure and availability to be considered viable by operators. Fuel sources (identified by color on the key to the right), are ranked by technology maturity along a scale from low maturity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

ALTERNATIVE FUEL TECHNOLOGIES

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

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

The primary energy sources considered to produce existing alternative fuels like hydrogen, ammonia, methanol, gas oil and electricity include: natural gas with capture and storage for hydrogen and ammonia, biomass and algae for methanol and gas, and renewable electricity for hydrogen and batteries. Hybridization and electrification can deliver emission savings regardless of the type of fuel used to generate electricity. To develop, prove, scale and commercialize ZEVs, operators are es-

tablishing collaborative joint ventures with fuel technology companies, equipment manufacturers and energy developers from other industrial sectors outside of shipping. The U.S. Department of Energy's Water Office, MARAD's Marine Environmental Technical Assistance office, and U.S. Coast Guard have initiated conversations about the availability and viability of new fuels for use in the maritime industry.

ALTERNATIVE VESSEL DESIGNS

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

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

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

[16] Kornei, K., Spinning metal sails could slash fuel consumption, emissions on cargo ships, Science, September 2017.

[17] Gallucci, M, Dreamboats, Grist, October 21, 2019. Accessed January 5th 2020.

[18] Gallucci, M., Shipping industry takes a page from bitcoin to clean up its act, Grist, Feb 21, 2019. Accessed January 5th 2020.

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

SHORE POWER AND ELECTRIFICATION

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

Electrification of port infrastructure and at-berth vessels has been demonstrated to significantly reduce per vessel emission reductions for NOx, particulate matter and CO2 emissions, including reductions in noise pollution.[19] Establishing emission control requirements for ports and terminals have been implemented at the state and local level in California to mitigate localized emissions impacts and reduce long-term operating costs.[20] Because cold ironing requires upgrades to ships and shoreside port infrastructure, shore power is most feasible for frequently calling ships, and may be cost-prohibitive for infrequent callers; industry analysts cite a lack of national legislation, tax exemptions on shoreside electricity, and a reduced price dif-

[19] Office of Transportation Air Quality, National Port Strategy Assessment: Reducing Air Pollution and Greenhouse Gases at U.S. Ports, Environmental Protection Agency, EPA–420–R–16–011, September 2016. Local governments in California have had success with reducing localized vessel emissions through At-Berth regulations in 2007 and 2009. Recent regulation requires a fleet operator to reduce at-berth oxides of nitrogen (NOx) and particulate matter (PM) emissions from its vessels' auxiliary engines in port by at least 80 percent by 2020.

[20] JD Supra, CARB Continues Roll-Out to Reduce Emissions from Vessels in California Ports and Targets Ride-Hailing Vehicle Greenhouse Gas Emissions; Update on AB 617, California Air and Climate Vol. 11, November 2019; Office of Transportation Air Quality, National Port Strategy Assessment: Reducing Air Pollution and Greenhouse Gases at U.S. Ports, Environmental Protection Agency, EPA–420–R–16–011, September 2016.

ferential between bunker fuel and electricity costs as barriers to global implementation.[21] Marine fuels are currently globally tax exempt, providing an additional incentive to use diesel fuels for shore power.[22]

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

CHALLENGES FOR THE MARITIME INDUSTRY:

1. *Availability*: New technologies and fuels require sufficient supply chains and safety infrastructure in whatever ports they intend to visit in the United States or abroad for each category of alternative fuel. LNG, for example, is available globally and in large volumes, but limited bunkering infrastructure has directed LNG-fueled vessels to ports that can ensure access to that fuel.
2. *Safety*: The new properties and qualities of alternative low emissions fuels may pose different safety challenges for vessel and port operators and which may result in changes to regulatory and enforcement capacity in the Environmental Protection Agency and the U.S. Coast Guard. For example, the significantly higher buoyancy of hydrogen compared to natural gas means that hazardous zones defined in current maritime safety codes for natural gas may be inaccurate if applied to hydrogen. Operators, regulators, and crew will need to adjust to vessel operations to safely accommodate new fuel sources.
3. *Enforcement*: Limited compliance and enforcement of the 2020 sulfur cap, emission reduction measures, and at-berth emissions regulations will undermine the efficacy of these programs. For example, from 2014–2016, one liner did not

[21] Sukharenko, D., Shore power lacks global investment, tax exemptions, Journal of Commerce online, accessed December 20th 2019.

[22] Hiene, D. and Gade, S., Unilaterally removing implicit subsidies for maritime Fuels: A mechanism to unilaterally tax maritime emissions while satisfying extraterritoriality, tax competition and political constraints. Int Econ Econ Policy (2018) 15:523–545.

meet operational time limits for diesel use for at least half of its visits to the Port of Los Angeles Long Beach.[23]

4. *Limitations of Electrification*: The potential for electricity in the maritime sector is currently limited to short-sea and in-port operations. Maersk is testing battery power at sea to utilize excess energy generated at off-peak hours to operate large container vessels.[24]
5. *Research and Development*: Eight global shipping associations have submitted a plan to the IMO for a fuel tax dedicated to helping eliminate CO2 emissions from international shipping.[25] The tax would generate funds of about $5 billion over a 10-year period, which the association deems necessary to achieve the IMO's 2050 emission reduction targets.[26]

WITNESS LIST

- Mr. Joshua Berger, Governor's Maritime Sector Lead, State of Washington
- Mr. John Butler, President and Chief Executive Officer, World Shipping Council
- Ms. Lee Kindberg, Director, Environment & Sustainability, Maersk Line/Maersk Agency USA
- Mr. Peter Bryn, Technical Solutions Manager, North America, ABB Marine & Ports
- Ms. Kathy Metcalf, President and Chief Executive Officer, Chamber of Shipping of America

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

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

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

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

THE PATH TO A CARBON-FREE MARITIME INDUSTRY: INVESTMENTS AND INNOVATION

TUESDAY, JANUARY 14, 2020

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

The subcommittee met, pursuant to notice, at 10:01 a.m. in room 2167, Rayburn House Office Building, Hon. Sean Patrick Maloney (Chairman of the subcommittee) presiding.

Mr. MALONEY. The subcommittee will come to order.

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

Without objection, so ordered.

Good morning. Welcome to today's hearing on innovations and new developments as we build towards a sustainable carbon-free maritime transportation future.

If international shipping were its own country, it would rank as the sixth largest polluter on the planet. The conventional heavy fuels used to move massive oceangoing vessels are laden with sulfur oxides, diesel particulate matter, and carbon dioxide. That is not pleasant stuff, and it can lead to acid rain, harm crops, acidify oceans, and, not incidentally, impact human health.

For example, shipping emissions contributed to 1,200 early deaths in the United States last year alone, disproportionately impacting low-income communities of color who live adjacent to ports and maritime terminals. That should not be acceptable.

Recognizing these impacts, the International Maritime Organization, or IMO, has committed to reduce total annual greenhouse emissions from international shipping by at least 50 percent by the year 2050 from 2008 emissions levels.

Additionally, just 2 weeks ago, the IMO's high seas maritime fuel sulfur emissions cap was reduced from 3.5 percent to .5 percent to protect air quality and human health. Shipowners, operators, refineries, and regulators like the Coast Guard have adapted to meet this new cap by burning cleaner, high-quality, low-sulfur fuels, or by installing scrubbing technologies.

The maritime industry has not taken on these restrictions merely for a challenge; they recognize, rather, that decarbonizing our global economy is a necessity and an opportunity. We are borrowing time from the next generation. The time for change is now. And I commend the maritime industry taking these initiatives.

Charting its own path to decarbonize the maritime industry, the IMO requires operators to reduce carbon intensity by vessel, by unit of work, and across the industry, as a whole. This will require investments in vessel efficiency, alternative fuels, alternative designs, clean shore power, and more.

For ships to serve their planned lifetime and to meet the 2050 emissions reduction goal, vessels coming online after 2030 will need to be either zero-emission vessels or very low-emission vessels to assure that they can operate for their expected commercial life. We should ensure we have the capability to design, build, and operate those vessels here in the United States.

Investing in innovative new technologies and clean maritime commerce is just one more opportunity we have to bring the American maritime industry into the 21st century, and one we cannot afford to miss. Indeed, the maritime community has risen to meet the challenge, although I must stress the U.S. can and should do much, much more.

Today we hear from carriers, engineers, and industrial designers about the steps they have taken to reduce emissions, the challenges they faced along the way, and what comes next along the path to a carbon-free but no less efficient, global maritime supply chain.

[Mr. Maloney's prepared statement follows:]

Prepared Statement of Hon. Sean Patrick Maloney, a Representative in Congress from the State of New York, and Chairman, Subcommittee on Coast Guard and Maritime Transportation

Good morning, and welcome to today's hearing on innovations and new developments as we build towards a sustainable, carbon-free maritime transportation future.

If international shipping were its own country, it would rank as the 6th largest polluter on the planet. The conventional heavy fuels used to move massive ocean-going vessels are laden with sulfur oxides, diesel particulate matter, and carbon dioxide, nasty stuff that can lead to acid rain, harm crops, acidify oceans, and not incidentally, also impact human health.

For example, shipping emissions contributed to 1,200 early deaths in the United States last year alone, disproportionately impacting low income communities of color who live adjacent to ports and marine terminals. This is unacceptable.

Recognizing these impacts, the International Maritime Organization, or "IMO", has committed to reduce total annual greenhouse emissions from international shipping by at least 50 percent by the year 2050 from 2008 emissions levels.

Additionally, just two weeks ago, the IMO's high seas maritime fuel sulfur emissions cap was reduced from 3.50 percent to 0.50 percent to protect air quality and human health. Ship owners, operators, refineries, and regulators like the Coast Guard have adapted to meet this new cap by burning cleaner, higher quality low sulfur fuels or by installing scrubbing technologies.

The maritime industry has not taken on these restrictions merely for a challenge: they recognize, rather, that decarbonizing our global economy is a necessity and an opportunity. We are borrowing time from the next generation. The time for change is now, and I commend the maritime industry taking the initiative.

Charting its own path to decarbonize the maritime industry, the IMO requires operators to reduce carbon intensity by vessel, by unit of work, and across the industry as a whole. This will require investments in vessel efficiency, alternative fuels, alternative designs, clean shore power, and more.

For ships to serve their planned lifetime and to meet the 2050 emissions reduction goal, vessels coming online after 2030 will need to be either zero emission vessel or very low emission vessels to assure they can operate for their expected commercial life. We should ensure we have the capability to design, build, and operate those vessels in the United States.

Investing in innovative new technologies and clean maritime commerce is just one more opportunity to bring the American maritime industry into the 21st century, and one we can't afford to miss.

Indeed, the maritime community has risen to meet the challenge, although I must stress, the U.S. can and should do much, much more. Today we will hear from carriers, engineers, and industrial designers about the steps they've taken to reduce emissions, the challenges they've faced along the way, and what comes next along the path to a carbon-free, but no less efficient, global maritime supply chain.

Mr. MALONEY. I ask unanimous consent to insert statements from Green Marine, the Ocean Conservancy, Scripps Institution of Oceanography, and the Coalition for a Safe Environment into the hearing record.

Without objection.

[The information is on pages 64–76.]

Mr. MALONEY. I would now like to call on the ranking member, Mr. Gibbs, for any opening remarks.

Mr. GIBBS. Thank you, Chairman Maloney, and thank you to the witnesses here today. The International Maritime Organization administers the Convention on the Prevention of Pollution from Ships, and sets targets for the reduction of sulfur emissions, which went into effect the beginning of this month.

I look forward to hearing what industry is doing to reach these targets, which took effect earlier in the North American and European emission control areas.

IMO also set targets for significant further reductions in vessel air emissions in 2030—40 percent below the 2008; and 2050—70 percent below 2008 levels.

I am also interested in whether the witnesses believe these targets can be met and, if so, what would the cost be.

IMO also sets international standards for various other discharges from vessels, including oil; garbage, including plastic; wastewater, and ballast water.

Efforts are also underway to require that ships be quieter.

I support market-driven solutions to great investment and innovation of new technologies, which will create a more efficient maritime transportation system. Government mandates will only hinder ongoing private-sector efforts to innovate and improve environmental sustainability. I think we need to look at the impacts of all these regulations on the shipping industry, and look to witnesses' comments on the collective impact of these various environmental regulations, and the cost and efficiency of ocean shipping.

[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

International shipping contributes 3 percent of total global emission of sulfur oxides, nitrogen oxide, particulate matter and carbon dioxide emissions. The International Maritime Organization which administers the Convention on the Prevention of Pollution from Ships set targets for the reduction of sulfur emissions which went into effect at the beginning of this month. I look forward to hearing what industry is doing to reach these targets which took effect earlier in the North American and European emission control areas.

IMO also set targets for significant further reductions in vessel air emissions in 2030 (40 percent below 2008) and 2050 (70 percent below 2008 levels). I am inter-

ested in whether the witnesses believe these targets can be met, and if so, at what cost.

IMO also sets international standards for various other discharges from vessels, including oil, garbage (including plastic), wastewater, and ballast water. Efforts are also underway to require that ships be quieter. I think we need to look at the impacts of all these regulations on the shipping industry, and I look to witnesses' comments on the collective impact of these various environmental regulations on the cost and efficiency of ocean shipping.

Mr. GIBBS. Thank you, Chairman, for holding this hearing today, and I yield back.

Mr. MALONEY. I thank the gentleman.

I would now like to welcome the witnesses on our panel: Mr. Joshua Berger, Governor's maritime sector lead for the State of Washington; Mr. John W. Butler, president and chief executive officer of the World Shipping Council; Dr. B. Lee Kindberg, director of environment and sustainability for Maersk/Maersk Agency USA; Mr. Peter Bryn, technical solutions manager, North America, for ABB Marine and Ports; and Ms. Kathy Metcalf, president and chief executive officer for the Chamber of Shipping of America.

Thank you for being here today. We look forward to your testimony.

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

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

Mr. Berger, you may proceed.

TESTIMONY OF JOSHUA BERGER, GOVERNOR'S MARITIME SECTOR LEAD, WASHINGTON STATE DEPARTMENT OF COMMERCE; JOHN W. BUTLER, PRESIDENT AND CHIEF EXECUTIVE OFFICER, WORLD SHIPPING COUNCIL; B. LEE KINDBERG, PH.D., HEAD OF ENVIRONMENT AND SUSTAINABILITY–NORTH AMERICA, MAERSK; PETER BRYN, TECHNICAL SOLUTIONS MANAGER–NORTH AMERICA, ABB MARINE AND PORTS; AND KATHY METCALF, PRESIDENT AND CHIEF EXECUTIVE OFFICER, CHAMBER OF SHIPPING OF AMERICA

Mr. BERGER. Thank you, Chairman Maloney, Ranking Member Gibbs, and members of the committee, for the opportunity to testify today. I proudly work as Governor Jay Inslee's maritime sector lead, and serve as board chair and founder of Washington Maritime Blue, a strategic alliance.

Mr. MALONEY. Yes, Mr. Berger, you will find that you can bring the box that the microphone is built into towards you. That will move. There you go. And if you can speak into it, it will help the Members a great deal. Thank you, sir. Sorry for the interruption.

Mr. BERGER. Can I start from the beginning for you?

Mr. MALONEY. If you want, but if you could just bring that microphone right towards you, sir, it will move, as well.

Mr. BERGER. Perfect.

Mr. MALONEY. There you go.

Mr. BERGER. Thank you. So I serve as Governor Jay Inslee's maritime sector lead, and board chair of Washington Maritime Blue. It is a strategic alliance for multisector stakeholders charged

to implement Washington State's strategy for the blue economy. It is a plan to accelerate innovation, investment, and sustainability in the maritime and ocean sectors.

I have submitted written testimony that outlines the details of our State's plan and our implementation strategy. And today I am here to share how coordination and multistakeholder partnerships have contributed to our success and national leadership, and I ask that Congress consider what role you can play to support both the necessary R&D plus the ecosystems for innovation it will take to achieve national and global targets.

The OECD predicts that the maritime and ocean economy will double to $3 trillion by 2030. Other nations in Europe and Asia are investing billions in zero-emission maritime solutions and ecosystems of innovation in a coordinated and organized approach. Not only are they drastically reducing emissions and increasing safety, but they are helping to save billions in operational costs. They are creating new markets, and driving capital investments and jobs into communities.

In the State of Washington we have decided that this is the course we want to set to do the right thing and stay economically competitive in a global stage. With great commitment from our industry leaders, we are building on our State's diverse and interdependent maritime sector, and leveraging the expertise of our research institutions, tech industry, advanced manufacturing, and ocean engineering to drive investment.

Add to this a long history of commitment to environmental performance, quality craftsmanship, and best management practices, and couple that with a culture of innovation, investment, and collaboration, and we will create a global hub for solutions and economic growth.

As we were wrapping up our strategy last year, it became clear that we needed mechanisms in place to begin implementing on day one. We investigated other world-class maritime regions. What we consistently found was an organized approach to bring together what we call the quadruple helix of innovation clusters: Government, industry, research institutions, and, in our case, workforce and community-based organizations, all partnering together.

The day we released the strategy, we launched Washington Maritime Blue in exactly that vein. In its first year we have grown to over 75 members from multiple sectors, all invested in Washington's maritime and ocean economy. Often, direct competitors are in the room collaborating to grow collective markets through standardization and technology transfer. They are working together.

Over the last year we have completed a capital landscape study for investments, we are supporting the electrification of the Washington State ferry system through supplier engagement, we have funded an innovation center, and are kicking off a maritime blue innovation accelerator with 11 companies. We are conducting a feasibility study and a triple bottom line decisionmaking tool for a zero-emission pilot boat, and facilitating at least two other joint innovation projects to develop zero-emission vessels.

But despite this incredible leadership our industry stakeholders have taken, they cannot do it alone. If we were to be successful, it will need to take an organized approach and the right strategic

investments by Congress to support the millions of existing jobs in the maritime sector, and create the next generation of workforce to make that a reality.

We are encouraged by the collaborative approach of some key leaders in the Department of Commerce, Department of Energy, NOAA, the Navy, Coast Guard, and MARAD, and we will continue to work closely with our partners there. However, to maintain momentum and stay competitive, we need Congress to support a national network of maritime and ocean innovation clusters. We cannot foster and enable these ecosystems of innovation in isolation. State and local leaders need assistance and resources to support local companies to collaborate and stoke the interest of entrepreneurs and investors to take advantage of that $3 trillion opportunity.

You have access to our complete State strategy, and I encourage you to read it through. It works to advance our goals as an industry. Together we can take advantage of models that are working, continue to gather our resources, and get to work.

Thank you, and I look forward to answering any questions you may have.

[Mr. Berger's prepared statement follows:]

Prepared Statement of Joshua Berger, Governor's Maritime Sector Lead, Washington State Department of Commerce

Thank you, Chairman Maloney, Ranking Member Gibbs, and members of the committee, for the opportunity to testify on the path to a carbon-free maritime industry and the investments and innovation needed to achieve this goal. I proudly work as Governor Jay Inslee's Maritime Sector Lead and Director of Maritime Economic Development at the Washington state Department of Commerce. Over the course of the last three years I have been charged by the Governor and his Maritime Innovation Advisory Council to both deliver and implement Washington state's Strategy for the Blue Economy [1]—a plan to accelerate innovation and sustainability in the maritime and ocean sectors.

For context, my role as sector lead is to be a liaison to the Governor, Legislature, and state agencies from our key economic sectors. I have worked in the maritime industry for over 25 years as a professional merchant mariner, maritime workforce educator and marine construction project manager—as well as an advocate for ocean literacy, marine conservation, and clean technology.

Today, I'm here to share our state's work to accelerate innovation and our investment to decarbonize the maritime sector. And to be clear, when I say "our state" I mean each of the stakeholders that impact, and are impacted by, the maritime and ocean economy across the state of Washington. This includes not only our government agencies, but employers, technology providers, universities, workforce training institutions, national laboratories, labor organizations, tribes, and community and environmental organizations, among the many. This level of coordination and multi-stakeholder partnership has contributed greatly to our success and national leadership as a center of excellence for maritime innovation and investment—specifically in vessel electrification and the path towards a carbon-free maritime industry.

We're doing this work because it's the right thing to do, and because it's how we stay economically competitive on a global stage. The Organization for Economic Cooperation and Development (OECD) predicts the maritime and ocean economy will double to $3 trillion by 2030—four times the current space economy. Other nations in Europe and Asia are investing billions in zero-emission maritime solutions. Other nations are supporting clusters or, ecosystems of innovation, in a coordinated and organized approach. The international maritime community is focused on tackling the climate crisis using the structure of the UN's Sustainable Development Goals

[1] Washington state's Strategy for the Blue Economy (2019) WA State Dept. of Commerce & DNV GL—www.maritimeblue.org

as a guidepost. The International Maritime Organization (IMO) that regulates the global maritime industry is dramatically increasing regulatory pressure. As other nations invest in solutions to the climate crisis, not only are they drastically reducing emissions and increasing safety—they are saving billions in operational costs, creating new markets, and driving capital investment and jobs into their communities through design, manufacturing, and technology development.

In the state of Washington, we have decided this is the course we want to set. We have decided that our state can leverage the expertise of our research institutions, tech industry, advanced manufacturing, and ocean engineering to drive investment. We have created a clear, multi-stakeholder strategy and are implementing its goals through the creation of a formal, independent organization and strategic alliance for maritime innovation and sustainability.

We offer our story as a model of how the federal government and other states can continue to support the maritime industry and stakeholders to meet global challenges, succeed in an increasing regulatory climate, and create equitable and resilient communities.

Washington state is already home to a diverse and interdependent maritime industry that generates $37 billion into our state's economy, directly employing 70,000 family-wage jobs and impacting another 120,000. One in every four jobs in the state are tied to international trade, and we have the fourth largest container gateway in the United States. Washington state operates the largest ferry system in the U.S. The Port of Seattle facilitates the fastest growing cruise industry in the U.S. and is home to the North Pacific Fishing Fleet, the largest and most sustainable fishery in the world along with our Alaskan neighbors. In fact, 90% of all goods on a shelf in Alaska, as well as construction, and infrastructure materials are shipped from Washington state.

Our ports, vessel operators, labor force, supply chain, designers, and service providers have a long history of commitment to environmental performance, quality craftsmanship, and best management practices. By coupling this legacy industry with a culture of innovation and investment, we can create a global hub for solutions and economic growth. This was the impetus for bringing together hundreds of diverse stakeholders to create a clear strategy for maritime innovation and sustainability—what we call the "Blue Economy."

Our vision is to be the home of a world-class, thriving and sustainable maritime industry, and after a year-and-a-half of stakeholder engagement, economic study, and technology trends review, we agreed on five strategic goals, each with detailed initiatives and pathways to achieve them:

1. a thriving low carbon maritime industry through deep decarbonization;
2. a global innovation and investment hub for maritime and ocean technology;
3. working waterfronts and growing gateways that are clean, smart and safe job creators;
4. an equitable, diverse, and inclusive 21st century workforce; and
5. a world-class, coordinated cluster of maritime and ocean stakeholders.

These goals are underpinned by a clear set of values and definition of the Blue Economy that all stakeholders could agree upon: a growing maritime industry, healthy ocean and marine ecosystems, and resilient communities. This set the stage for us to collaborate across the many interests involved in our process.

The success of the strategy development, support and adoption is due to our commitment to a collaborative process. We invited each of our state's stakeholders from a growing and clean maritime industry. Besides inviting the usual groups of industry leaders, labor organizations and public agencies involved in the maritime industry, we intentionally sought input, early and directly, from tribal leadership, research institutions, community groups, environmental NGOs, workforce development providers and the investment community. We understand that many of the potential solutions to achieve efficiency and reductions in emissions in maritime operations can be nuanced. It can be challenging, and some solutions can come with unintended consequences, and require significant capital costs in an industry with low margins.

It can be easy to hold fast to pre-conceived ideas about technology, transitions, and impacts. However, committing to a multi-stakeholder and collaborative planning process can highlight and secure shared values and commitment. Therefore, when it's time to begin implementing initiatives and demonstration projects we've been able to obtain early support and investment of resources, time and capacity.

As we were wrapping up our strategy development last year, it became clear to our Advisory Council that we needed mechanisms in place to begin implementing the pathways, initiatives and demonstration projects outlined in the plan on day-one. We investigated other world class maritime regions in Norway, Singapore,

France, Japan, Germany and the Netherlands, and elsewhere to understand the structure and investment pathways for research and development (R&D), commercialization and operations of technology solutions. What we consistently found was an organized approach to bring together what we call the "Quadruple Helix" of an innovation cluster: government, industry, research institutions, and (in our case) workforce and community partners working together to advance and accelerate innovation and sustainability.

The day we released the strategy we launched Washington Maritime Blue as an independent, nonprofit cluster organization, a strategic alliance for maritime innovation and sustainability. As a partnership between industry, public sector, research and training institutions, and community organizations, the mission of this new non-profit is to create a world-class, thriving, and sustainable maritime industry through knowledge sharing, collaborative R&D, commercialization, and business and workforce development.

Supported by the Washington state Department of Commerce, grants, contracts, industry members and sponsors, the scope of work of the new organization includes:

- Operate a media, marketing and outreach platform for sharing the opportunities and growth in the maritime/ocean sectors.
- Produce public forums and events addressing key topics such as digitalization, R&D pathways for decarbonization, investment and entrepreneurship, marine battery safety, etc.
- Project manage business development opportunities and Joint Innovation Projects for members and partners to collaborate on R&D, demonstration projects, planning and feasibility studies.
- Act as an intermediary for the development of equitable, diverse, career-connected maritime workforce programming for youth, internships and apprenticeships.
- Drive investments and funding to key demonstration projects and entrepreneurs.
- Develop a Maritime Innovation Center as a focal point and hub for supporting startups and technology development.

In its first year, Washington Maritime Blue has grown to over 75 members including global maritime technology firms, local maritime operators, design firms, startups, manufacturers and service providers, as well as public partners such as state agencies, municipalities, ports, research institutions and community organizations. All of these members are invested in Washington's maritime and ocean economy in some way.

Our members are eager to work together to address the technological challenges the industry is facing. Often, direct competitors are in the room collaborating to grow collective markets through standardization and technology transfer. Working together, we are accomplishing the following:

- Completed a "Capital Landscape Study" for maritime and ocean investments in Washington.
- Supported the electrification of the Washington state Ferry fleet through supplier engagement.
- Launched a Maritime Innovation Business accelerator with 11 maritime and ocean companies for four months of programming and a "Demonstration Day" to potential investors and funders.
- Conducting feasibility study and triple bottom-line decision-making tool for a zero-emission pilot boat.

Among others, there are two specific demonstration projects of note that members of Maritime Blue are working to complete through the structure of a Joint Innovation Project. The first is to complete a feasibility and concept design for a zero-emission, inland cargo vessel to deliver recycled corrugated cardboard from the urban core in central Puget Sound out to the Olympic Peninsula to a newly re-opened paper mill. The mill supports about 150 jobs in a struggling rural community. A perfect example of what we call "short sea shipping". Inspired by the first all-electric, autonomous cargo vessel delivering fertilizer throughout the inland waterways of western Norway, Yara Birkland[2], this vessel would take hundreds of trucks off the roads, eliminate all emissions, and support job creation in a rural maritime community. Naval architects, electrical engineers, system designers, utilities, classification societies and the Coast Guard will route plan, provide technology reviews, a concept design and operational profile to determine feasibility. The role of the cluster organi-

[2] Yara Birkland Media Kit, https://www.yara.com/news-and-media/press-kits/yara-birkeland-press-kit/

zation is to gather multiple sources of public and private funding, manage the partners and produce a final study.

The second is a complete design and construction of a zero-emission, high-speed, passenger ferry to address both congestion and impact in the Puget Sound region. The Cluster and project members will take an existing concept design to complete engineering and construction with local fabricators, shipbuilders and others in the product supply chain. Again, we will seek to utilize public dollars to help buy down the risk of the private investors, owners, and operators so that we can prove the technology capabilities and begin to commission similar zero-emission vessels. We hope to rebuild what we have historically called the "Mosquito Fleet"—Passenger ferries crisscrossing Puget Sound, but now with zero-impact on marine waters, air quality and marine mammals. Greater Seattle has received half a million new residents in the last ten years, 2,300 last year alone—that's just under 200 people a day moving to Seattle that will commute up and down the I–5 corridor. A recent feasibility study of a Tacoma to Seattle passenger ferry service estimates it would take around 600 cars, twice a day off of the freeway—a 30 mile, but often 2-hour commute by car.

Washington Maritime Blue is in a unique position to manage these Joint Innovation Projects. It has the ability to bring together multiple partners in a structure that can manage competitors as collaborators. We can create, manage and protect intellectual property as we innovate together. As an independent organization, it has the flexibility to bring in capital from multiple sources, public and private. We can draw expertise and support from our research partners and others in a supply chain. It is a model most successfully found in the Norwegian Innovation Cluster Program[3]—supported by Innovation Norway, a program under the Ministry of Trade and Industry. Ampere, the first all-electric car ferry was a Joint Innovation Project. The Yara Birkland was born out of a Joint Innovation Project, as will the first hydrogen-powered car ferry which is in design and engineering now.[4]

Having gained insight and examples from others around the globe to be an effective enabler of innovation, Washington Maritime Blue itself has now become a model for cluster development. We have fostered an MOU between the Washington state Department Commerce and Norwegian Ministry of Trade and Industry to develop economic and business development opportunities for maritime clean technology. We have partner organizations in Norway, France, Portugal, Singapore, Canada and Mexico as well the cities of Boston, San Diego and Anchorage. We have been supporting federal agencies such as the US Coast Guard (USCG), Department of Energy (DOE), Maritime Administration (MARAD), National Oceanographic and Atmospheric Administration (NOAA), and Environmental Protection Agency (EPA) as they seek to broaden their role in the development of clean technology for maritime transportation and the blue economy. We are supporting other states and regions to develop their own strategies and cluster organizations such as Rhode Island, the Gulf Coast, and Alaska.

In Washington state, we often look towards Norway for inspiration. Our western coastlines have remarkably similar weather, and we both have naturally deep-water ports with strong fisheries and access to global trade routes, as well as a legacy of shipbuilding and craftsmanship. We both have some of the cheapest and cleanest electricity in the world, and a similar culture. In fact, there are more Norwegians in Washington state than anywhere else in the world, outside of Norway. And yes, Norway may have the largest sovereign wealth fund in the world, but how they invest in innovation in direct partnership with industry is what sets them apart as a dominant force in the maritime industry. They have clear strategic plans, and invest not only in solutions but in the ecosystem and culture of innovation through industry clusters. Private industry actually asks their government for stronger regulation so they can build new markets. They trust that the government will work with them to establish a clear and consistent regulatory framework and put incentives in place that allow them to make the incredibly large capital investments needed to achieve carbon-free solutions. These are the type of actions we ask Congress to consider.

Industry, ports and communities cannot do it alone. If we are to achieve the IMO's targets to have zero-emission shipping by 2050, it will take an organized federal approach, and the right strategic capital investments by Congress, to support the millions of existing jobs in the maritime sector and create the next generation

[3] Norwegian Innovation Cluster Program, https://www.innovasjonnorge.no/no/subsites/forside/Om_NIC/

[4] NCE Maritime CleanTech hydrogen ferry with Norled, https://maritimecleantech.no/project/hydrogen-ferry/

of workforce to make that a reality. This federal support can take many forms: tax incentives, directed reinvestment strategies, competitive awards, and others.

We are encouraged by the collaborative approach of some key leaders in the Department of Energy, NOAA, the Navy, Coast Guard and Maritime Administration. Washington Maritime Blue recently held a workshop for federal agencies and national laboratories to engage with our industry members to help focus and organize R&D pathways for maritime energy solutions. We intend to help them replicate and scale this approach around the U.S. We were also pleased to participate in the executive branch's Summit on Ocean Science and the Blue Economy last November to help strategize a cross-federal agency approach to solutions.

To maintain momentum and stay competitive, we need Congress to support a national network of maritime and ocean innovation clusters. States, regions and cities like ours are bringing together local government agencies, industry, and research institutions to solve challenges and create business opportunities and jobs. However, they cannot foster and enable these ecosystems of innovation and collaboration alongside growing competitive markets in isolation. State and local leaders need federal assistance and resources to support local companies to collaborate and stoke the interest of entrepreneurs and investors to take advantage of this $3 trillion opportunity over the next decade.

Washington Maritime Blue is grateful for the U.S. Economic Development Administration's grant support to develop our state's strategy and seed our cluster organization. Continued federal support for the operation of innovation cluster organizations could take the form of direct funding, providing teams of professional advisors, marketing support, and facilitation of cross-sector business opportunities, entrepreneurship, and joint innovation.

It can be risky to be a trailblazer. It can require significant capital investment, and it can prove challenging to build trust with community stakeholders. This either becomes a cycle of doubt that slows the velocity of change or, when collaboration, effective regulation, and action are embraced, it becomes the sustaining energy that accelerates a cycle of progress. It is a fact that when maritime companies are supported in an innovation-based business plan, they can and will make investments geared toward community empowerment and sustainable returns. The Maritime Blue Strategy embraces this cycle to propel the industry and communities forward.

It has been a tremendous process to get to where we are today, but the course we were able to identify and plot through engaging with all of our stakeholders and analyzing innovation trends enabled us to build a plan that does more than sit on a shelf with pretty graphics. As you see, we are already underway, industry and partners are engaging, and projects are happening, and we continue to look for public and private funding opportunities.

You have access to our complete state strategy[5], and I encourage you to read through it. It works to advance our goals as an industry, as a state, and as a partner in the global movement to decarbonize the maritime industry and improve ocean health, and it seeks to address our challenges with open dialogue in a thoughtful manner.

We are enabling an entire ecosystem of passionate communities researching, developing, and implementing a carbon-free maritime transportation industry. We are investing and innovating for a global, sustainable blue economy so that we can address these pressing issues through balance, alignment and careful, committed consideration of impacts and unintended consequences. We are proud of what we have created. We are proud to be part of collaborative group of stakeholders. We are proud to help lead our nation while strengthening communities and protecting the ocean ecosystem that we are so vitally connected to.

Together, we can take advantage of models that are working, continue to gather our resources, and get to work!

Thank you, I look forward to answering any questions you may have.

Mr. MALONEY. I thank the gentleman. Before I proceed, I would just like to welcome the congressman from Pennsylvania to the subcommittee, Mr. Lamb. He is a new member of the committee, replacing our beloved Elijah Cummings. Congressman Lamb is an extraordinary Member of Congress, he has very big shoes to fill.

But we welcome you to the committee. We appreciate you being here.

[5] Washington state's Strategy for the Blue Economy (2019) WA State Dept. of Commerce & DNV GL—www.maritimeblue.org

Mr. Butler, you may proceed.

Mr. BUTLER. Chairman Maloney, Ranking Member Gibbs, members of the committee, thank you very much for the invitation to testify today.

The subcommittee's focus on decarbonization of shipping is timely. This issue has been under discussion at the International Maritime Organization for a number of years. But the IMO's discussions and actions have become much more focused and urgent in the past 2 years.

Mr. Chairman, as you referenced, in 2018 the IMO adopted an initial greenhouse gas strategy, and it has set numeric goals for reduction of greenhouse gases from international shipping.

The first goal is a 40-percent increase in efficiency by 2030. The second goal is a 50-percent reduction in absolute greenhouse gas emissions by 2050, versus a 2008 baseline. And thereafter, the strategy calls for emissions to be reduced to zero, or near zero, as soon as possible after 2050.

The first goal, the efficiency goal for 2030, can most likely be met by wringing further efficiencies from fossil fuel-powered ships.

The second goal, the 2050 goal, will require that we find new fuels and related technologies to replace fossil fuels. That is where the activities in the title of this hearing come into play: "Investments and Innovation."

When we examined the progress being made on research and development to move shipping away from fossil fuels, it became clear that the scope of R&D underway today is insufficient to deliver the results that we need for deep-sea vessels. In response to that need to jumpstart R&D, we began work over 2 years ago on a proposal to the IMO to create an industry-funded global R&D program focused on developing fuels and related technologies that can allow shipping to move away from fossil fuels. That work has resulted in a comprehensive proposal that we and seven other maritime organizations submitted to the IMO last month, and that full proposal has been included with my written testimony.

This proposal, if adopted, would create a new body under the IMO that we have called the International Maritime Research and Development Board, or IMRB. Boiled down to its essence, the IMRB would manage a global, targeted R&D grant program funded by a mandatory contribution on each ton of fuel burned. Based on current global marine fuel consumption, this should generate between $5 and $6 billion in R&D funding over the next 10 to 12 years.

As you will see from my written testimony, we have addressed funding, governance, intellectual property, conflicts of interest, and many other details that have to be gotten right in order to make this proposal work. There are lots of details, but the logic behind why we made this proposal is quite simple.

First, it is clear that we have to get beyond fossil fuels in order to make the dramatic cuts in greenhouse gases from shipping that are necessary to meet the IMO's goal.

Second, today, we do not have the fuels and related systems that we can install on oceangoing vessels to meet those goals.

Third, the current level of R&D work is not likely to deliver the necessary fuels and systems in time to meet the IMO's ambitious targets, particularly the 2050 target.

And finally, the necessary level of research and development will not simply materialize by itself. So we need to take action now in an organized fashion to make sure that that work gets done.

We look forward to working with the United States and other IMO member states to bring the IMRB into existence.

I welcome your questions.

[Mr. Butler's prepared statement follows:]

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

INTRODUCTION: THE WORLD SHIPPING COUNCIL AND THE LINER SHIPPING INDUSTRY

Chairman Maloney, 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 (WSC or the Council).[1] The Council 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.

GREENHOUSE GAS (GHG) EMISSIONS AND THE TECHNOLOGICAL CHALLENGE OF TRANSFORMING THE INTERNATIONAL FLEET

The Subcommittee's focus on decarbonization of shipping is timely. This challenge is today the single largest issue under consideration by the International Maritime Organization (IMO), a specialized United Nations body that regulates international shipping. As discussed later in this testimony, the World Shipping Council and seven other shipping organizations last month submitted to the IMO a comprehensive proposal to establish a $5–6 billion research and development effort over a 10–12 year period to identify the fuels and related technologies of the future that will be necessary for the maritime industry and to meet the aggressive decarbonization goals that the IMO has recently established. That program would be organized under the IMO, and it would be paid for by a fee on each ton of marine fuel burned.

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 2030 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. A highly competitive liner shipping market, fuel price increases associated with the IMO 2020 marine fuel sulphur cap

[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.

regulation, and increasing societal and customer requirements to reduce emissions provide vessel operators with powerful incentives to make their operations as efficient as possible.

In contrast to the likelihood that the IMO's 2030 GHG objectives can be met by operational and design measures 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. In order to meet the IMO's ambitious global GHG reduction goals, it is imperative that new fuels and related propulsion, fuel storage, and fuel infrastructure are engineered and deployed. Moreover, that 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. Ocean vessels have a commercial lifespan of 20–25 years, which means that investment decisions made today will be with us for a generation. This means that 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 that the industry faces is that, although there are promising possibilities for the fuels of the future, none of those candidate fuels are available today to be installed on large ships serving trans-oceanic routes. Hydrogen, ammonia, and other fuels have been identified as possible replacements for fossil fuels in marine applications, but these fuels present storage, handling, and production challenges that must be overcome before they are practically and safely available for widespread use. There may be additional options which have not yet received the same level of examination.

Vessels that sail across oceans must obviously carry their fuel with them, and that means that 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 critical criteria represent technical challenges that will require substantial effort and engineering expertise to resolve. The solutions will not simply appear by themselves.

THE PROPOSAL FOR AN INTERNATIONAL MARITIME RESEARCH AND DEVELOPMENT BOARD

Based on the introduction 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 International Maritime Organization 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 would be to create and support a dedicated research and development effort to identify and develop, for 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 find 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, the World Shipping Council and seven other international shipping organizations submitted to the IMO a proposal to create the International Maritime Research and Development Board (IMRB).

A copy of the comprehensive submission that we made to the IMO on the IMRB proposal is attached to my testimony as Exhibit A. Boiled down to its essence, the decarbonization research and development effort would be a global, targeted grant program funded by a mandatory contribution based on each ton of fuel burned. This is a detailed proposal that 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. Research and development 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 research and development 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.
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 research and development work that is essential to decarbonizing shipping. That research is not occurring today on a schedule or on 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 reduce and 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 growing 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.

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 al-

lowed 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 logical next 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 United States and other IMO member states to bring the IMRB into existence.

EXHIBIT A

INTERNATIONAL MARITIME ORGANIZATION

REDUCTION OF GHG EMISSIONS FROM SHIPS

PROPOSAL TO ESTABLISH AN INTERNATIONAL MARITIME RESEARCH AND DEVELOPMENT BOARD (IMRB)

[Exhibit A is retained in committee files and is available online following page 6 of Mr. Butler's prepared statement at https://docs.house.gov/meetings/PW/PW07/20200114/110356/HHRG-116-PW07-Wstate-ButlerJ-20200114.pdf.]

Mr. MALONEY. I thank the gentleman.

Dr. Kindberg, am I saying your name correctly?

Ms. KINDBERG. [No response.]

Mr. MALONEY. Dr. Kindberg, am I pronouncing your name correctly?

Kindberg? See, I knew there was a good chance I had that wrong, so forgive me.

Dr. Kindberg, you may proceed.

Ms. KINDBERG. Thank you. Chairman Maloney, Ranking Member Gibbs, and members of the committee, thank you for the invitation to speak today.

Ocean shipping has the most energy-efficient way to move cargo long distances, and has the lowest carbon footprint per unit shipped of any mode of transportation. Ships use very large diesel engines to move those mountains of cargo. Think 80,000 horsepower engines with great big cylinder heads. And that creates greenhouse gases and other pollutants coming out of the exhaust. Shipping generates 2 to 3 percent of all manmade greenhouse gases.

Since 2008, Maersk has reduced our greenhouse gas and other emissions by 42 percent per container moved, 42 percent since 2008. And I might mention that your colleague, Congressman Lowenthal, has been with us, encouraging and sometimes pushing us, all the way since about 2006 on this.

Now our customers and other stakeholders are now asking us to do more, to go all the way to zero-carbon shipping. And a year ago we made a commitment to do just that, to achieve zero-carbon shipping by 2050. Now, that sounds like a distant and rather fluffy goal, but the lifetime of a vessel is 20 to 25 years. So let's think through this.

And we, by the way, operate 700 vessels. So to have zero emissions for the whole fleet by 2050, that means we have to have the first commercial vessel on the water by 2030, which means that we

have to order it by 2028, which means we have to have designed it by 2027, which means we have got the next 5 to 7 years to define what is going to go into that design.

This is not a distant goal. This is a major transformation, and we can't do it alone.

We are continuing our cutting-edge efficiency work with a goal of 60-percent reduction by 2030. We are already testing biobased fuels, batteries, and other technologies, some of them actually on commercial vessels. As we speak, our first net-zero-carbon shipments are on a ship headed back from Singapore, using a renewable biofuel blend made from used cooking oil. And we are developing new renewable fuels, including one that involves ethanol and lignin from plants and wood.

But the biggest challenges ahead are not just on the ships. The land-based industries and infrastructure must be there to supply the fuels and technologies at scale, and we must do it without jeopardizing food production or forests. Economic and policy systems must also adapt to support this transformation.

So what we need to make this happen, first, focused R&D, which, of course, Mr. Butler discussed; alignment between national, State, and international goals, and the legal systems that support them. The International Maritime Organization sets the rules for international shipping and has set metrics and goals for vessel emissions.

Requirements also need to be clearly written and well enforced, and encourage early action, but not penalize early actors. And yes, we advocate for strong enforcement, and we are doing so globally. We need a level playing field. And we count on enforcement to make that happen.

Now, let me give a recent example to show the importance of this. A couple of you mentioned the 2020 fuel rule, which reduced sulfur significantly. And most of the global fleet has started complying with that. And, of course, it just went into effect a couple of weeks ago. But where—most of us are complying with that, using cleaner fuels. It is expensive, cleaner fuels. It is going to cost my company $2 billion a year. So it is very expensive. And we fully support the goals, and we are complying.

But the temptation is probably out there for others. A vessel sailing from Asia to Europe could save close to $750,000 for one ship on one voyage by ignoring the new rule. 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, too.

Ladies and gentlemen, the transformation to low- or zero-carbon shipping is an energy transformation, not just a vessel modification. Huge changes to both vessel and land-based infrastructures must happen to produce and distribute those new energy sources, and policies and laws must adapt to enable that change.

Therefore, thank you for this opportunity to be part of the conversation.

[Ms. Kindberg's prepared statement follows:]

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

Chairman DeFazio, Chairman Maloney, Ranking Member Gibbs, and Members of the Committee, thank you for the invitation to testify today.

Maersk is the world's largest container shipping company and has long been committed to environmental leadership in our operations. We are headquartered in Copenhagen Denmark and operate over 700 container vessels globally, as well as our APMT marine terminals, Svitzer ocean-going tugs, and other supply chain logistics facilities in North America and around the world.

Maersk is committed to ensuring that our business practices are safe, responsible and transparent. Our vision and priorities are discussed in more detail in our Sustainability Reports, available on our website at https://www.Maersk.com/en/business/sustainability.

Our global Sustainability Strategy identifies four key sustainability priorities, our Shared Value Programs:

1. Decarbonizing logistics,
2. Contributing to halving food loss,
3. Helping to multiply the benefits of trade in developing regions,
4. Leading change in the global ship recycling industry.

Our most significant environmental impact is the air emissions produced by fuel consumption in our ships' very large diesel engines. These include both Greenhouse gases (primarily CO2, often referred to as "carbon") and criteria air pollutants (SOx, NOx, fine particles).

The shipping industry emits 2–3% of the world's anthropogenic CO2 and is the only industry to have set global metrics and goals on energy efficiency, greenhouse gas emissions and other pollutants such as sulfur.

Maersk alone emits approx. 0.1% of this 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 reduces operating costs and also reduces emissions of both greenhouse gases and criterial pollutants. In the last decade Maersk has reduced our fuel consumed and related emissions by 42% 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 management practices.

In December 2018 Maersk announced a goal of *Net Zero Carbon Shipping by 2050*. That commitment means we are working to launch our first zero carbon vessel by 2030. We are also continuing our energy efficiency work with a 2030 goal of a 60% reduction in emissions vs. 2008.

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 providers, investors, legislators and especially our customers to meet the target.

INVESTMENTS

We are approaching full implementation of the Radical Retrofit program, a $1Billion investment commitment over 5 years started in 2015. We also continue to make significant progress on maturing, hardening and fully implementing the "Connected Vessel" digitalization project. This program is connecting our fleet digitally with our global operations coordination centers and enables real-time optimization of operational conditions to reduce fuel consumption and related emissions. These programs are successfully delivering increased efficiencies and reduced emissions.

Maersk's recent announcement of Net Zero Carbon emissions by 2050 comes with significant plans for future investments, including further energy efficiency work, alternative fuel development, and the technologies needed to build zero carbon vessels.

ACTION ON ZERO EMISSIONS SHIPPING

As an industry leader Maersk feels a great responsibility to do our part to fight climate change and reduce our impacts significantly. Significant innovative solutions must be developed and start to be implemented by 2030 in order to meet the goal of net zero carbon emissions by 2050 from our vessel operations.

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 ship yards.
2. *Electrification*. We are preparing an installation of a major battery on a vessel during 2020 to learn how this technology might be useful on a vessel and to drive further development on the technology. Our work in this area will increase significantly going forward. 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 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 was conducted together with 4 major customers. This success led to a new Net Zero Carbon shipping service called "ECO-Delivery." The first commercial voyage including ECO Delivery shipments is currently on the water.
   - Lignin Ethanol Oil ("LEO") biofuel: Maersk, together with a coalition of US-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.

THE NEED FOR STRONG ENFORCEMENT OF CLIMATE AND AIR EMISSIONS RULES

As of 1 January 2020, all ships had to cut their SOx emissions by over 80%. This has been a major and comprehensive transition and the vast majority of the global fleet (including Maersk vessels) has done so by switching to low sulfur fuel. This comes at a very steep price; for Maersk alone, the additional bill is estimated to be around $2 billion per year. Maersk fully supports the IMO2020 Regulation and will naturally respect it.

However, given the very large potential savings by non-compliance, we would like to emphasize the need for strong enforcement and adequate fines to deter non-compliance. Such fines should as a minimum cover the total amount saved by non-compliance including the part of the voyage on the high-seas. 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 to secure 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 paraphrase one of our senior leaders who stated that the main challenge in the transformation to low or zero emissions shipping is not at sea but on land. The technological changes inside the vessels are minor compared to the massive innovative solutions and fuel transformation that must take place to produce and distribute entirely new energy sources.

Thank you again for the opportunity to provide this input.

Mr. MALONEY. Thank you, Dr. Kindberg.

Mr. Bryn, am I saying your name correctly?

Mr. BRYN. Yes, thank you.

Mr. MALONEY. Thank God. You may proceed, sir, thanks.

Mr. BRYN. I have gotten a lot of versions, so that—you got it. Thank you.

Chairman Maloney, Ranking Member Gibbs, members of the subcommittee, and my fellow panelists, good morning and thank you for the opportunity to testify on this incredibly important topic.

ABB has been an electrification and automation leader for over a century. With 147,000 global employees, 24,000 of which are here in the U.S., we are a market leader in power grids, advanced manufacturing, and electric transportation. For example, ABB has deployed over 13,000 electric vehicle fast chargers, worldwide. ABB has 60 manufacturing sites in the U.S., with domestic headquarters in North Carolina, and global headquarters in Switzerland.

One example of ABB's marine technology is aboard the U.S. Coast Guard Great Lakes icebreaker, *Mackinaw*, where ABB provided our electric azipod propellers and the vessel's integrated diesel-electric power system.

ABB is excited to help lead the maritime industry toward zero emissions, as climate change is one of the greatest challenges of our time. ABB supports the Paris Agreement to avert the potentially devastating consequences of climate change. As a company with 9,000 technologists set to invest $23 billion in innovation through 2030, ABB urges policymakers to adopt sound and predictable climate policies to encourage innovation.

Today I would like to cover three main points: the current state of marine technology, the opportunity to lower life-cycle costs and emissions, and how the Federal Government can help speed adoption.

Globally, the maritime industry remains dominated by diesel power, but the beginnings of a significant shift are underway. For many vessels the first step is to electrify the propulsion system, meaning the propeller is directly powered by an electric motor. This arrangement allows for any energy sources to provide the power from diesel or LNG generators, to batteries, to fuel cells. In the near term, this can help many Jones Act vessels reduce their emissions. Longer term, this makes it far easier to retrofit low-carbon technologies as they commercialize.

So what zero-emission solutions are available today? It is critical to fit the right solution to each vessel's needs. And in the U.S. there are three primary vessel segments to consider: tugs and towboats, passenger vessels, and oceangoing vessels.

Let's begin with ferries, as they have become one of the pioneering vessel types for zero-emission battery deployment. This is because they operate a predictable schedule to just a few ports, meaning batteries can be sized with confidence, and only limited shoreside charging infrastructure is required.

As an example, ABB is proud to be powering the new *Maid of the Mist* tour boats in Niagara Falls, which will become the first new-build, all-electric vessels in the U.S. when they enter service this spring. The battery banks on these 500-horsepower boats will be recharged in 7 minutes between each voyage. Much larger will be the Washington State Ferries fleet, which operates throughout

Puget Sound, as this organization has committed itself to an all-electric future.

But what about tugs, towboats, and oceangoing vessels? Well, that, too, depends on their operating profile. For example, many harbor tugs, inland towboats, and dredgers spent significant time at idle or low load, which is inefficient for the diesel engine. For these vessels, a diesel-electric plant with a battery can help optimize engine efficiency, while significantly reducing engine hours.

Conversely, for vessels that spend most of their time near full power, like a product tanker, containership, or linehaul towboat, the diesel engine already operates quite efficiently. And so installation of a shaft generator and/or fuel switching to LNG or biofuels may be more appropriate in the near term.

But despite these near-term improvements, to get to zero emissions, new technologies like hydrogen fuel cells must be considered. ABB is already working with smaller commercially available fuel cells, and is jointly developing a 3-megawatt marine fuel cell with Ballard Power Systems for oceangoing vessels. In France, ABB is proud to be powering what will become the world's first fuel-cell-powered towboat.

With that, I would like to close with a few policy opportunities to support the transition to a zero-emission marine future.

First, green the Federal fleet. The U.S. Government is a globally leading shipowner. And, as such, it can use its buying power to deploy cost-effective advanced technologies for its own vessels.

Two, support financing mechanisms and direct funding for private-sector, zero-emission vessels. While the total life-cycle cost of an electrified vessel can be lower than a diesel-mechanical equivalent, the upfront costs are often higher. This investment can still be a challenge for shipowners, and so financial support for early adopters to help build volume will bring down costs, long term, for the private sector.

Three, invest in research and development. While there are commercially available solutions today for some marine segments, continued technology improvement is needed to serve more challenging vessel applications.

I thank you again for the opportunity, and look forward to your questions.

[Mr. Bryn's prepared statement follows:]

Prepared Statement of Peter Bryn, Technical Solutions Manager–North America, ABB Marine and Ports

EXECUTIVE SUMMARY

ABB has been an electrification and automation technology leader for over a century. With about 147,000 employees across the globe and 24,000 here in the US, we are a market leader in power grids, advanced manufacturing technology, and electric transportation. This includes electric vehicle charging infrastructure as well as marine and port electrification and automation solutions. The marine industry in the early stages of a transformation to low and zero emissions technologies. While there is no one-size fits all approach to reducing marine emissions, ABB believes the future of marine vessels will be electric, digital, and connected.

1. *With electric propulsion systems, marine vessels can get to zero emissions*. Most alternative propulsion system arrangements are centered around an electric powertrain, including diesel or LNG electric hybrids ships, full battery powered

ships, and fuel cell powered ships. Electric propulsion not only cuts emissions but also improve safety and reliability while reducing lifecycle costs. An electric-based powertrain is also futureproof as new power sources are developed. Whether the power source is fuel cells, batteries, ammonia-fueled generators, or a wave energy harvesting system, electric powertrains can integrate them. This is especially important for Jones Act vessels which often undergo multiple repowers over their sometimes 50+ year lives.

2. *It's critical to fit the right solution to the vessel*. Vessel types are as varied as the missions they serve and cargoes they carry. Ferries, inland towboats, harbor tugs, offshore workboats, and oceangoing vessels all have different operational characteristics that require different low or zero emission technologies. Fortunately, there are a number of such technologies either available today or under development including diesel or LNG electric hybrids, biofuels, fuel cells, and batteries. Accordingly, policies should focus on setting emissions targets for the marine industry, allowing the industry to assemble the best technology solution for meeting emissions and operational goals, and providing support to the marine industry as they meet those targets.
3. *Lifecyle costs of electric powertrains are typically lower than conventional diesel powered vessels.* Vessels with electric powertrains and direct current (DC) electrical systems typically cost less to operate over their lifetime due to higher energy efficiency, lower maintenance, and reduced fuel costs. However, their upfront capital costs tend to be higher. This challenge is similar to other recent energy technology breakthroughs, like wind and solar power and electric vehicles. However, through a myriad of research, development, and deployment policies and incentives, those upfront costs have come down considerably and have reached or are approaching cost parity. With appropriate support, the same will happen with zero emission marine technologies.
4. *Low and zero emission marine vessel technologies are in the early stages of adoption and need government and policy support*. Today there are commercially available zero emission marine technologies for some segments, like ferries. However, they tend to be more expensive upfront to purchase, which is a big deterrent to ship owners and operators, even though they are cheaper to operate. For other segments like offshore workboats, and oceangoing vessels, cost-effective commercially available zero emission solutions are still in their very early stages of development. To lower costs and reach a fully zero emission vessel fleet, deployment of existing technology and development of new technology must be expedited. The industry would benefit from government investments in research, development, and deployment of zero emission marine technologies.

INTRODUCTION

Good morning Chairman DeFazio, Chairman Maloney, Ranking Member Graves, Ranking Member Gibbs, members of the Subcommittee and my fellow panelists. Thank you for the opportunity to testify today. My name is Peter Bryn and I am Technical Solutions Manager in ABB Inc.'s Marine and Ports Business Line.

ABB is an electrification and automation technology leader that is driving digital transformation of industries. With a history of innovation spanning more than 130 years, ABB has four customer-focused, globally leading businesses: Electrification, Industrial Automation, Motion, and Robotics & Discrete Automation, supported by ABB AbilityTM digital platform. With about 147,000 employees across the globe, we are a market leader in power grids, advanced manufacturing technology, and electric transportation. This includes electric vehicle charging infrastructure and marine and port electrification and automation.

ABB is proud of our 24,000 US employees along with our 60 US manufacturing or assembly sites and significant operations in 32 states, including Arkansas, Missouri, Ohio, Oregon, Pennsylvania, Tennessee, Wisconsin, and North Carolina which is home to our U.S. headquarters. Our global headquarters is in Zurich, Switzerland. Over the past decade we have invested over $14 billion in the United States, more than tripling our workforce.

ABB COMMITMENT TO REDUCING EMISSIONS

Climate change is one of the biggest challenges of our time. ABB supports the Paris Agreement, which came into force in November 2016, and considers it the linchpin of efforts to limit global warming and avert the potential devastating consequences of climate change. ABB actively contributes to climate goals by encouraging the early and rapid adoption of clean technologies and by helping its cus-

tomers improve energy efficiency and productivity while extending the lifecycles of their equipment and reducing waste.

Meeting the goals of the Paris Agreement will require significant investment in new and upgraded technologies, which will only be forthcoming with solid, reliable, and predictable policymaking. As a company with around 9,000 technologists that is set to invest around $23 billion in innovation between the signing of the Paris Agreement and 2030, ABB urges policymakers to adopt sound climate policies to encourage innovation and create secure investment conditions.

ABB understands that investments in developing and deploying technologies that reduce climate impacts, while incrementally higher cost at first, lead to significant intermediate and long-term cost savings. Such technologies are core to ABB, as nearly 60 percent of ABB's global revenues are derived from technologies that directly address the causes of climate change through energy efficiency, renewables integration, and resource conservation. The marine sector also holds a similar promise of reducing emissions and overall costs.

ABB's contributions to climate goals are widely acknowledged and were recognized in August 2018 by "Fortune" magazine, which named ABB as one of the top 10 companies that are changing the world. ABB has set its own target to reduce its GHG emissions by 40 percent by 2020 from a 2013 baseline.

Reducing Marine Emissions

We are in the very early stages of a transformation of the marine industry to low and zero emissions technologies. While ports have already begun their march toward electrification, which enables zero emission operations, the marine sector is just beginning. ABB provides ship and port electrification and automation technologies and solutions. From replacing diesel powered cranes at ports with electric solutions powered by microgrids, to fully electrifying marine vessel propulsion systems, and everything in between, we believe the future of the maritime industry will be electric, digital, and connected. These technologies are used in ports across the US, from Charleston, South Carolina to Long Beach, California. And the Coast Guard has deployed one of ABB's advanced diesel-electric hybrid propulsion systems on the Great Lakes Icebreaker, the USCGC Mackinaw.

Global Adoption of Zero Emissions Technology

Globally, the maritime industry remains dominated by diesel-power, but the beginnings of a significant shift in energy source is underway. The start of adoption of low to zero emission ship technology is shown in Figure 1. While conventional power plants still dominate, a significant jump in both battery powered and liquified natural gas (LNG) ships is evident in Figure 2.

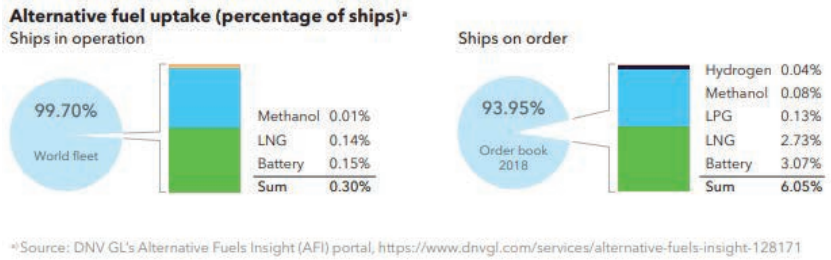


Figure 1. Alternative fuel by ship count (DNVGL, 2018)

By vessel type, certain technologies are emerging because they complement the vessel's operational profile. For example, ferries are great candidates for batteries because of their short distance operation and predictable port calls, which allow for installation of shore chargers. Conversely, container ships travel long distances and have incredibly high power demands. Because battery and fuel cell technologies need more research and development to be able to meet oceangoing vessels' needs cost-effectively, these ship owners and operators have begun adopting LNG.

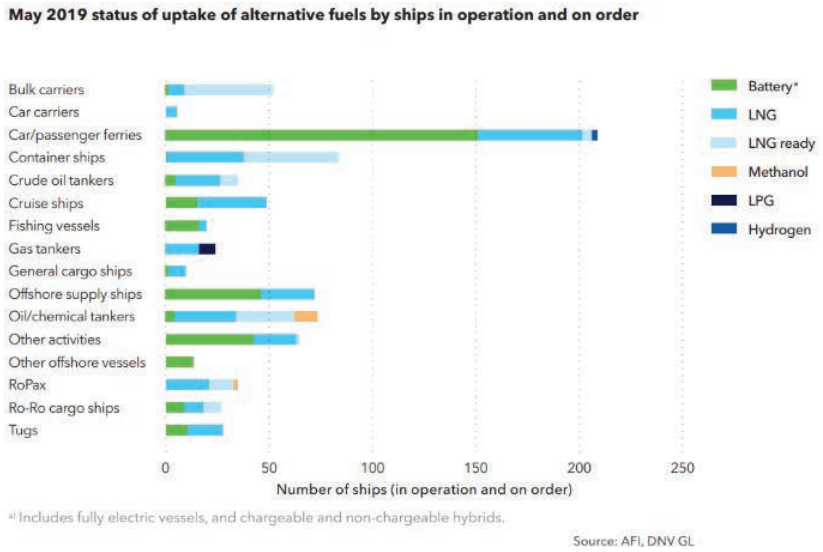


Figure 2. Alternative fuel by ship type (DNVGL, 2018)

An Electrified Propulsion System

Most alternative propulsion system arrangements are centered around an electrified powertrain. Whether diesel or LNG electric hybrids, full battery power, or fuel cell power, most low and zero emissions vessels will employ an electrified powertrain. Electric propulsion can not only cut emissions but also improves safety and reliability while reducing lifecycle costs. An electric-based powertrain is critical as it allows for easy integration of current and future power sources, which is important for Jones Act vessels that often undergo multiple repowers over their sometimes 50+ year lives.

Fitting the Right Solution

Vessel designs vary significantly, based on the vessel's application and purpose. The low and zero emission technologies that will be selected for a particular project will be dictated by the needs and operational profile of the vessel. These technologies may include:

Low Emissions	Net Zero Emissions
• Diesel-Electric • Diesel-Electric with Battery • Diesel-Electric with Battery and Shore Charging • Power Take In/Take Off (PTO/PTI) • LNG/dual-fueled engines • Biofuels (some) • Fuel Cell with Fossil-Derived Fuel	• Full Battery-Electric Propulsion and Shore Charging • Fuel Cell with Net-zero Fuel • Biofuels (some) • Ammonia

It is critical that ship owners and operators identify the proper solution for their vessel whether using a conventional diesel engine arrangement or some combination of low or zero emissions technologies. For example, a harbor tug which operates with a significant amount of idle time and short bursts of full power during operation has a very different operational profile than a Very Large Crude Carrier (VLCC) tanker which trades internationally on the spot market across oceans and can spend days at anchorage. Failing to consider the vessel's operation may lead to a propulsion system that is less efficient and cost effective than the diesel-mechanical baseline.

ABB is working with many Jones Act vessel owners, operators, and designers to seek the best solution for their operation. This ranges from ferries to fishing boats, harbor tugboats to dredgers, and passenger vessels to river towboats.

Across segments, some recurring challenges persist. First, while the total lifecycle cost of ownership of a vessel with electric propulsion is lower than a diesel-powered vessel, the upfront costs are often higher. Second, research, development, demonstration, and deployment investments are needed to bring down costs of these new systems and commercialize zero emissions solutions for more challenging applications like high speed catamarans and oceangoing cargo vessels.

US Newbuild Market

In the private sector, newbuild construction in the US is largely dominated by Short Distance Shipping (SDS) vessels, particularly tugs, towboats, and passenger vessels. By comparison, there is a small number of Oceangoing Vessels (OGV), as per Figure 3.

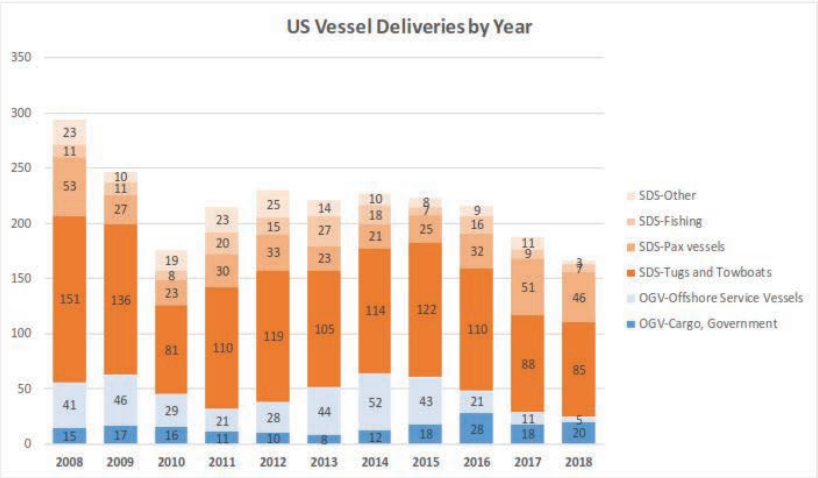


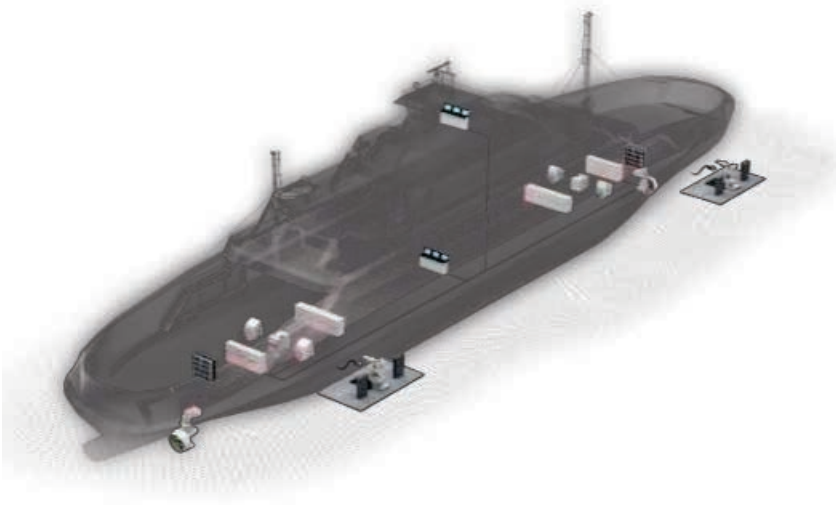
Figure 3. Recent US newbuild construction (Colton, 2019)

There are some exciting opportunities for Jones Act oceangoing vessels in the burgeoning offshore wind market, government fleet, offshore oil/gas activity, and larger cargo vessel markets. However, the bulk of this testimony will focus on the coastal and inland vessel markets, where most US newbuild construction is occurring.

Common US Vessel Types and Solutions

Road and Passenger Ferries

Ferries have become one of the pioneering vessel types for zero-emission battery deployment because they combine generally shorter routes with regular port visits. The shorter routes allow installation of battery packs that can fully power the vessels on their journeys while the predictable routes and turnaround times enable efficient deployment of shoreside charging infrastructure.



Operational profile	Fixed route, limited distance, not overly weight sensitive, volume limited.
Conventional solution	Diesel mechanical to propeller.
Reduced emission solution	Diesel electric with battery with propulsion motor to propeller.
Zero emissions solution	Battery-electric with propulsion motor to propeller.
Common challenges	Charging infrastructure, utility demand charges.

For these reasons, it's unsurprising that the ferry industry is among the first marine segments to adopt full battery-electric solutions. The first fully electric, battery-powered vessels to be built in the US are the two new Maid of the Mist ferries being powered by ABB. These Niagara Falls tour boats will be powered by a pair of battery packs with a total capacity of 316 kWh, split evenly between two catamaran hulls creating two independent power systems providing full redundancy.

Figure 4. New Maid of the Mist Ferry

The vessels will charge between every trip while passengers disembark and board. Shoreside charging will only take seven minutes, allowing the batteries to power the electric propulsion motors capable of a total 400 kW (563 HP) output. This will all be controlled by ABB's integrated Power and Energy Management System (PEMS), which will optimize the energy use on board.

From small to large, most ferry boats and routes can be electrified. In 2018, two ForSea Ferries, operating between Denmark and Sweden, became the largest battery powered ferries, following an ABB-led conversion.

Figure 5. ForSea Ferries

Economics play a large part in the push toward electrification. While zero emission boats tend to have higher capital costs, operational costs are much lower than diesel powered ships, making them more cost-effective over the lifetime of the vessel. Figure 6 is an example for an existing ferry opportunity where the battery electric option (Case E) is more expensive up front, but because it costs less to operate, the ship owner or operator ends up saving $800,000 over the life the vessel. Just like with electric vehicles, increased deployments, financing support, as well as research and development can help lower the upfront capital cost of zero emission options.

2.0 Results - Lifecycle Cost Calculation

	(A) Diesel Mechanical (DM)	(B) Diesel Electric (DE)	(C) DE w/Battery for Peak Shave	(D) DE w/Battery & Shore Charge	(E) Battery Electric Vessel	(F) Shaft Generator Vessel	
CAPEX	$0.66	$1.33	$1.46	$1.61	$1.50	$1.62	$M
AVG OPEX	$0.31	$0.26	$0.24	$0.20	$0.17	$0.24	$M/yr
ANALYSIS 1: Payback Years							
Payback Years	--	11	12	9	6	13	yrs
ANALYSIS 2: Internal Rate of Return							
Internal Rate of Return	--	8%	7%	11%	19%	6%	
ANALYSIS 3: Lifecycle Total Cost of Ownership							
Lifecyle Cost*	$4.5	$4.5	$4.5	$4.2	$3.7	$4.6	$M
Lifecyle Savings	--	$0.0	$0.0	$0.3	$0.8	-$0.1	$M

*28 year life, 7% discount rate

Figure 6. Example of Project Economics for ABB Ferry Project

In addition to the cost savings of choosing a zero emission solution, the CO2 emissions reductions are stark, as shown in Figure 7. A significant reduction of CO2 is shown in the battery electric option, which assumes an emissions profile in line with the energy generation mix of the power grid in California.

3.4 CO2 Emissions Summary

	(A) Diesel Mechanical (DM)	(B) Diesel Electric (DE)	(C) DE w/Battery for Peak Shave	(D) DE w/Battery & Shore Charge	(E) Battery Electric Vessel	(F) Shaft Generator Vessel	
FUEL AND RUNNING HOURS							
Diesel Fuel consumed	79,213	69,100	67,098	34,097	0	65,606	gallons/yr
Electricity consumed	0	0	0	497,636	1,039,034	0	kWhe/yr
EMISSIONS TOTALS*							
Diesel Fuel CO_2 emissions	806,391	703,439	683,058	347,111	0	667,870	kg CO_2/yr
Electricity CO_2 emissions	0	0	0	107,261	223,954	0	kg CO_2/yr
TOTAL EMISSIONS	806,391	703,439	683,058	454,372	223,954	667,870	kg CO_2/yr
TOTAL REDUCTION	--	102,953	123,333	352,020	582,437	138,522	kg CO_2/yr

*diesel emissions intensity per EPA; electric emissions intensity based on average for California

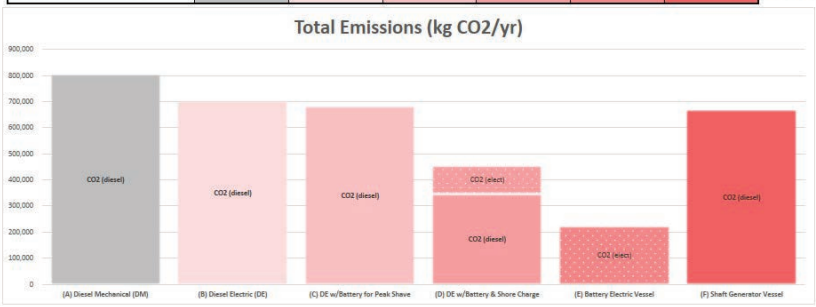


Figure 7. Example of Project Emissions Estimate for ABB Ferry Project

Harbor Tugs

Like ferries, harbor tugboats operate on short routes and typically return to the same port every evening. However, unlike ferries, they have significant idling time and higher power demands. To reduce emissions, a diesel-electric system with a smaller diesel generator and a battery bank can satisfy onboard power requirements when stationary while being ready to provide maneuvering power in an instant.

Operational profile	~60% idle time, ~35% at <40% power, <5% at full power.
Conventional solution	Diesel mechanical to propeller.
Reduced emission solution	Diesel electric with peak shaving battery, possibly plug-in, propulsion motor to propeller.
Zero emissions solution	Battery-electric or fuel cell-electric, propulsion motor to propeller.
Common challenges	Space for battery room, sometimes unpredictable periods away from dock.

Figure 8 is an example of a typical tugboat use-case where a smaller diesel-electric powertrain paired with smaller battery for peak shaving (Cases C) or a larger battery for propulsion to be charged at port (Case D) were recommended by ABB. Like the ferry example above, despite higher upfront capital costs, the lower operating costs of an electric propulsion system can save the ship owner operator over $6m over the life of the vessel. Programs that address upfront capital costs will help increase deployments of low emission technologies and enable price reductions that come with scale and experience. For example, a low-interest loan program to cover the difference in capital cost could increase adoption.

2.0 Results - Lifecycle Cost Calculation

	(A) Diesel Mechanical (DM)	(B) Diesel Electric (DE)	(C) DE w/Battery for Peak Shave	(D) DE w/Battery & Shore Charge	(E) Battery Electric Vessel	(F) Shaft Generator Vessel	
CAPEX	$2.20	$5.53	$6.68	$7.88	$10.16	$6.48	$M
AVG OPEX	$1.85	$1.58	$1.30	$0.82	$0.52	$1.36	$M/yr
ANALYSIS 1: Payback Years							
Payback Years	--	12	8	5	6	9	yrs
ANALYSIS 2: Internal Rate of Return							
Internal Rate of Return	--	7%	11%	20%	17%	11%	
ANALYSIS 3: Lifecycle Total Cost of Ownership							
Lifecyle Cost*	$25.3	$25.3	$23.8	$19.2	$18.6	$24.0	$M
Lifecyle Savings	--	$0.0	$1.5	$6.1	$6.7	$1.3	$M

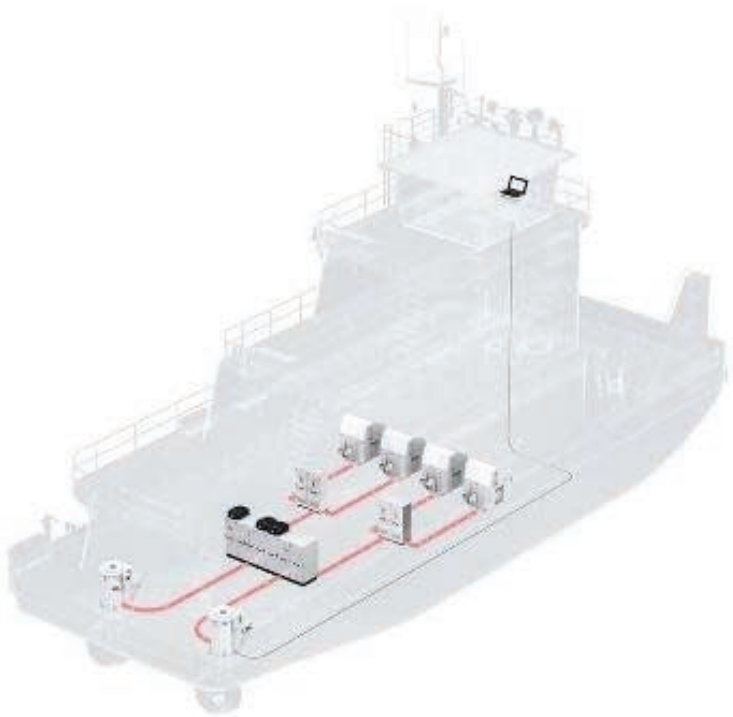
*20 year life, 7% discount rate

Figure 8. Example of Project Economics for ABB Tugboat Project

Inland Towboats

Inland towboats operate under a wide range of profiles. Factors like voyage length and consistency of docking schedule will drive either a battery-electric or fuel cell-electric solution. Less ambitious emission reductions can be achieved using a diesel-electric hybrid system with a battery.

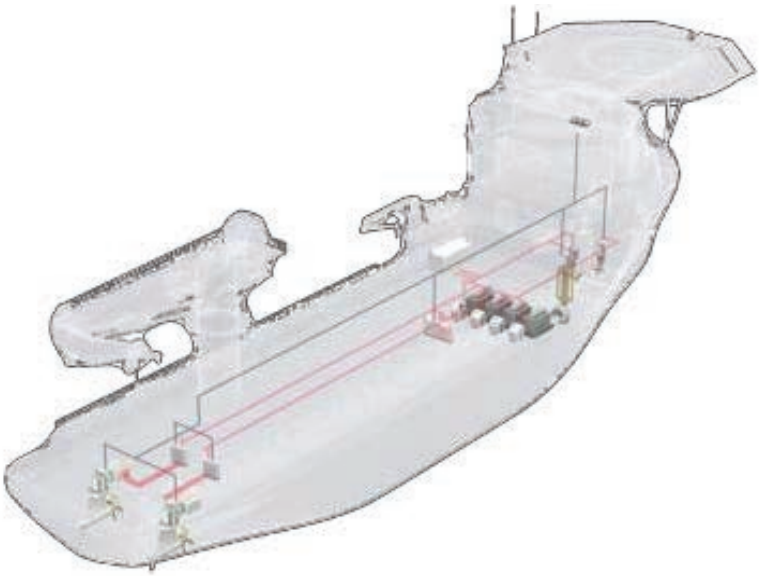
ABB is proud to be providing a complete fuel cell-electric power system for what will become one of the world's first fuel cell powered towboats, which will be operated by Compagnie Fluviale de Transport (CFT) of France.



Operational profile	*Unit tows*: varying length voyages.
	Shuttle boat: short distance transits, long idle time.
	Fleeting boat: stays local to fleet moving barges in and out.
	Linehaul boat: regular long-distance hauls.
Conventional solution	Diesel mechanical to propeller.
Reduced emission solution	*Unit tows, shuttleboat*: Diesel electric with battery.
	Fleeting boat: Battery-electric.
	Linehaul boat: PTO/PTI.
Zero emissions solution	*Unit tows, shuttle boat, linehaul boat*: Fuel cell-electric.
	Fleeting boat: Battery-electric.
Common challenges	Highly capex-focused market, cautious about new technology.

Offshore Workboats

Offshore workboats have yet a different operational profile. Many have long dwell-times when servicing offshore assets like a wind farm or oil and gas rig, while also needing onboard power for ancillary service-related systems. A first step to reduce emissions for these workboats is to add batteries to a diesel-electric system. The batteries can be used to optimize diesel performance by assuming the very transient loads arising from the podded thrusters as they start and stop while in dynamic positioning mode. The diesel may shut off completely, or if running can operate at an optimal, steady point and avoid constantly ramping up and down. A movement to zero emissions will likely entail a fuel cell-electric propulsion system with battery.



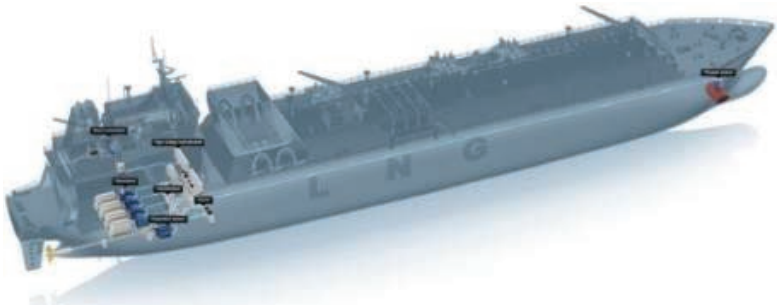
Operational profile	Varied, but often have high dwell times and significant non-propulsive loads.
Conventional solution	Varies, but often diesel-electric with podded propulsors.
Reduced emission solution	Diesel-electric with battery storage for optimized operation.
Zero emissions solution	Fuel cell-electric with battery storage.

ABB is proud to have powered the NKT Victoria, a specialized offshore cable-laying workboat, with ABB's Onboard DC Grid system and achieved a remarkable 60% CO2 reduction versus a comparable vessel. This was achieved both because of greater efficiency in the propulsion system, but also due to operational changes that the electrified system permitted.

Figure 9. NKT Victoria

Oceangoing Cargo Vessels

Oceangoing cargo vessels often have predictable operational characteristics, however their long distance routes, coupled with very short port stays, make full battery-electric propulsion systems challenging. The first step toward reducing emissions is to use an alternative fuel like LNG or biofuel, and potentially adding battery storage. A move toward zero emissions would likely incorporate a fuel cell-electric propulsion system, which ABB is developing for this need.



	At Sea	In Port
Operational profile	Most spend long periods of time at sea with limited port turnaround time	
Conventional solution	Slow speed diesel to propeller	Operate diesel-powered generators and steam boiler.
Reduced emission solution	Alternative fueled (e.g. LNG, Dual fuel), possibly with battery.	Cold ironing (vessel plugs into local shore power) or battery.
Zero emissions solution	Fuel cell-electric with propulsion motor to propeller, or engine with net-zero fuel (e.g. ammonia, biofuel) direct to propeller	

While in port, achieving zero emissions is possible for some vessels today by connecting to a shoreside power source, often called "shore power," "ship to shore," or "cold ironing". ABB has provided a number of cold ironing installations across the globe involving both the onboard and shoreside equipment. There are challenges to

cold ironing as most older vessels are not outfitted to accept shore power and not all ports are currently equipped to support it. Cold ironing can be of limited value if there are substantial non-electric loads (e.g. crude oil tanker steam-powered cargo pumps) or if the in-port power demands are not overly significant (e.g. a bulker with only hotel loads). In light of the unique demands of oceangoing vessels, more investment in research, development, and demonstration projects is needed to deliver cost-effective and commercially scalable zero emission solutions for these vessels.

SUMMARY AND RECOMMENDATIONS

The marine industry is just beginning its march toward zero emissions with commercially ready cost effective solutions available today to meet the needs of multiple vessel segments. There are, however, some segments, like oceangoing vessels, that require significant additional technology research and development in order to reach a zero emission target. One commonality across all segments, which is also true across many new technologies, is that with scale and experience, costs trend downward. This has been the case with solar and wind power, and also electric vehicles. To same will hold true for marine vessels.

There are a number of actions that the Federal Government and this Committee can take to increase deployment of existing zero emission technologies, invest in the zero emissions technologies of the future, and grow US leadership in the marine sector for decades to come.

1. *Green the Federal Fleet*. The US government is a globally leading shipowner, and as such it can become a pacesetter in deploying cost-effective, advanced technologies. In addition to Department of Defense ships, the US owned fleet includes Coast Guard, MARAD, and National Park Service vessels.

   ABB encourages the Committee to set an ambitious, long-term national plan to achieve zero emissions for all vessels under its operation. Doing so would have a meaningful impact directly on vessel emissions and establish the private US maritime industry as a global technology leader. This would also help the US do its part toward meeting the International Maritime Organization's (IMO) Sustainability Goals. ABB is prepared to support the Committee in developing such a strategy to seek realistic, cost-effective solutions.
2. *Limit Tier 4 Engine waivers to where true hardships exist*. After a thorough rulemaking process and cost justification, EPA requirements for reduced emission engines have arrived. Engine manufacturers have provided proven, cost-effective engine solutions to meet these requirements. While EPA is not under the jurisdiction of this Committee, waivers for vessels under this Committee's jurisdiction should be issued judiciously and only after thorough demonstration of hardship to meet the requirement.
3. *Support financing mechanisms and direct funding for private sector, zero-emission vessels, projects, and equipment providers*. Zero emission vessels often have higher up front capital costs, but lower operating costs and therefore lower total cost of ownership than conventional diesel systems. Government investment in research and development can help lower those costs. As such, we recommend supporting and expanding programs like the Maritime Education and Technical Assistance (META) Program. The Federal Transit Administration's Ferry Grant Program should be expanded and could include a focus on zero emission technologies, just like the Transit Bus "No/Lo" program. We also suggest exploring establishing a low-interest loan program to cover the incremental capital cost of choosing a zero emissions technology.
4. *USCG Marine Safety Center*. The Coast Guard's Marine Safety Center (MSC) is faced with the challenge of ensuring the safety of vessels, regardless of propulsion technology. As lithium ion batteries, fuel cells, hydrogen, and other new technologies become commercially available, the MSC is tasked with updating the Code of Federal Regulations (CFR) to address these new technologies. This will require time and resources. ABB is prepared to support MSC in this role and asks the Committee to do the same.
5. *Invest in Research and Development*. While there are commercially available zero emission solutions available today for some marine segments, others still require significant research and development, particularly in the area of fuel-cells, advanced battery chemistries, and advanced net-zero fuels. Through the US Coast Guard's Research Development Test and Evaluation Program, the Department of Energy, and MARAD's META Program, the Committee could encourage development of a zero emissions ship research and development program.
6. *Help solve shore charging*. As vessels like ferries electrify, electric utilities are faced with high power loads during recharge. This can often trigger demand

charges which can significantly challenge the otherwise favorable economics to move to electric. Solutions like shoreside energy storage systems are available to mitigate this cost, though they can add cost and complexity to the project. The Committee could also direct MARAD to invest in shoreside power through funding mechanisms like the Port Infrastructure Development Grants.

7. *Training*. Support Maritime Academies and ensure labs and curriculum include the latest technology. While alternating current (AC) electrical systems remains a common standard on vessels, ships powered by electric propulsion will be built using direct current (DC) architecture. Training curriculum should be updated to address these changes to how ships are powered.

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DNVGL. (2018). *Energy Transition Outlook*.

Mr. MALONEY. Thank you.

Ms. Metcalf?

Ms. METCALF. Yes. Perfectly said.

[Laughter.]

Ms. METCALF. Good morning, Chairman Maloney, Ranking Member Gibbs, and members of the subcommittee. Thank you very much for allowing us to testify here. And this is not my testimony, but I have to also be very proud, because I live in the western suburbs of Philadelphia. I Amtrak down here every day. So it is nice to see a friend of mine from Pennsylvania on the dais.

I am Kathy Metcalf, president and CEO of the Chamber of Shipping of America, representing member companies who are U.S.-based that own, operate, or charter a number of different vessel types.

When I was first contacted about this hearing, the indication was that it would be a green shipping hearing. And so, over the holidays, I dutifully did some testimony, and then I found out when I received the invitation that it was a little bit more narrow, it was more towards carbon free, or zero carbon.

But then I thought further, and when I noticed my good friend, John Butler, and Lee Kindberg was going to sit and talk about the specifics of the IMO plan, you are smart guys and girls and you don't need to hear the same thing twice.

So I thought it might be helpful, since I was sitting between you and lunch, to go up to about a 40,000-foot level and talk about green shipping and sustainable shipping, because the only environmental issue of importance to the maritime industry is not just greenhouse gases, it is a multiple of many, many issues. And most of them are linked together, kind of like a spider web. You pull on one, you might undo another one.

So what I have tried to do is—I noticed that Mr. Thoreau once stated, "it's not what you look at that matters, it's what you see." I realize that we all have different perceptions of what green shipping or sustainable shipping is. And, in the simplest of terms, green shipping is a focus on reducing the environmental profile of vessels. Sustainable shipping is a much larger, broader issue that involves society, human factors. And there is an excellent diagram in my testimony from the European Union on this.

Global industry, 90 percent of our goods, are transported by water. It is also the most environmentally friendly mode of trans-

portation. Now, why do I say that? Not because we shouldn't be doing anything, but because we need to be sure that the most environmentally friendly mode of transportation remains and keeps its share. We cannot afford transmodal shifts to less environmentally friendly forms of shipping.

So the regulatory framework—a couple of my colleagues have already talked about this—it is critically important that ships engaged in international trade have a set of robust, enforceable regulations at the international level. We are never going to get rid of national and sometimes subnational regulations around the world. But to maximize the efficiency and the environmental benefit of regulation, that consistency needs to be maintained at the IMO level.

I am not going to waste your time, as I mentioned, talking about the path to a carbon-free maritime industry; John and Lee and others have done that quite well. But I would say that exactly what they said we totally support; the need for R&D is critical.

In my testimony I have included a few summaries of a number of environmental issues: air emissions, not just greenhouse gases, but the more conventional pollutants that the industry has been working on; discharges to the water, including ballast water—thank you for passing VIDA. It is really—after, I think, 12 years on my part, it was a welcome addition to see that we are going to finally get a set of consistent regulations that govern those discharges.

Biofouling, hull husbandry, critical. A clean hull is a happy hull, is a more efficient hull, which means you have better fuel efficiency, less emissions per ton-mile.

Marine plastics. This is going to be hot, the hot part is the single-use plastics. We are seeing it already, internationally. Two countries in particular have banned the use of single-use plastics.

Ship recycling, another important one.

And we talked about it before the hearing, protection of marine resources, and noise.

What I would say in closing, Mr. Chairman and Members, a Chinese philosopher once said, "A journey of a thousand miles begins with a single step." Nothing could be truer for the global maritime industry at this point in time. But we have to understand that it is a transitional period as we approach 2050.

Thank you, and I am happy to answer any questions.

[Ms. Metcalf's prepared statement follows:]

Prepared Statement of Kathy Metcalf, President and Chief Executive Officer, Chamber of Shipping of America

Good morning, Chairman Maloney, Ranking Member Gibbs and Members of the Subcommittee. We appreciate the opportunity to provide testimony at this hearing to discuss paths to a carbon-free maritime industry as well as the more general concepts of green and sustainable shipping.

Mister Chairman, we respectfully request that our testimony be entered into the record for this hearing.

I am Kathy Metcalf, President and CEO of the Chamber of Shipping of America (CSA). CSA represents member companies which are U.S. based that own, operate or charter both US and non-US flag oceangoing tankers, container ships, and other merchant vessels engaged in both the domestic and international trades. Through CSA's long time participation in various national and international organizations,

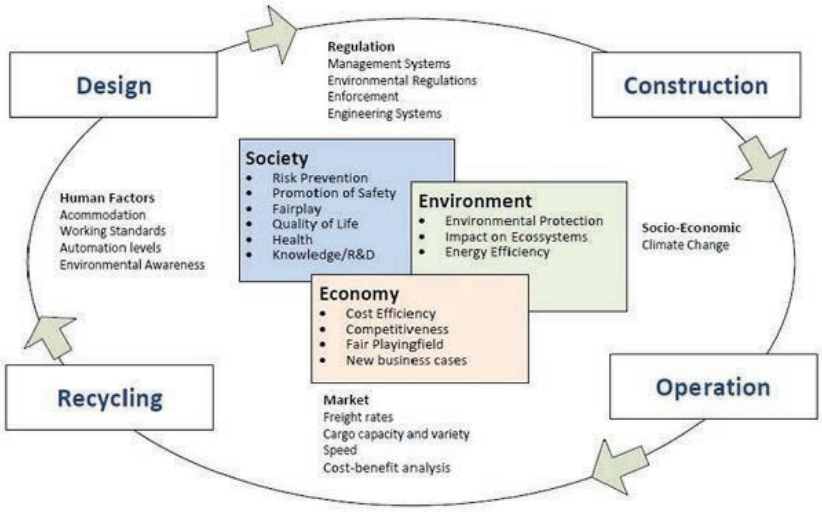
including the International Maritime Organization (IMO), our members are actively supporting a number of initiatives which will advance the concepts of green shipping and sustainable shipping in the global maritime industry including those leading toward a carbon-free maritime industry.

WHAT IS GREEN SHIPPING/SUSTAINABLE SHIPPING?

Henry David Thoreau once stated "It's not what you look at that matters, it's what you see." Taking into account this simple statement on perspective as it applies to defining green and/or sustainable shipping provides the reason that a detailed internet search results in a myriad of definitions for these terms. Some view green and sustainable shipping as interchangeable terms. CSA and others, view green shipping as a subset of sustainable shipping.

In the simplest of terms, green shipping is a process by which the environmental footprint of the marine industry is reduced subject to the principle of continuous improvement. It is not about one specific environmental impact but rather all the environmental impacts associated with vessel and port operations. A good case in point is the current focus on greenhouse gases (GHGs). Many speak of green shipping within the context of climate change and the reductions of GHGs, but in fact green shipping is much broader than that and represents an overarching concept that relates to all types of environmental impacts including air emissions, discharges to the water, impacts on living marine resources to name a few.

Sustainable shipping is an even broader and arguably more important concept defined most often as a holistic management concept for sustainable development incorporating environmental and social responsibility and includes the three co-equal pillars of environment, society and economy. Sustainable shipping incorporates these three in a continuous loop of design, construction, operation and recycling principles with supporting principles of regulation, socio-economic, market related and human factor issues. Reproduced below from the European Maritime Safety Agency website is an informative graphic describing the multiple interfaces which comprise sustainable shipping.



Because of the many different stakeholders which are involved in the process, one of the most critical factors in the advancement of sustainable shipping principles, is the need for constructive dialogues, partnerships and the development of synergies to fully take into account the wide range of perspectives of all parties including their concerns, needs and expectations. Although a daunting challenge, it is only with consideration of these many stakeholders and their perspectives that sustainable shipping can be successfully implemented to the benefit of all. Sustainable shipping is not a project with a clearly defined time line, but rather is a continuous voyage with goals changing over time in an ever evolving world.

THE GLOBAL MARITIME INDUSTRY AND ITS REGULATORY FRAMEWORK

Approximately 90% of world trade is transported by ships, including raw materials, energy, food, as well as manufactured goods and products. Global shipping is the main facilitator of international trade and is obviously of vital importance to the global economy. Global shipping is also the most environmentally friendly mode of transportation. As an example, according to the IMO GHG Study (2009), oceangoing vessels produce on average 5.6 grams of CO2 per ton-kilometer compared to 80 for trucks and 435 for aircraft. Similar benefits of global shipping are also observed in the areas of safety (fatalities per million ton-miles) and fuel efficiency (ton-miles per gallon). The relevance of these facts is key to the conclusion that global shipping is critical to both economic and environmental sustainability when compared to other transportation modes. This also leads to a further conclusion that any regulatory changes to the current environmental regulations at both the international and national levels should not impair the critical role global shipping plays in the global economy and should not result in the transfer of cargo to other less environmentally friendly modes of transportation. This is not a justification for lack of action as regards green shipping initiatives, but rather is a call for acknowledgment of these sensitivities as future regulatory requirements are considered and adopted at all levels of governance and ensures any actions taken relative to shipping do not result in cross media transfers or cross modal transfers to less friendly modes of transportation.

The regulatory framework which governs the global shipping industry is complex. The IMO creates new environmental requirements which are agreed to by IMO member states and then implemented at the national level. In some cases, national and sub-national requirements are imposed which are different than or more stringent than those adopted by the IMO. In these cases, vessels calling in a particular port are faced with a patchwork quilt of requirements making compliance a challenge at best. In our view, because shipping is global, so also should be the environmental regulations which apply to global shipping. Fuel sulfur requirements are a relevant case study. At one point in time, vessels trading to California were subject to CARB fuel sulfur requirements, the US Emission Control Area requirements and the IMO fuel sulfur requirements. Fortunately as time has passed, these three sets of requirements have moved closer together in content. Illustrative in this example is the fact that many IMO treaties contain provisions for national programs where more stringency is deemed necessary such being the case with the US request for an IMO approved emission control area for North America and the Caribbean. The point of this conversation is that global shipping, the marine environment and society benefit from a robust set of international requirements that apply to vessels regardless of the areas to which they trade. It is within this context that the concepts of green shipping and sustainable shipping should be discussed and agreed so that one set of requirements are applicable to all vessels regardless of flag or location.

THE PATH TO A CARBON-FREE MARITIME INDUSTRY

The path to a carbon-free maritime industry is related to the reduction of GHG emissions from vessels. IMO has adopted its GHG reduction strategy with current discussions focusing on the identification of short, medium and long term measures which will allow the global shipping industry to gradually reduce or eliminate its CO2 emissions. The IMO Strategy establishes ambitious targets including the phase-out of GHG emissions "as soon as possible this century" and reducing annual GHG emissions from international shipping by at least 50% by 2050 compared to the 2008 baseline. This is quite likely the most important and impacting initiative ever applied to the global shipping industry and will require the development of new vessel design and propulsion technologies as well as zero carbon or carbon neutral fuels.

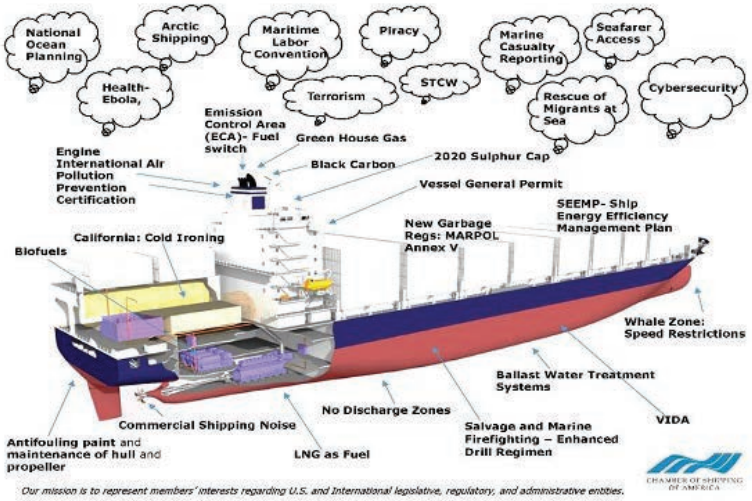
So what is the path to a carbon-free, or at least carbon neutral, maritime industry? In our view, the most critical first step to making progress on this initiative is the development of a robust global research and development program, a program which is, in fact, being proposed by the global maritime industry at the next meeting of the IMO Marine Environment Protection Committee in the spring of 2020. Key elements of this proposal include the establishment of a new research and development organization to pave the way for the decarbonization of shipping, core funding from shipping companies across the world of about USD 5 billion over a 10 year period and the acceleration of the design and construction of commercially viable zero carbon-emission ships by the early 2030's. Reaching these reduction goals will require the deployment of new zero-carbon technologies and propulsion systems such as green hydrogen and ammonia, fuel cells, batteries and synthetic fuels produced from renewable energy sources. These fuels do not yet exist in a form or scale

that can be applied to large commercial ships, especially those engaged in transoceanic voyages and which are currently dependent on fossil fuels. Some have questioned why the global maritime industry cannot conduct these R&D efforts in a private setting. It is important to understand that the global shipping industry is comprised of tens of thousands of companies located in over a hundred countries. Creation of this mandatory R&D contribution mechanism is critical to ensure a level playing field exists as well as ensuring that the necessary funding to support these initiatives is shared across the global industry, is maintained at sufficient levels and the results of the R&D efforts are shared across the global maritime industry.

As indicated above, the creation of this global R&D initiative is only the first step in the long and likely never ending path to a carbon free maritime industry. The MEPC through its GHG working group is addressing a number of other issues the resolution of which are critical to a successful outcome. In broad terms, these issues include discussions around how and to what degree existing technical and operational programs can be improved, developing procedures for assessing the impacts of mandatory measures on IMO member states, and development of cooperative efforts with ports and other land-based stakeholders throughout the entire logistics chain.

Specific short term measures being discussed include improvements to the existing energy efficiency requirements (Energy Efficiency Design Index (EEDI), Ship's Energy Efficiency Management Plan (SEEMP)), development of technical and operational energy efficiency measures for both new and existing ships, analysis of the use of speed optimization, consideration of methane emissions, development of national action plans, enhancement of technical cooperation and capacity building, encouragement of logistics chain wide collaborative efforts and others. Mid-term and long-term measures include further refinement of the short term measures noted above, the development, implementation and provision of zero-carbon or fossil-free fuels including land-based manufacturing and distribution systems, and the identification and development of new/innovative emission reduction mechanisms.

OTHER (EQUALLY IMPORTANT) ENVIRONMENTAL ISSUES RELATED TO THE ADVANCEMENT OF GREEN AND SUSTAINABLE SHIPPING CONCEPTS



As some of my fellow witnesses have likely experienced, we are often asked to identify and discuss the top 5 or top 10 environmental issues facing our industry. As illustrated above, this is a near impossibility as at any given point in time, we are working on at least 20 environmental issues, each with different priorities over time and at various stages of analysis. The illustration above provides an example of the number of issues with which we deal on an everyday basis. It is also important to appreciate that initiatives that address one of these issues, may result in

positive or negative impacts of others. Short summaries of the key issues are found below.

Air Emissions

There are two distinct sub-topics relative to air emissions. The first relates to the reduction of GHG emissions from vessels which is discussed above. The second relates to the reduction of traditional pollutants from vessels including SOx, NOx and particulate matter at both the international and US domestic levels. IMO and the US are addressing these issues by further tightening requirements for engine design, the imposition of fuel sulfur requirements within ECAs as well as the imposition of the recent global sulfur cap of 0.5% for vessels operating in areas outside of ECAs. Related to this issue is the topic of alternative control strategies which includes the installation and use of exhaust gas scrubbers in lieu of low sulfur fuel. IMO regulates this issue under Annex VI of the International Convention for the Prevention of Pollution from Ships (MARPOL).

Discharges to the Water

Issues within this subject matter being addressed at both international and US domestic levels include ballast water discharges, bilgewater/oily water separator effluent, exhaust gas scrubber washwater discharge, graywater and anti-fouling coatings/leachate, sewage and garbage as well as discharges/releases associated with a marine casualty. At the international level, these issues are discussed under separate initiatives within the Marine Environment Protection Committee under the provisions of the 6 annexes of MARPOL and separate stand-alone conventions addressing ballast water management, anti-fouling systems, and oil pollution preparedness, response and cooperation (conventional oils as well as hazardous and noxious substances).

In the US, 27 discharges to the water, including those noted above, are currently covered by the Vessel General Permit issued by EPA and the Oil Pollution Act (marine spill prevention, readiness and response). As you are aware, in December 2018, the President signed the "Frank LoBiondo Coast Guard Authorization Act of 2018," which included the Vessel Incidental Discharge Act (VIDA). After literally decades of collaborative efforts among Members of Congress, the industry and environmental groups, the enactment of these provisions were welcomed by the industry and will provide for a clear and comprehensive set of regulations governing discharges incidental to the normal operation of vessels. We have been informed that EPA is close to finalizing its proposed regulations as mandated by VIDA and we expect them to publish a proposed rule in the January/February 2020 timeframe. These regulations are required to be finalized by December 2020 at which time the USCG will develop their companion regulations which are required to be finalized by December 2022. Most importantly to this discussion of sustainable shipping is the recognition that both the international requirements and the US domestic requirements are under continuous review and as technology and best practices develop over time, are subject to change with due regard to the need for continuous improvement.

Biofouling/Hull Husbandry

Hull biofouling/husbandry is an issue critical to the improvement of vessel energy efficiency as well as the prevention of the transfer of aquatic nuisance species. As regards the energy efficiency aspect, accumulation of marine species on the hull and in niche areas, creates additional drag which reduces fuel efficiency and negatively impacts air emissions issues identified above. As regards aquatic nuisance species, studies suggest that, at least in some areas, hull fouling contributes to the transfers of aquatic nuisance species more than ballast water discharges. Given the cross media scope (air and water) of positive impacts associated with good hull husbandry practices, the global marine industry embraces best management practices so that these environmental benefits can be maximized. An issue directly related to biofouling is the proper selection and use of anti-foulant hull coatings. While there are a number of coating types, current discussions are focused on the leachate which naturally occurs from metal based components of the coating. Tributyltin was phased out a number of years ago with the adoption of the IMO Antifouling Convention and US regulations banning its use. The current discussion focuses on copper based coatings and what impact their use may have on the marine environment in large part due to initiatives within the European Union. The industry is in constant discussions with coating manufacturers to assess what new coatings are being development with due regard for the reduction of their environmental impacts.

Marine Plastics

Currently the issue of marine plastics use and disposal is regulated under MARPOL Annex V (Garbage), national and, in some cases, subnational regulations.

As is the case with all MARPOL annexes, Annex V is under continuous review by the Marine Environment Protection Committee (MEPC) and has recently been amended to update the criteria for determining whether cargo residues are harmful to the marine environment and a new Garbage Record Book format which includes a new garbage category for e-waste. MARPOL Annex V explicitly prohibits the discharge of plastics at sea and requires disposal to shore reception facilities. A new topic which has recently arisen is the subject of single-use plastics. It is expected that MEPC will take up this issue due to at least two national laws (India, Kuwait) that seek to ban the use and disposal of single-use plastics in their waters and ports. The imposition of this ban is in violation of these countries obligations under MARPOL Annex V which requires that adequate reception facilities be available in their ports. Further complicating this issue is the fact that vessels can only purchase ship stores from ship chandlers based on the inventory of those chandlers and few, if any, provide the ability to purchase multi-use plastics or acceptable alternatives to single-use plastics for use onboard vessels. While the industry supports waste minimization concepts, including the use of multi-use plastics, any prohibitions on the use of single-use plastics must necessarily take into account the availability of alternatives (including multi-use plastics), a discussion best left to resolution at the IMO MEPC.

It should be noted that a substantial fraction of marine plastic debris in the ocean originates from land-based sources and rivers and are related to the mismanaged plastic waste generated from land-based sources along these rivers. The 10 top-ranked rivers transport 88–95% of the global load in the ocean (Export of Plastic Debris by Rivers into the Sea, Environ. Sci. Technol. 2017, October 11, 2017).

Ship Recycling

International requirements for environmentally responsible ship recycling is a decades long discussion which resulted in the IMO Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships (2009). The Convention was agreed in 2009 but has yet to enter into force due to low ratification rates by IMO member states. The Convention is aimed at ensuring that ships, when being recycled after reaching the end of their operational lives, do not pose any unnecessary risks to human health, safety and to the environment. The Convention intends to address all the issues around ship recycling, including the fact that ships sold for scrapping may contain environmentally hazardous substances such as asbestos, heavy metals, hydrocarbons, ozone-depleting substances and others. It also addresses concerns raised about the working and environmental conditions at many of the world's ship recycling locations. Ship recycling is also addressed in the European Union Ship Recycling Directive as well as under national laws. It is hoped that regional and national requirements for ship recycling will become aligned with the provisions of the Convention when it receives sufficient ratifications to enter into force.

Protection of Living Marine Resources including Noise from Commercial Shipping

The impacts of all ocean users, including shipping, is an active point of discussion in a number of organizations with current activities focused on determining the impacts of these activities on living marine resources. Two specific issues related to global shipping have received much attention at international and national levels. The first issue relates to ship strikes of large marine mammals and discussions are ongoing as to how governments and the industry can minimize the likelihood of vessels striking marine mammals. This issue is challenging when taking into account that large marine mammal populations are subject to annual migration patterns and the fact that most large marine mammals are not usually visible to the eye of the navigation officer that is controlling the movements of a vessel. IMO efforts thus far have resulted in the creation of guidelines for minimizing the risk of ship strikes with cetaceans (2009). US efforts thus far include programs focusing on the reduction of ship strikes of the North Atlantic Right Whale (East Coast of the US) and multiple whale species off the coast of California.

The second issue relates to the underwater noise generated by the movement of vessels through the water. Over 85% of the underwater radiated noise from a given vessel is a result of propeller cavitation and much work is being done to identify solutions related to the design and construction of vessels as well possible operational changes which could reduce the underwater radiated noise. While IMO has produced guidelines on the reduction of underwater noise (2014), it is expected that at least one IMO member state will propose the addition of this issue to the MEPC work plan for future discussion and potentially the development of mandatory provisions.

CONCLUSION

Global marine transportation is vital to the world's economy, moving a vast majority of goods and bulk materials to the world's population in the most environmentally responsible manner of all transportation modes. Notwithstanding, the importance of to the global economy, it is recognized that the environmental footprint of shipping should, and is being continuously reduced, by the initiatives described above. The global industry, through its work at IMO, supports these and future initiatives which will reflect our continuous improvement on environmental issues. CSA is also proud to continue to work with executive branch agencies in the US to address these issues at the national level.

Ralph Waldo Emerson once said "Life is a journey, not a destination". A Chinese philosopher once said "A journey of a thousand miles begins with a single step". Nothing could be truer for the global maritime industry and its march toward sustainable shipping.

Thank you for the opportunity to testify at this hearing. We would be happy to answer any questions.

Mr. MALONEY. Thank you, Ms. Metcalf. We will now proceed to the Members' questioning, following the 5-minute rule. I will begin by recognizing myself for 5 minutes.

I have the great honor of representing the Hudson Valley of New York, which was named after Henry Hudson, of course, who sailed up the Hudson River in 1609, September 1609, and actually camped in a little spot—you can see it from my back yard—called Con Hook, about 40 miles up the river, September 14th, 1609. And he, of course, began a process of using that river and so much of our water infrastructure to move goods and services, conduct discovery, and create the American economy. And this was all done by wind.

And so what is interesting to me is the role that wind power may play in maritime shipping. It is not exactly a new idea, but can you comment on the role that wind-powered vessels may play in helping us achieve some of the goals we are discussing today?

It is for any member of the panel.

Mr. BRYN. Thank, Mr. Chairman. ABB does not, I don't believe, directly play in this space, currently. But there is—there have been—I would point to two interesting technologies, one of which are sort of kites and sail technology. There are some challenges there that I am probably not in a position to speak to. But there are some technologies there.

There has also been—for the first time we have seen commercial deployment of an idea called a Flettner rotor, kind of these tall columns that spin and kind of generate lift and actually help pull the ship along. So it is an interesting technology, and worth a look at, if you are not familiar with it.

Mr. BUTLER. Mr. Chairman, just to add to that, my expectation is that, at the end of the day, we will see more contribution from wind power on land to create green processes for future fuels. In other words, if you are producing hydrogen, you need to do it in such a way that you are using carbon-free electricity, right?

So my guess is, at the end of the day, while some of these technologies can—well, shipboard technologies can contribute to efficiency on the water, the biggest impact from wind is going to be in producing fuels on land that are then carried by vessels.

Mr. MALONEY. And building off of that, I am interested in your remark, Mr. Butler, but anyone feel free to answer, that there is a technological layer, or an incentive layer that is going to be re-

quired to move to zero emissions past the 2050/50-percent reduction benchmark you mentioned. Could you elaborate on that?

And what kind of incentives and assistance is the industry going to need to make that goal of zero emissions attainable in time to do us some good?

Mr. BUTLER. So, I mean, the basic premise is no matter how efficient you make a diesel engine, you are still burning diesel, and you are still creating carbon dioxide as a combustion byproduct. So if we are going to get to zero emissions, we simply have to have a different propulsion mechanism using a different fuel, different technologies, and having a different emissions profile.

So the single most important thing that we can do right now is to create and develop for commercial application those new technologies. We don't know what they are right now, there are candidates. We have talked about hydrogen. People have talked about ammonia, and using hydrogen either as direct burn or in fuel cells. But there are tremendous engineering questions with respect to the production of those fuels, the handling of those fuels, and the safe use of those fuels on board.

So, you know, there are lots of discussions going on in various places about how you push people to adopt new technologies, carbon pricing, and this sort of thing, more regulations. The fact of the matter is, unless that pathway exists, you can flog people all day long, but if they have no place to go, the change won't happen. And that is why we are so focused on the research and development piece.

Mr. MALONEY. And let's talk about the shoreside infrastructure. What could we do in that regard to make the decarbonization of that, of the import process, come about more quickly?

Mr. BUTLER. Well, there is the—you know, you have to do things in the proper order. Before you start talking about investing in shoreside infrastructure, you need to know what fuels and propulsion systems you are trying to support on the ships. Right?

So it is all of a piece, but I think you would risk stranding a lot of investment, or making the wrong investments if you jumped too quickly into picking a particular shoreside infrastructure before you know what the end goal is. So I think a lot of what can be productively done by Government is to assist in figuring out what the right order is, and supporting it, each phase of that process, you know, the thing that has to happen next, before you can get to the next phase.

Mr. MALONEY. Ms. Metcalf, and my time is expired, I will yield to Mr. Gibbs, but if you want to say a word on that——

Ms. METCALF. I just wanted to add one thing, Mr. Chairman. Thank you.

There is no doubt that ports and shipping are going to have to work together, and we need to start now, and we actually have started talking. John put it well, saying that the order of things is the most important.

But the one thing—and I will cite the American Bureau of Shipping classification society and DNV GL classification society have done a number of studies. The DNV GL, particularly, I would recommend. It is called the Energy Outlook 2050, and there is a great chapter in there on transitional fuels.

So the key—and my point in intervening here—is we don't go from traditional marine fuels now to zero fuels. There are transitional fuels—fuels such as LNG is a good example—that we need to be able to build the infrastructure ashore, so that the new LNG-fueled ships are able to use that fuel, instead of having to go back to conventional. Thank you.

Mr. GIBBS. Thank you. Again, I think you make a good point about the transition fuels.

I want to ask Dr. Kindberg. I have seen those big containerships. What is the average age in your fleet? When you put a ship on, how long do you expect it to be in service?

Ms. KINDBERG. The life expectancy of those ships is 20 to 25 years, but the average age of our fleet is somewhere around the 7-year mark.

Mr. GIBBS. OK. So the transition is a huge deal.

Ms. KINDBERG. Oh, yes. It is a big deal.

Mr. GIBBS. Are you looking at—are any of your ships fueled with LNG or not?

Ms. KINDBERG. We do not currently have any ships that are fueled with LNG. A couple of our competitors have one or two. But it is definitely a bridge fuel that there does need to be infrastructure for. Just like for biofuels, there will need to be infrastructure.

And we think biofuels will be perhaps another bridge fuel, but perhaps a long-term fuel, because with biofuels you take the carbon dioxide out of the atmosphere to grow the plants. Then you make that into fuel and you burn it immediately. So there is no new carbon dioxide. Whereas, if you take it out of the ground as a petrochemical, you are actually adding new carbon dioxide to the atmosphere. So there is a difference, and biofuels will absolutely be part of this blend. But we have to do that intelligently, too——

Mr. GIBBS. LNG also, I believe, when it comes to particulate matter, is zero emissions on oxide, sulfur oxide and nitrous oxide. It is close to a 100-percent reduction in emissions, and probably is, what, 40-percent reduction in greenhouse gases?

Ms. KINDBERG. I don't know that number off the top of my head.

Mr. GIBBS. Mr. Berger, I understand that the Governor of Washington has come out in opposition to building a new LNG fueling facility in Tacoma. When we talk about transition, is the Governor of Washington State more inclined to just wait until new technology comes, maybe two, three, four decades away, and not look at a transition fuel like LNG?

Mr. BERGER. Thank you, Ranking Member. So I understand that many in this sector investing in LNG and infrastructure to meet immediate timelines, particularly in the IMO and—in Washington State, Governor Inslee wants to focus on zero-emission solutions.

My role is to be a liaison and facilitator. Washington Maritime Blue is a member-based organization that is set up to support each of its member goals. The commitment it makes is to be a convener around some of those difficult questions in a thoughtful dialogue.

Another example like that is automation. These are tough questions that we need to have as we make major transitions across the industry. And as a cluster, if we are able to bring together all those multiple stakeholders to work on a common vision and how we get to sustainability, how we get to zero emission, we need to figure

out ways to address those difficult questions. And as a cluster organization we are able to facilitate that.

As long as we are making decisions that are based on science, and seek to balance those three prongs that we are helping to grow our maritime sector, we are making healthy decisions for our ocean and marine ecosystems, and——

Mr. GIBBS. And also looking——

Mr. BERGER [continuing]. Communities.

Mr. GIBBS. [continuing]. At those decisions. Have you factored in the economics? Because we don't want to put our companies, our shippers in a very disadvantaged competitive position, compared to the competitors elsewhere. Is that a factor?

Mr. BERGER. Yes. Keeping a viable, economically viable and forward-thinking innovation sector is absolutely a factor.

Mr. GIBBS. Mr. Bryn at ABB, the technology for batteries—in your testimony—from the last several years has just exponentially improved. When you talk about your ships that are ferrying across the waterways, recharging them in 7 minutes, and I know you got the—working out there in Washington State—I believe it is Washington State—with a huge megawatt—recharging in, like, 15 minutes. We are talking about 15 megawatts, right?

Mr. BRYN. Correct, yes.

Mr. GIBBS. Have you guys done any research or studies? You know, obviously, that would be a zero-emission vehicle, vessel, OK? But are we just moving one emission from here to there? Because the generation to generate that kind of megawatts—has anybody looked at that situation, so we are just not moving emissions from here to there, and not really addressing a net reduction?

Mr. BRYN. Yes, absolutely. I appreciate the question, and it is a very good one. It comes up often.

One thing I would like to point to—I am looking through our written testimony here—figure 7 shows an example of a study that we have done for a typical ferry, and it shows the estimated CO2 impact of different design decisions.

So you are absolutely right, and I sort of look at this as sort of a two-phase process. The first is does it help with emissions today, and does it help with emissions long term?

And what I mean by that is if we are, for example, going for an electric ferry, the immediate impact will be whatever the CO2 and other emissions of the grid are. How does that compare to a diesel engine? And what we find is, even in the most conservative case, where you are getting all of your power, for example, from coal, the electric vessel does tend to be lower carbon and lower on a lot of other pollutants than the diesel equivalent. And it is because the coal plant can do a lot of waste heat recovery and after-treatment, things like that.

So, in the short term, the answer is almost always yes. And that is, like I said, the most conservative case. If you are getting your power from hydropower or gas or something, it would be improved.

In the long term I think we also have to recognize that the grid continues to clean itself up. And so we would like to get this technology deployed in parallel, so that, as the grid cleans itself up, we also have an——

Mr. GIBBS. I am out of time. Just one quick comment.

Mr. BRYN. Sure.

Mr. GIBBS. The infrastructure of the grid and our base generation capacity to do what you are talking about, because you are talking about recharging a vessel, one vessel, 15 megawatts. I mean I can just see the powerplant going—you know, melt down. But the challenge is there.

Mr. BRYN. Thank you. Yes, it is a challenge. We are working with utility partners to make sure that is feasible.

I should be clear. For the Washington State Ferries project we are not currently selected for that. We are hopeful to be, but that has still not been decided yet. So I just wanted to be clear, we are not a partner on that yet. Hopefully.

Mr. MALONEY. I thank the gentleman. Mr. Larsen?

Mr. LARSEN. Thank you.

First off, I want to thank the ranking member for his concern about issues in my State. I appreciate that.

Second, Mr. Berger, on the electric ferries, can you—first off, thanks for being out here and testifying. What is the cost of the transition to electric ferries? This is a retrofit and not a new build, is that correct?

Mr. BERGER. Thank you, Congressman. So we actually have both going on at the same time. We are both retrofitting what we call our Jumbo Mark IIs, starting with the first vessel, which will be coming out of the water soon—that is now under contract—as well as a new-build construction. The State legislature has paid for the first, a series of five new-build constructions. So it is a retrofit to a hybrid electric, as well as new builds.

The new-build vessels, we are looking at about $15 to $20 million more, upfront costs, which would also be inclusive of the shoreside charging mechanisms that need to be. It is very similar, almost same design as the previous *Olympic*-class vessels, but with new propulsion systems.

Mr. LARSEN. And then the anticipated life-cycle costs relative to a new-build diesel?

Mr. BERGER. Well, when we were looking at the battery technology, we are slating for—Mr. Bryn might be able to answer this, because he is putting the bid together for it, but I think——

Mr. LARSEN. I won't ask him that——

Mr. BERGER [continuing]. The batteries were about 5 to 8 years. We are bringing that cost comparison right now.

Mr. LARSEN. Oh, you are? OK.

Mr. BERGER. As we look at some of those key challenges when we are talking about particularly kind of this both/and approach, and making sure that we are paying attention to the entire system, yes, we need to be looking at that grid at the same time.

We are very fortunate Washington State makes this a great place to start building and proliferating this kind of technology, because we have some of the cleanest and cheapest power in the United States. And so it is a great place for us to build on these vessels, to make the ROI come back right in less than 10 years, if not sooner.

But the attention and the investments that need to be made to kind of build smart grids and have the grid capacity to support charging up to 10 megawatts of these vessels is also critical, as

well as we look at other technologies, like energy storage onshore in order to kind of take care of the peak shaving on the grid. All that is under consideration, and we need to invest in it.

Mr. LARSEN. So in the—in testimony from—a few of you have talked about the relative ease of passenger vessel implementation here, because you have set schedules and so on. The State, our State, has a larger system, but they are a smaller, county-based system. Specifically Skagit County, as you know, the Guemes Island Ferry. They just need one ferry to replace. And they are trying to move forward on getting an electric ferry for that.

Is that something the State does support, or do you have ideas about how these smaller systems can fit into a larger maritime blue strategy?

Mr. BERGER. You are exactly right, Congressman. You know, so smaller ferries, both in our county system as well as when we are taking into account the growth of a high-speed passenger ferry fleet—as population growth across western Washington is so astronomical, there is more and more look at bringing that mosquito fleet back—there are lots of mechanisms in place within the State, and we are looking for others, as well.

We have our clean energy fund, we also have the opportunity to bring in some private investment, right. As we start talking about those opportunities for operational savings, it starts to make sense to bring some private investment into some of those projects.

Of course, each of those ferries look for both that kind of hybrid stack of capital, they are looking at opportunities for various different Federal funds, State funds, and private dollars. All that is necessary. What we are fortunate to do is now have a mechanism in place to help support those type of projects, go out and seek, and then receive those various different types of funding into a particular project. And the cluster organization is there to help support that.

Mr. LARSEN. Thanks.

Dr. Kindberg, our U.S. Navy has a lot of ships, but there are a few ships that are hybrid. And the idea is that, when they are underway, they can switch to an electric drive, so—because they are just going in a straight line, they don't really need to be doing anything much else. But when they are getting in—out of port and into port, they need to have a little more maneuverability, a little more control, and so on.

So I am wondering if, looking at the larger oceangoing vessels, if that is an option, or are we looking at one propulsion system, one kind of propulsion system, or a hybrid system for the 2030 or even the 2050 timeframe.

Ms. KINDBERG. No, I am not really familiar with what the U.S. Navy might define as a hybrid.

Mr. LARSEN. Sure. All right. Well, answer my question, then. What are you looking at?

Ms. KINDBERG. What are we looking at? We are certainly looking at batteries, we are looking at new fuels. But we have also added waste heat recovery. We have changed out propellers to be much more energy efficient. We have changed out bulbous bows. We actually give the vessels a nose job. You cut off that bulbous bow and weld on a new one, so that it is more energy efficient at today's

speeds. And then, of course, you have all heard of slow steaming. And then we have got new, larger, more energy-efficient vessels per container.

So those are all different approaches that we have taken to try to push this forward and achieve that 42-percent reduction that we have achieved so far.

Now we are going into new technologies, what we call the connected vessel strategy, so that Big Brother actually is watching all of those ships, and monitoring all of the different engineering sensors, and making sure that we are squeezing that last bit of energy out of what is on the vessel.

Mr. LARSEN. Thank you.

Thank you, Mr. Chairman.

Mr. MALONEY. I thank the gentleman. Mr. Weber?

Mr. WEBER. Thank you, Mr. Chairman. I hope we get a second round. I have got three pages of questions.

Mr. Butler, you talked in your comments about a 2030 goal, a 2050 goal, and going forward. And has there been any thought to nuclear, and just powering these ships that would be nuclear?

Mr. BUTLER. Well, that has been a debate, sir, that has been going on for years. My personal take on that is that the politics of that are going to prevent it from ever being a widespread solution for——

Mr. WEBER. It hasn't prevented it thus far, has it?

Mr. BUTLER. Well, for the commercial fleet——

Mr. WEBER. That is a joke, Mr. Butler; of course it has. Thank you.

Well, let me move on. So the focus is away from fossil fuels, although I am hearing Dr. Kindberg talk about—was it cooking oil as a substitute? What were you calling that?

Ms. KINDBERG. That fuel is actually pretty limited in availability, because it is actually made from used cooking oil that is collected in Europe.

Mr. WEBER. Right. Well, you want to talk about needing infrastructure, OMG, you really need infrastructure there to collect all that.

Are we really talking about just completely doing away with—is Maersk thinking they're just completely doing away with combustion engines?

Ms. KINDBERG. One of the early moves that we will make will be biofuels, and that is why I mentioned it, again, earlier. Because, again, biofuels are considered renewable, and that carbon, when you do the carbon accounting, doesn't count, because it is taken out of the atmosphere and returned quickly back to the atmosphere.

Mr. WEBER. OK. If you do biofuels, again, you are still back to an infrastructure need. Correct?

Ms. KINDBERG. Yes, sir.

Mr. WEBER. How do biofuels compare, for example, to—I will use LNG. We will move off of diesel. Hopefully that is our goal, here. How do biofuels compare to an LNG-powered vessel?

Ms. KINDBERG. Biofuels is a broad category. There could be bio-LNGs that could be derived from biological sources, but would still need the infrastructure to be delivered to the vessel.

Mr. WEBER. Well, if you are talking about liquified natural gas, now you are talking about storage where you have got tanks that are really, really cold, cryogenic storage. Now you are talking about some really, really major—you know, I have five ports in my district in the gulf coast of Texas. We do a lot of energy. We export a lot of LNG, and so this is extremely important that we are talking about it.

And I think you also said that an 80,000-horsepower engine was most efficient. Can you—I am just trying to read my notes here, I was scribbling quickly. What did you say about 80,000-horsepower engines?

Ms. KINDBERG. That was an example—our engines, unlike some of the military ships, our vessels operate with one great, big diesel engine.

Mr. WEBER. OK.

Ms. KINDBERG. And one big propeller. Some of the biggest ships today do actually have two engines and two propellers. But it is—we don't have some of the flexibilities or the costs that the military has.

Mr. WEBER. Right. Well, you know that submarines were dual-powered, where they ran on batteries under water, of course, and they would surface and recharge with diesel engines, their batteries. Have you looked at kind of the dual set-up like that?

Not necessarily diesel; it could be LNG or biofuels, or whatever, and then batteries. Yes, ma'am?

Ms. KINDBERG. Continue? Yes, thank you. We are looking at batteries. As a matter of fact, we have got a battery being shipped to a vessel right now for on-board testing. But there are also concerns about risk assessments, in terms of large batteries.

Mr. WEBER. How does the size of that battery compare to, say, a fuel tank, in terms of—you are going to use up cargo space, right, if you have too big of a fuel tank, or too big of a battery. How does a battery size compare to a fuel tank, do you know?

Ms. KINDBERG. Well, the battery we are going to be testing is the size of a 40-foot container. So it is 40x8x9 feet. But it is not going to be capable of moving the vessel. It is going to be used for peak shaving

Mr. WEBER. It is going to be used for what?

Ms. KINDBERG. Taking off the peak when we need to generate more power than the main engine is normally generating. So we might have to start up an auxiliary generator.

Mr. WEBER. OK.

Ms. KINDBERG. We would use the battery instead.

Mr. WEBER. You mean for, like, living quarters, or operation of the ship?

Ms. KINDBERG. A lot of our energy is used for pumps and valves, but it is also used for refrigerated containers, because there is a tremendous amount——

Mr. WEBER. Oh, sure.

Ms. KINDBERG [continuing]. Of refrigerated goods moved.

Mr. WEBER. So that is interesting, because you could take a couple of 40-foot 8x8 containers and have a pretty good energy supply there.

And you are going to see if the battery lasts, is that what your—because you know what the footprint is. Are you looking for how powerful it is? What are you looking at?

Ms. KINDBERG. Well, again, the battery that we are going to be testing is not even capable of operating a vessel at—alongside at shore for multiple days.

Mr. WEBER. Yes, but how about it——

Ms. KINDBERG. It is a first step.

Mr. WEBER. How about the refrigerated units? How about vessel lights and comfort? Will it do that?

I am not talking about powering the ship, but I am just talking about running the living quarters, for example.

Ms. KINDBERG. It could run part of them.

Mr. WEBER. OK. Lots of questions. Thank you, Mr. Chairman.

Mr. MALONEY. All right, thank you, Mr. Weber. Now to the newest member of the subcommittee, who enjoys his own fan club among the witnesses, the gentleman from Pennsylvania, Mr. Lamb.

Mr. LAMB. Thank you, Mr. Chairman.

Welcome, everyone. Thank you for coming. I would like to shift the discussion a little bit towards vessels on our inland waterways.

Western Pennsylvania, where I live and represent, has one of the largest inland ports in our country in Pittsburgh, with a lot of boats, mostly tugs and barges, on our three rivers. And we were the beneficiaries of a very interesting Government initiative a couple of years ago in which the U.S. Maritime Administration made a $730,000 grant to the Pittsburgh Region Clean Cities, which covered about half the cost of retrofitting a single towboat to go from diesel to natural gas/diesel combination.

So it was about a $1.4 million project, single boat, dual fuel system. It decreased diesel by about 60 percent, overall. And they have been monitoring ever since how it has been working, but this is a boat that I think was built back in the 1940s, so it is a pretty old vessel that they were retrofitting to do more work with.

So I think it sounds like a great idea. I am happy we did it to demonstrate that it could work. And I guess my question to the group is, hearing that, is that a good use of Government investment dollars at that price, to be retrofitting these old vessels? What are some other options in that category, particularly as it relates to LNG?

Because I share some of my colleagues on the other side's interest in using LNG more, especially what we produce in western Pennsylvania. And I do think it could be what Ms. Metcalf called a transition fuel here. But obviously, it is all about price, retrofitting versus designing new engines that would require LNG, as well.

So I know that is kind of a lot in there, but any thoughts folks have on that?

It looked like Mr. Bryn and Ms. Metcalf both, so maybe we could start on the end with the sole member of my fan club there, and then move over. So——

Ms. METCALF. I promise we will promote it, we will get you some more members.

My opinion? And we do have some tug barge members. The American Waterways Operators has a primary inland coverage.

Generally, what we find in large and small vessels, if you are going to incorporate new technology, it is cheaper to do it at new construction. Retrofitting—I think it is great they did this project, but retrofitting a 40-year-old vessel just doesn't make a whole lot of financial sense to me, other than to see if it can be done.

Now, keep in mind, also, vessels on the Great Lakes are not at that 20- to 25-year lifespan. They are—there are some of them up there 50, 70 years old, I believe. OK, well, I am old, too, but I don't want to get too old. So it is a different marketplace up there, as well.

The other thing about alternative fuels on the Great Lakes, or electricity, is that you have got shorter runs. You don't have 5,000 miles of Pacific Ocean that you are having to transit. You have got stops in between that you may be able to integrate a shore-based infrastructure of fuels and/or electricity that would be alternatives.

Mr. LAMB. Thank you.

Mr. Bryn?

Mr. BRYN. Thank you for the question, Congressman. Yes, this is a topic that is sort of near and dear to our hearts. We have been working with the inland industry, and the inland towboats—it is a very interesting industry, and towboats come in all flavors and sizes.

For example, there are what we call unit towboats that might run from a refinery in Congressman Weber's district and drop off some barges up in your area. It is a very, very interesting system. We have unit towboats, there are linehaul towboats, which push 40, 50 barges at a time on kind of a regular liner service. There are shuttle boats that run up, across the river.

My point is that, depending on the vessel's profile and need and its service, the best solution can vary quite a bit. And so, what we have found with a lot of boats is what is common—if you take linehaul boats out of it and look at the rest of the types of boats, a lot of them do a lot of time actually sitting around. If it is a shuttle boat, they will be sitting alongside a barge for hours, days on end sometimes. When you get up into the locking river, where you all are, it would be spending a lot of time going through the locks.

And anyway, at that low power, oftentimes these engines need to still idle, because the crew still needs instant power if, you know, in the event of an emergency or something.

And so, what we found is a diesel-electric arrangement, while not zero emissions, can reduce engine running hours quite a bit. And then, if you add a battery, you can also just shut the engines off altogether, run off battery for a few hours. It can save quite a bit of fuel, and it is—you know, it is just a nicer environment for the folks on board, as well.

So there are solutions. The key is fitting the right solution to the vessel. And that can work with LNG or diesel fuel.

Mr. LAMB. Yes. I guess what I am asking is, you know, within the Government we always—oh, and I am basically out of time, so I will save that thought for next time and yield back to the chairman. Thank you.

Mr. MALONEY. I appreciate that. I thank the gentleman.

Mr. Lowenthal?

Mr. LOWENTHAL. Thank you, Mr. Chair, and thank you all, members of the panel.

As you know, I represent one of the largest port complexes in North—well, the largest in North America in Long Beach/L.A. So I am interested in something that we started a number of years ago, or California started, and that is—I am going to first ask Mr. Bryn—and that goes to your—in your recommendations about solving the shore charging, and talking about shore charging. I think that the rollout of shore charging and shoreside power systems is vital to be moving in this direction.

For example, in my community, as I mentioned, the L.A./Long Beach, we have driven substantial reductions in localized diesel emissions. And we are an area that is out of compliance, so this was critically important, not only to move the industry, but to protect our communities, which are—which—we have this tremendous movement of goods in an area that is very densely populated and ecologically tends to capture this pollution and let it sit, unless we really try to prevent it.

So we have driven substantial reductions in localized diesel emissions through investment in dockside power in a State mandate for commercial vessels to use shore power. But we know that the adoption of this technology has been lagging across the country. And an EPA analysis in 2017, that found that, outside of California, only a handful of ports have any shore power capacity.

And you talked about also—Mr. Bryn—about possible grants. And I know—if Congress made additional Federal grants or loan funds available to install shore power infrastructure, do you believe there is an interest at ports and terminals to adopt this technology without a mandate?

And I want each—you know, we can start with Mr. Bryn, and then we are going to ask Dr. Kindberg.

Mr. BRYN. Yes, thank you, Congressman. The Clean Air Action Plan in California was certainly a model, and it was forward-thinking, for sure. And it has led to a lot of the development.

We should be clear about shore charging. First of all, there are a few flavors. One is to plug in vessels like Maersk's when they arrive at the terminal to power the on-board load while they are at port. The other flavor is to charge up, like, a battery bank on a ferry or a tug in between voyages. Both have their own challenges.

I would say, on the side which I think you are more referring to, which is charging oceangoing vessels, there are opportunities there. One of the challenges—well, I guess I would say two challenges, generally. One is that many vessels, especially older vessels, are not outfitted with the equipment. So, you know, that needs to be an upgrade done on board.

The second challenges is that not all vessels are, let's say, obviously suited to it. So, for example, a containership or—a cruise ship is a perfect example. A cruise ship has an electrified power system. A containership, most of the loads that are happening on board are electric in nature, whether it is running the reefer boxes or the on-board loads, pumps, things like that. A bulker, though, doesn't have a lot of load when it is in port. A crude oil tanker runs a steam pump to offload its cargo.

So my point, again, just like before, is it depends. And so, finding the right solution for the right vessel can be a challenge. And that may be——

Mr. LOWENTHAL. But you could duplicate this not everywhere, but certainly in certain ports. It could be more widespread.

Mr. BRYN. It certainly could be, but we would have to, as an industry, look at making sure—there is standardization already, making sure that is there, and making sure, you know, that all new vessels are outfitted——

Mr. LOWENTHAL. Well, then I want to go to Dr. Kindberg, and asking is the industry ready to convert to shore power.

In your testimony you did mention that Maersk uses cold ironing in California. Could your fleet use shore power if the infrastructure is put in place across the country?

Ms. KINDBERG. We are actually connecting today in China.

Mr. LOWENTHAL. Pardon?

Ms. KINDBERG. China has been adding infrastructure very rapidly. As you know, they have very serious——

Mr. LOWENTHAL. Onshore power, too. So the United States——

Ms. KINDBERG. So the vessels calling in California are also now connecting in China.

Mr. LOWENTHAL. What about other ports in the United States? Would you be able——

Ms. KINDBERG. The barrier, I think——

Mr. LOWENTHAL [continuing]. To connect to shore power?

Ms. KINDBERG. We don't have many vessels calling the east coast that actually have full shore power capability. Only about 5 to 8 percent of the global container fleet is currently fully equipped for shore power. It is about $1 million per vessel to equip it for shore power, and then per berth you could be talking anywhere from $1 to $5 million, plus the infrastructure to bring the power to the port.

And, as you know, California bit the bullet and has made those big investments.

Mr. LOWENTHAL. Right, California——

Ms. KINDBERG. But other places——

Mr. LOWENTHAL [continuing]. Wants to protect its residents and the community. And so it made those investments.

Ms. KINDBERG. Right, but other places have looked at that and then decided perhaps they could get their reductions in other ways that were more cost effective. But, of course, California had already been through clean trucks and those things.

Mr. LOWENTHAL. Do you think it is good to be moving towards more shore power throughout the——

Ms. KINDBERG. I think it is, but I think we have to find ways to do it more flexibly.

Mr. LOWENTHAL. Thank you.

Mr. Chair, I yield back.

Mr. MALONEY. I thank the gentleman. We are going to proceed to a second round of questions, with the witnesses' indulgence.

Before we do that, just a point of personal privilege. I wanted to thank the person sitting next to me, whose name is Rennie Meyers, who has been here with the committee on a 1-year fellowship, NOAA's Sea Grant Fellowship, and has done great work for the committee.

She is sitting in this chair today, normally occupied by the gentleman behind her, in recognition of her great work for the committee and her extraordinary skill in many areas, but especially in the areas of environmental concern. She will be going to another important position, where she will continue to support the committee. So we thank Rennie for her work.

Proceeding to the second round, Doctor, if we could just finish up on some of the questions that my colleague from California was asking you, I am interested in the investments the Chinese are making that you alluded to. And, if you could, describe why that would be important to the Chinese Communist Party to make those investments.

Ms. KINDBERG. China has a very serious air quality problem. And so they have been looking at best practices around the world, and imitating some of those.

So, as we begin to fuel switch here—and you were there when we first started doing that—they made that voluntary and then mandatory to use cleaner fuel in ports. And that is a very good way to reduce the sulfur that, as you mentioned, Mr. Chairman, does have health effects.

They also are having the vessels connect to shore power, and then you turn off the engines, so there is no engine exhaust. And that way it reduces the air emissions, the toxic air emissions that are created while you are alongside.

Mr. MALONEY. And what kind of investments are we talking about by the Chinese Government in that regard?

Ms. KINDBERG. I don't know what the total is, but I know that there are about 12 or 14 ports that have very quickly installed shore power capability on lots of berths.

Mr. MALONEY. Is that going to merely serve an environmental purpose in China? Or will there be international economic opportunities for that technology, that type of equipment, in shoreside infrastructure that the Chinese can then export?

Ms. KINDBERG. I believe a lot of us are actually using Italian-made—although they may be produced in China, but in terms of the plugs and so forth——

Mr. MALONEY. And in terms of the U.S. industry in that regard?

Ms. KINDBERG. I am not aware of any U.S. industry that is doing that.

Mr. MALONEY. Right. And in other words, I am interested in the types of investments, in response to Mr. Weber's questioning about batteries, and the critical role they can play, and the size and the safety issues, what role could robust Federal investments in battery technology play in assisting you in that effort?

How much of that currently is being borne by the private sector?

In other words, that is a generic technology, to Mr. Bryn's point about making the technology fit the mission or the vessel. But there are some basic, core technologies involving an enormous need for research and development.

Help us understand what role the Federal Government could play in assisting private industry and moving that to market in a cost-effective way.

Ms. KINDBERG. There are tremendous opportunities, but tremendous challenges, in terms of coming up with energy storage. And

it is not just the maritime industry, it is our entire economy. That is a game-changer, if we could come up with cost-effective ways to store energy, and not just have to take it as it is made.

So battery technologies would be a game-changer, not just for the maritime industry, but I think our whole economy.

Mr. MALONEY. But from your perspective, is the private sector going to be able to get there on its own, or do we have a role to play?

Ms. KINDBERG. I think I would have to turn to those who know——

Mr. MALONEY. Sure.

Ms. KINDBERG [continuing]. Better than I do.

Mr. BRYN. Thank you, Mr. Chairman. So, looking at battery—looking at marine battery technology, specifically, if you look at the cost structure for some of our marine battery manufacturers, when I talk with them, they say that the cost of the cells—which is the fundamental building block of the battery banks—it is on the order of about 20 to 30 percent of the overall cost. And the remaining 70 percent is specific to a marine-built battery with—and, obviously, safety is always paramount, and we have a very high standard in the maritime industry.

So that is to say that—I would say that about 20 to 30 percent of the cost is going to benefit from the global trend of high battery volume production, so that cell cost will come down, just following global trends. The remaining 70 or so percent, that is up to maritime to get that cost down. And that is going to be a challenge, because it is generally a low-volume industry. So I think that is where we can help some of our marine battery manufacturers out.

And I am happy and proud to say that, despite the fact that Europe is leading on actually deploying a lot of these battery technologies, we actually have a lot of manufacturers right here in the U.S. that are actually supplying some of those, two in the U.S. and one in Canada that are some of the global leaders on marine battery systems.

Mr. MALONEY. On a different subject, would the panel comment on the role the Coast Guard plays in the international enforcement of some of the issues we have been talking about?

It was touched on in some of the testimony. What is the most effective international enforcement mechanism?

And can you talk on the role the United States Coast Guard will play?

Mr. BUTLER. Mr. Chairman, the entire international enforcement regime, basically, has two prongs. It is flag-state control and it is port-state control. And the U.S. Coast Guard, a primary role when we talk about enforcing these environmental laws, with respect to international ships it is primarily a port-state control operation.

So it is a question of having the Coast Guard have the necessary staff and the necessary tools to efficiently inspect vessels to make sure that they are complying with these various regulations.

And, as Dr. Kindberg said earlier, it may sound a little strange for industry to be calling for more enforcement, but the issue of having a level playing field and making sure that we are not distorting commerce here is quite critical.

Mr. BERGER. I would say the other key role that the Coast Guard is playing there in terms of inspections is working closely with industry as we are commercializing new technology.

So other maritime authorities around the globe have clear standards, let's say, for battery technology, in particular. But the United States Coast Guard is working hard and working closely on a case-by-case basis for all battery-operated systems. We do not have a clear CFR within the Code of Federal Regulations on battery technology and battery systems on board vessels.

And so the role that they can play—and I know they are working hard to do that, and they are in support. But on—at this point they are still working on a case-by-case basis, versus having a clear regulation in place to support that. And what that does is help industry then make investments as they are commercializing new technology, and that is working their way up into the fleet.

Mr. MALONEY. Thank you.

Mr. Gibbs?

Mr. GIBBS. Thank you. I know Mr. Butler talked about the IMO making it by 2050 is probably unlikely, the IMO requirements. But I want to pursue this a little bit about the technology with Dr. Kindberg.

What are the horsepower requirements of these containerships? They are big ships.

Ms. KINDBERG. Again, it depends on the size of the vessel. But when we talk a small vessel, we are talking something that is 1½ football fields long.

Mr. GIBBS. Yes.

Ms. KINDBERG. And when we talk big, we are talking four football fields long. So these are big ships.

Mr. GIBBS. What kind of horsepower are those engines?

Ms. KINDBERG. And the biggest ones might run two engines that are 55,000 horsepower.

Mr. GIBBS. Are those direct mechanical—not—they are not running motors. So running a propulsion system, it is mechanical, right, or——

Ms. KINDBERG. It is one big propeller or two big propellers, depending——

Mr. GIBBS. So it is a mechanical, off the——

Ms. KINDBERG. Yes, and you have got a main shaft.

Mr. GIBBS. Go to Mr. Bryn. When we are talking batteries, talking—to make that kind of energy equivalent, what kind of—the battery technology—I know we have made big strides in the last few years in battery technology, but are we anywhere close to having that kind of technology to have a battery technology to propel through electric motors? That would help the quieter issue, too. That is another issue. Where are we in that?

Mr. BRYN. Yes, thank you, Congressman. The short answer is no. And I wouldn't expect batteries to ultimately be the solution for oceangoing vessels. I think batteries may play a role. They will continue to improve on space and weight and cost, which are the three main factors that we have to consider.

I don't think, long term, we ever expect batteries to have sufficient energy density for a containership. Where ABB would likely expect one potential candidate, are—as I mentioned—fuel cells, and

that is because you get much greater energy density in hydrogen fuel than you do in batteries.

So—but batteries may have a role to play, even with fuel cell systems, because they can handle transient loads much better. So if you have an instant ramp-up or ramp-down of power, the battery can help to keep the fuel cell on a steady output. But fuel cells are one of several solutions being considered, and it is certainly one that we are focused on.

Mr. GIBBS. Dr. Kindberg, is Maersk looking at fuel cell technology or not?

Ms. KINDBERG. We are looking at it. We are not currently using it, commercially.

Mr. GIBBS. I yield my—thank you.

Mr. MALONEY. Mr. Larsen?

Mr. LARSEN. Thank you.

Mr. Berger, on the maritime blue strategy that you have, that we have in the State, can you comment? Based on your experience as a merchant mariner, as well as working in the maritime beyond that, can you comment on what you are planning to do with regards to workforce development to support these changes?

It seems that sometimes we can flip a switch on the economy and move on, but this is new technology, new research and development that seems to require maybe not all new skills, but some new thinking on how we develop that workforce. What is the State doing to prepare for that?

Mr. BERGER. Absolutely. Thank you, Congressman. This is another area where I am a firm believer in that "yes, and" approach. As we are looking at new technology, we are focused on innovation, and we are focused on that investment.

Exactly to your point, we need to be focusing on what the next generation maritime workforce looks like, and how we approach that. This is a topic, worldwide. In Washington State the average age working in the industry right now is 54 years old. We call it the silver tsunami. The average——

Mr. LARSEN. Just a minute. I am 54 years old.

[Laughter.]

Mr. BERGER. And there is a role for you on board a vessel, absolutely.

[Laughter.]

Mr. LARSEN. I am sure there is.

Mr. BERGER. Yes. The majority of ferry captains——

Mr. LARSEN. I can pour a mean bowl of cereal.

Mr. BERGER. Likewise, likewise. The majority of captains and chief engineers in our State ferry systems are ready for retirement within the next 5 years, the majority of them.

We also have issues around gender equality and underrepresentation of youth of color that are looking at the maritime industry as opportunities. That is particular issues in Washington State. So those are things that we are particularly focused on—Washington Maritime Blue, as a cluster organization, is.

We developed a program called the Youth Maritime Collaborative, and trying to create specific workforce pipelines and pathways that go right into what we call career-connected internships and apprenticeships. It is a big focus in our State of Washington's

workforce development planning. So we are paying particular attention both to making sure that we are providing pathways, or just the outreach and awareness, particularly to underrepresented communities, as well as a focus on the new technologies.

We have done a lot within the State to invest, particularly in our trades-based programs. But much like all of the focus, there have been parts and pieces from the Federal perspective, and focus on both workforce development, as well as in innovation, where we do not yet have a coordinated approach. There is not one agency that is focused on maritime, or that is focused on maritime workforce.

And so, without kind of a concerted effort, without some sort of coordinated approach, we are not able to really make the best use of those dollars, or focus those dollars to where investments are going to make the most sense.

Mr. LARSEN. I know that the State has signed an MOU with the Norwegians. I am not sure which agency in Norway we all signed with——

Mr. BERGER. The MOU is between the Washington State Department of Commerce and Innovation Norway, which is part of their Ministry of Trade, Industry and Fisheries.

Mr. LARSEN. So within that MOU—this is now moving back to the technology side of things—within the MOU, I am trying to figure out how best to kick-start the challenge that the shipping industry has with regards to getting ships that have to be ready in 2030 for 2050, and what role that collaboration plays in developing, and which technologies that can support shipping to meet those goals in 2050.

Mr. BERGER. Right. And even sooner, as Dr. Kindberg was saying.

Mr. LARSEN. Yes.

Mr. BERGER. That is on multiple fronts. The big part of the relationship between Washington State and Norway has been focused on electrification of ferries, in that Norway is a global leader in that work. And so the opportunities for technology and knowledge transfer have been remarkable, as well as some cross-investments.

We have also found great relationships between the different research universities and research labs. So we are setting up meetings now between folks in our department of energy and the Pacific Northwest National Laboratory and the NTNU that is up in Trondheim in Norway that are, you know, diving deep into what these potential new fuel source solutions might look like, whether they are hydrogen or ammonia or likewise.

So, you know, coupled with Norway's expertise on battery technology on ferries, and research institutions that we have, I think, coupled expertise with, that is where—that in line, I think, focuses on where our MOU is between Washington State. And it is about cluster-to-cluster relationships. So they have a built-out system that supports these innovation clusters across Norway.

Again, this is a public-private relationship, where you have competitors working together to create new markets and create new technologies, and with support from Government and support from research institutions. And we have found that that has been the best way to move forward actual commercialized projects that go—that are on the water.

The first all-electric ferry, *Ampere*, came out of a joint innovation project, out of a cluster organization. The first hydrogen ferry that is being built in Norway is coming out of a joint innovation project within their cluster organization. These are federally funded, or nationally funded programs—some of those dollars come from the European Union, as well—coupled with private investment and R&D and their research institutions.

And so, yes, we have, you know, business-to-business relationships with them as we build out projects. We are also learning from one another on how we develop these types of joint innovation projects, but we are coupling national Federal dollars with private investment.

Mr. LARSEN. Thank you, thank you.

Mr. MALONEY. Mr. Weber?

Mr. WEBER. Thank you, Mr. Chairman. Is it Dr. Kindberg or Kindberg? I missed what you said.

Ms. KINDBERG. It is Kindberg, like kindergarten.

Mr. WEBER. Like kindergarten? OK, thank you.

So you said early—well, let me back into it this way. So the American Association of Port Authorities, which consists of Canada, the Caribbean, Latin America, United States, I looked at their website real quick, just for the benefit of the panel and for our group up here. And under their issues they really don't talk about any of this. So there is—we are having a discussion about having ports build facilities, infrastructure, to charge huge batteries on board ships. And shore power, we are calling it.

As I said, I have got five ports in my district, more than any other Member of Congress, and actually ran a transportation company for a short time, which delivered to ships at the Port of Galveston. So I have got some first-hand experience in that.

Any time you ask a port to build a—whether it is electrical, plant, call it whatever you want to—a system of building out, you are going to have to be taking—to power ships you are going to be taking very, very, very valuable real estate to build an energy plant, for example. That is going to take away from some of the local economy, because a lot of these harbors and these shoresides and stuff, the docks, are used to supply these oceangoing vessels.

In the Gulf of Mexico you can go across—down into Galveston, and look during the night, and you can just count all the lights, lined out about 40 miles out, 30, 40 miles out, because—waiting to get in the Houston Ship Channel. If you use that area for electrification, if you will, powering the ship, you are taking up a very valuable berth or docking area that the ports might not be willing to give up, at least at a very low cost.

Are you with me?

If you look at the American Association of Port Authorities website, they have a list of issues, and none of this is being discussed in their issues that I see. So it might behoove us, Mr. Chairman, to bring them in here in the next discussion, and to say, "What say you all about the prospect and possibility of being able to build out this infrastructure, so that we can service these on these oceangoing vehicles?"

I hope that makes sense, because this is a group that really will have a vested interest in it.

Dr. Kindberg, you said early on that there needed to be an agency that could enforce those rules, enforce them fairly, but help—something to the effect of, you know, not necessarily enforce them early on. Kind of as this—you want to elaborate on that for a second?

Ms. KINDBERG. Let me clarify just a little bit. There are those of us who are acting early, just like we fuel-switched early in California, and it cost us about $20 million. But then, when California made it mandatory, we already knew how to do it.

[Pause.]

Ms. KINDBERG. I have lost track of where I was going, I am sorry.

Mr. WEBER. Well, let me fill in some blanks here from another part of your conversation, while you are thinking.

So you said a ship coming from China to Europe could save $750,000 on that one trip. How many trips can they make? Is it one a month? Is it 12 a year? What is it?

Ms. KINDBERG. That trip is maybe 12 weeks.

Mr. WEBER. So it is 3 months.

Ms. KINDBERG. It is—yes.

Mr. WEBER. So we want somebody that is able to enforce those rules, and enforce them fairly. And as—I think what you are alluding to—as the learning curve is happening, you don't necessarily want an agency to come in here and just blast everybody with fines and fees if they are acting in good faith. I think that is what you are alluding to.

Ms. KINDBERG. Well, the point that I was making is sometimes you have people who try something new.

Mr. WEBER. Right.

Ms. KINDBERG. Say if we tried a battery from Mr. Bryn. And then a rule were put in place that made that battery no longer meet the requirements.

Mr. WEBER. OK.

Ms. KINDBERG. You would want to grandfather that.

Mr. WEBER. Sure.

Ms. KINDBERG. And there are also programs that have been put in place by some ports and other entities that have actually provided incentives for going beyond the regulatory requirements.

Mr. WEBER. Sure.

Ms. KINDBERG. And those have been very effective in some places.

Mr. WEBER. And those are voluntary, by the way, those incentives.

Ms. KINDBERG. Yes.

Mr. WEBER. And you shouldn't be penalized in case you don't want to agree with those.

Mr. Butler, you look like you wanted to weigh in there for a second.

Mr. BUTLER. No, I just wanted to emphasize the point that Dr. Kindberg made. There is short-term enforcement, if you will, and then there is the question of policy development in such a way that you create the proper incentives and as Dr. Kindberg said, you don't penalize people that have tried things new, and you don't set up situations where you are going to strand investment——

Mr. WEBER. Sure.

Mr. BUTLER [continuing]. Think it through.

Mr. WEBER. Right. And I have been handed a note, Mr. Chairman, that Ms. Metcalf would like to weigh in.

If you can, do that quickly, please.

Ms. METCALF. I can do it very quickly. Robust enforcement is critical. One thing that has not been mentioned yet is the fact that the industry was fully supportive and, in fact, recommended initially that the new amendments to MARPOL Annex VI has a ban on carriage of noncompliant fuel. So it—you don't just have to not use it. After 1 March 2020 you can't have it on board.

Mr. WEBER. Thank you, Mr. Chairman.

Mr. MALONEY. I thank the gentleman. I will just note for the record that the American Association of Port Authorities, to its credit, has a section on its website entitled, "Environment and Energy," which includes the language, "As environmental leaders in the maritime environment, seaports employ alternative fuels, such as electricity, fuel cells, solar power, wind energy, and LNG."

Mr. WEBER. Thank you for that, Mr. Chairman. I scrolled quickly and didn't see that. Thank you.

Mr. MALONEY. I am always happy to be helpful to my friend.

Next, Mr. Lowenthal.

Mr. LOWENTHAL. Thank you, Mr. Chair. I would like to follow up on the question of hydrogen fuel cells, and where we are going with hydrogen fuel cells.

Kind of an interesting process is taking place in my port at this moment. Toyota, which has been one of the leaders in hydrogen fuel cells, is in the process of trying to develop a facility in the Port of Long Beach, which will generate hydrogen to create hydrogen.

Now, they are going to be using it, I believe—well, first of all, let me preface that. And our local utility has some issues with that, as that develops, because of the—what it is going to take to develop that hydrogen, and how that fits into our air quality goals. And so this is not an easy thing.

But the port is going to go forward with Toyota with a demonstration project, and that demonstration project is really going to be used for heavy-duty trucks and for yard equipment. I think that is the focus, if this hydrogen facility is developed, to move forward with that.

My question is, is there a possibility to use this also? Could this be a stepping stone to the maritime industry itself to begin to use some of this, if we have a plant in the port that actually produces hydrogen?

Mr. BERGER. Congressman, we also in Washington State have a couple of demonstration projects——

Mr. LOWENTHAL. Yes?

Mr. BERGER [continuing]. Similar to what you are talking about. Tacoma Power, which is a utility in the city of Tacoma, is also looking at the potential of a demonstration project, not only to power, like you say, yard equipment and trucks. They also operate a small train that moves containers around throughout that yard. Grant County PUD in central Washington State is also looking at it.

That kind of infrastructure, and being able to use those demonstration projects to take a look at maritime applications, I think,

is absolutely critical. And we saw the first passenger ferry, hydrogen-powered passenger ferry, in San Francisco. It was a partnership that was a private partnership, along with technology that came out of the Sandia National Labs. So another opportunity for partnering with Federal dollars.

Our department of energy in the water power technology office has focused their energy for wave and tidal on how to develop alternative and renewable fuels out at sea. And they are looking towards what the maritime applications are for offshore and renewable energy.

So I think all those projects are going to be absolutely critical, as we look at a network of what the next future fuel looks like, certainly for global and offshore and deep sea, but also, as well, for near shore and short sea shipping.

Mr. LOWENTHAL. Yes, I get it, I am just wondering and listening to—thank you for that. I just see that, with the limitations of battery, that we are really looking at, in the future, other alternatives. And I certainly think that this is a potential.

I am glad to hear of these demonstration projects. Although they have not really reached out yet in our community to deal with some of the maritime shipping part, but they are doing, you know, every—the—all the other equipment that is needed at—in the port, itself, is really what they are going to be using it for.

But I see this as a step in the right direction, and I am just wondering if others have any thoughts about that.

Ms. Metcalf?

Ms. METCALF. Thank you, Mr. Chairman. I will be very brief. I am not an engineer, I was a deckie, so I like to see the sun. I am not technically as proficient as some of my colleagues here. But I did pass organic chemistry, as I know you did. And even though I am older, I still have to fight to think outside the box. But it just keeps coming back to me what water is. It is salt, sodium chloride, it is oxygen, and it is hydrogen.

Mr. LOWENTHAL. Right.

Ms. METCALF. And I think that may be the line that you are following.

We might have a whole ocean out there of potential hydrogen fuel, if we can figure out how to actually do it. I will leave that up to the certified smart people, though. Thank you.

Mr. LOWENTHAL. Thank you.

Mr. BUTLER. Mr. Lowenthal, just one observation about that. The question you raise, which is a very good one, about how do we use some of these demonstration projects to figure out perhaps where we go next on a bigger scale——

Mr. LOWENTHAL. That is right.

Mr. BUTLER [continuing]. Is one of the fundamental research and development questions out there, because there has been a lot of discussion today about short sea and ferry applications. Mr. Bryn properly pointed out that a lot of the technologies that are available for those applications are not, in fact, scalable, or not likely to be scalable for transoceanic, deep sea shipping.

So I think, as we have this discussion about encouraging investment, about ways in which the Government can help, private actors can move this forward. We have to keep in mind that the scale

is different for a transoceanic, international, large vessel sector than it is for the short sea sector.

Mr. LOWENTHAL. Right.

Mr. BUTLER. And we can't make the mistake of simply saying, if batteries work for ferries, we just need a bigger battery. That is not necessarily the case.

Mr. BERGER. Congressman, on your example about the demonstration projects, you know, I guess the one thing I wanted to point back out, as well, is as we were working with the national laboratory systems and the Department of Energy, as well as Coast Guard and MARAD and NOAA and the Department of Commerce and EDA funding, there are parts and pieces of folks across the Federal agencies and enterprise that are having small parts of this discussion separately.

Until we kind of have a focus and organized conversation, I think, across the Federal enterprise, it is going to be hard for us to make the right investments and to the right vessels. As Congressman Lamb was talking about, it is going to be hard for us to understand the nuances of different vessel types and different appropriate fuel types for different—so until we have that level of organized approach and directed funding towards that, it is going to be hard for us to really start to scale and have those level of conversations.

And I think cluster organizations, coupled with your focused approach, can really help us make some leap-forwards.

Mr. MALONEY. Well, I thank you very much, and——

Mr. LOWENTHAL. I yield back.

Mr. MALONEY [continuing]. I thank the panel.

If there are no further questions, I would just conclude by saying, you know, it is just clear from this conversation—and one of the reasons behind today's hearing—is that many of us up here do understand that if we are going to ask you to be who we want you to be, we are going to have to be who you need us to be, in terms of the role the public sector needs to play. And I think that effective teamwork between the public and private sector in this area, as in so many, is critical.

And so we are very interested in continuing to understand the productive role the Congress can play, the Federal Government can play, and the public sector can play, in terms of resolving some of these issues of effective enforcement, getting you the basic research and investments necessary to bring these technologies to market in an economically efficient way. Some of the political issues involving shoreside infrastructure and the tradeoffs there, they are all legitimate concerns and questions. But working together, there is not a reason in the world we can't solve these issues and make your industry more successful, more efficient in time to do us some good in terms of our responsibilities to the climate.

So, with that, seeing no further questions, I would like to thank all the witnesses for participating in today's hearing. Your contribution has been tremendous.

And I would ask unanimous consent that the record of today's hearing remain open until such time as the witnesses have provided answers to any questions that may have been submitted to them in writing.

So ordered.

And I ask further 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.

If no one has anything else to add, we will stand adjourned. Thank you.

[Whereupon, at 11:40 a.m., the subcommittee was adjourned.]

SUBMISSIONS FOR THE RECORD

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

Thank you, Chairman Maloney, I commend you for taking up the topic of "green shipping" as the first hearing in the new year for the Subcommittee on Coast Guard and Maritime Transportation.

Since new international low sulfur emission standards for marine transportation kicked in two weeks ago, the timing of this hearing could not be more appropriate.

For too long global marine carriers have been able to evade complying with emission control standards, notwithstanding the fact that other transportation modes did have to comply with emission standards to reduce a whole host of noxious emissions and other harmful particulate matter from cars, trains, and planes.

Slowly, the International Maritime Organization was able to build a consensus on a schedule of emission reductions, that when fully implemented, will have reduced absolute vessel emissions by at least 50 percent from the 2008 baseline. This is a very positive development that stands to improve air quality and reduce human health impacts. I commend the IMO for taking this initiative and moving ahead, but we can and must do better.

The world's largest shipping company has set a goal of zero emissions by 2050, but that should be a goal for the entire industry. If the maritime industry merely reduces vessel emissions by 50 percent over the next 30 years, the impact of such a reduction could be largely offset by an increase in vessel traffic.

But to meet even the 50 percent reduction target, the global maritime industry must overcome substantial technical, economic, financial, and logistical challenges.

It is the discussion of those challenges that most interests me, in particular how this scenario could play out here in the United States.

For example, it remains uncertain what role the Federal government will play in fostering or facilitating the transition to a carbon-free maritime industry for both our coastwise and foreign trades.

If anything, over the past thirty years the maritime industry has become almost an orphaned child and an afterthought in the Department of Transportation. And were it not for the Navy shipbuilding program, our shipbuilding industry might have entirely lost its capability to build ocean-going vessels.

Additionally, the switch to a carbon-free maritime industry will have repercussions across more than just the vessels themselves. Corresponding impacts also will affect port facilities and maritime industries that provide fuels, logistical support, and stevedoring for the new "green" fleet of vessels calling on U.S. ports.

So, when we take up the topic of "green shipping" we are talking about much more than just new, innovative vessel designs, or low sulfur fuels. We are talking about a dynamic shift. A shift that in a relatively short fifteen- to thirty-year period will result in the virtual makeover of the conventional global maritime transportation system.

This is exciting stuff. There are, however, no assurances that we will end up with a new global maritime supply chain that is more efficient and less harmful to the global environment. The only way forward is to engage the industry to learn what they are doing and to determine the best course of action for the Federal government.

If one thing is clear today it is this: we can no longer afford to sit on our hands and be idle. Collectively, both the Congress and the administration need to get to work today reimagining the maritime industry of tomorrow.

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, Chairman Maloney, and thank you to our witnesses for being here today.

If the international shipping community were a foreign nation, they would rank sixth in the world in terms of air emissions from ships. In light of those significant emissions levels, new International Maritime Organization (IMO) rules went into effect on January 1st, and IMO has set more stringent air emission reduction targets for 2030 and 2050.

I applaud the industry for tackling this issue head on, including proposing new ways to raise funds for research on reducing carbon emissions.

With that said, we want to make sure any regulations or set targets are realistic and achievable.

I look forward to hearing the witnesses' assessment of the new rules which just went into effect, and their views on how the industry will meet the 2030 and 2050 goals.

Letter of January 14, 2020, from David Bolduc, Executive Director, Green Marine, Submitted for the Record by Hon. Sean Patrick Maloney

JANUARY 14, 2020.

Hon. SEAN PATRICK MALONEY,
Chairman,
Subcommittee on Coast Guard and Maritime Transportation, U.S. House Committee on Transportation and Infrastructure, 2331 Rayburn House Office Building, Washington, DC.

Hon. BOB GIBBS,
Ranking Member,
Subcommittee on Coast Guard and Maritime Transportation, U.S. House Committee on Transportation and Infrastructure, 2446 Rayburn House Office Building, Washington, DC.

RE: Comments regarding the January 14th Subcommittee on Coast Guard and Maritime Transportation's Hearing on *The Path to a Carbon-free Maritime Industry: Investments and Innovation*

DEAR CHAIRMAN MALONEY AND RANKING MEMBER GIBBS,

Green Marine appreciates the opportunity to submit these comments regarding the January 14th hearing titled *The Path to a Carbon-free Maritime Industry: Investments and Innovation*. This hearing comes at a critical time, as the maritime industry moves to meet the International Maritime Organization 2030 and 2050 carbon emissions reduction goals.

In our comments, we would like to address the importance of collaboration between the maritime industry, government, and NGOs; how essential is a clear, data-based, enforced regulatory baseline; and finally, the value of voluntary programs to achieve greater sustainability.

Our work and goals

Established in 2007, Green Marine is a voluntary marine industry certification program with the goal of achieving increasing levels of environmental performance that exceed regulatory requirements. There are currently more than 140 ship owners, port authorities, terminals and shipyards from coast to coast in the United States and Canada participating in the program [1]. The Green Marine environmental certification program addresses key environmental issues through 12 performance indicators that include greenhouse gases, air emissions, spill prevention, waste management, environmental leadership, and community impacts—some applicable to shipping activities, others to landside operations. The certification process is rigorous and transparent with results independently verified every two years. Each company's individual performance is evaluated and made public annually.

Green Marine's mission is to advance environmental excellence. Our environmental certification program offers a detailed framework for maritime companies to first establish and then reduce their environmental footprint. Our participants—

[1] A complete list of all Green Marine participants is available online here: https://green-marine.org/wp-content/uploads/2017/07/GM__Members__December2019.pdf

ship owners, port authorities, Seaway corporations, terminal operators and shipyard managers—have to demonstrate year-over-year improvement in measurable ways to maintain their Green Marine certification.

Green Marine's success as the premier environmental certification program for North America's maritime industry stems in good part from its efforts to identify and address regional as well as continental issues. As a result, some of the performance indicators have been developed to protect specific habitat and/or species in a region or to deal with particular maritime operations within that area. The program has earned support from more than 70 environmental organizations, scientific research programs and government agencies. These supporters[2] contribute to shaping and revising the program.

The importance of a collaborative approach

As Green Marine has grown, we have still held true to our founding goals to strengthen our industry's environmental performance and strive for continual improvement; engage with government agencies and gain their recognition, input, and support for the industry's efforts and outcomes towards sustainability; and, build our relationships with the NGO and environmental community. Familiarize them with the industry's advancement and benefits. Earn their trust and support.

For example, Green Marine formally engaged in a few strategic Memorandums of understanding. The MoU signed on October 2013 with the American Association of Port Authorities was pivotal to Green Marine membership expansion in the United States, raising the number of participating U.S. ports from the initial five in Green Marine to the current 22 American ports. Through this agreement, the AAPA and Green Marine formally recognize their mutual interests and support and share common goals to advance environmental protection at seaports in the Western Hemisphere.

AAPA determined that the Green Marine program is legitimate, applicable, voluntary and scalable for port authority and marine/intermodal terminal operations, and the association encourages their members who find it beneficial to their operations to participate in the program.

Green Marine also seeks international and technical collaborations. For example, the Society of Naval Architects and Marine Engineers (SNAME) became a new association member of Green Marine in March 2019 and signed an accord with Green Marine to further their common goals in fostering greater environmental sustainability in the maritime sector. The partnership will enhance the exchange of technical information between Green Marine and SNAME to further minimize the environmental impact of marine commerce.

Last year, Washington State rolled out its plan to accelerate maritime tech innovation, create jobs, protect the environment, and ensure industry sustainability and growth. Maritime Blue 2050 is the first initiative of its kind in the United States, and Green Marine is proud to be recognized within the strategy and to have supported the development and now the implementation and leadership for the strategy through West Coast & US Program Manager Eleanor Kirtley serving on the Steering Committee and Board of Directors.

Green Marine counts 30 associations members, a dozen based in the United States.[3] We believe a collaborative approach is essential to tackle the decarbonisation challenge, and Green Marine makes a point of fostering partnerships within the industry and outside. Our regional advisory committees and workgroups bring a diversified group of stakeholders (industry representatives, NGOs, governmental agencies, academics, technology suppliers, etc.) to the table to discuss the environmental program development.

The regulatory baseline

Green Marine criteria regularly undergo reassessment to ensure that all levels are sufficiently demanding in relation to existing or imminent regulations, as well as the availability and feasibility of new technologies and/or best management practices. The 2020 IMO sulfur emissions regulation, for example, influenced our indicator on Sulfur oxides (SOx) and particulate matter (PM) emissions. Green Marine supports clear, data-based, and enforced regulations for the marine transportation industry so we can provide our ship owners, port authorities, terminals and shipyards operators with a detailed and comprehensive set of criteria helping them stay beyond compliance.

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[2] A complete list of all Green Marine Supporters is available online here: https://green-marine.org/members/supporters/

[3] A complete list of all Green Marine Association members is available online here: https://green-marine.org/members/associations/

The positive, effective impact of voluntary programs

Green Marine has a track record of measured improvement, year on year for the past twelve years. On a scale of Levels 1 to 5, where 1 is the regulatory baseline and 5 stands for Excellence and Leadership, half of our participants reach an average of Level 3 and above. Our participants who have been in the program the longest, on average achieve the highest levels. We have gone beyond environmental compliance while growing the program scope of the environmental issues, strengthening the criteria each year, and increasing the number of participants. Membership has grown by 10% year on year. The growth of our membership proves that it answers a need and a tangible desire within the industry for a voluntary program under which participants take on concrete steps to minimize the environmental impacts of their activities. The overall level improvements registered by all the different types of participants in the latest results[4] is a testimony to the real commitment by the membership to continually strive to do better while accepting greater challenges.

Conclusion

Thank you for the opportunity to voice our support for clean shipping initiatives; for collaboration with industry and NGOs; for clear, data-based, and enforced regulations; and for recognition for the efficacy of voluntary programs like ours for example.

It is gratifying to have Green Marine's certification program recognized by more and more enterprises as a challenging but feasible approach to improve sustainability through a step-by-step framework to address priority issues. We hope that the international regulatory shift towards more stringent requirements and the general public increased awareness towards sustainability can promote a culture of continual improvement beyond regulatory compliance. We also respectfully hope Green Marine can continue play a central role in intensifying dialogue and direct collaboration between the maritime industry and stakeholders (NGOs, governments, municipalities, scientists, etc.), and establishing and/or strengthening the existing collaborations and environmental strategies with partners in both Canada and the United States.

Thank you again for the opportunity to submit these comments regarding the Subcommittee on Coast Guard and Maritime Transportation's hearing on *The Path to a Carbon-free Maritime Industry: Investments and Innovation*.

Sincerely,

DAVID BOLDUC,
Executive Director, Green Marine.

Letter of January 14, 2020, from Daniel Hubbell, Shipping Emissions Campaign Manager, Ocean Conservancy, Submitted for the Record by Hon. Sean Patrick Maloney

JANUARY 14, 2020.

Hon. SEAN PATRICK MALONEY,
Chairman,
Subcommittee on Coast Guard and Maritime Transportation, U.S. House of Representatives, 2331 Rayburn House Office Building, Washington, DC.

Hon. BOB GIBBS,
Ranking Member,
Subcommittee on Coast Guard and Maritime Transportation, U.S. House of Representatives, 2446 Rayburn House Office Building, Washington, DC.

DEAR CHAIRMAN MALONEY AND RANKING MEMBER GIBBS,

Ocean Conservancy thanks the Subcommittee for highlighting the pressing challenges of climate and the maritime industry in the upcoming hearing on The Path to a Carbon-Free Maritime Industry. Shipping, both domestic and international, accounted for approximately 2.6% of global CO2 emissions in 2015.[1] This places the

[4] The latest results relate to the 2018 year of operation and are published in Green Marine 2018 Annual Performance report (https://green-marine.org/wp-content/uploads/2019/06/2018Perfo_Report_final_WEB-1.pdf). The evaluation period for the 2019 operations is currently in progress and the next results will be released in early June 2020.

[1] Olmer, N., Comer, B., Roy, B., Mao, X., Rutherford, D. (2017). Greenhouse Gas Emissions from Global Shipping, 2013–2015. The International Council on Clean Transportation. Available at: https://theicct.org/publications/GHG-emissions-global-shipping-2013-2015

sector in the same class as a G7 country, roughly equivalent to Germany's national emissions. While the sector continues to improve its energy efficiency and remains more efficient than any other form of cargo transportation, these improvements have not kept pace with the growth of trade, and emissions have continued to increase.[2] If no advances in technology and low or zero carbon fuels are adopted, emissions from shipping could continue to grow up to 250% from 2012 levels by 2050.[3] The industry can adapt but an effort from government and industry is needed.

While shipping is a prime contributor to climate change, it is also exposed to its impacts. Many American ports are vulnerable to sea-level rise and storm surges made worse by climate change. Even temporary disruptions of these facilities have serious economic consequences. For instance, in the aftermath of Hurricane Sandy the Port Authority of New York and New Jersey was forced to divert more than 25,000 shipping containers to other ports, part of an estimated $2.2 billion in damages and losses to the Authority.[4] Rising seas also impact our naval bases. In the past ten years, Norfolk Naval Shipyard has suffered nine major floods that damaged equipment.[5] At present, few American ports are climate resilient or ready for the realities of a world that has already warmed more than 1.8 °F from pre-industrial levels, and could rise to more than 2.7 °F by 2030.[6] It is clear that we need to build resilience to climate impacts—and significantly reduce greenhouse gas emissions from all sources.

In 2018, the International Maritime Organization (IMO) adopted its Initial IMO Strategy on Reduction of GHG Emissions from Ships.[7] The ultimate goal is to eliminate greenhouse gas (GHG) emissions from the sector as soon as possible, and reduce emissions by at least 50% from 2008 levels by 2050.[8] In our view it is essential that full decarbonization of the shipping sector be achieved as soon as possible, and no later than 2050. Notably, shipping was not directly included in the Paris Agreement.[9]

Many technologies and operational changes are available today to reduce a ship's GHG emissions. Ships can slow down to save fuel; reducing speed by 20% can not only reduce emissions by up to 34% but also potentially reduce other environmental impacts, such as underwater noise or air pollution.[10] Ship operators can also install wind-assisted propulsion technologies that can significantly reduce fuel consumption, up to 47% for some ships.[11] Additionally, hull air lubrication systems can cut fuel use and emissions by 10% or more.[12] The sector will require a combination of energy-saving technologies, such as wind-assisted propulsion, as well as alternative zero or low-carbon fuels, such as hydrogen or ammonia, to truly decarbonize by

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[2] Ibid. At 8

[3] Balcombe, P., Brierley, J., Lewis, C., Skatvedt, L., Speirs, J., Hawkes, A., & Staffell, I. (2019). How to decarbonise international shipping: Options for fuels, technologies and policies. Energy conversion and management, 182, 72–88.

[4] Strunsky, S. (2019). Port Authority puts Sandy damage at $2.2 billion, authorizes $50 million to power wash PATH tunnels. NJ.com Available at: https://www.nj.com/news/2013/10/port_authority_sandy_22billion_outlines_recovery_measures.html

[5] Kusnetz, N. (2018). Rising seas threaten Norfolk Naval Shipyard, raising fears of 'catastrophic change'. NBC News. Available at: https://www.nbcnews.com/news/us-news/rising-seas-threaten-norfolk-naval-shipyard-raising-fears-catastrophic-damage-n937396

[6] IPCC, 2018: Summary for Policymakers. In: Global Warming of 1.5 °C. An IPCC Special Report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press.

[7] IMO. (2018). Resolution 304(72). Available at: Initial IMO Strategy on Reduction of GHG Emissions from Ships http://www.imo.org/en/OurWork/Documents/Resolution%20MEPC.304%2872%29%20on%20Initial%20IMO%20Strategy%20on%20reduction%20of%20GHG%20emissions%20from%20ships.pdf

[8] Rutherford, D. & Comer, B. (2018). The International Maritime Organization's initial greenhouse gas strategy. The International Council on Clean Transportation. Available at: https://theicct.org/publications/IMO-initial-GHG-strategy

[9] Light, J. (2018). A Paris Agreement for the Shipping Industry. UN Dispatch. Available at: https://www.undispatch.com/a-paris-agreement-for-the-shipping-industry/

[10] Leaper, R. C. (2019). The role of slower vessel speeds in reducing greenhouse gas emissions, underwater noise and collision risk to whales. Frontiers in Marine Science, 6, 505.

[11] Comer, B., Chen, C., Stolz, D., & Rutherford, D. (2019). Rotors and bubbles: Route-based assessment of innovative technologies to reduce ship fuel consumption and emissions. The International Council on Clean Transportation. Available at: https://theicct.org/publications/working-paper-imo-rotorships

[12] Ibid. at 8.

midcentury.[13] These technological and operational changes present opportunities for the industry; however the lifespan of vessels requires coordination and innovation to be successful.

Given the lifespan of oceangoing vessels (oceangoing ships routinely sail for 20–30 years or more,[14] while Great Lakes ships have been known to last for over 100 years[15]), the first zero emission oceangoing vessels must be on the water by 2030 if there is any chance for decarbonization by 2050. In recognition of this, The Getting to Zero Coalition, an alliance of more than 90 companies from multiple sectors, formed in 2019 with the purpose of getting commercial deep sea zero emission ships on the water by 2030.[16] Although use of these fuels would constitute a radical shift for the industry, shipping has demonstrated its ability to adapt and change fuel types over its history, including in the global shift to lower sulfur fuels that began on January 1st, 2020.[17]

The United States alone accounts for approximately 8% of global trade and has the opportunity to be a leader. Billions of dollars of goods flow through our ports each day.[18] Moreover, the United States has the technical know-how to be a leader in zero emission technologies, with world-class research facilities, such as Sandia National Laboratories, which have done research on zero emission vessels and their fuels.[19] These innovative research labs and technical know-how place the United States in a strong position to foster innovation and drive the operational and technological changes the maritime industry needs if it is to decarbonize successfully.

As this Subcommittee considers what incentives and support U.S. vessels need to thrive in a decarbonized maritime industry, Ocean Conservancy suggests the following options,

1. Support collaboration across ports. Some U.S. ports, such as Long Beach, Los Angeles, and New York/New Jersey, have already committed to exploring investment in alternative fuels and other initiatives like onshore power, but more work is needed. In the long term, such investment by multiple ports could open the possibility of zero emission short sea shipping by U.S. flagged ships.
2. Explore a federal fuel tax per ton of CO2 emitted by maritime ships entering U.S. ports. Not only could a tax encourage more energy efficient ships in the short term but the proceeds could finance research and development of zero emission ships.[20] [21]
3. Offer grants for development of zero emission technologies or tax incentives for companies which install fuel saving equipment such as wind-assisted propulsion technologies, such as rotor sails.
4. Identify innovative initiatives to reduce shipping emissions within individual ports and states, and encourage their regional and national adoption.
5. Fund the procurement of zero emission vessels for government agencies. By procuring zero emission vessels, the government can, in partnership with both public and private ports, build the market for zero emission fuel infrastructure within key ports, either with additional direct financial support or in public-private partnerships.
6. Encourage the U.S. delegation to the IMO to support ambitious global standards that encourage the worldwide uptake of zero-carbon fuels and technologies. We encourage the Subcommittee to consult with the U.S. Coast Guard, which is the lead agency for the IMO, on its current position, and its own cross agency discussions with other relevant agencies like the Environ-

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[13] Hall, D., Pavlenko, N., & Lutsey, N. (2018). Beyond road vehicles: Survey of zero-emissions technology options across the transport sector. The International Council on Clean Transportation. Available at: https://theicct.org/publications/zero-emission-beyond-road-vehicles

[14] UNCTAD. (2019). Review of maritime transport 2019. United Nations Conference on Trade and Development. Available at: https://unctad.org/en/pages/PublicationWebflyer.aspx?publicationid=2563

[15] Greene, M. (2019, April 18). Former 'jinx ship' breezes through Chicago without a hitch. *The Chicago Tribune*. Available at: https://www.chicagotribune.com/news/breaking/ct-met-st-marys-challenger-barge-chicago-20190416-story.html

[16] Global Maritime Forum. (2019). Getting to Zero. Available at: https://www.globalmaritimeforum.org/getting-to-zero-coalition/

[17] Balcombe *et al*. 2019

[18] O'leary, A. (2019). Legal Pathways to Deep Decarbonization In the United States. Chapter 17: Shipping. Edited by Gerrard, M.B., and Dernbach, J.C. Environmental Law Institute.

[19] Sandia National Laboratories. (2019). Maritime applications for hydrogen fuel cells. Available at: https://energy.sandia.gov/programs/sustainable-transportation/hydrogen/market-transformation/maritime-fuel-cells/

[20] Id. At 456

[21] Wan, Z., El Makhloufi, A., Chen, Y., & Tang, J. (2018). Decarbonizing the international shipping industry: Solutions and policy recommendations. *Marine pollution bulletin*, 126, 428–435.

mental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA).

As you work to develop a strategy for zero emissions vessels, we encourage the Committee take a collaborative approach engaging maritime industry stakeholders, lead maritime federal agencies, and nongovernmental groups like Ocean Conservancy to develop a robust approach that allows us all to move toward a decarbonized future.

Thank you for your consideration of this important topic. Ocean Conservancy looks forward to working with you as you develop solutions.

Thank you,

DANIEL HUBBELL,
Shipping Emissions Campaign Manager, Ocean Conservancy.

Letter of January 13, 2020, from Bruce Appelgate, Associate Director, Scripps Institution of Oceanography, Submitted for the Record by Hon. Sean Patrick Maloney

JANUARY 13, 2020.

A ZERO-EMISSION HYDROGEN FUEL CELL OCEANOGRAPHIC RESEARCH VESSEL AT SCRIPPS INSTITUTION OF OCEANOGRAPHY

Scripps Institution of Oceanography urgently needs a new research vessel to replace its venerable R/V *Robert Gordon Sproul*, which after serving scientists, students and engineers for 38 years has reached the end of its service life. Ships like *Sproul* are critical for understanding the physical and biological processes in our oceans, and how they are impacted by human activities.

We are actively engaged in designing a new replacement vessel. We envision a new state-of-the-art ship that will carry on the important scientific activities that *Sproul* has made possible, and to provide new and compelling educational opportunities for upcoming generations of scientists, engineers, policy makers and educators during this time of rapid environmental change.

A key part of such a vessel is a clean power plant that fits our University's pledge to become carbon neutral by 2025. In November 2013, President Janet Napolitano announced the Carbon Neutrality Initiative [1], which commits the University of California to emitting net zero greenhouse gases from its buildings and vehicle fleet by 2025, something no other major university system has done. As part of the UC San Diego campus, Scripps is joined in this effort. We have completed a feasibility study [2] to build and operate a Zero Emission Research Vessel (ZERO–V) that uses a fuel cell system to convert liquid hydrogen fuel to electricity to supply all the power required on board. This comprehensive study demonstrated the technical and regulatory feasibility of a coastal research vessel powered solely by hydrogen fuel cells.

For a research vessel, the advantages of using hydrogen fuel cells are considerable. Zero emissions hydrogen technology allows the collection of air samples with no contamination from vessel exhaust. Since fuel cells are very low noise power systems, such research vessels are quieter and thus radiate substantially less underwater noise, which enables better scientific acoustic operations reduces noise impacts on marine wildlife. PEM fuel cells offer faster power response than internal combustion engine technology, which is an advantage in vessel handling and positioning. Fuel cells generate pure, deionized water which is needed for laboratory use and can also be treated to use as the ship's source of potable water (both of which we currently go to great lengths to produce this at sea). No fossil fuels on board means there is no risk of an oil spill, which improves our ability to work in sensitive habitats without fear of polluting them.

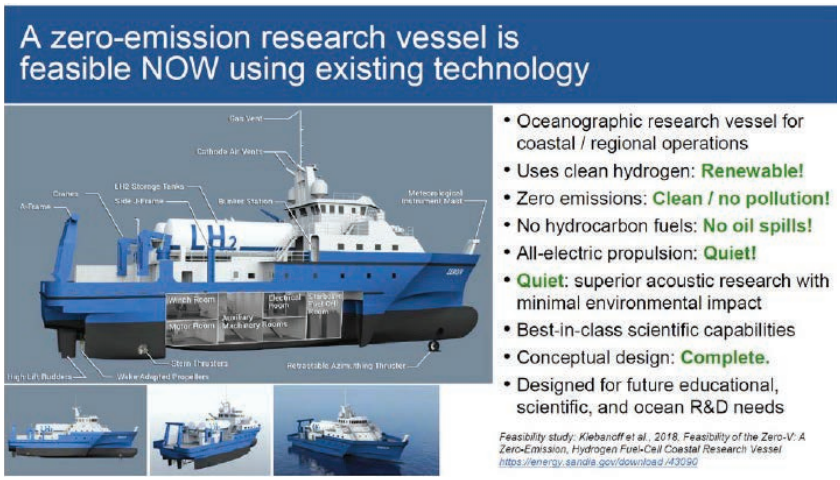
This is a game-changing approach to marine power that, if demonstrated and adopted widely, could significantly reduce pollution and CO2 emissions from ships, which have been shown to have major health impacts on population centers ashore, and contribute to greenhouse warming. To realize our vision of clean renewable marine hydrogen power, we are faced with substantial challenges. The federal regulatory framework for building and operating U.S.-flagged liquid hydrogen-fueled

[1] University of California Carbon Neutrality Initiative, www.ucop.edu/carbon-neutrality-initiative

[2] Klebanoff, L. E. et al, Feasibility of the Zero-V: A zero-emission hydrogen fuel-cell, coastal research vessel, Sandia National Laboratories, Livermore CA, 2017.

ships is a work in progress, and requires important participation by the U.S. Coast Guard. Most of the hydrogen available today is "dirty"—it is derived from methane in a process that releases methane's carbon into the atmosphere as CO2. For hydrogen fuel to be truly CO2-free it needs to be sourced from hydrolysis of water using renewable power. Hydrogen currently costs more than diesel per mile, meaning that the cost of operating a clean ship is currently more than operating one that uses fossil fuels.

All of these challenges can be overcome with the maturation of the hydrogen industry in general, and the maritime hydrogen power sector in particular. I urge congress to work with the hydrogen and maritime industries so that we can develop a production and distribution infrastructure in America that can reliably provide clean hydrogen to consumers, at rates that are competitive with polluting fossil fuels.



Sincerely,

BRUCE APPELGATE,
Associate Director, Scripps Institution of Oceanography.

Letter of January 14, 2020, from Jesse N. Marquez, Executive Director, Coalition For A Safe Environment, Submitted for the Record by Hon. Sean Patrick Maloney

JANUARY 14, 2020.

Hon. SEAN PATRICK MALONEY,
Chairman,
Subcommittee on Coast Guard & Maritime Transportation, U.S. House Committee on Transportation and Infrastructure, 2331 Rayburn House Office Building, Washington, DC.

Hon. BOB GIBBS,
Ranking Member,
Subcommittee on Coast Guard & Maritime Transportation, U.S. House Committee on Transportation and Infrastructure, 2446 Rayburn House Office Building, Washington, DC.

Subcommittee on Coast Guard & Maritime Transportation,
507 Ford House Office Building, Washington, DC.

RE: Subcommittee on Coast Guard and Maritime Transportation's Hearing on The Path to a Carbon-Free Maritime Industry: Investments and Innovation on January 14, 2020

SU: Public Comments

DEAR CHAIRMAN MALONEY AND RANKING MEMBER GIBBS:

The Coalition For A Safe Environment as a member of the Moving Forward Network respectfully submits our public comments to the Subcommittee on Coast Guard and Maritime Transportation's Hearing on The Path to a Carbon-Free Maritime Industry: Investments and Innovation.

The Moving Forward Network is a national network of over 50 member organizations that centers grassroots, frontline-community knowledge, expertise, and engagement from communities across the US that bear the negative impacts of the global freight transportation system. The Moving Forward Network builds the capacity of network participants working to improve the U.S. Freight Transportation System in the areas of environmental justice, public health, quality of life, the environment and labor.

We thank you for the opportunity to submit public comments on the following themes:

- Industry Resistance To Innovation & Decarbonization of the Maritime Industry
- Benefits of Decarbonization
- Status of Zero Emissions On-Road Freight Transportation Vehicles
- Status of Zero Emissions Off-Road Cargo Handling Equipment
- Status of Ship Emissions Capture & Treatment Technologies
- Status of Zero Emission Ships and Barges
- Status of Zero Emissions Construction Equipment
- International Maritime Organization Standards—MARPOL Annex 6, 13
- Current & Past Port Freight Transportation, Infrastructure & Mitigation Funding Mechanisms
- Homeland Security

1. Industry Resistance To Innovation & Decarbonization of the Maritime Industry

We have witnessed numerous times year-after-year, project-after-project Ports, Terminal Operators, Railyard, Shipping and Trucking Companies resistance to the introduction of clean zero emission technologies and even emission capture and treatment technologies across all sectors of on-road, off-road and ocean going vessel, freight transportation vehicles and cargo handling equipment.

We understand that new innovative technologies take time to develop, a significant upfront investment and time to mature just like all of their predecessors. Even today proven certified new Class 8 Diesel Engine Drayage Trucks off the production line breakdown for various equipment failure reasons. It requires patience, understanding and diligence to prevail.

- It is a fact that new technologies will eventually replace old technologies.
- It is a fact the new technologies are more cost-effective and efficient than old technologies.
- It is a fact that most new technologies have zero emissions.
- It is a fact that there are governmental agency approved ship emissions capture and treatment technologies.

Ports, Terminal Operators, Railyard, Shipping and Trucking Companies historically have not introduced one new carbon-free or zero emissions technology on their own accord in the last 20 years.

It has been public comments, public outcry, protests, demonstrations, environmental lawsuits, grass roots campaign to replace elected officials with progressive candidates and new public sponsored laws, rules, regulations, programs that has allowed innovation and change to occur.

It has been the public and community organizations partnering and supporting new innovative technology companies that has opened the Pandora's Box and the challenge to the sacred cow.

In 2001 it took San Pedro, California homeowners associations and residents to file an environmental lawsuit against the #1 largest container port in the U.S. the Port of Los Angeles to force them to incorporate clean technologies. The Port of Los Angeles was so arrogant they did not even prepare an environmental Impact Statement/Environmental Impact Report for the new China Shipping Terminal. They were found guilty, a court injunction ordered them to cease and desist all construction on a 60% completed new terminal and established a $ 50 million Miitgation Fund.

The Plaintiffs demanded that the new terminal be electric, the Port of Los Angeles refused saying it was not feasible and not cost-effective. The court disagreed. Several studies have now been published which disclosed that it is in fact cheaper for a ship to plug-in then use bunker fuel.

The courts ordered the Port of Los Angeles to build the first electric shorepower terminal, retrofit 70% of the ships to plug-in, install diesel truck emission capture

technologies and mitigate community impacts. The settlement also required the use of Low-Sulfur Marine Fuel. Then 10 years later the Port of Los Angeles was found again guilty of not-complying with the court order stipulation mitigation agreement. We the public also found out that the Port of LA forgot to sign a binding contract with China Shipping.

In 2006 the California public and environmental organization supported AB32 the Global Warming Solution Act which became law. The law required that California adopt early actions measures to reduce greenhouse gases within 5 years. The Coalition For A Safe Environment as a member of the Environmental Justice Advisory Committee recommended that all major California ports should be required to have electric shorepower. The recommendation was adopted by the California Air Resources Board and a new ship shorepower regulation was issued in 2014. Today all California major ports have electric shorepower power. However, the majority of all ships are not retrofitted to plug into electric shorepower.

Advanced Cleanup Technologies, Inc. (ACTI) a new emerging small minority owned Hispanic business 13 years ago presented their idea for a ship and locomotive engine exhaust capture and treatment technology to the Port of Los Angeles Board of Harbor Commissioners and Port Staff, they laughed at him and said it was an unproven technology.

ACTI was able to secure several governmental agency grants to build a prototype in 2006 to test on locomotives. The Advance Locomotive Emissions Contrail System (ALECS) technology was found to be 80%–90% effective in capturing and treating locomotive engine exhaust emissions. In 2008 the Port of Long Beach gave ACTI permission to install and begin testing their Advance Maritime Emissions Contrail System (AMECS) technology with a terminal operator on their ships. In 2014, the City of Long Beach and the California South Coast Air Quality Management District give ACTI a contract for a formal demonstration of the AMECS technology. The AMECS technology was now 90%–99% effective in capturing and treating ship auxiliary engine and boiler exhaust emissions.

On October 17, 2015 AMECS was approved by the California Air Resources Board and has been used on over 300 ships. AMECS has even been proven to be more cost-effective then electric shorepower. AMECS Use existing state-of-the art off-the-shelf proven technologies, does not require any modification of a ship, any modification of terminal infrastructure, does not require any shorepower & not subject to power outages, does not require any additional special permits, can be built Stationary On-Dock or Mobile On-Barge and works on any category class of ship. As of today not one port in California or Terminal Operator has purchased an AMECS system.

The first two companies in the U.S. to build a Zero Emissions Electric Truck have went bankrupt. Balcon built the first electric battery Class 8 Drayage Truck and Vision Motor Corp another local Los Angeles small business built the first Hydrogen Fuel Cell Battery Truck. Yes the Port of Los Angeles has given grants (public money) to conduct their first pilot projects with 1–2 trucks but after years of developing and improving their technologies, the ports refused to purchase more trucks. Vision Motor Corps had two major trucking companies willing to purchase 200 and 300 hydrogen fuel cell Tyrano trucks but the Port of Los Angeles refused to support them, would not recognize or give the trucking companies pollution credits. Ports will give grants to test and do pilot demonstrations forever. No Port has included Zero Emissions Trucks as mitigation in any EIS/EIR as of today. They include a lease agreement statement to conduct a technology assessment every five years.

California and other states have innovative technology companies that we need to embrace and invest in before foreign companies steal our innovative technology leadership. The US has already lost 99% of its merchant ship building base to foreign countries.

2. Benefits of Decarbonization

- It is a fact that new technologies support long term economic sustainability.
- It is a fact that new technologies significantly reduce air pollution.
- It is a fact that new technologies significantly reduce greenhouse gas reductions.
- It is a fact that new technologies reduce significantly public health impacts.
- It is a fact that new technologies reduce significantly reduce public health care costs.
- It is a fact that new technologies support long term economic sustainability.
- It is a fact that new technologies reduce premature transportation infrastructure.
- It is a fact that new technologies create more new jobs

3. STATUS OF ZERO EMISSIONS ON-ROAD FREIGHT TRANSPORTATION VEHICLES

Trucks

Ports and the Traditional Diesel Fuel and Natural Gas Freight Truck Transportation Industry give the impression that Carbon-Free Zero Emission Class 8, Class 7 etc. trucks are not available, which is not true. The Coalition For A Safe Environment publishes almost monthly a Zero Emission Transportation Vehicles, Cargo Handling Equipment & Construction Equipment Commercial Availability Survey. Here are a few facts:

	Currently Available For Purchase/ One Year Delivery
Electric Trucks Class 8	11
Electric Class 7 Truck	1
Electric Trucks Class 6	6
Electric Trucks Class 5	2
Electric Trucks Class 4	1
Electric Trucks Class 3	2

It is a fact that all Class 8 Zero Emission Trucks can meet the demand for all short hauls of less than 100 miles. The Ports refuse to include these trucks for mitigation for all projects, terminals, railyards, intermodal facilities that have short haul requirements.

Trains

Ports and the Traditional Diesel Fuel and Natural Gas Freight Train Transportation Industry give the impression that Carbon-Free Zero Emission Trains are not available, which is not true. The Coalition For A Safe Environment publishes almost monthly a Zero Emission Transportation Vehicles, Cargo Handling Equipment & Construction Equipment Commercial Availability Survey. Here are a few facts:

	Currently Available For Purchase/ One Year Delivery
Electric Trains	22

The Port of Rotterdam has been using electric trains exclusively for over 50 years in Europe. There are over 5 countries that are using electric freight trains.

4. STATUS OF ZERO EMISSIONS OFF-ROAD CARGO HANDLING EQUIPMENT

Trucks

Ports and the Traditional Diesel Fuel and Natural Gas Freight Truck Transportation Industry give the impression that Carbon-Free Zero Emission Class 8, Class 7 etc. trucks are not available, which is not true. The Coalition For A Safe Environment publishes almost monthly a Zero Emission Transportation Vehicles, Cargo Handling Equipment & Construction Equipment Commercial Availability Survey. Here are a few facts:

	Currently Available For Purchase/ One Year Delivery
Electric Yard Tractors Class 8	10
Electric Class 7 Truck	1

It is a fact that all Class 8 and Class 7 Zero Emission Trucks can meet the demand for all short hauls of less than 100 miles. The Ports refuse to include these trucks for mitigation for all projects, terminals, railyards, intermodal facilities that have short haul requirements.

Cranes

Ports and the Traditional Diesel Fuel and Natural Gas Cargo Handling Industry give the impression that Carbon-Free Zero Emission vehicle and equipment are not available, which is not true. The Coalition For A Safe Environment publishes almost monthly a Zero Emission Transportation Vehicles, Cargo Handling Equipment & Construction Equipment Commercial Availability Survey. Here are a few facts:

	Currently Available For Purchase/ One Year Delivery
Electric Ship-to-Shore (STS) Rail-Mounted Gantry Cranes	3
Electric Rubber-Tired Gantry (RTG) Cranes	6
Electric Rail-Mounted Gantry Cranes	1
Electric Bulk Handling Crane	1
Carry Deck Crane	2
Reach Stackers	7
Shuttle Carrier	1
Straddle Carrier	4
Trailer Spreader	1
Electric Forklifts	109
Electric Pallet Truck	1
Top Front End Payloader	1

It is a fact that that almost every manufacturer will build zero emission Cargo Handling Equipment if a customer requests it.

5. Status of Ship Emissions Capture & Treatment Technologies

Ports and the Traditional Shipping Industry give the impression that there are no ship emissions capture and treatment technologies available, which is not true. Here are a few facts:

	Currently Available For Purchase/ One Year Delivery
Ship Emissions Capture & Treatment Technologies	2

Only one company can accommodate all ship classes and categories. ACTI which is now Advanced Environmental Group, LLC (AEG).

6. Status of Zero Emission Ships & Barges

As of today there are no Zero Emission Freight Transport Ships, however, in 2012 Nippon Yusen launched the first partially 10% solar powered RoRo Ship the Auriga which visited the Port of Long Beach.

The nation's first hydrogen fuel cell electric powered Zero Emission Passenger Ferry is now operating in San Francisco Bay and in 2012 the largest Swiss designed solar 50 passenger ship the Turanor PlanetSolar completed an 18 month global world trip.

In 2018 the Ports of Rotterdam, Antwerp and Amsterdam became the first in the world to begin using Zero Emission Barges. The Dutch manufacturer Port Liner built the five Carbon-Free Barges which have no engine rooms which allowed 8% more cargo to be carried.

We believe that hydrogen fuel cell electric power is the current available clean sustainable technology to invest in that will meet the need of carbon-free ship freight transportation.

7. Status of Zero Emissions Construction Equipment

Ports and the Traditional Diesel Fuel and Natural Gas Cargo Construction Industry give the impression that Carbon-Free Zero Emission construction vehicles and equipment are not available, which is not true. The Coalition For A Safe Environment publishes almost monthly a Zero Emission Transportation Vehicles, Cargo Handling Equipment & Construction Equipment Commercial Availability Survey. Here are a few facts:

	Currently Available For Purchase/ One Year Delivery
Electric Dredgers	5
Tracked Dozer (Tractor)	1
Excavators	4
Top Front End Payloader	1
Wheeled Loader	5
Rope Shovels	3
Wheel Dumper	1
Concrete Mixers	1

	Currently Available For Purchase/ One Year Delivery
Dump Trucks	4
Delivery Truck	8
Cab Chassis Delivery Truck	8
Flat Bed Truck	3
Cargo Panel Van	11
Electric Pickup Trucks	7
Utility/Electric Trucks	3
Aerial Boom Trucks	4
Compact Utility Vehicles	22

7. INTERNATIONAL MARITIME ORGANIZATION STANDARDS—MARPOL ANNEX 6, 13

Currently requires the worldwide transition into low-sulfur marine fuels.

Currently requires that all ships entering the U.S. West Coast Emission Control Area (ECA) must comply with NOX, SOX and PM emissions requirements.

Currently requires that all ships entering the U.S. West Coast ECA built after January 1, 2016 must have cleaner Tier 3 Engines.

8. CURRENT & PAST PORT FREIGHT TRANSPORTATION, INFRASTRUCTURE & MITIGATION FUNDING MECHANISMS

California has been the national leader in introducing innovative funding mechanism to support investment in freight transportation and infrastructure.

In 1998 the Carl Moyer Memorial Air Quality Standards Attainment Program (Moyer Program or Program) has cost-effectively reduced smog-forming and toxic emissions. The Carl Moyer Program is implemented as a partnership between the California Air Resources Board (CARB) and California's 35 local air districts. CARB works collaboratively with the air districts and other stakeholders to set Guidelines and ensure the Program reduces pollution and provides cleaner air for Californians. Approximately $1 billion has been allocated to date and the Program continues to provide over $60 million in grant funding each year to clean up older polluting engines throughout California.

The 2001 China Shipping San Pedro Homeowners environmental lawsuit settlement with the Port of Los Angeles also included an extra Mitigation Fund Container Fee of $ 30 per TEU if the China Shipping Terminal exceeded the 328,000 EIS/EIR TEU's cap per calendar year. The China Shipping Terminal did exceed the EIS/EIR cap and generated $ 10 million.

In 2005 the Pier Pass Traffic Mitigation Fee (TMF) was established at the Ports of Los Angeles and Long Beach as an incentive to shift some container movement to night hours vs day hours to relieve traffic congestion and truck idling which causing significant air pollution in harbor communities. A flat fee for daytime container moves at the Ports of Los Angeles and Long Beach during peak day time hours. The Tariff was $31.52 per TEU and $ 63.04 for all other TEU Sizes. The TMF reached high of $ 72.09 TEU in 2018. PierPass was in response to a stern warning from the California Legislature in 2003 to either mitigate port-caused traffic congestion in Los Angeles-Long Beach or the legislature would impose a solution.

In 2006 Proposition 1B the Highway Safety, Traffic Reduction, Air Quality, and Port Security Bond Act of 2006, is approved by California voters and authorizes the Legislature to appropriate $1 billion in bond funding to the California Air Resources Board to reduce air pollution emissions and health risks from freight movement along California's priority trade corridors. Approximately $200 million is allocated every year.

In 2006 the California Air Resources Board approves the Cap & Trade Program under Assembly Bill (AB) 32 the Global Warming Solutions Act of 2006 which allows the purchasing of air pollution credits to mitigate greenhouse gas environment impacts. Over $ 12 billion has been raised since 2012 by California and over $ 250 million annually allocated for public and freight transportation. Funds support zero emission, near zero emission, emission capture & treatment technologies and energy efficiency programs.

In 2007 the Ports of Los Angeles and Long Beach establish a Clean Truck Fund as part of the newly adopted Clean Air Action Plan. A tariff of $ 35 per TEU would be assessed on every loaded container entering or leaving the Ports by drayage truck beginning June 1, 2008.

In 2007 environmental organizations, homeowner associations and residents opposed the Port of Los Angeles TraPac Container Terminal Expansion Project for fail-

ing to adequately mitigation all community impacts. The threat of another public environmental lawsuit forced the Port of Los Angeles into a pre-court settlement. The settlement MOU included a Mitigation Fund Container Fee of $ 3.50 per TEU, $1.50 PX or 0.15 Per Ton of Cargo for the projected 1,497,142 EIS/EIR TEU's cap per calendar year.

In 2011 the California Air Resources Board approves the Cap & Trade Program under AB 32 the Global Warming Solutions Act of 2006 which allows the sales and purchasing of air pollution credits to mitigate greenhouse gas environment impacts. Over $ 12 billion has been raised since 2012 by California and over $ 250 million annually allocated for public and freight transportation. Funds support zero emission, near zero emission, emission capture & treatment technologies and energy efficiency programs.

In 2015 Senate Bill (SB) 513 was approved providing new opportunities for the Program to contribute significant emission reductions alongside implemented regulations, advance zero and near-zero technologies, and combine program funds with those of other incentive programs.

In 2017 AB 617 Nonvehicular Air Pollution: Criteria Air Pollutants and Toxic Air Contaminants is approved requiring the reduction of emissions of toxic air contaminants and criteria pollutants in communities affected by a high cumulative exposure burden. Over $ 245 million is allocated annually for mitigating mobile sources and stationary sources.

Sample Federal Grant Funding Programs:

U.S. Dept. of Energy—The Vehicle Technologies Office (VTO) supports high impact projects that can significantly advance its mission to develop more energy efficient and environmentally friendly highway transportation technologies that enable America to use less petroleum.

U.S. Dept. of Transportation—Fixing America's Surface Transportation Act or FAST Act—Fostering Advancements in Shipping and Transportation for the Long-term Achievement of National Efficiencies, or FASTLANE, grant program.

9. HOMELAND SECURITY

No dependence on fossil fuels using Electric Battery and Hydrogen Fuel Cell Power Zero Emission Technologies.

In conclusion, we can provide detailed information, studies and reports on all available zero emissions and emissions capture and treatment technologies. We can also provide introductions to many of the new emerging technology companies.

Respectfully Submitted,

JESSE N. MARQUEZ,
Executive Director, Coalition For A Safe Environment.

APPENDIX

QUESTIONS FROM HON. PETER A. DEFAZIO TO JOSHUA BERGER, GOVERNOR'S MARITIME SECTOR LEAD, WASHINGTON STATE DEPARTMENT OF COMMERCE

Question 1. Reports of emerging environmental, climate, and health impacts of black carbon produced by current "alternative" fuels like LNG indicate that the full transition away from LNG-powered transportation may be a critical step to ensure a livable future on earth. What are the necessary steps to transition our marine transportation system toward 100 percent clean energy sources?

ANSWER. It is well established within the maritime transportation industry and its supply chain that LNG is a growing "transition" fuel seeking to bridge the gap from today's typical emission profile towards a 100% clean energy, zero-emission future. Investments are being made in order to meet current international regulations and significantly limit other emissions like NOx, SOx and diesel particulate matter, particularly in disproportionately low-income communities of color. However, it is also accepted that this is not a long-term solution to get to zero-emissions and many believe that investing in the infrastructure necessary for LNG will prolong the necessary investment in R&D and solutions for a 100% clean energy future.

In my opinion, the steps necessary to get towards a 100% clean energy future and zero-emission transportation include:

- Establish and invest in current infrastructure known to support zero-emission fuels. For example, developing an electrical grid that can support the types of loads necessary to electrify inland and short sea shipping as well as cold ironing for deep-sea vessels, cruise ships, etc. This would include ways to produce zero-emission fuels in the future like hydrogen and/or ammonia fuel cells and a distinct look at how existing infrastructure can support future alternatives. These infrastructure investments would need to look systemically along the working waterfront and be part of a deliberate and strategic approach to decarbonization.
- Invest in a coordinated approach to R&D and commercialization of zero-emission solutions within the federal enterprise. There is a nascent but effective group being led by the US Department of Energy to coordinate with other relevant agencies, departments and offices where R&D is underway seeking to address alignment and support of industry's direction. The Blue Economy spans across many federal agency interests and areas of responsibility. If there is a centralized place, or group that could facilitate federal investment and strategy for R&D this would drastically scale our effectiveness and ability to find solutions. One example being discussed is the revival of the National Oceanographic Partnership Program (NOPP)[1] which could be resourced and expanded to include the breadth of the Blue Economy, including maritime transportation.
- Empower the US maritime industry by leading the global maritime community at the IMO, UN and other intergovernmental forums. For example, the proposal put forward by the World Shipping Council and several other industry associations to establish an IMO backed R&D fund would be a significant step towards what is needed on a global scale to find zero-emission solutions and the infrastructure needs to support them[2]. The US has an important voice at the IMO and could increasingly engage the global maritime and ocean economy at the UN level to be part of the solution. This would send a leadership signal to the US maritime industry that we are engaged and want to lead the work in this

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[1] National Oceanographic Partnership Program, https://www.nopp.org/

[2] World Shipping Council Proposal to IMO–MPEC for R&D Fund, http://www.worldshipping.org/public-statements/regulatory-comments/MEPC__75-7-4__-__Proposal__to__establish__anInternational__Maritime__Research__and__Development__Board__-IMRB-__-ICS__BIMCO__CLIA__INTERCA...-__18__Dec__2019.pdf

major maritime transformation underway. So far, we are not leading this effort and are lagging behind both Europe and Asia.

- Support the efforts of regional innovation clusters. At a local scale, the maritime and ocean supply chain of operators, technology developers, and designers are engaging with state and local governments, research institutions, entrepreneurs, investors and community groups to accelerate innovation. These formal organizations are drawing participation and collaboration to manage successful demonstration projects, deploy private and public capital, and develop new technology. All other world-class maritime regions are investing in these "innovation ecosystem builders" to lead these efforts. Norway, France, Portugal, England, Singapore, Dubai, and others have a national system of innovation clusters supported, at least in part, by government. Just now the US is starting to recognize the role of these cluster organizations, incubators and accelerators. The recent Build to Scale Notice of Funding Opportunity (NOFO), a partnership between the Economic Development Administration and the Department of Energy, to support the Blue Economy is a tremendous start[3]. We would hope this would be an ongoing commitment to supporting the underlying operational needs of this activity.

Question 2. What strategies is Washington state using to reach its zero-emission by 2030 goal? Please send a list of the technologies being deployed across the fleet.

ANSWER. Washington state owns and operates the largest ferry system in the United States and is committed to convert the entire fleet of 25 vessels and 20 terminals to electric and hybrid-electric operations by 2040[4]. We are starting with the conversion of our largest vessels and starting a 5-vessel newbuild program of another class. The conversion of our largest vessels and largest polluters is from diesel electric to diesel/battery hybrid. These are 200 + vehicle ferries designed to run at 90% zero-emission with the appropriate charging infrastructure at the terminals. Washington State Ferries also use a B20 blend of biodiesel.

Other public (local municipality transit and ferry districts) and private operators of ferries are utilizing both hybrid-electric systems and designing all-electric systems, with both battery and fuel cell technology being explored. Electric and hybrid solutions are competitive for ferry, short sea and inland vessel operations where charging infrastructure can be deployed to support operations.

Washington state is also investing in electrification of cargo terminals at our major gateways through the state's VW mitigation settlement. A portion of these funds, along with state capital dollars, are being used to support port investments to provide cold ironing at container and cruise terminals. As well, the state administers the Clean Energy Fund, a competitive grant program for electrification of transportation, including for maritime applications.

Other fuel technologies I am aware of that are being researched or developed throughout the private commercial fleet in Washington include: biodiesel, biogas, LNG, LNG/battery hybrid, hydrogen fuel cell, hydrogen injection w/diesel, and ammonia fuel cell.

Washington based design, architecture and construction firms are developing more efficient hull designs and materials to increase efficiency for alternative, zero-emission options like foiling for high speed passenger ferries.

Washington has also become a center for battery/energy storage design and development both for on-board as well as supporting shoreside charging. There are new marine specific battery companies in Washington state. One is working on commercializing a solid-state lithium ion battery to be completely manufactured in the US. Others are bringing new technologies, chemistries, cooling and management systems as the market for marine batteries continues to exponentially grow.

Question 3. What work has the Washington Maritime Blue cluster done to operationalize alternative fuels and energy sources with the smallest greenhouse gas emission impact?

ANSWER. As an independent non-profit, cluster organization, Washington Maritime Blue operates on a number of levels to support alternative fuels and zero-emission solutions to meet the State's strategy goals for deep-decarbonization. They include:

- Marketing and communications for our members and the growing center of excellence in our region, particularly around electrification.

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[3] US Commerce Economic Development Administration FY2021 Build to Scale Funding Opportunity, https://www.grants.gov/web/grants/view-opportunity.html?oppId=324375

[4] Washington State Ferries 2040 Long Range Plan, https://www.wsdot.wa.gov/sites/default/files/2019/01/07/WSF-2040-Long-Range-Plan-2019.pdf

- Knowledge sharing events, called Blue Forums, that bring together hundreds of stakeholders on key topics such as maritime energy solutions, digitalization, battery safety, etc.
- Managing Joint Innovation Projects to achieve demonstration and/or commercialization of new technology and collaborative R&D. For Example; managing members and funding mechanisms to design, construct and support operations of a zero-emission fast foil ferry for Puget Sound passenger service.
- Administer a partnership between service providers, educational institutions, and employers to make maritime an accessible option for low-income youth and youth of color to create a 21st century maritime workforce.
- Attract various forms of investment and funding to demonstration projects and entrepreneurs working on solutions for the blue economy and decarbonization of maritime transportation.
- Develop and manage a Blue Innovation Accelerator for young companies working on solutions to achieve our state's Strategy for the Blue Economy and building a Maritime Innovation Center to be a hub for our region's growth as a center of excellence.

Question 4. How have you collaborated with shore infrastructure operators (i.e., ports, marine terminals, fuel suppliers) to source fuels? What challenges arose, and what federal support can enable further successful implementation?

ANSWER. Incorporating technology and infrastructure development on shore is key to successful deployment of technology on board vessels as well as the ability to reduce impact of vessels at berth and shoreside operations. A number of projects are underway to further implement:

- Washington State Department of Ecology is administering a grant program utilizing VW Settlement dollars, a portion of which is slated for marine terminal electrification adding cold ironing capacity as well as terminal equipment.
- Washington State Department of Commerce is working with a major bio/renewable fuel producer to expand operations and production in the state for both aviation and marine fuels.
- Washington Maritime Blue is leading a team in a grant application to bring renewable hydrogen production to a major port in Washington that would be used for marine/maritime applications including terminal equipment and local rail.
- Washington Maritime Blue is supporting technology supplier input to standardization of charging technology for ferry operations.
- Washington Maritime Blue is working with several digital/tech companies and terminal operators to increase efficiency for terminal movements, drayage, and just in-time arrivals seeking to decarbonize up to 30% through efficiencies, tracking and incentives alone.
- Washington Maritime Blue is working with a team to produce a decarbonization strategy for Seattle's working waterfront along with the Port of Seattle, Seattle City Light (the utility), terminal operators, owners and tenants.

One of the largest challenges that has arisen for us working to develop shore-side infrastructure is how to best engage with the utility. They are often supportive but either the technology or rate-based systems that are in place seemingly limit the economic viability of large electrification projects. However, we have found that working collectively we can find ways to make the economics work to look for solutions like micro-grid technology, new rate systems, energy storage and renewable energy production. With the leadership of Governor Inslee, we now have new Clean Energy Transition policies passed in 2019 that incentivize the public and private utilities to transition to renewables and gain credits for supporting electrification of transportation systems. Finding federal mechanism to incentivize utilities to modernize and account for the large increase of electrification in all sectors will be essential to scale these types of projects.

Another challenge is the ability to permit and complete large industrial projects. Not only are there challenges protecting maritime industrial lands in a fast-growing region, but gaining social license for industrial projects, even if the end use is to reduce/eliminate emissions. Many of these are state, local and stakeholder issues—however there has been a lack of consistency and predictability when it comes to federal permitting of infrastructure projects. For example, there is still no clear standard accounting for greenhouse gasses in NEPA nor is there consistency or clear federal to state standards for the 401/404 water quality permit from the application process to decision making. This makes it very challenging for developers and operators who work with very small margins to weigh the cost/benefit of approaching large scale projects, especially those along the waterfront. Washington state is proud of our high environmental standards, we believe these are not unsurmountable. However, it is critical that permitting and regulatory bodies provide consist-

ency and predictability for developers to plan the very large capital investments necessary to decarbonize maritime transportation and power a clean economy.

Additionally, as stated above, having R&D and infrastructure dollars that are distinctly available for maritime energy solutions and coordinated across multiple federal agencies and departments is critical. Many of these solutions are ready to plan and build, some need further testing to scale. There are some examples that can be used as models, including the Department of Energy's H2@Scale grant program[5] where maritime applications are a specific category. Other areas could be adding maritime decarbonization criteria to BUILD grants and other port and infrastructure funding mechanisms through US DOT and MARAD.

Question 5. What would it take to advance the US position in the clean maritime industry and totally decarbonize our maritime sector?

ANSWER. Many of the steps necessary to decarbonize the maritime sector are outlined above. That there will not likely be a single solution makes it challenging to fully account. However, global estimates put the scale of investment at $1 trillion[6]. If the US was able to commit and dedicate a certain amount of relative investment with coordinated leadership our position would be significantly advanced. Much like the role of a cluster organization for a local or regional maritime cluster the US would need a central organizing and coordinating office to bridge and leverage the appropriate agencies across the federal enterprise. Again, the NOPP is already set up to handle that sort of role if resourced and directed appropriately.

Question 6. The International Council on Clean Transportation reports that over 59,000 people died from effects of shipping emissions in 2015, and the ongoing effects of port activity on local communities—disproportionately low-income communities of color—include asthma and other chronic illnesses. What steps has the Office of Maritime taken to mitigate these impacts?

ANSWER. Addressing the disproportionality of affected communities by climate impacts is a top priority for Governor Inslee and is part of the criteria for decision making in all appropriate state agencies. Related to maritime transportation:

- The Washington State Department of Ecology has set criteria to prioritize electrification projects that receive funding with dollars from the VW settlement account. The process looks at NOx, SOx and diesel particulate matter reductions in relation to economically stressed census tracts. This heavily weights electrification projects in and around port industrial areas due to heavy emissions from shipping and vessel activity. "Using data from the Washington Tracking Network's 'Diesel Pollution and Disproportionate Impact', we identified communities that have historically borne a disproportionate share of the diesel air pollution burden. These priority communities have high-traffic transportation corridors and urban population centers, ports, and industrial facilities that can be sources of diesel air pollution, so they provide the greatest opportunity for Washington to achieve its mitigation plan principles and priorities"[7].
- The Washington State Department of Commerce–Energy Division, manages the state's Clean Energy Fund which competitively awards clean energy projects in various sectors and programs. The recently released Electrification of Transportation Systems Program[8] heavily weights projects that reduce impacts in disproportionality affected communities using the same health disparity data referenced above.

QUESTION FROM HON. ANTHONY G. BROWN TO JOSHUA BERGER, GOVERNOR'S MARITIME SECTOR LEAD, WASHINGTON STATE DEPARTMENT OF COMMERCE

Question 1. In your opinion, what policy actions can Congress take to ensure that the Department of Defense's investment in blue carbon capture technology is accessible and leveraged by the commercial maritime industry?

ANSWER. It has been, and will continue to be, a critical connection between the nation's Department of Defense and commercial-industrial sectors in order to leverage investments in projects like blue carbon capture, and others. As well, we need

[5] US Department of Energy H2@Scale Program, https://www.energy.gov/eere/fuelcells/h2scale

[6] UMAS/Energy Transitions Commission study for the Global Maritime Forum: Getting to Zero Coalition, https://www.globalmaritimeforum.org/press/new-analysis-puts-a-price-tag-on-maritime-shippings-decarbonization

[7] Washington State Department of Ecology VW Federal Enforcement Action, https://ecology.wa.gov/Air-Climate/Air-quality/Vehicle-emissions/Volkswagen-enforcement-action/VW-federal-enforcement-action

[8] Washington State Department of Commerce's Electrification of Transportation Systems Program, https://www.commerce.wa.gov/growing-the-economy/energy/clean-energy-fund/electrification-of-transportation/

to insure there continues to be effective mechanisms to leverage innovation in the commercial sector to support the needs of DOD—like the Small Business Innovation Research (SBIR) program and others.

Washington State's military and defense sector is a critical component to our state's economy. "As the second largest public employer in Washington employing more than 127,000 active duty, reserve, guard and civilian personnel, home to over 540,000 veterans including 71,000 retirees and 88,674 military families; Washington's military and defense community supports over $13 billion dollars in annual procurement supported by nearly 2,000 businesses across the state, representing nearly 3% of the state's GDP"[9]. This impact is closely linked to our maritime sector in particular due to the Puget Sound Naval Shipyard, the Naval Base Everett, the Naval Submarine Base Bangor, and the Naval Undersea Warfare Center Division Keyport. A Navy program that was created to support technology transfer and we are working directly with is NavalX–NW Tech Bridge.

"Northwest (NW) Tech Bridge was the result of an alignment of many factors. As the Department of the Navy identified its need to develop new technology and partnerships at scale, the Washington State Manufacturing Extension Partnership (MEP), Impact, simultaneously engaged with a group of stakeholders from the Washington State maritime sector, industry and academia to increase capabilities of the Washington maritime industry. These initiatives, coupled with Washington's multi-million dollar investment in local innovation centers, culminated in very fertile ground for collaboration on national Navy challenges.

Our NW Tech Bridge will identify a low-barrier off-base facility to support rapid collaboration, workshops, and problem-solving events nearby in Kitsap County. Naval Undersea Warfare Center Keyport is working on a contractual agreement that will allow for day-to-day collaboration on problems with industry and academia in a physical collision space. Extensive academic and industry collaboration already occurs within the state with our top tier research and training institutions such as Washington State University (WSU), University of Washington (UW) and UW Tacoma, Western Washington University, and Olympic College. Leveraging these relationships are critical to the success of NW Tech Bridge and the Navy"[10].

QUESTIONS FROM HON. PETER A. DEFAZIO TO JOHN W. BUTLER, PRESIDENT AND CHIEF EXECUTIVE OFFICER, WORLD SHIPPING COUNCIL

Question 1. Reports of emerging environmental, climate, and health impacts of black carbon produced by current "alternative" fuels like LNG indicate that the full transition away from LNG-powered transportation may be a critical step to ensure a livable future on earth. What are the necessary steps to transition our marine transportation system toward 100 percent clean energy sources?

ANSWER. To transition the maritime transportation system to clean energy sources requires an intensive and dedicated research and development effort that is specifically focused on evaluating what combination of clean fuels and technologies are feasible for application in the commercial maritime sector. While tremendous strides have been made in the development of low carbon and zero emission technologies in the on-road sector, the level of research, development, and related activities devoted to developing zero-emission fuels and technologies designed for use in the commercial maritime sector is very limited with many projects focused on small ferries and other vessels with modest power requirements.

Recognizing this challenge, the World Shipping Council ("WSC" or "the Council"), together with a number of other maritime industry organizations, has submitted a detailed proposal to the International Maritime Organization (IMO) that calls for establishment of an *International Maritime Research and Development Board (IMRB)* whose purpose would be to undertake the necessary research to develop and introduce zero-emission ships (including systems appropriate for large transoceanic ships) as soon as possible. The proposal also includes a legally binding funding mechanism that would generate roughly 5 billion USD from ocean carriers over a ten-year period. WSC believes this action is a critical step in developing the technical pathways for the introduction of low-carbon and zero-emission ships. The proposal submitted to the IMO is included in my written testimony provided in advance of the January 14 hearing.

Question 2. What strategies is the Council using to reach the IMO emission reduction targets? Please send a list of the technologies being deployed across the fleet.

[9] Washington State Department of Commerce Industry Sector Development Program, https://www.commerce.wa.gov/growing-the-economy/key-sectors/military-defense/

[10] NavalX–NW Tech Bridge, https://www.secnav.navy.mil/agility/Pages/tb__northwest.aspx

ANSWER. WSC and its members are working with a large number of governments, the IMO Secretariat, environmental organizations, and other interested parties to gather support for the proposed IMRB (discussed in Item 1) as well as other measures currently under development at the IMO. A short indicative list of technologies currently being used to significantly reduce emissions of sulphur, NOx, PM, CO2, black carbon, and other air emissions include:

- Use of low-sulphur fuels (both within Emission Control Areas and on a global scale);
- Use of exhaust gas cleaning systems (EGCS);
- The introduction of new, more fuel-efficient ship designs that have led to significant improvements in the fuel efficiency of container ships and vehicle carriers with many of the larger container ships improving their design efficiency in excess of 45%;
- Trials in the use of biofuels in a number of ships; and
- The conversion of many container ships to utilize shore-side power in California and other locations where connections are available.

Question 3. What alternative fuels and energy sources will have the smallest greenhouse gas emission impact? What work have your members done to operationalize the use of those fuels?

ANSWER. Notable uncertainty still surrounds the question of what fuels offer the greatest potential to reach near-zero carbon emissions in the commercial maritime sector, but ammonia and hydrogen are two of the more promising fuels, if produced using renewable energy such as solar. Some small-scale demonstrations of hydrogen and battery applications have been undertaken on small vessels with very limited power requirements. The greatest technical challenges lie with identifying what fuels and technology systems may prove feasible for large transoceanic ships that have very large power demands (e.g., engine power capabilities of 30,000–80,000 kW) and need to sail distances measured in thousands of miles between refueling.

The proposal to establish an IMRB is designed to devote considerable effort not only in exploring the different fuel and technology configurations necessary that can be applied in the maritime fleet (including large transoceanic ships), but to develop and test shipboard prototypes and to explore shore-to-ship fuel infrastructure protypes for the most promising fuels and technology systems.

To operationalize the use of these fuels requires intensive technical research and development work and prototype development. This type of work exceeds the capability of any single company or probably any single government. Consequently, WSC and other industry organizations have worked for roughly two years to develop the IMRB proposal to the IMO.

Question 4. How has the industry collaborated with shore infrastructure operators (i.e., ports, marine terminals, fuel suppliers) to source fuels? What challenges arose, and what government support enabled successful implementation?

ANSWER. Experience in this area to date is largely relevant to use of LNG and the use of shore-side auxiliary power in California ports. In the case of LNG use, WSC member companies have developed direct fuel supplier relationships in specific ports where specialized arrangements have been made for delivery of LNG to ships (often truck-to-ship transfers). The support of the U.S. Coast Guard and local port authorities has been critical to establish the necessary protocols and standards to ensure safe handling of the fuel.

In the case of shore-side auxiliary power, the overwhelming majority of experience falls in California where fleet requirements apply to container ship operators visiting California ports. The introduction of shore-side electrical infrastructure with adequate connection vaults is an extremely challenging, costly, and complicated undertaking. California has provided a test case for the numerous technical and regulatory challenges that accompany such rules and the California Air Resources Board (CARB) is currently considering a series of major amendments (including expansion of the program to other ship types) to the existing California at-berth power requirements.

WSC has been working closely with CARB as they move forward with these amendments and we believe the revised regulations should produce better results as legal obligations are proposed to be established for terminals and ports to provide the necessary infrastructure and to ensure connections are made to visiting vessels in a timely manner. Any state or locality considering shore-side power requirements should carefully study the experience and lessons learned in California.

Question 5. What would it take to comprehensively and sustainably advance the US position in the clean maritime industry and totally decarbonize our maritime sector?

ANSWER. Totally decarbonizing the commercial maritime sector will require the development of zero-carbon fuels and technology systems specifically designed for the unique requirements of large transoceanic ships and a broad array of ship types with specific operational demands. This will require an intensive examination of fuel density characteristics, materials science, the potential for green production, and the development of specific systems that meet the demands of ships that transit long distances before refueling. We believe that the proposed establishment of an IMRB is critical to achieving this objective (*see also the response to question 1*).

Question 6. Shore power technology has the potential to virtually eliminate greenhouse gas emissions from maritime vessels while at berth, put upfront capital expenditure has deterred operators from investing in such infrastructure.

COMMENT FROM MR. BUTLER. It should be noted that shore power technology only eliminates GHG emissions for ships at berth if the electricity supplied is itself "green power." If the power plant generating the electricity is producing GHG emissions, emissions are in most cases reduced (depending on the fuel used), but not eliminated. The most significant air quality benefits of shore power are generally associated with the reduction of NOx and PM in the port area, and these emissions are the primary reasons that shore power has been pursued in California.

a. What sorts of incentives and supports could help promote at-berth electrification for your members' vessels?

ANSWER. While retrofitting and equipping ships with shore power capability is expensive, the most complicated and expensive investments involve the provision of electrical infrastructure in the port and terminals. This requires extensive consideration of what the most efficient and cost-effective design is for electrical sub-stations throughout the port as well as the location and construction of electrical vaults that will enable visiting ships to connect as planned.

For some ship types, such as transoceanic vehicle carriers that visit a given port on a very infrequent basis (e.g., some vehicle carriers may visit a given port once or twice in a two to three year period), a system that uses shore-based emission capture technology instead of shore-based electrical connections may prove more practical and cost effective as an emission reduction strategy.

b. What sorts of collaboration and coordination are necessary to ensure international operators can plug in to an electric grid here and abroad? What are the advantages of that approach?

ANSWER. Years of experience in California has demonstrated that an effective at-berth emission program (whether that is electrification or emission capture) requires extensive shore-side planning and coordination between the port authority, terminals, ship operators, and regulatory authorities. The experience in California has also demonstrated that an effective at-berth program requires that definitive obligations be placed on shore-side entities and not only on visiting ships. Failure to do so can result in a situation where shore-power equipped vessels are unable to connect to shore-side power due to inadequate shore-side infrastructure and insufficient incentives or requirements to ensure timely connection of the vessel. Any program also needs to ensure that the relevant electrical power and connection requirements are fully consistent with international standards.

Question 7. The International Council on Clean Transportation reports that over 59,000 people died from effects of shipping emissions in 2015, and the ongoing effects of port activity on local communities—disproportionately low-income communities of color—include asthma and other chronic illnesses. What steps has the Office of Maritime taken to mitigate these impacts?

ANSWER. To effectively mitigate these impacts, port authorities and relevant regulatory bodies need to consider a suite of actions that look at the overall movement of goods in and out of the port and the efficiency of inter-modal transfers. The availability of rail transportation in the port, the use of clean fuels and technology in drayage operations, and emissions from truck traffic, locomotives, and ships need to be examined as a whole. In short, more efficient movement of cargo in and out of the port area results in reduced emissions and improved air quality.

The North American Emission Control Area (ECA) established through the IMO in 2012 has reduced sulphur content in marine fuels from a maximum of 3.5% m/m to 0.10% m/m. This regulatory action has resulted in dramatic reductions of both SOx and PM emissions generated by ships visiting U.S. ports and transiting within 200 miles of the Atlantic, Pacific, and Gulf Coasts (*specific coordinates are provided in Appendix VII of MARPOL Annex VI*). On 1 January 2020 the IMO also lowered the maximum sulphur content of marine fuels used outside of emission control areas from a maximum of 3.50% m/m to 0.50% m/m. Both actions are expected to result in significant air quality benefits and reductions in estimated premature deaths in the United States and across the world.

QUESTION FROM HON. ANTHONY G. BROWN TO JOHN W. BUTLER, PRESIDENT AND CHIEF EXECUTIVE OFFICER, WORLD SHIPPING COUNCIL

Question 1. In your opinion, what policy actions can Congress take to ensure that the Department of Defense's investment in blue carbon capture technology is accessible and leveraged by the commercial maritime industry?

ANSWER. DOD's investment in blue carbon technology is an interesting area of technology development. If these research efforts lead to technologies that are appropriate and cost-effective for application in the commercial maritime sector, we would be interested in following such developments. At this point we do not have enough information to know whether this is a promising approach that could be applicable to commercial applications.

QUESTIONS FROM HON. PETER A. DEFAZIO TO B. LEE KINDBERG, PH.D., HEAD OF ENVIRONMENT AND SUSTAINABILITY–NORTH AMERICA, MAERSK

Question 1. What strategies is Maersk using to reach its zero-emission by 2030 goal? Please send a list of the technologies being deployed across the fleet.

ANSWER. Over the last decade Maersk has reduced our fuel consumed and related emissions by 42% per container moved. This energy efficiency improvement was achieved in three primary ways: new larger, highly efficient vessels, significant retrofits of our existing vessels, and improved operational and vessel management practices. Retrofits to our existing vessels include optimizing propulsion systems and bulbous bows, engine modifications, and elevating the bridge and lashing racks to carry more cargo on the same vessel.

In December 2018 Maersk announced a goal of Net Zero Carbon Shipping by 2050. More near-term goals are to launch our first zero carbon vessel by 2030, and to continue our energy efficiency work with a 2030 goal of a 60% reduction in CO2 emissions vs. 2008.

To achieve these goals we are investing in a range of new innovative fuel and technology programs, and are piloting other technologies such as installation of a large marine battery. We will continue implementation of the radical retrofit program mentioned above and continue improving planning and optimizing of our networks and operations. We also maturing, hardening and fully implementing the innovative digitalization Connected Vessel program. This program is connecting our fleet digitally with our global operations coordination centers and enables real-time optimization of operational conditions. A brief video with more information is available at https://www.bing.com/videos/search?q=youtube+maersk+zero+carbon&view=detail&mid=1081847AE8FF0279FA751081847AE8FF0279FA75&FORM=VIRE.

Question 2. What alternative fuels and energy sources will have the smallest greenhouse gas emission impact? What work has Maersk done to operationalize the use of those fuels?

ANSWER. In October 2019 we published a study together with Lloyds Register where we openly shared what we see as the three best option to Decarbonize ocean shipping: Alcohols (biofuels/LEO etc.), Biogas and Ammonia. We are also following developments in fuel cells and

Biofuels can have no "tailpipe" CO2 emissions, reducing the lifecycle CO2 footprint to the levels required to produce and transport the fuel (comparable to "well to wheel" metrics for conventional fuels). Our work on innovative biofuels includes a Lignin Ethanol Oil project, and the new Maersk ECO Delivery product.

Question 3. How has Maersk collaborated with shore infrastructure operators (i.e., ports, marine terminals, fuel suppliers) to source fuels? What challenges arose, and what government support enabled successful implementation?

ANSWER. At this time the fuels needed have been available through our traditional suppliers, with whom we have worked closely for many years (especially for the successful implementation of the IMO 2020 fuel program). Shore power/electrification has required close cooperation with marine terminals and ports in California for over 10 years to ensure vessel and shore-side infrastructure are compatible and aligned. Continued communication and cooperation are needed for ongoing shore power operations.

For future fuels, the shore side need will be driven by the fuel types selected—their physical properties and any possible fuel handling risks identified. Clearly cooperation with shippers and ports will be essential, and time and investment needed to enable implementation. As an example, the Port of Rotterdam was one of the core partners in our first biofuel trial in April–May 2019.

Question 4. What would it take to advance the US position in the clean maritime industry and totally decarbonize our maritime sector?

ANSWER. Global action is required to address the challenges of decarbonizing international shipping. Mr. Butler of the World Shipping Council, who also spoke to the Subcommittee hearing on this topic, may be an excellent resource on policies to advance decarbonization.

Question 5. Shore power technology has the potential to virtually eliminate greenhouse gas emissions from maritime vessels while at berth, put upfront capital expenditure has deterred operators from investing in such infrastructure.

a. What sorts of incentives and supports could help promote at-berth electrification for Maersk vessels?

b. What sorts of collaboration and coordination are necessary to ensure international operators can plug in to an electric grid here and abroad? What are the advantages of that approach?

ANSWER (a.–b.). The investment required for shore power is indeed significant, both on vessels and the land side. In addition, like other electrification programs, the benefit of shore power is dependent on availability of plentiful electricity from clean sources. Only California has made the enormous investment required to provide both shore power infrastructure and to green their electric grid.

Even in California shore power is only in use for container, cruise and refrigerated cargo in five ports. And some of these ports do not have sufficient off-port electrical power supply or on-port infrastructure to enable full use of this technology. Other types of vessels and ports (e.g., tankers, vehicle carriers and bulk cargo ships) do not yet have shore power capability. Some US military installations do have shore power capability.

While there is an international ISO/IEEE standard for shore power it may need updates to serve a broader range of vessel types and cargos. This standardization is essential for international compatibility. Technical and operational challenges also still impede full use of shore power, including aligning connections for vessel and shore as vessel sizes change, congestion, and challenges with equipment reliability in the ocean salt environment. Close cooperation between ports, marine terminals, vessel owners and operators and regulatory agencies is important for this implementation, and to date public funding has been required for broad implementation.

Question 6. The International Council on Clean Transportation reports that over 59,000 people died from effects of shipping emissions in 2015, and the ongoing effects of port activity on local communities—disproportionately low-income communities of color—include asthma and other chronic illnesses. What steps can we take today to mitigate these impacts?

ANSWER. Since 2015 a number of measures have been implemented to reduce the environmental impacts of ports in the US. The North American Emissions Control Area (ECA) is a 200-mile band around the US and Canada where cleaner fuel has been required since 2012. In 2015 the ECA fuel sulfur limit stepped down from 1.0% sulfur to 0.1%S, reducing emissions of sulfur oxides by an additional 90%, and also reducing related fine particles significantly. In January 2020 the global fuel sulfur limit changed from 3.5% to 0.5%. IMO and the North American ECA also set requirements for engines to produce fewer oxides of nitrogen (NOx). These requirements will continue to phase in as new vessels replace older ones, continuing to reduce emissions from the global fleet for the next decades.

Other steps being taken in some ports include incentive programs for voluntary vessel speed reductions and encouraging deployment of newer lower-emitting vessels. On the land side, cargo handling equipment can be electrified, incentive programs help implement newer lower-emitting trucks sooner, and shore power can reduce emissions if electric power is from clean or renewable sources.

Question 7. Has Maersk invested in any of the following existing zero-emission technologies: Electric Ship-to-Shore (STS) Rail-Mounted Gantry Cranes, Electric Rubber-Tired Gantry (RTG) Cranes, Electric Rail-Mounted Gantry Cranes, Electric Bulk Handling Crane, Carry Deck Cranes, Reach Stackers, Shuttle Carriers, Straddle Carriers, Trailer Spreaders, Electric Forklifts, Electric Pallet Trucks, or Top Front End Payloaders?

ANSWER. Our sister company APM Terminals has invested in several of these technologies in their US and global facilities.

QUESTION FROM HON. ANTHONY G. BROWN TO B. LEE KINDBERG, PH.D., HEAD OF ENVIRONMENT AND SUSTAINABILITY–NORTH AMERICA, MAERSK

Question 1. In your opinion, what policy actions can Congress take to ensure that the Department of Defense's investment in blue carbon capture technology is accessible and leveraged by the commercial maritime industry?

ANSWER. I was not familiar with the DoD's blue carbon capture technology. Carbon capture is certainly of interest for all large energy users, and we will seek further information on this capability. Transparency and collaboration between military and civilian industry are important in technology transfer, and we would be interested in discussing such potentials further.

QUESTION FROM HON. CAROL D. MILLER TO B. LEE KINDBERG, PH.D., HEAD OF ENVIRONMENT AND SUSTAINABILITY–NORTH AMERICA, MAERSK

Question 1. It is impressive that MAERSK has reduced their fuel consumption by over 40 percent in the last decade. As we enter a new decade, what progress do you expect the industry to make over the next ten years?

ANSWER. Maersk is continuing our work to dramatically improve energy efficiency and thus reduce fuel-related emissions. Our 2030 goal is to have reduced our fuel use and related CO2 emissions by 60%, and to launch our first carbon neutral vessel. We have committed to Zero Carbon Shipping by 2050.

Based on results reported annually to the Clean Cargo Working Group, which do include Maersk's results, the container shipping industry as a whole has also made impressive progress in emissions reduction. Since Clean Cargo began publicly reporting data from the industry in 2009, emissions per container per kilometer have dropped 37.1 percent on average. Maersk and the other members of Clean Cargo remain committed to continued progress.

The international regulatory structure for emissions reduction is developing at IMO, with some metrics and goals in place and others being developed. The IMO website describes these goals as follows (source: http://www.imo.org/en/MediaCentre/HotTopics/GHG/Pages/default.aspx):

> "In April 2018, IMO's Marine Environment Protection Committee (MEPC) adopted an initial strategy on the reduction of greenhouse gas emissions from ships, setting out a vision to reduce GHG emissions from international shipping and phase them out, as soon as possible in this century. The vision confirms IMO's commitment to reducing GHG emissions from international shipping and, as a matter of urgency, to phasing them out as soon as possible.
>
> "More specifically, under the identified "levels of ambition", the initial strategy envisages for the first time a reduction in total GHG emissions from international shipping which, it says, should peak as soon as possible and to reduce the total annual GHG emissions by at least 50% by 2050 compared to 2008, while, at the same time, pursuing efforts towards phasing them out entirely. "The strategy includes a specific reference to "a pathway of CO2 emissions reduction consistent with the Paris Agreement temperature goals".
>
> "The full text of the Initial IMO Strategy on reduction of GHG emissions from ships can be downloaded here [https://unfccc.int/sites/default/files/resource/250__IMO%20submission__Talanoa%20Dialogue__April%202018.pdf], . . ."

QUESTIONS FROM HON. PETER A. DEFAZIO TO PETER BRYN, TECHNICAL SOLUTIONS MANAGER–NORTH AMERICA, ABB MARINE AND PORTS

Question 1. What technologies can help operators meet a zero-emission by 2030 goal? Please send a list of the technologies you would consider.

ANSWER. There are a number of technology options available to ship owners and operators for reducing or eliminating emissions. It is critical that ship owners and operators identify the proper solution for the operational needs of their vessel. For most segments and technologies, an electric propulsion system is a key enabling technology. My testimony provides a list of those technologies on page six and then provides further detail by vessel segment on pages 8–14.[†]

Some vessel segments have more readily available zero emissions options than others. For example, ferries have become one of the pioneering vessel types for zero-emission battery deployment because they combine generally shorter routes with regular port visits. The shorter routes allow installation of battery packs that can fully power the vessels on their journeys while the predictable routes and turnaround times enable efficient deployment of shoreside charging infrastructure. For these reasons, its unsurprising that the ferry industry is among the first marine segments to adopt full battery-electric solutions.

[†] Editors's note: Please see Mr. Bryn's testimony as it appears at https://docs.house.gov/meetings/PW/PW07/20200114/110356/HHRG-116-PW07-Wstate-BrynP-20200114.pdf.

Question 2. How has ABB collaborated with shore infrastructure operators (i.e., ports, marine terminals, fuel suppliers) to source fuels and energy? What challenges arose, and what government support enabled successful implementation?

ANSWER. ABB provides a number of low and zero emissions technologies to ports and marine terminals including: electric cranes and gates, microgrids, energy storage solutions, control systems, and ship to shore electrical infrastructure. Some examples include: Long Beach Container Terminal [https://www.youtube.com/watch?v=JIrPWW6r1uo], and a number of ship to shore projects [https://new.abb.com/substations/port-electrification-and-shore-to-ship-power]. Emission reduction policies and targets have played an integral role in incentivizing low and zero emission technology deployments at ports, particular for ship to shore connections. Other low and zero emission solutions like electric port operations (gates, cranes, vehicles) benefit from government policies focused on lower emissions as well as funding mechanisms to assist owners and operators convert existing diesel powered systems to electric grid powered systems.

Question 3. What would it take to advance the US position in the clean maritime industry and totally decarbonize our maritime sector?

ANSWER. The US could position itself as a leader in the clean maritime industry by setting clear, national, and ambitious decarbonization targets for both federal and merchant fleets as well as providing financial support and incentives for research, development, and deployment of zero emissions marine technologies, including shoreside infrastructure for charging and carbon free fuels.

Question 4. The International Council on Clean Transportation reports that over 59,000 people died from effects of shipping emissions in 2015, and the ongoing effects of port activity on local communities—disproportionately low-income communities of color—include asthma and other chronic illnesses. What steps can we take today to mitigate these impacts?

ANSWER. Transitioning to low and zero emissions technology for port operations, on vessels, and for ship to shore power (cold-ironing), can reduce or eliminate local emissions. Importantly, low and zero emission solutions often have strong economic benefits, including increased container throughput and productivity, and lower maintenance and operations costs for both vessels and ports. The federal government has a number of policy tools at its disposal to encourage this transition that range from setting emission standards to investing in electrification of port operations and shoreside power for cold-ironing.

Question 5. What vessels in Federal fleet, particularly those used the Coast Guard, could see substantial emissions reductions using existing technology while still meeting mandated use? What federal programs (existing or not) could facilitate rapid uptake of no/low-carbon technologies?

ANSWER. There are a number of Federal Fleet ships that could use existing technology to reduce their emissions, while also preparing them for even further reductions as new zero emission technologies are commercialized over the course of their lifetime. Two types of vessels that provide near term emission reduction opportunities include: (1) MARAD National Security Multi-Mission Vessels and (2) Coast Guard Waterways Commerce Cutters. Other vessel classes that provide opportunities for emissions reductions include vessels operated by: National Park Service, US Coast Guard, National Oceanic and Atmospheric Administration, among others.

In the near-term, the Passenger Ferry Grant Program (S.5307) could facilitate the uptake of commercially ready zero-emission ferries in a number of ways, including, for example: requiring a certain portion of grant funding to specifically support zero-emission ferries or infrastructure; or establishing a zero-emission sub-program similar to the transit bus low/no program (S.5339c).

QUESTION FROM HON. ANTHONY G. BROWN TO PETER BRYN, TECHNICAL SOLUTIONS MANAGER–NORTH AMERICA, ABB MARINE AND PORTS

Question 1. In your opinion, what policy actions can Congress take to ensure that the Department of Defense's investment in blue carbon capture technology is accessible and leveraged by the commercial maritime industry?

ANSWER. Blue carbon capture refers to technology to remove CO2 directly from the atmosphere and is in the very early stages of research and development. A few policy principles could help facilitate commercial readiness and adoption, including, but not limited to:

- Providing consistent, predictable and steady federal investment over a number of years;
- Establishing cross-disciplinary planning, research, development, and deployment teams;

- Involving commercial and private sector advisors, collaborators, and project partners from the start of the program;
- Promoting and fostering cross-agency cooperation, including: Department of Energy, National Science Foundation, National Oceanic and Atmospheric Administration, Department of Defense, and others.

FOREWORD TO RESPONSES FROM KATHY METCALF, PRESIDENT AND CHIEF EXECUTIVE OFFICER, CHAMBER OF SHIPPING OF AMERICA

SUMMARY OF PERSPECTIVES OF THE COMMERCIAL MARITIME INDUSTRY IN PROVIDING RESPONSES BELOW

While understandably, this hearing focuses on the relationship of this issue to the US maritime system, it is important to recall that shipping is global in nature as are the impacts of greenhouse gases (GHGs) and CO2 emissions. The most robust control mechanisms in one country will never make up for the lack of control systems in other countries. Thus the solution to a successful GHG emissions reduction program must be global in nature, adopted by the International Maritime Organization's (IMO) Member States and fully implemented by national governments with jurisdiction over ports (port states), coastal states, and flag states. In this respect, the "common but differentiated responsibilities" (CBDR) principle applied by the United Nations Framework Convention on Climate Change (UNFCCC) which distinguishes between developed and developing countries should have no place in the development of GHG control mechanisms for global shipping. Rather the International Maritime Organization's (IMO) "no more favorable" treatment principal should apply and thus the IMO should be the lead UN agency in developing the way forward in addressing GHG emissions from shipping. It is critical that the US and its fellow IMO Member States work together to develop a truly global program for GHG emissions reductions and establish a level playing field for vessels, ports and coastal states.

The solutions to address the decarbonization of shipping rest with both governments and the private sector. A good example of private sector activities is the Global Maritime Forum (GMF) which is founded on the idea that "progress happens when people from all parts of a system—in this case the global maritime industry and its stakeholders who have the will and the influence to make positive change—come together to discuss challenges and work together on finding new solutions". Its objective is "to shape the future of global seaborne trade to increase sustainable long-term economic development and human wellbeing". To put the magnitude of this problem and its solution in perspective, the GMF has estimated that at least USD 1 trillion in investments will be needed to decarbonize shipping with the major need for investment upstream in energy and fuel production (87%). For more information on the GMF, please see their website at https://www.globalmaritimeforum.org/. For more information on their scale of investment study, please see https://www.globalmaritimeforum.org/press/new-analysis-puts-a-price-tag-on-maritime-shippings-decarbonization.

We provide this information to make the point that the research and development and costs associated with the decarbonization of shipping and the land-based industries which will support this paradigm change, is not within the financial bounds of most countries or the industry. It is however within the bounds of an international collaboration among all the stakeholders including governments, the shipping industry, energy producers, ports and environmental organizations. Collaboration on what is arguably one of the most significant issues of our generation is critical to execute the transition to the decarbonization of the shipping industry and all its supporting components.

It is important to realize that not all vessels are the same either in structure or in operational profiles. To successfully transition, a number of solutions will likely be identified unique to a particular type/size of vessel and/or trading patterns, making even more complex, the ultimate solution for application to the global fleet.

To fully appreciate the commitments the global shipping industry has made to achieve these goals, the International Chamber of Shipping (ICS), of which we are a founding member, co-hosted a successful side event at the UNFCCC Conference of the Parties (COP 25) in mid-December. During that side event, ICS on behalf of the global shipping industry stated that "as shipping's global regulator, the UN International Maritime Organization has successfully enhanced the sector's impressive environmental performance through a comprehensive framework of regulations which enjoy robust enforcement worldwide and this includes greenhouse gas reduction". The ICS spokesperson further stated that "there are already mandatory CO2 reduction regulations in force globally that will require all ships to be at least 30%

more carbon-efficient by 2025. In line with the ambitious CO2 reduction targets which IMO Member States agreed last year (2018), the IMO will adopt a new package of regulations in 2020 with a focus on operational fuel efficiency and speed optimization. This should ensure further CO2 reductions by 2023 and assure that the sector is on track to exceed the IMO target of a 40% efficiency improvement across the entire world fleet by 2030." Regarding the ambitious 2050 goal, the ICS spokesperson stated that "the industry's greatest priority is to help the IMO make rapid progress with implementing its very ambitious 2050 target, cutting the sector's total CO2 emissions, regardless of trade growth, by at least 50%, with full decarbonisation soon after. Accelerating R&D of zero-carbon technologies and propulsion systems that can be applied on trans-oceanic ships must therefore be at the heart of the IMO strategy."

QUESTIONS FROM HON. PETER A. DEFAZIO TO KATHY METCALF, PRESIDENT AND CHIEF EXECUTIVE OFFICER, CHAMBER OF SHIPPING OF AMERICA

Question 1. Reports of emerging environmental, climate, and health impacts of black carbon produced by current "alternative" fuels like LNG indicate that the full transition away from LNG-powered transportation may be a critical step to ensure a livable future on earth. What are the necessary steps to transition our marine transportation system toward 100% clean energy sources?

ANSWER. The first step towards operationalizing 100% clean energy sources is the creation of a global R&D program which can identify alternative fuels both transitional and zero carbon. To date possible alternatives include electric/battery, hydrogen, green ammonia, and biofuels. Once the "possible" is identified, research needs to be done to determine the capabilities of ships, port infrastructure and energy producers to use, produce and distribute fuels on a global basis. Parallel work to the alternative fuel initiative is identifying the needed changes to marine propulsion systems and onboard storage requirements so that reliable and safe systems can be integrated into new ship design.

Question 2. What strategies is are members of the Chamber using to reach the IMO emission reduction targets? Please send a list of the technologies being deployed across the fleet.

ANSWER. To the best of our knowledge, very few large commercial ships are able to integrate zero carbon solutions on board their vessels at this point in time due to the non-availability of zero carbon fuels and propulsion systems that can utilize these fuels. Various technologies are being reviewed and in some cases are the subject of research programs which include application of more stringent energy efficiency design standards, application of energy efficiency design concepts to existing ships, mandatory power limitations on ships, goal based short term reduction measures as part of the Ship's Energy Efficiency Management Plan (SEEMP), strengthening of the existing SEEMP, and speed optimization. While these examples are concepts, the technologies associated with implementing some of these measures are not yet developed or in extreme cases, not yet identified. An excellent primer on the challenges facing the industry may be found in the document published by the classification society DNV–GL entitled "Energy Transition Outlook 2019" which may be downloaded at https://eto.dnvgl.com/2018/maritime. Of particular note is the information found on alternative fuel technology (Chapter 3), fuel flexibility as a bridge towards low-carbon shipping (Chapter 4) and the ecosystem approach to bridge the emissions cap (Chapter 5).

Question 3. What alternative fuels and energy sources will have the smallest greenhouse gas emission impact? What work have your members done to operationalize the use of those fuels?

ANSWER. As indicated above, operationalization of lower carbon or zero carbon fuels on large commercial ships is not yet possible in most cases due to the nonavailability of the alternative fuels and propulsion systems designed to use them. Our members, via CSA's involvement and information sharing with international industry colleagues and IMO Member States, are reviewing a number of alternatives for consideration in future new builds which also includes discussions with governments, the global classification societies and engine manufacturers. Although much research remains to be done on the GHG emissions impacts of specific transitional (low carbon) and zero carbon fuels, current focus is on methanol, LNG/LPG, electrification (battery hybrid systems), biofuels, hydrogen and ammonia.

Question 4. How have your members collaborated with shore infrastructure operators (i.e., ports, marine terminals, fuel suppliers) to source fuels? What challenges arose, and what government support enabled successful implementation?

ANSWER. The nature of our members' collaboration with shore infrastructure varies with the commercial arrangements between vessel owners and terminal operators and ship types. For example, one of our member companies own and operate container vessels and own and operate their terminal facilities in the US. In this case, integration of shore power (cold ironing) into the port operating profile of their vessels was facilitated by the fact that both the ship and terminal were owned and operated by the same entity. In other cases (the majority,) vessels call at terminals that are not owned by the company which owns the vessel which makes the implementation of vessel/shore infrastructure collaboration more difficult especially when taking into account that ownership of the terminal may range from a private entity to a public port authority. As regards sourcing of fuels, vessel owners work very closely with established marine fuel/bunker providers to assure the availability of compliant fuel (0.1% for use in the emissions control areas, 0.5% for use outside the emission control areas). Although zero carbon fuels are not yet available in the global marketplace (nor are vessels which can utilize these fuels), it would be expected as we transition to zero carbon fuels, a similar dialogue will occur between fuel providers and the vessels which will purchase and use these fuels.

CSA as an organization is working with a number of global port initiatives which are discussing the need for infrastructure to accommodate both transition fuels and eventually zero-carbon fuels. Two examples of these collaborative efforts are the World Ports Sustainability Program (WPSP) and the Global Industry Alliance (GIA).

WPSP is composed of the American Association of Ports Authorities, the European Sea Ports Organization, the International Association of Cities and Ports and the World Association for Waterborne Transport Infrastructure. WSPS is focused on the UN Sustainable Development Goals by engaging business, governments and societal stakeholders to add value for local communities and wider regions in which ports are embedded. More information on this project can be found at https://sustainableworldports.org/

GIA is an ongoing project overseen by the IMO in partnership with two other UN agencies and is focusing on the development of public/private partnerships among key stakeholders including shipowners, operators, classification societies, engine and technology builders and suppliers, big data providers, oil companies and ports. More information on this project can be found at https://glomeep.imo.org/global-industry-alliance/global-industry-alliance-gia/

Both programs are a result of the recognized need for collaboration and coordination across all stakeholders to address environmental issues associated with shipping and ports, including the decarbonization of shipping.

Question 5. In your testimony, you discussed a complex web of environmental impacts in the maritime sector. What would it take to comprehensively and sustainably advance the US position in the clean maritime industry and totally decarbonize our maritime sector?

ANSWER. While marine transportation is by far the most environmentally friendly form of transportation on a ton per distance traveled basis, the industry has long been committed to the principle of continuous improvement in our safety and environmental performance and reduction of our environmental footprint. The complex web of environmental issues to which I referred in my testimony relates to the need to appreciate that environmental improvements in one specific area of vessel operations may adversely impact the environmental performance in other areas. Our goal is, of course, to address these issues holistically so that the maximum net environmental benefit is realized. The same is true with regard to all transportation modes and their GHG emissions control strategies. As noted above that shipping is the most environmentally friendly form of transportation on a ton per distance traveled basis, we must be certain that shifts to other less friendly transportation modes do not result from GHG reduction strategies applied to the global maritime industry.

Question 6. Shore power technology has the potential to virtually eliminate greenhouse gas emissions from maritime vessels while at berth, put upfront capital expenditure has deterred operators from investing in such infrastructure.

a. What sorts of incentives and supports could help promote at-berth electrification for your members' vessels?

b. What sorts of collaboration and coordination are necessary to ensure international operators can plug in to an electric grid here and abroad? What are the advantages of that approach?

ANSWER. Please permit me to respond to these two questions in a single response. In our opinion, the largest obstructions to the global adoption of the use of shore power while a vessel is at berth is two-fold. The first is the lack of a global land-based and shipboard standard for shore power provision and standardization of the

ship/shore interface. This is a significant challenge since the energy demands of a vessel at berth vary with the type of vessel. The second, and equally important obstruction, is capital cost to the terminal operator (land-based infrastructure) and to the vessel owner to retrofit its vessels to connect to shore power. While these are not insurmountable challenges, they will require a coordination between the global shipping industry and terminals to assure a safe and sufficient power supply is available to vessels of all types. Another confounding aspect of this issue relates to the commercial ownership profiles of terminals worldwide. In some cases, terminals are privately owned while in other cases, these terminals are owned and operated by national governments or regional port authorities and thus funding streams would need to be created by both public and private entities.

In our opinion the necessary incentives and supports to promote a global at-berth electrification program require collaboration and coordination of all stakeholders to provide a globally consistent set of requirements for both the vessel and land-based infrastructure which will provide the shore power to the vessels. This process has been underway at IMO as regards standardization of the ship to shore interface for vessels but does not seem to be developed on the shore side of the connection, understandable due to the wide variation in terminal ownership characteristics as well as national initiatives to promote the shore power concept. Once this coordination is well underway, discussions on funding should ensure that funding for the shore based infrastructure would occur at least at a national level or in some cases at regional or port level programs.

One comment we would offer on the use of shore-power is the need to recognize that emissions reduced at the ship/shore interface through a shore power program, must be viewed in the perspective of the ultimate source of the shore power. For example, China has put a limited shore power usage requirement in some of its major ports, but to the best of our knowledge the power is being generated by coal-fired power plants which, at a minimum, results in a zero net emissions reduction or, more likely, an increase in net emissions given the land-based emissions associated with coal-fired power plants.

Question 7. The International Council on Clean Transportation reports that over 59,000 people died from effects of shipping emissions in 2015, and the ongoing effects of port activity on local communities—disproportionately low-income communities of color—include asthma and other chronic illnesses. What steps can we take today to mitigate these impacts?

ANSWER. While we are not in a position to address environmental issues ashore which result from the close proximity of port and terminal facilities with low-income communities of any type, the global maritime industry's commitment to reduction of its environmental footprint via all media, will result in the net improvement of environmental quality in the port/terminal areas at least as regards the emissions from the vessel while at berth. Collaboration between the port and global maritime community can further decrease the impacts of marine operations in these areas even further.

QUESTION FROM HON. ANTHONY G. BROWN TO KATHY METCALF, PRESIDENT AND CHIEF EXECUTIVE OFFICER, CHAMBER OF SHIPPING OF AMERICA

Question 1. In your opinion, what policy actions can Congress take to ensure that the Department of Defense's investment in blue carbon capture technology is accessible and leveraged by the commercial maritime industry?

ANSWER. The important issue highlighted by this question is not unique to the commercial access to blue carbon capture technologies being pursued by the Department of Defense (DOD). As a result of the significant R&D budgets allocated to DOD, many cutting edge environmental issues have been the subject of DOD research projects including hull fouling, underwater noise generation by vessels and technologies used to control and monitor operational discharges from vessels. While some sharing of information has occurred in the past, the commercial maritime industry has rarely been the benefactor of findings from DOD studies due to security classifications. While it would clearly be inappropriate to publicly share information with national security implications, a better process to timely review and remove security classifications from studies which have never or no longer carry national security implications would be a critical development to enable sharing of information between the military and commercial maritime sectors.

QUESTIONS FROM HON. CAROL D. MILLER TO KATHY METCALF, PRESIDENT AND CHIEF EXECUTIVE OFFICER, CHAMBER OF SHIPPING OF AMERICA

Question 1. The shipping industry has pledged to generate 5 billion dollars over the next 10 years to help meet the International Maritime Organization 2050 emission reduction targets. How will the money be used to accomplish this goal?

ANSWER. The global maritime transport industry has submitted a proposal to form the world's first collaborative shipping R&D program to help eliminate CO2 emissions from international shipping. This proposal was discussed at length at the hearing by Mr. John Butler of the World Shipping Council. A copy of the industry proposal to IMO is attached to his testimony at Annex A. CSA participated in the development of this initiative as a founding member of the International Chamber of Shipping, one of the 8 sponsors of this proposal which also included the World Shipping Council. This proposal includes the creation of an International Maritime Research and Development Board (IMRB), a non-governmental R&D organization that would be overseen by IMO Member States with a primary focus of accelerating the research, development and deployment of low-carbon and zero-carbon fuels, energy sources, propulsion systems and other new GHG reduction technologies that will be necessary to meet the 2050 goal set by the IMO strategy. The IMRB would be composed of a Board of Directors, Executive Director and a professional staff with specific responsibilities including:

- Development, direction, management and administration of the international maritime research and development strategy designed to promote the development of low-carbon and zero-carbon technologies and fuels for use across the maritime sector, including propulsion systems;
- Identification, definition and ongoing refinement of the specific research priorities established within the mandate and charter of the IMRB;
- Development of specific R&D programs, review of proposals received, and decisions concerning specific project approval and funding;
- Consideration of changes and modifications to specific research and development objectives in light of project results, technology developments, and experience gained;
- Administration of the collection of R&D contributions and the issuance of evidence of contributions having been made by shipowners; and
- Management and administration of the International Maritime Research Fund (IMRF) including all fiduciary responsibilities and provision of regular progress reports, assessments, and recommendations to the supervisory body which would report to the IMO Marine Environment Protection Committee.

While the IMRB is still in proposed form and will be discussed at the spring 2020 meeting of the IMO Marine Environment Protection Committee, it is envisioned that the IMRB Board would include non-governmental professionals with experience in research and development, shipping, shipbuilding, zero-carbon fuels, environmental energy policy and other expertise relevant to the work of the Board, all contributing to the identification of promising research projects and the necessary oversight of these projects as they are being conducted.

Question 2. How has the shipping industry worked with the U.S. Government to promote smart, proactive regulations and what can we do in Congress to make sure that American shipping remains competitive?

ANSWER. The Chamber of Shipping of America is committed to work with stakeholders at the international and US national level, first as a member of the International Chamber of Shipping delegation to the IMO as well as working with members of the US delegation to IMO which includes representatives from EPA, the US Coast Guard and the Maritime Administration (MARAD). Nationally, MARAD, although working with a woefully inadequate budget, has conducted a number of research projects in this area through its Maritime Environmental and Technical Assistance (META) Program. Under the META program, MARAD partners with federal, state and local agencies, the maritime industry and academia, to develop and carry out projects that provide information and insight on key maritime environmental issues. To date, projects have been carried out or are currently underway in the areas of vessel and port emissions, biofuels, fuel cells, liquefied natural gas (LNG), emissions reduction technologies, hybrid and batteries and energy efficiency technologies. The META program's impacts could be significantly increased with a larger budget allocation which would enable MARAD to delve into new issues and expand the scope of their studies on existing issues.

Similar programs are underway in a number of countries but better coordination at the international level is needed to avoid duplication and promote a sharing of information and expenses in conducting these much needed research projects.

As regards the competitiveness of the US shipping industry i.e. US flag, there is no doubt that these initiatives will significantly add to the capital cost of building a vessel as well as the operating costs associated with what are likely to be more expensive fuels. While it is expected that these costs will be borne across the entire industry, regardless of flag, the current cost differentials between US flag vessels versus non-US flag vessels will at least remain the same if not increase.

Question 3. It is important to recognize the importance that traditional fuel will continue to play in global trade in powering our fleets, especially in deep sea shipping. How has the industry continued to innovate when it comes to traditional fuel sources?

ANSWER. In an ideal world, the shift from traditional fuels to carbon neutral fuels would be a seamless and accelerated transition regardless of whether the fuel was used in a land based or sea based application. As is implied in this question, use of traditional fuels will continue until such time as new carbon neutral fuels are produced in sufficient volumes, new vessels are constructed with propulsion systems that can utilize these carbon free fuels and the necessary shore infrastructure is in place to supply these carbon free fuels to the global maritime industry. In the meantime, the global shipping industry has adopted a number of measures already in place that are reducing emissions from vessels. These measure include the adoption of the energy efficiency design index (EEDI) applicable to new vessels, the ship's energy efficiency management plan applicable to both new and existing vessels and more stringent requirements for reduced nitrogen oxide (NOx) emissions from marine engines. In addition to these measures the sulfur levels of marine fuels have been drastically reduced from an average 2.5% sulfur level to a 0.5% sulfur level for fuels used on the high seas and a 0.1% sulfur level for fuels used in IMO adopted emissions control areas which includes the North America and the Caribbean emission control areas. While it is recognized that these measures will not bring the CO2 emissions down to the goals included in the IMO greenhouse gas emissions control strategy, these are early steps in reducing vessel emissions until such time as low or zero carbon fuels and vessels are in place.

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