S. HRG. 116–349

# THE UPCOMING IMPLEMENTATION OF THE INTERNATIONAL MARITIME ORGANIZATION'S NEW GLOBAL SULFUR STANDARD FOR MARINE FUELS, WHICH IS SET TO TAKE EFFECT ON JANUARY 1, 2020

## HEARING

BEFORE THE

## COMMITTEE ON ENERGY AND NATURAL RESOURCES UNITED STATES SENATE

ONE HUNDRED SIXTEENTH CONGRESS

FIRST SESSION

DECEMBER 10, 2019

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# THE UPCOMING IMPLEMENTATION OF THE INTERNATIONAL MARITIME ORGANIZATION'S NEW GLOBAL SULFUR STANDARD FOR MARINE FUELS, WHICH IS SET TO TAKE EFFECT ON JANUARY 1, 2020

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**TUESDAY, DECEMBER 10, 2019**

U.S. SENATE,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
*Washington, DC.*

The Committee met, pursuant to notice, at 10:00 a.m. in Room SD–366, Dirksen Senate Office Building, Hon. Lisa Murkowski, Chairman of the Committee, presiding.

## OPENING STATEMENT OF HON. LISA MURKOWSKI, U.S. SENATOR FROM ALASKA

The CHAIRMAN. Good morning, everyone. The Committee will come to order.

We are here this morning to examine the implementation of the International Maritime Organization's New Global Sulfur Standard for Marine Fuels. This is known as IMO 2020. This new standard will formally take effect on January 1st of 2020, just about three weeks from today.

IMO 2020 has been years in the making, decades in the making, so this is really no surprise that we are up against this implementation date, but I still think that for some, it is like, where did this come from? Well, there is a little bit of history out there. Its purpose, of course, is to reduce air pollution from shipping around the world. It accomplishes that purpose by limiting the sulfur content of marine fuel, which is how much sulfur is in the diesel that ships use to move across the ocean, and limiting that amount to 0.5 percent by mass. Those sulfur reductions will bring global health benefits that all of us should welcome and support.

At the same time, I think we can be proud that here in the United States the sulfur content of marine fuel is already limited to 0.1 percent by mass. As is true on so many different environmental issues, the United States is leading the way here and that is a good thing. Over the last several years the global shipping industry has been preparing to comply with IMO 2020. Three primary options to do that appear to be number one, of course, using low-sulfur diesel fuel; secondly, installing exhaust scrubbers; or third, switching to liquified natural gas which, of course, emits virtually zero sulfur.

No matter which method is chosen, I think we recognize it takes time and it takes money. Whether it is a ship installing a scrubber, a refinery making an upgrade to produce low-sulfur fuel, or a company buying or converting to an LNG-powered vessel, we all know it just takes time and, of course, it takes money. It is generally agreed that the U.S. refining industry is uniquely positioned to benefit from IMO 2020. The investments have been made. Refineries are optimized. All of that supports good paying jobs and will help mitigate potential impacts to domestic and global fuel prices.

There is still some disagreement over what those exact impacts will be, but I am glad to see a consensus, or at least something that resembles a consensus, among the many analysts that the impacts of IMO 2020 will be less than what was projected just a year ago. We had a hearing back in February and I remember asking at that point in time, are we ready for this? And there was some criticism. It is like, whoa, is Murkowski backpedaling on this saying that we don't need to do it? But I was asking the perfectly legitimate question, are we going to be ready? And I think that we do appear to be in a better place today than we were back then.

What is critical now with implementation just a few weeks away is for compliance to continue at full speed. There is no stopping IMO 2020, and I certainly hope that no one will construe that this oversight hearing was an effort to do that.

With that said, it is also important for us to be vigilant. I come from a state that, as you all know, we pay some of the highest prices for energy in the country. So I have been paying very, very close attention to what IMO 2020 could mean for Alaskans, especially those who live in rural and remote areas where shipping prices are already very high and truly the case of economic hardship for so many. I had written the Administrator, Dr. Capuano, who is with us today. We appreciate you being here. But I had written asking that the EIA closely monitor implementation. I am going to enter your response to that letter, Dr. Capuano, in today's hearing record. So I thank you for that.

[Letter to Dr. Capuano and her response follows.]

**Department of Energy**
Washington, DC 20585

November 7, 2019

The Honorable Lisa Murkowski
Chairman
Committee on Energy and Natural Resources
United States Senate
Washington, DC 20510

Dear Madam Chairman:

You inquired about U.S. Energy Information Administration (EIA) analysis and updates regarding the impact of the International Maritime Organization (IMO) 2020 regulation in your letter dated September 17.

EIA updates and includes our analysis of the potential impact of the new IMO limitations on the sulfur content of marine fuels in our Short-Term Energy Outlook (STEO), Annual Energy Outlook (AEO), and International Energy Outlook (IEO). We have also included additional analysis in several *Today in Energy* and *This Week in Petroleum* articles; and, have enclosed an EIA report titled *The Effects of Changes to Marine Fuel Sulfur Limits in 2020 on Energy Market.*

EIA expects the impacts from the IMO sulfur regulation on petroleum product prices to be moderate, peaking in 2020 and dissipating over the next few years as the market adjusts. This conclusion is particularly relevant to states, like Alaska, where fuel prices tend to be higher, and where diesel fuel is important to the economy because of its use in oil and gas production, fishing vessels, forestry equipment, and inter- and intra-state transportation and shipping.

Overall, EIA expects that the IMO 2020 regulations will put about $2/b of upward pressure on light-sweet crude oil prices in 2020 because of higher demand for light-sweet crude oils. However, EIA expects global oil inventories to continue to build and put downward pressure on the price. As a result, our October STEO forecasts Brent crude oil prices of about $60 per barrel in 2020.

EIA also expects that IMO regulations will cause demand for diesel fuel to rise globally to meet the need for low-sulfur compliant fuel. As a result, EIA forecasts that U.S. diesel fuel refining margins will rise in 2020 compared with 2018 and 2019.

We also analyze the price of heating oil, or distillates, for home heating. EIA forecasts that, while the IMO will affect prices in 2020, distillate prices will be lower in 2020 when compared with 2018 because of other factors. For example, crude oil prices and the severity of weather will likely have more influence on what customers pay for heating oil during the winter of 2019-2020 than effects from the new sulfur regulation.

While EIA expects that most of the impact of the IMO2020 regulation on petroleum and shipping markets will dissipate, a long-term effect will be an increase in the number of ships that run on liquefied natural gas (LNG). EIA believes that economic and regulatory factors will increase the rate at which LNG-based engine technologies are incorporated into new ship construction.

EIA continuously monitors global economic conditions as part of our forecast analysis. The impact of the IMO's sulfur regulation for marine fuels will be included in that analysis, which we update and publish monthly in EIA's STEO.

Please do not hesitate to contact me if I can be of further assistance.

Sincerely,

Linda Capuano
Administrator
U.S. Energy Information Administration

Enclosure

Independent Statistics & Analysis
U.S. Energy Information Administration

# The Effects of Changes to Marine Fuel Sulfur Limits in 2020 on Energy Markets

March 2019

Independent Statistics & Analysis
www.eia.gov

U.S. Department of Energy
Washington, DC 20585

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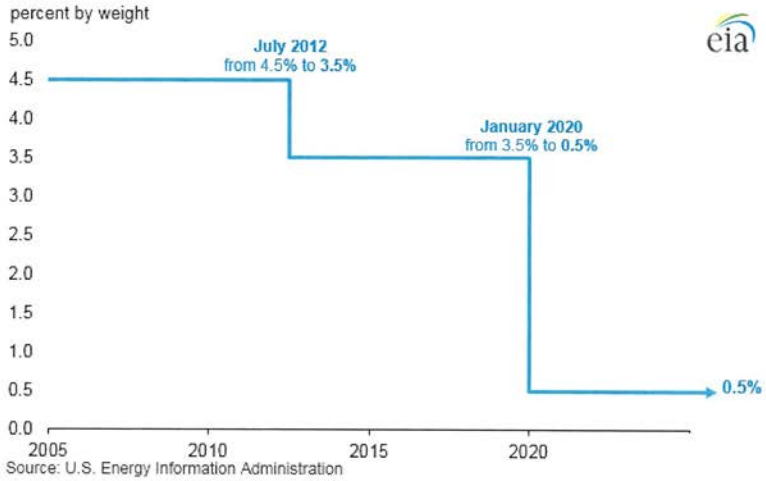
## Introduction

With a planned effective date of January 1, 2020, the International Maritime Organization's (IMO) new regulations (IMO 2020) limit the sulfur content in marine fuels that ocean-going vessels use to 0.5% by weight, a reduction from the previous limit of 3.5% established in 2012. The IMO adopted the plan for this policy change in 2008, and in 2016 reaffirmed an implementation date of 2020. The change in sulfur limits has wide-ranging repercussions for the global refining and shipping industries as well for petroleum supply, demand, trade flows, and prices. The shipping and refining industries have already begun making preparations and investments to varying degrees to accommodate IMO 2020 regulations. As the implementation date for the 0.5% sulfur cap approaches, the U.S. Energy Information Administration (EIA) expects that shifts in petroleum product pricing may begin as early as mid-to-late 2019. EIA anticipates that the effects on petroleum prices will be most acute in 2020, and the effects on prices will be moderate after that. However, the regulations will affect petroleum supply, demand, and trade flows on a more long-term basis.

**Figure 1. Marine fuel sulfur limits**




Source: U.S. Energy Information Administration

EIA shows the effects of these new regulations in both the *Short-Term Energy Outlook* (STEO), published monthly, and the *Annual Energy Outlook 2019* (AEO2019), released in January 2019. Because IMO 2020 will affect petroleum markets across several years, EIA's STEO forecast and AEO2019 projections provide complementary insights into the effects of the regulations.

Both STEO and AEO2019 are based on current laws and regulations. AEO2019 centers around a Reference case based on relationships and general equilibrium models that satisfy projected energy demand under a set of constraints.

STEO provides forecasted data that are updated every month. EIA uses a combination of econometric models based on historical data to forecast where EIA anticipates energy markets will move in the next two years. The STEO relies on historical data, short-term trends, and analyst judgment in creating this forecast. Although the STEO forecasts fewer variables than the Annual Energy Outlook, STEO's publication frequency allows EIA to incorporate developments related to the IMO rule more regularly than AEO2019, which projects variables at an annual frequency through the year 2050. In addition, because the STEO is published monthly, EIA adjust its forecasts continuously to incorporate new information.

Because the current STEO forecasts end in December 2020, the data in AEO2019 provide EIA's projections with insight into how IMO 2020 will affect petroleum markets beyond 2020. In addition, AEO2019 has more detailed data on refinery operations, marine fuel use, and fuel costs than the STEO. Projections in the Annual Energy Outlook are generated from EIA's highly detailed, structured equilibrium models in its National Energy Modeling System.

The first section of this report explains the findings related to IMO 2020 from the STEO and AEO2019 analysis. The second section discusses the uncertainties that might affect the way that actual outcomes deviate from EIA's forecasts and projections.

## Section I: Forecasts and projections of IMO effects

### Demand for marine fuels

Globally, marine vessels are a critical part of the global economy, moving more than 80% of global trade by volume and more than 70% by value. They account for about 4% of global oil demand (about 4.3 million barrels per day (b/d) according to the International Energy Agency). In the United States, consumption of bunker fuel (the fuel mix consumed by large ocean-going vessels) is a relatively small share of total energy demand. In 2018, U.S. bunker fuel consumption represented about 3% of total transportation energy use and just 2% of total U.S. petroleum and liquid fuel use. Of the 4.3 million b/d of global marine sector demand, about 10% of those sales originated at U.S. ports. Those sales of marine fuels at U.S. ports represent the AEO2019 international marine demand projections (Figure 2).

Residual oil—the long-chain hydrocarbons remaining after lighter and shorter hydrocarbons such as gasoline and diesel have been separated from crude oil—currently accounts for the largest component of bunker fuel. Although distillate fuels, the other large component in bunker fuel, have alternative uses and markets outside of marine fuels, residual oils have few other alternative markets. About 80% of total U.S. residual fuel demand is for marine bunkering. Therefore, the steps vessel operators take to comply with the new IMO 2020 sulfur limits have major implications for the use of residual fuel oils in marine fuels, for the price of residual fuel oil and its competitors, and for the refineries that produce residual fuel oil.

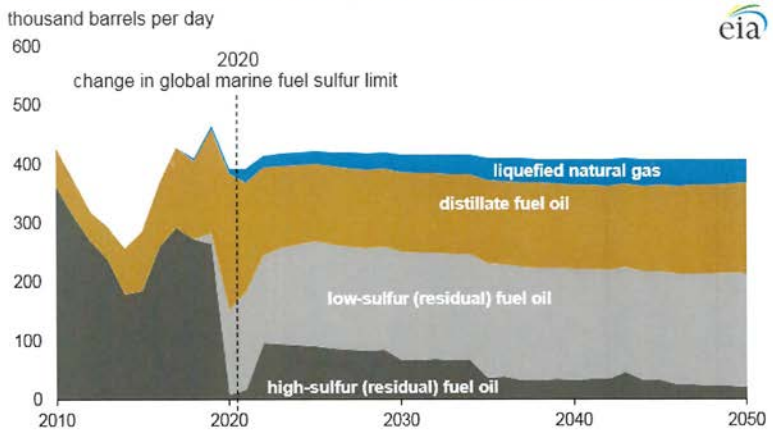
Operators of marine vessels have several options for complying with IMO 2020 sulfur limits. They can switch their ships to a lower-sulfur fuel that complies with the new IMO rules, which would likely increase demand for distillate and low-sulfur residual oils. Another option is to use scrubbers to remove pollutants from ships' exhaust, allowing ships to continue to use higher-sulfur fuels. Vessel operators

can also switch their ships to nonpetroleum-based fuels, such as liquefied natural gas (LNG). In the AEO2019 Reference case projections, the fuel mix of ocean-going marine vessel bunkering in the United States changes significantly because of the new global sulfur fuel limits.

The AEO2019 and STEO projections only consider sales of bunker fuel from ports inside the United States. Because the United States is a member of the IMO and U.S. port and maritime authorities currently enforce all IMO regulations, the implied rate of compliance to the IMO sulfur limits for the United States in the AEO2019 and STEO is 100%. Although the level of compliance with the new IMO sulfur limits may vary globally, the AEO2019 (and the STEO) do not make explicit assumptions about compliance levels beyond the United States.

EIA projects that the share of high-sulfur residual fuel oil consumed by U.S. ocean-going bunker fuel markets drops from 58% in 2019 to 3% in 2020, and then rebounds to 24% in 2022. Despite a recent increase in scrubber installation and orders, the number of vessels installed with scrubbers required to continue using high-sulfur residual fuel oil remains limited. As a result, AEO2019 projects a large but brief increase in the share of distillate fuel oil and low-sulfur residual fuel oil in 2019 and shortly after 2020. A recovery in high-sulfur residual fuel oil consumption driven by scrubber installations does not occur until 2022 but at levels far lower than before the 2020 IMO rule implementation. After 2023, high-sulfur residual fuel oil consumption declines throughout the AEO2019 Reference case projection, down to a 22% share of U.S. ocean-going marine vessel bunker fuel by 2025. In AEO2019, EIA projects that the share of low-sulfur residual fuel oil consumed in U.S. ocean-going marine vessel bunkering will increase from 38% in 2020 to 43% in 2025. Similarly, EIA projects that the need to use distillate in lower-sulfur bunker fuels will increase distillate's share of U.S. bunker demand from 36% in 2019 to 57% in 2020, although this share declines to 29% by 2025.

**Figure 2. International marine shipping consumption by ocean-going vessel bunkering at U.S. ports**




Source: U.S. Energy Information Administration, AEO2019 Reference case

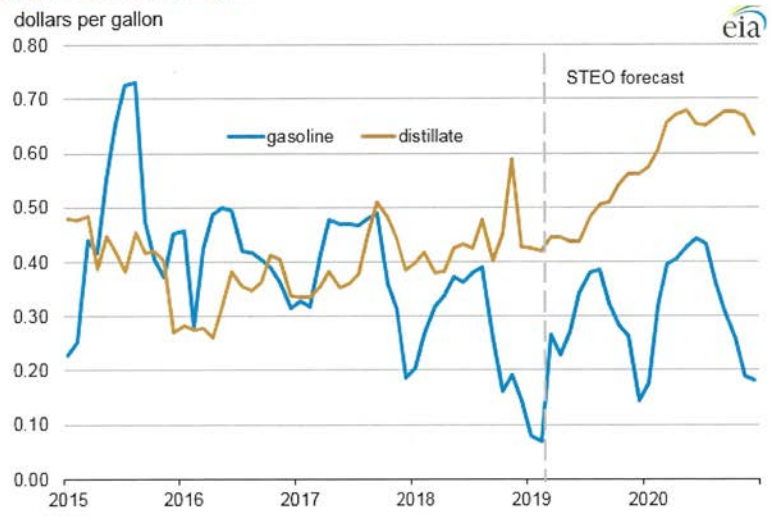
Outside of residual fuel oils and distillate, STEO forecasts that the use of LNG in marine bunkering will be limited through 2020. Similarly, the AEO2019 Reference case projects limited use of LNG in the next five years, reflecting the high initial infrastructure development cost and the limited current infrastructure to accommodate LNG bunkering at U.S. ports. In the medium and long term, this infrastructure barrier decreases, and LNG's share of U.S. bunkering grows to 7% in 2030 and to 10% by 2050.

Despite bunker fuel's relatively small share of both the global and U.S. liquid fuels markets, EIA expects a shift in demand in the global bunker fuel market from high-sulfur fuel oil to low-sulfur distillate fuel and low-sulfur fuel oil. This shift will result in a change in the relative prices of those fuels. EIA expects the demand shift to increase global prices for light- and low-sulfur refined petroleum products such as diesel fuel, gasoline, jet fuel, and low-sulfur fuel oil. This shift, in turn, will lead to a decrease in the prices of high-sulfur refined petroleum products, such as high-sulfur fuel oil. This price premium for lower-sulfur refined products will be most evident at the wholesale (refinery and bulk terminal) level in the form of higher refining margins for low-sulfur products such as diesel.

## Refining margins

The price consumers pay for petroleum products includes three components—the cost of crude oil, the refining margin, and the retail margin (including taxes). The wholesale price of refined product is the cost of crude oil plus the refining margin. The main cause of changes in the price consumers pay for petroleum products are changes in the price of crude oil. Changes to crude oil prices can occur for a wide variety reasons, and any large change in the price of crude oil, either higher or lower, from the levels assumed in STEO and AEO2019 would result in different ultimate wholesale and retail prices of products than EIA projections.

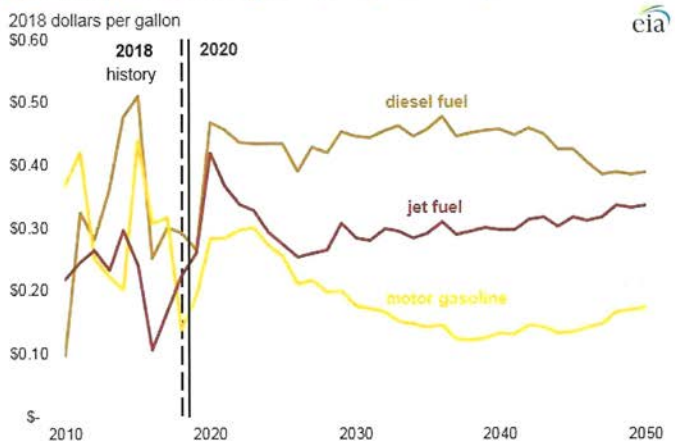
**Figure 3. U.S. refinery margins**




Source: U.S. Energy Information Administration, *Short-Term Energy Outlook*, March 2019

However, in the short-term, refining margins will experience the most price effects because of IMO 2020. Because of an increased premium on low-sulfur fuels, in the STEO, EIA expects that diesel fuel refining margins will increase from an average of 43 cents per gallon (gal) in 2018 to 48 cents/gal in 2019 and to 65 cents/gal in 2020. After 2020, EIA expects diesel fuel prices to moderate as the shipping and refining sectors react to these price signals. In AEO2019, EIA projects that diesel refining margins will gradually decrease after 2020 and will average 39 cents/gal in 2026.

Figure 4. Projected U.S. diesel, gasoline, and jet fuel crack spreads



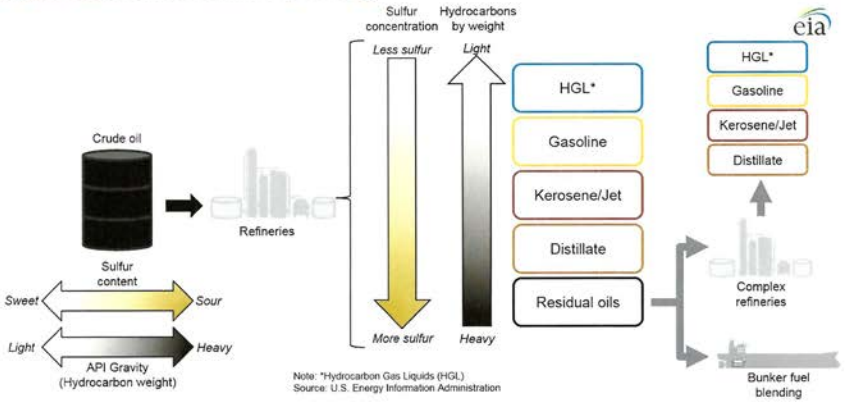

Source: U.S. Energy Information Administration, AEO2019 Reference case

## Refinery operations and production

The increase in diesel refining margins will prompt U.S. refiners to produce more diesel fuel. EIA expects this increase to occur in two ways—an increase in diesel yields and in overall throughput into refineries. Much of U.S. refining capacity, especially on the U.S. Gulf Coast, has downstream units that upgrade residual oils into more valuable and lower-sulfur products such as diesel. These refineries can economically process heavier and higher-sulfur crude oils that yield large quantities of residual oils for further processing, and they will be well positioned to supply the global marine-fuel market with low-sulfur bunker fuel when IMO 2020 goes into effect. As refiners maximize diesel fuel production, STEO forecasts distillate fuel refinery yields will increase from an average of 29.5% in 2018 to 29.9% in 2019 and to 31.5% in 2020. As diesel refining margins decline, EIA projects that diesel yields at refineries will also decline.

The increase in diesel yields in 2020, driven by increased diesel refining margins, largely comes from a shift away from motor gasoline and residual fuel oil. EIA forecasts that gasoline yields will fall from an average of 47.0% in 2018 to averages of 46.6% in 2019 and 45.6% in 2020. In STEO, residual fuel yields decrease from an average of 2.5% in 2018 to an average of 2.2% in 2020. Through 2025, EIA projects some shift back to gasoline production as margin differences between diesel and gasoline narrow and the market returns to historical levels.

**Figure 5. Crude oil and residual oil processing**




Source: U.S. Energy Information Administration

In addition to shifting production toward diesel fuel, refiners are also expected to increase their overall throughput of crude oil. In STEO, EIA expects that gross inputs into refineries will increase from an average of 17.3 million b/d in 2018 to a record level of 17.8 million b/d (up 2.6%) on average in 2020. This increase in gross inputs will result in refinery utilization increasing from an average of 93.2% in 2018 to 93.2% to an average of 95.4% in 2020. If realized, a utilization rate of 95.4% would be the highest for the U.S. refining sectorsince a record of 95.8% in 1998. A utilization rate higher than 95% would likely put stress on the U.S. refining sector and might only be sustainable for about a year. In AEO2019, EIA projects that refinery utilization falls to 93.7% in 2021 and averages 92.9% from 2022–2025. Overall U.S. refining capacity only increases slightly during this timeframe.

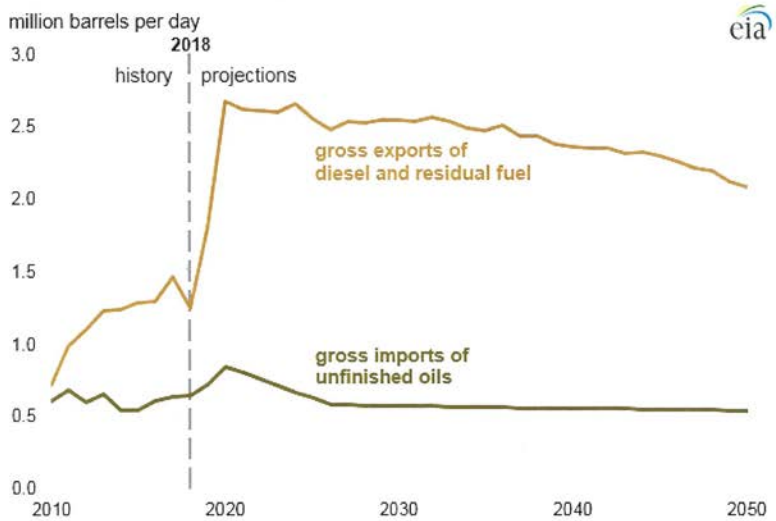
EIA's modeling capabilities do not currently include a detailed, fully integrated global refining model. The Liquid Fuels Market Module in NEMS has a detailed representation of the U.S. refining sector but only a general representation of global petroleum markets through import and export curves. The forecast increase in diesel margins for U.S. refineries from IMO 2020 will likely be replicated, to varying degrees, in diesel margins for refineries in the rest of the world. How refiners in the rest of the world respond to an increase in diesel margins is uncertain, and it is possible that they too would increase utilization, that then would reduce the increase in U.S. refinery utilization that EIA expects to occur. This possibility would reduce the pull on supplies from the United States and cause U.S. refinery utilization rates in 2020 to be lower than EIA's forecast.

## Trade and crude oil spreads

The United States represents a relatively small share of demand in the global bunker fuel market. EIA expects that much of the increase in diesel fuel production and other refined product production resulting from higher refinery runs will be exported. As U.S. refiners export diesel to supply an increasing share of the global demand for low-sulfur bunker fuel, EIA expects gross exports of diesel and residual

fuel to rise from 1.2 million b/d in 2018 to almost 2.6 million b/d in 2020. In AEO2019, EIA projects net exports of diesel will decrease from 2021–2025 as the global shipping industry demands less diesel because of higher scrubber adoption.

**Figure 6. U.S. diesel, residual fuel, and unfinished oils trade**




Source: U.S. Energy Information Administration, AEO2019 Reference case

The increase in net exports of diesel fuel is a key reason why EIA forecasts that the United States will be a consistent net exporter of combined crude oil and petroleum products by the end of 2020. EIA forecasts in the March 2019 STEO that for all of 2020, U.S. net exports of crude oil and petroleum products will average 0.1 million b/d and will average 0.9 million b/d by the fourth quarter of 2020.

Despite this expected increase in overall net exports, EIA expects the imports of unfinished oils (UFO) to increase because of IMO 2020. EIA defines UFO as all oils requiring further processing, except mechanical blending, and they include naphthas and lighter oils, kerosene, light gas oils, heavy gas oils, vacuum gas oils, and residuum. As a result of the IMO sulfur limits, some of the UFO that are lower in sulfur are likely to be used in blending a new compliant low-sulfur bunker fuel or will be directed to other refinery units for additional processing as part of shifting refinery yields. The high sulfur UFO produced by simple refineries—that lack advanced units to process the higher sulfur UFO into finished products—is often sold for use in high-sulfur bunker fuel blending or to more advanced refineries for additional processing. As the demand for high-sulfur UFO as bunker fuel blendstock decreases as a result of the IMO sulfur limits, prices will likely decrease and demand from advanced refineries, such as those on the U.S. Gulf Coast, is expected to increase. The demand for UFO by advanced U.S. Gulf Coast

refineries and higher refinery margins are responsible for the increasing imports of UFO in late 2019 and 2020.

EIA expects IMO 2020 effects on the crude oil market to be less significant than on the product market. Because of the discount that sulfur is expected to receive in global oil markets starting in late-2019 and into 2020, EIA assumes that the price difference between light-sweet crude oil and heavy-sour crude oil will widen. A possible proxy for a light-sweet/heavy-sour spread is the difference between the landed cost of crude oil that is 25 API gravity or less and the WTI spot price. This spread averaged about $12/b in 2018. EIA assumes that this spread has narrowed to about $8/b in the first quarter of 2019, and EIA assumes it will widen by about $5/b to $13/b in 2020. This widening spread can be expected to lower crude oil costs for U.S. refiners, other market factors being equal, because much of the crude oil U.S. refineries import is heavy. EIA expects the cost of imported crude oil to average $5.44/b less than West Texas Intermediate (WTI) spot prices in 2020, compared with $3.50/b less than WTI in 2018.

Similarly, U.S. refineries' average acquisition costs for all crude oil is forecast to be $2.64/b less than WTI spot prices in 2020, compared with 63 cents/b less than WTI in 2018. However, current market developments—including U.S. sanctions on Venezuela and Iran, along with production cuts from the Organization of the Petroleum Exporting Countries (OPEC)—have reduced the amount of heavy-sour crude oil available to the market, narrowing heavy-sour price discounts to light-sweet. To the extent that those factors continue to affect heavy-sour crude oil availability beyond what EIA currently forecasts, the pricing of heavy-sour crude oil could also be affected into 2020.

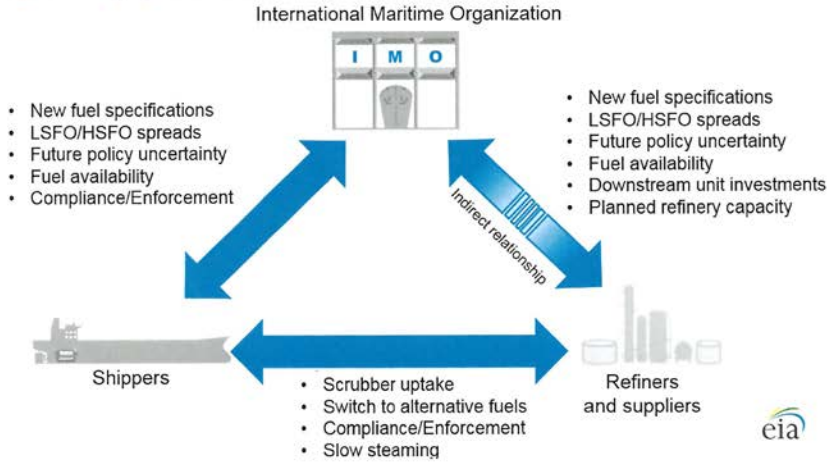
Although EIA expects that the effect on crude oil quality spreads could be relatively significant, EIA does not expect a significant impact on crude oil price levels. In the March 2020 STEO EIA forecasts Brent crude oil prices (the global benchmark for light-sweet crude oil) to average $63/b in 2019 to $62/b in 2020. EIA estimates that about half of the $5/b price spread between heavy-sour and light-sweet crude oils that it forecasts will occur in 2020 comes from higher light-sweet crude oils prices, and half comes from lower, heavy-sour oil prices. EIA assumes IMO regulations put about $2.50/b of upward pressure on Brent crude oil prices as a result of higher demand for light-sweet crude oils. However, EIA expects broader global crude oil market conditions to have more significant effects on Brent prices than IMO regulations.

## Section II: Uncertainties of IMO projections

The effects of implementing the IMO 2020 regulations are highly uncertain. Many policy and technical complications, as well as potential market participant responses, create numerous interrelated factors that will have a significant influence on the eventual outcome. Further, these factors are highly interdependent on one another, making cause and effect difficult to disentangle.

The IMO designed the 2020 sulfur regulation as an open policy without designating one compliance method but instead letting market participants decide for themselves how best to comply. However, this openness, the complexities of implementation, and the number of participants limited the first-mover advantage toward compliance. In the years leading up to 2020, with little to no first-mover advantage, stakeholders have been slow to provide clear intentions of their compliance methods.

Figure 7. IMO projection uncertainties across stakeholders




Source: U.S. Energy Information Administration

EIA's forecasts and projections related to IMO 2020 are a result of detailed insights, modeling, and data on the U.S. refining and shipping sectors and from more general assumptions about how these sectors would react globally. Because the shipping industry and the fuels used in that industry are globally integrated markets, a globally integrated supply and demand model would be required to comprehensively model the effects of the IMO 2020 rule. Although EIA does not currently have such a model, it does employ an integrated supply and demand model for the U.S. petroleum market, which was used to produce many of the results outlined in the first section of this report. The global response of these industries is equally as important as the response in the United States; however, without the same level of modeling globally, the degree of uncertainty in EIA's assessment increases significantly. In addition, the current lack of production, consumption, efficiency, and logistical data for non-U.S. marine fuels and the shipping industry makes this effort more difficult.

EIA will continue to readjust its forecast and projections related to IMO 2020 as more information on these uncertainties become clear, as more data become available, and as newer models are developed.

## Uncertainties for both refiners and shippers

*New fuel specifications:* The IMO set the sulfur limit for marine fuels at 0.5% or lower after January 2020, but the many other specifications needed to establish a uniform fuel specification were left to the International Standards Organization and other industry participants. As of March 2019, a final specification for the new, compliant low-sulfur marine (bunker) fuel is not complete, however ISO has issued a statement that the existing 2017 standard may be used with the lower sulfur requirement.

This lack of certainty means refineries do not know how to optimize their outputs and how much the compliant fuel would cost to produce. Without clear guidance on how much the new compliant fuel would cost and its specifications, ship owners cannot make operational, engineering, and logistical decisions because some compliant fuels may not be compatible with their ships' engines. Once new compliant marine fuel specifications are final, refiners and shippers will be better able to determine the cost to produce it, its price, and how to make it widely available.

***LSFO/HSFO spreads:*** The price discount of high-sulfur fuel oil (HSFO) to either low-sulfur fuel oil (LSFO) or marine distillate oil (MDO) will shape the decisions that refiners and shippers make. Refiners will only invest to produce more low-sulfur fuels if the price difference between low- and high-sulfur fuels covers the associated costs. However, if high-sulfur fuel oil sells at a significant discount to low-sulfur fuel oil or MDO, shippers would be more inclined to install scrubbers to save on fuel costs. As January 2020 approaches, the LSFO, MDO, and HSFO price spread will be more certain , providing clearer signals to market participants on how to react, invest, and plan.

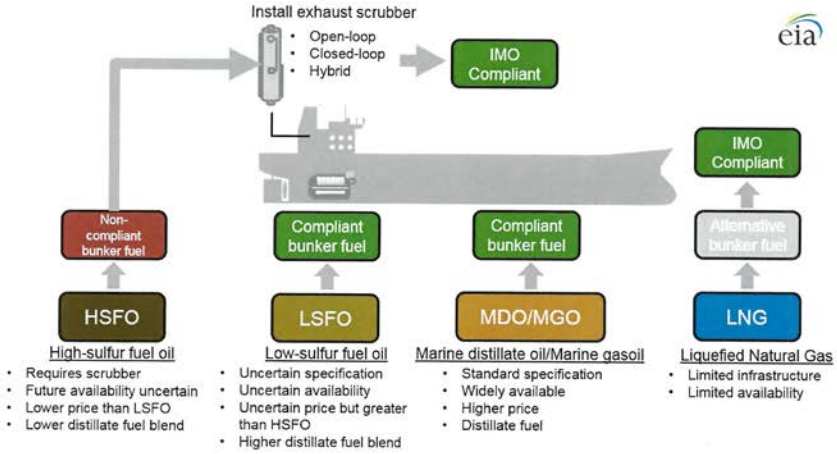
***Future policy uncertainty:*** The IMO has signaled its intention to implement additional controls and regulations on other types of pollution from ships in the future. These future regulations may result in shippers switching to alternative non-petroleum fuels such as LNG. Because of this uncertainty, refiners and shippers may be hesitant to invest in complying with IMO 2020 if additional IMO regulations in the future could cause those investments to lose value or no longer be needed.

***Fuel availability:*** The logistics and availability of marine fuels as part of the IMO 2020 ruling are also uncertain. Vessels visiting ports across the globe require certainty they will be able to acquire the fuel they need wherever they travel. The most common practice is for shippers to sign bunker fuel supply contracts with suppliers that have operations or supply agreements across many ports. However, it is uncertain how much IMO-compliant fuel versus non-compliant fuel will be needed or available in each port after 2020. Although large bunkering ports, such as Singapore, Fujairah in the United Arab Emirates, and Rotterdam in the Netherlands, are likely to have both IMO-compliant fuels and non-compliant fuels, smaller ports and the vessels that visit them may have difficulties. In addition, the potential necessity of commingling IMO-compliant fuel from different producers may present significant problems. A multi-fuel market for bunker fuel creates challenges and logistical problems that result in increased projection uncertainty.

The IMO has also established a system of waivers—if a vessel not equipped with a scrubber visits a port where no IMO-compliant fuel is available, that vessel can apply for a fuel availability waiver. The ease and extent to which these fuel availability waivers will be obtained is uncertain, and these waivers increase the risks for refinery investments related to IMO compliance if they become widely available.

## Uncertainties mainly for shippers

**Figure 8. Shipping industry compliance pathways**




*Scrubber uptake:* A small number of existing marine vessels have already installed scrubbers, and EIA does not expect that number to increase significantly before 2020 because of time constraints and limited installation capacity. Even if scrubbers become widely adopted, which would allow operators to continue to use fuels with higher sulfur content, the price and availability of higher-sulfur fuels after 2020 remains uncertain.

In addition, some maritime and port authorities have regulations in place or may implement regulations that would limit the operation of scrubbers in their waters, depending on the configuration. Open-loop scrubber systems use seawater to remove sulfur from exhaust gas, but they discharge the resulting *wash water* back into the ocean. A closed-loop scrubber system retains the *wash water* onboard for later processing and disposal. A hybrid-loop scrubber system allows *wash water* to be discharged when in the open seas, but the system retains it onboard when in controlled waters. In terms of cost, open-loop scrubber systems are the least expensive, followed by hybrid, and then closed-loop scrubber systems.

Several major ports, including Singapore and large commercial ports in China, have banned open-loop scrubber systems. This ban forces ships equipped with the less expensive open-loop systems to switch to a lower-sulfur marine fuel when operating in certain waters, adding to scrubber uptake uncertainty.

*Switch to alternative fuels:* Another option for vessel operators to comply with the IMO 2020 rule is to switch to non-petroleum based fuels. Marine bunkering using LNG is often considered a potential alternative. In the past several years, many newly built ships were either built with or were offered to be equipped with LNG ready engines—engines that could be configured to run LNG at a later date.

However, very few vessels consume LNG as their primary fuel, and the infrastructure to support LNG as a shipping fuel is currently limited in both scale and availability.

Although numerous petroleum-based and non-petroleum-based marine fuel alternatives would comply with the IMO 2020 sulfur regulations, none are used on a large scale and have limited infrastructure.

***Compliance/enforcement:*** The sulfur content of transportation fuels has been declining for many years because of increasingly stringent regulations implemented by individual countries or groups of countries. However, the upcoming IMO 2020 rules apply across multiple countries' jurisdictions to fuels used in the open ocean, and they leave the enforcement up to flag states—or the nation in which a vessel is registered. The capacity and willingness to enforce the IMO 2020 ruling among flag states are uncertain.

However, many large commercial port and maritime authorities have stated they intend to enforce IMO compliance on vessels entering their waters, in a similar way that they enforce local and national regulations on fuel quality, but the penalties or costs of non-compliance vary widely. If the costs of complying exceed the penalty for non-compliance or if the risks of enforcement are low, then use of high-sulfur marine fuels may continue in larger quantities than expected past 2020. Conversely, if the penalties for non-compliance and the risk of enforcement are high, then the continued use of high-sulfur marine fuels may be much lower than expected past 2020. For these reasons, changes in the rate of compliance and enforcement have significant influence on market outcomes because of the IMO 2020 rules.

To increase compliance certainty, the IMO passed a ban on carrying non-compliant high-sulfur bunker fuel on any ship that did not have a scrubber system installed unless the non-compliant fuel was that ship's cargo. This ban is set to go into effect in March 2020. This carriage ban gives port and maritime authorities another method of enforcing compliance with the new sulfur regulations.

***Slow steaming:*** If the costs for marine fuels increase, ship owners may try to reduce consumption by reducing a vessels operating speed, a technique called *slow steaming*. This change would, in turn, reduce the overall amount of marine fuels consumed globally, which would alter the amount of marine fuels refineries need to produce and may counteract higher fuel prices. However, many of the efficiency increases possible from slow steaming have likely already been captured in recent years, and how much additional efficiency could be gained is unclear.

## Uncertainties mainly for refineries

***Downstream unit investments:*** Removing sulfur from residual oils or upgrading them to more valuable lighter products such as diesel and gasoline can be an expensive and capital-intensive process. The possibility of widespread scrubber installations, which would allow continued use of higher sulfur residual oils, could make refiners hesitant about making large investments to build refining units capable of upgrading the residual oils.

Recently, several plans have been announced to restart portions of idled refineries in both Europe and the Caribbean ahead of or shortly after 2020. These restarted refinery units would process higher sulfur

residual oils and upgrade them into lighter fuels such as gasoline and distillate. This restarted processing capacity would provide a market for higher sulfur residual oils that are no longer used in marine fuels blending and supply more distillate fuels for possible use in low-sulfur marine fuel blending. However, the margins these refinery projects may earn are uncertain and depend on scrubber uptake and other factors, which would affect the price and availability of high- sulfur residual oil feedstock.

***Planned refinery capacity (new/expanded):*** The exact configurations, crude oil feedstocks, and product output profiles of new or expanded atmospheric crude distillation units (ACDU), mostly in Asia and the Middle East, are unknown and contribute to projection uncertainty. New or expanding ACDU capacity projects under construction or planned for construction are assumed to have accounted for IMO 2020 outcomes in their design decisions. As a result, both the market conditions when these new refineries come online and their influence on the market are uncertain. In addition, any changes in the configurations of existing refineries also add to the uncertainty.

The CHAIRMAN. I welcome the panel that has joined us this morning to share with us what you have seen in the markets and what you believe may be coming soon. I think we recognize that even while we have known that this is coming, there are some complexities here. So we appreciate you being here to share your expertise with us.

With that, I turn to my colleague, Senator Manchin.

**STATEMENT OF HON. JOE MANCHIN III, U.S. SENATOR FROM WEST VIRGINIA**

Senator MANCHIN. Thank you, Madam Chairman, and thank you for convening this meeting today to discuss the International Maritime Organization's New Global Sulfur Standards for Marine Fuels. With less than a month until their standards go into effect, I look forward to discussing implementation with our esteemed witnesses and I thank you all for being here today.

As you might know, West Virginia might not be on the firing line of these new ocean vessels, but we are concerned. It is somewhat familiar territory for me also because we have done this work already on coal plants to cut emissions for $SO_X$ and $NO_X$ and particulates, as you know, and we have been successful at that. And let me tell you, it made a big difference in states like mine. I have told people before, I remember growing up, my mother would hang our clothes out and they came back a little bit dirtier than when they went out. So it did make a big difference, and we all really, truly noticed it.

These new sulfur standards for open ocean shipping will help us take another step in the right direction by ensuring sulfur content in maritime fuels drops from 3.5 percent to 0.5 percent. This will be an impactful change as more than 80 percent of our global trade is transported by sea. In fact, marine fuels account for just 7 percent of our transportation fuels demand, yet they account for 90 percent of the transportation sector's sulfur dioxide emissions. That is hard to comprehend, 90 percent are coming from one source, even though it is only 7 percent of the total.

It is estimated that as a result of these standards more than two million barrels per day of high-sulfur fuel will be displaced from the sector. Implementing these regulations will dramatically decrease the $SO_X$ emissions which is both good for the environment and for human health. My understanding is that the IMO has also already implemented efficiency standards and plans for reducing greenhouse gas emissions so that the shipping industry moves forward on climate solutions in addition to local air pollution.

There are three main options for reaching the new 0.5 percent standard using lower-sulfur diesel fuels, switching to other lower sulfur emitting fuels such as LNG or biofuels or outfitting ships with scrubbers to clean high-sulfur fuel oil. In U.S. waters, ships already are required to comply with a more stringent standard, but I look forward to hearing about how industry is prepared for this switch for global routes.

At this point it is estimated that only three to five percent of the total global ship fleets will be outfitted with scrubbing technology. That means that in short-term, at least, most ships will switch to using lower-sulfur diesel fuels. With increasing demand for cleaner

fuels, the U.S. is well-positioned to capture that increased market share with fuels already in the market. We checked with some of the refineries, and they say they are capable of meeting this demand.

This puts American refineries and energy producers at an advantage. We are ahead of the curve because, I have said, we have had sulfur standards in place since 2015 that are five times more stringent than the new global sulfur standards, and our refiners have invested billions in upgrading their infrastructure to make cleaner fuels. The IEA estimates that the new standard will further increase refining capacity to meet increased demands for low-sulfur bunker fuels by 300,000 barrels per day. And as new ships are being built, other low-sulfur fuels such as LNG are expected to play an increasing role in helping ships meet the new standards.

Some forecasts show that the amount of LNG used as bunker fuel globally may double by 2030 as a result of this rule from three percent to seven percent. This is a success story for many U.S. companies. We need to keep our eye on the ball and ensure that we continue to position U.S. companies to lead the world in clean energy. Ensuring that we maintain a competitive advantage can go a long way in promoting our nation's energy security while benefiting the economies and communities of oil and gas producing states, such as my home State of West Virginia. We keep saying that we need to continue to innovate, and elimination is not going to solve the world global problem.

West Virginia ranks fourth among the states in total energy production. It is the seventh largest producer of marketed natural gas in the nation. Our underground gas storage capacity accounts for almost six percent of the nation's total capacity. Promoting sound policies and regulations that responsibly tap into these resources and others, including those in Alaska and along the Gulf Coast, will only benefit our nation's energy security and will add much needed jobs. That is important for our economy and for geopolitical balance around the world. It is also important for human health and the environment. We have made great progress reducing air pollution and acid rain with scrubbers and cleaner fuels. This rule keeps our foot on the gas. We also need progress reducing global carbon dioxide emissions, which the EIA said in a report last month, rose in 2018 for the first time since 2014. We must all be cognizant of that. This is a concerning trend. I hope today's conversation can highlight the types of solutions we should be pursuing.

With that, Chair Murkowski, I look forward to hearing from our esteemed witnesses today.

The CHAIRMAN. Very good, thank you.

We will begin this morning's panel with Dr. Linda Capuano, who I have just introduced, who is the Administrator for the Energy Information Administration (EIA) and has been before this Committee many times. We welcome you back.

Mr. John Butler is the President and the CEO of the World Shipping Council. Thank you for joining us this morning.

Mr. Derrick Morgan is the Senior Vice President for Federal and Regulatory Affairs at the American Fuel and Petrochemical Manufacturers (AFPM) Association. Thank you.

Mr. Neelesh Nerurkar is the Vice President for ClearView Energy Partners. Thank you for joining us.

And Mr. Jamie Webster has also been before this Committee before. He is the Senior Director at the Boston Consulting Group's (BCG) Center for Energy Impact. So we welcome you to the Committee.

We would ask that you try to keep your comments to about five minutes. Your full statements will be included as part of the Committee record. Once you have all concluded your statements, we will have an opportunity for questions and your responses.

Again, thank you for joining us, and Administrator Capuano, if you would like to begin please.

**STATEMENT OF HON. LINDA CAPUANO, ADMINISTRATOR, U.S. ENERGY INFORMATION ADMINISTRATION, U.S. DEPARTMENT OF ENERGY**

Dr. CAPUANO. Chairman Murkowski, Ranking Member Manchin and members of the Committee, I appreciate the opportunity to testify about EIA's view on the effects that the upcoming IMO 2020 regulations may have on the global oil market as presented in our November Short-Term Energy Outlook, or STEO. The upcoming regulations take effect on January 1st and will limit marine fuel sulfur content to 0.5 percent by weight, down from 3.5 percent which was established in 2012. We expect this will increase demand for low-sulfur crude and put about $2 per barrel of upward pressure on light, sweet crude oil prices in 2020.

EIA expects the price impact to dissipate as the market adjusts. This is particularly relevant to states like Alaska where diesel fuel is important to the economy. However, we also expect the projected slowing growth of global GDP to slow oil demand growth and cause global oil inventories to generally increase placing an offsetting downward pressure on oil and petroleum product prices. As a result, our November STEO forecasts Brent crude oil prices to average slightly higher than $60 per barrel in 2020 compared with the average of $64 per barrel in 2019. Relative to refined products, the bunker fuel is a small share of the global and U.S. liquid fuels market.

However, low-sulfur refined products have experienced upward price pressure in the U.S. as ship operators purchase and store low-sulfur marine fuels. Trade Press reports that the price differential between low- and high-sulfur fuel oil on the U.S. Gulf Coast has increased over threefold in the last three months. Similar trends have emerged on trading locations around the world. The price effects from this shift in marine and fuel demand is most visible in the low- and high-sulfur residual fuel oil market, but other refined, excuse me, other refined petroleum products such as diesel fuel, gasoline and jet fuel may also be showing small price increases.

Relative to retail prices at the pump, in general, we expect the price premiums for low-sulfur, refined products to be reflected in higher refining margins through 2020. We also expect these price premiums will be offset by the forecasted lower crude oil prices. As a result, we expect that 2020 gasoline and diesel retail prices at the pump to be similar to those in 2019.

Relative to U.S. exports, the current high refining margins are providing economic incentive for global refiners to maximize low-sulfur distillate fuel output. Much of the U.S. refinery capacity, in particular, is well-positioned to produce the low-sulfur diesel fuel, and we project U.S. refinery average utilization rates will increase to more than 90 percent in 2020. Because U.S. demand for bunker fuel is relatively low, we expect U.S. refiners will export much of the increased production to supply increasing global demand. We estimate that U.S. exports of crude oil and petroleum products started exceeded imports in September of this year. We expect the U.S. net exports will continue to grow in 2020 and that low-sulfur fuels will provide a large share of the increases in exports.

However, in the long-term, our Annual Energy Outlook 2019 projects that the U.S. net exports of diesel will eventually decrease as the global shipping industry installs more scrubbers that will reduce the demand for low-sulfur diesel and as more liquified natural gas technologies are incorporated into new ship construction and the number of LNG-powered ships increases. Although we expect limited effects on the price of crude oil from the IMO 2020 regulations, there are many unknowns about how the global refining and shipping industries will respond and how actual industry decisions will affect crude oil prices.

For example, in the short-term, smaller, more remote crude oil, excuse me, smaller, more remote ports may face logistical and fuel availability issues compared with larger, more active ports. However, we believe that supply patterns will evolve over time and ship owners will adjust to potential short-term dislocations of fuel.

In summary, despite the upward pressure on prices from the IMO 2020 regulations, we expect crude oil prices to average slightly higher than $60 per barrel in 2020 as the downward pressure, oil price pressure, from the slowing global economic growth outweighs concerns about the IMO 2020 regulation. EIA continuously monitors global economic conditions as part of our forecast analysis. The impact of the IMO's sulfur regulation for marine fuels will be included in that analysis which we update and publish monthly in our STEOs and annually in the AEO.

Chair Murkowski and members of the Committee, thank you for the opportunity to present this information and this concludes my testimony.

[The prepared statement of Dr. Capuano follows:]

Testimony of Linda Capuano
Administrator
U.S. Energy Information Administration
U.S. Department of Energy
Before the
United States Senate
Energy and Natural Resources Committee

December 10, 2019

Chairman Murkowski, Ranking Member Manchin, and Members of the Committee, I appreciate the opportunity to testify about the U.S. Energy Information Administration's (EIA) view of the effects that the upcoming International Maritime Organization (IMO) 2020 regulations may have on the global oil market as presented in our November *Short-Term Energy Outlook* (STEO).

The upcoming IMO 2020 regulations, set to take effect on January 1, 2020, will limit the sulfur content in marine fuels that ocean-going vessels use to 0.5% by weight, a reduction from the previous limit of 3.5%, which was established in 2012. The change in sulfur limits has wide-ranging repercussions for not only the global refining and shipping industries, but also for petroleum supply, demand, trade flows, and prices. The shipping and refining industries have already prepared for and invested in modifications to accommodate the IMO 2020 regulations. We anticipate that the IMO 2020 regulations will put upward pressure of about $2 per barrel on light, sweet crude oil prices in 2020, which will moderate in the following years. However, the regulations will have a longer-term effect on petroleum supply, demand, and trade flows.

We expect the IMO 2020 regulations to put upward pressure on light, sweet crude oil prices in 2020 because of increased demand for that crude oil to produce lower-sulfur marine fuels. As a result, we are forecasting the price difference between light, sweet crude oil and heavy, sour crude oil to be wider next year. However, as a result of the slowing growth in global gross domestic product and the resulting slower growth in global oil demand, we expect global oil inventories to increase and, in general, put downward pressure on oil and petroleum product prices. As a result, our November STEO forecasts Brent crude oil prices to average slightly higher than $60 per barrel in 2020, compared with an average of $64 per barrel in 2019. We expect the effects of IMO 2020 regulations on crude oil prices to be less significant than the effects on petroleum product prices.

Although the regulations do not go into effect until January 1, preparations are already affecting oil markets, and we expect further market changes into 2020. The bunker fuel market accounts for a relatively small share of both global and U.S. liquid fuels. However, demand in the global bunker fuel market has shifted from high-sulfur fuel oil to low-sulfur fuel oil and low-sulfur distillate fuel in anticipation of the upcoming regulations. Because petroleum product prices are set in the global market, the new regulations have placed upward pressure on prices for low-sulfur refined products in the United States. In the U.S. Gulf Coast, the price differential between low-sulfur fuel oil and high-sulfur fuel oil increased as ship operators began storing and purchasing low-sulfur marine fuels in place of high-sulfur fuels to prepare for the specification change. Trade press reports indicate that the price differential between low-sulfur fuel oil and

high-sulfur fuel oil on the U.S. Gulf Coast has increased more than threefold between June and November 2019. Similar trends have emerged at trading locations around the world. The price effects from this shift in demand for marine fuels are most visible in low-sulfur and high-sulfur residual fuel oil markets, but other refined petroleum products such as diesel fuel, gasoline, and jet fuel may already be showing some small price increases as well.

In general, price premiums for lower-sulfur refined products through 2020 are most evident at the wholesale (refinery and bulk terminal) level in the form of higher refining margins for low-sulfur products, such as diesel fuel. In our *Annual Energy Outlook* (AEO2019), we project that diesel refining margins will gradually decrease after 2020. Because the retail prices that consumers pay are a function of both crude oil prices and refining margins, we expect that generally lower crude oil prices in 2020 will mostly offset the effects of the higher refining margins related to the regulations. We expect that prices at the pump for gasoline and diesel next year will be similar to prices in 2019.

The prevailing high refining margins have provided plenty of economic incentive for global refiners to increase refinery runs and maximize the upgrading of high-sulfur heavy fuel oil into low-sulfur distillate fuel to create compliant bunker fuels. These same trends are evident in the United States, where refiners are producing more diesel fuel by increasing not only diesel yields but also refinery runs. Refineries in the United States, where much of the refining capacity has downstream units that upgrade residual oils into more valuable and lower-sulfur products such as diesel, are well positioned to supply the global marine-fuel market with low-sulfur bunker fuel. We expect that gross inputs into refineries will increase to a record level in 2020, resulting in an average utilization rate of more than 90%, a high rate by historical comparison.

The United States represents a relatively small share of demand in the global bunker fuel market. We believe that U.S. refiners will export much of the increased production of diesel fuel and other refined products that will result from higher refinery runs. As U.S. refiners export diesel and low-sulfur residual fuel oil to supply an increasing share of the global demand for low-sulfur bunker fuel, we anticipate that exports will continue to grow in 2020. In fact, we estimate that in September of this year, U.S. exports of crude oil and petroleum products started exceeding imports. We expect that U.S. net exports will continue to grow in 2020 and that low-sulfur fuels will provide a large share of the increased exports.

In the longer term, our AEO2019 projects that U.S. net exports of diesel will largely decrease from 2021 to 2025 as the global shipping industry demands less diesel because of increased scrubber adoptions. Beyond 2025, we project that the number of ships that run on liquefied natural gas (LNG) will also increase as economic and regulatory factors increase the rate at which LNG-based technologies are incorporated into new ship construction. Although we expect limited effects on the price of crude oil as a result of the IMO 2020 regulations, many unknowns remain about how the global refining and shipping industries will respond, and actual outcomes of these industry decisions will affect crude oil prices.

Furthermore, smaller, more remote ports across the world may face logistical and fuel availability issues in the short term. Although the largest and most active ports have supplies of both high-sulfur and low-sulfur fuels, these fuel availability concerns are real at smaller or more

remote ports. However, we believe that new logistical supply patterns will develop over time, and ship owners will adjust to these potential short-term dislocations of fuel.

As noted earlier, despite the upward pressure on prices from the IMO 2020 regulations, we expect crude oil prices to average slightly higher than $60 per barrel in 2020. In effect, our view is that downward oil price pressure from slowing global economic growth will outweigh concerns of the IMO 2020 regulations next year.

Chairman Murkowski and Members of the Committee, thank you for the opportunity to present this information. This concludes my testimony, and I look forward to answering your questions.

## Appendix

Figure 1. U.S. diesel and crude oil prices, 2016-2020

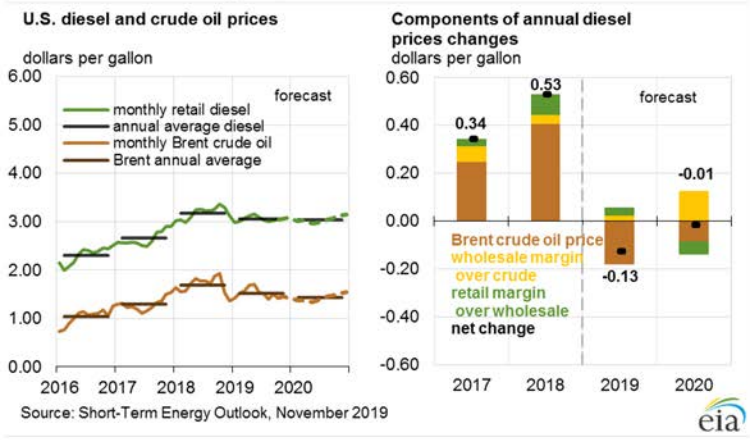



Figure 2. U.S. gasoline and crude oil prices, 2016-2020

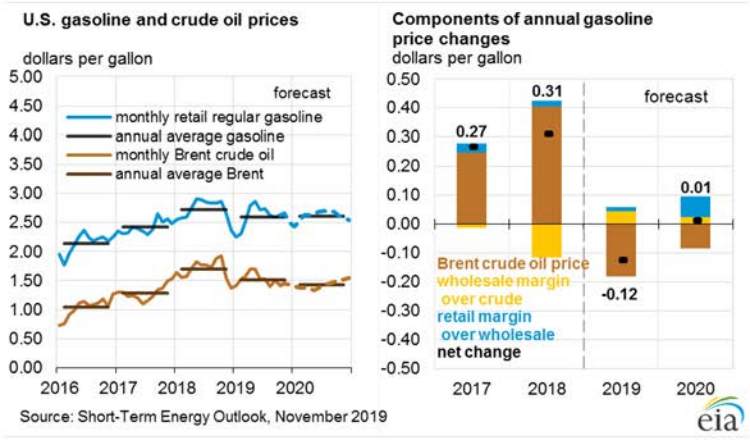
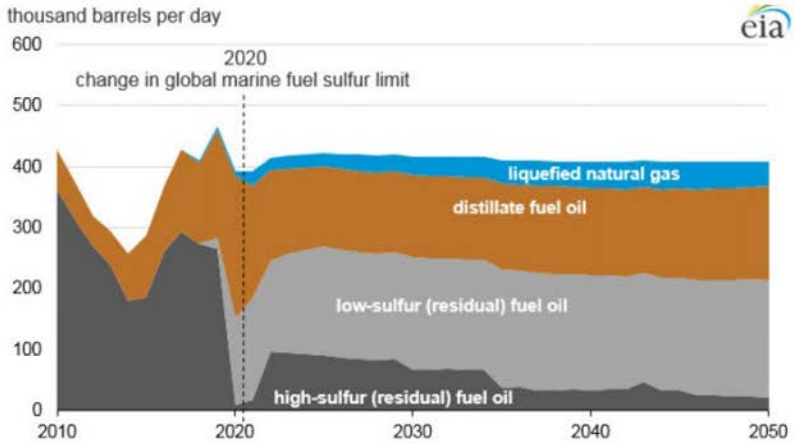
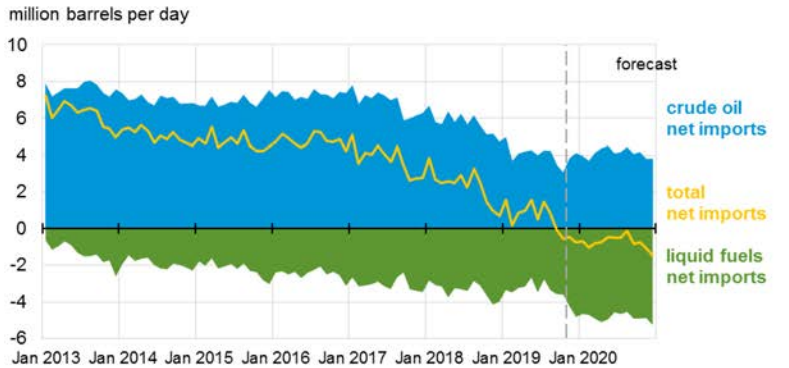


Figure 3. International marine shipping consumption by ocean-going vessel bunkering at U.S. ports




Source: U.S. Energy Information Administration, AEO2019 Reference case

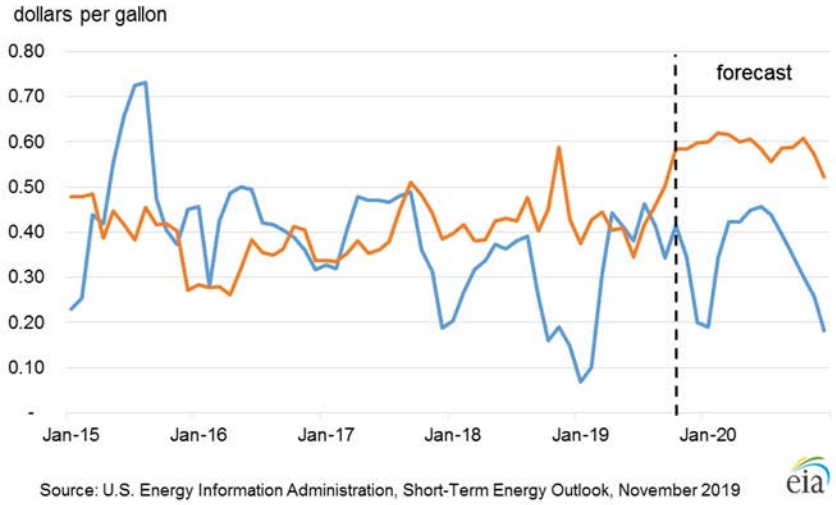
Figure 4. U.S. net imports of crude oil and liquid fuels




Note: Liquids fuels include: gasoline, distillate fuels, hydrocarbon gas liquids, jet fuel, residual fuel oil, unfinished oils, other hydrocarbons/oxygenates, and other oils.

Source: Short-Term Energy Outlook, November 2019

Figure 5. U.S. refinery margins

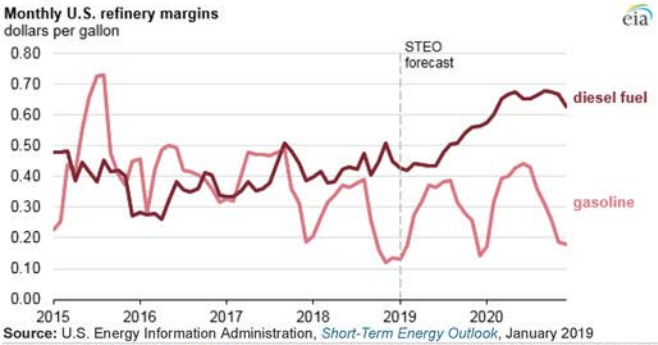


U.S. Energy Information Administration

## Today in Energy

January 15, 2019

# Changes in marine fuel sulfur limits will put temporary upward pressure on diesel margins




**Source:** U.S. Energy Information Administration, *Short-Term Energy Outlook*, January 2019

The January 2019 *Short-Term Energy Outlook* (STEO), released at noon today, for the first time includes analysis of the effect that upcoming changes to marine fuel sulfur specifications will have on crude oil and petroleum product markets. Beginning January 1, 2020, the International Maritime Organization's (IMO) new regulations limit the sulfur content in marine fuels used by ocean-going vessels to 0.5% by volume, a reduction from the previous limit of 3.5%. The change in fuel specification is expected to put upward pressure on diesel margins and modest upward pressure on crude oil prices in late 2019 and early 2020. EIA's analysis indicates that the price effects that result from implementing this new standard will be most acute in 2020 and will diminish over time.


**Source:** U.S. Energy Information Administration, based on International Maritime Organization

Residual oil—the long-chain hydrocarbons remaining after lighter and shorter hydrocarbons such as gasoline and diesel have been separated from crude oil—currently comprises the largest component of marine fuels used by large ocean-going vessels, also known as

bunker fuel. Marine vessels account for about 4% of global oil demand.

Removing sulfur from residual oils or upgrading them to more valuable lighter products such as diesel and gasoline can be an expensive and capital-intensive process. Refineries have two options with regard to residual oils: invest in more downstream units to upgrade residual oils into more valuable products or process lighter and sweeter crude oils in order to minimize the production of residual oils and the sulfur content therein.

EIA forecasts that the implementation of the new IMO fuel specification will widen discounts between light-sweet crude oil and heavy-sour crude oil, while also widening the price spreads between high- and low-sulfur petroleum products. In the January STEO forecast, Brent crude oil spot prices increase from an average of $61 per barrel (b) in 2019 to $65/b in 2020 with about $2.50/b of this increase being attributable to higher demand for light-sweet crude oils priced off of Brent.

The expected increased premium on low sulfur fuels will likely mean higher diesel fuel refining margins, which EIA forecasts will increase from an average of 43 cents per gallon (gal) in 2018 to 48 cents/gal in 2019 and 65 cents/gal in 2020. Motor gasoline margins averaged 28 cents/gal in 2018 and are expected to increase slightly to an average of 29 cents/gal in 2019 and 33 cents/gal in 2020.

As refiners maximize production of diesel fuel, distillate fuel refinery yields are forecast to increase from an average of 29.5% in 2018 to 29.9 % in 2019 and 31.5% in 2020, while motor gasoline yields fall from an average of 46.9% in 2018 to averages of 46.5% in 2019 and 45.6% in 2020. Residual fuel yields decrease from an average of 2.4% in 2018 to an average of 2.2% in 2020. Refinery runs are expected to increase from an average of 17.2 million barrels per day (b/d) in 2018 to a record level of 17.9 million b/d on average in 2020, so small changes in refinery yields can have large implications for the volumes of petroleum products produced.

Because of the numerous and diverse set of decision makers involved in complying with the regulations and the global nature of the regulation, significant uncertainty exists regarding the forecast outcomes of the regulation. EIA's *This Week in Petroleum* article published tomorrow afternoon will go into more detail on EIA's outlook for how the new sulfur specifications will affect crude oil and petroleum product markets through the end of 2020. On Thursday, January 24, EIA will release its *Annual Energy Outlook 2019* with projections through 2050, which will reflect the long-term implications of the new sulfur requirements.

**Principal contributors:** Hannah Breul, Tim Hess

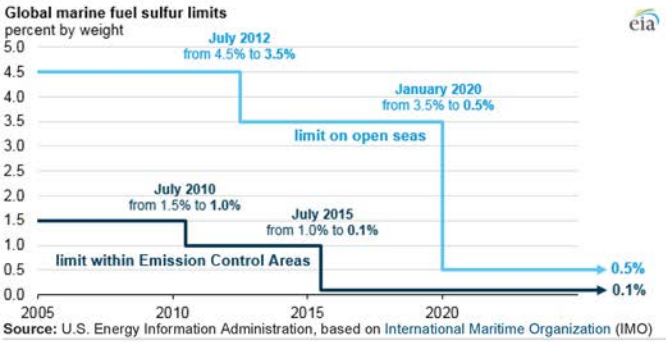
U.S. Energy Information Administration

## Today in Energy

December 14, 2018

# Coming changes in marine fuel sulfur limits will affect global oil markets

For the next two weeks (December 17–December 31), *Today in Energy* will feature a selection of our favorite articles from 2018. New articles will resume on January 2, 2019.




**Source:** U.S. Energy Information Administration, based on International Maritime Organization (IMO)

International regulations limiting sulfur in fuels for ocean-going vessels, set to take effect in January 2020, have implications for vessel operators, refiners, and global oil markets. Stakeholders will respond to these regulations in different ways, increasing uncertainty for crude oil and petroleum product price formation in both the short and long term.

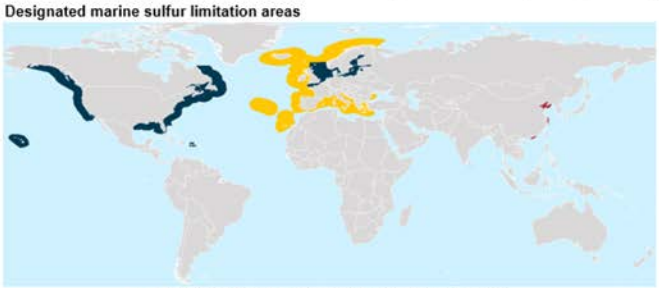
When burned, the sulfur in marine fuel produces sulfur dioxide, a precursor to acid rain. The sulfur content of transportation fuels has been declining for many years because of increasingly stringent regulations implemented by individual countries or groups of countries. In the United States, federal and state regulations limit the amount of sulfur present in motor gasoline, diesel fuel, and heating oil.

The upcoming 2020 rules apply across multiple countries' jurisdictions to fuels used in the open ocean, representing the largest portion of the approximately 3.9 million barrel per day global marine fuel market, according to the International Energy Agency.

The International Maritime Organization (IMO), the 171-member state United Nations agency that sets standards for shipping, is set to reduce the maximum amount of sulfur content (by percent weight) in marine fuels used on the open seas from 3.5% to 0.5% by 2020. These regulations are intended to reduce sulfur dioxide, nitrogen oxides, and other pollutants from global ship exhaust.

The 2020 reduction in sulfur limits follows a series of similar reductions in marine fuel sulfur limits, such as those that reduced sulfur content of marine fuels in IMO-designated Emission Control Areas from 1.0% to 0.1% in 2015. Other areas around ports in Europe and parts of China have adopted similar sulfur restrictions.

**Designated marine sulfur limitation areas**



International Marine Organization Emission Control Areas

European Union Sulfur Directive  Chinese Emission Control Areas

**Source:** U.S. Energy Information Administration, based on International Marine Organization, European Union, and China's Ministry of Transport

Vessel operators have several choices for compliance with the new IMO sulfur limits. One option is to switch to a lower-sulfur fuel compliant with the new IMO rules. However, the cost, widespread availability, and specifications of a new fuel for use in marine engines is still uncertain.

Another option is to use scrubbers to remove pollutants from ships' exhaust, allowing them to continue to use higher-sulfur fuels. However, the process of installing scrubbers can be costly and can increase a ship's operating costs. A small portion of existing marine vessels has already installed scrubbers, and that portion is not expected to increase greatly before 2020 because of time constraints and limited installation capacity. Even if scrubbers become widely adopted, which would allow the continued use of fuels with higher-sulfur content, the price and availability of higher-sulfur fuels after 2020 remains uncertain.

Ships also have the option to switch to nonpetroleum-based fuels. Some newer ships and some currently being built have dual-fuel engines that would allow them to use nonpetroleum-based fuels such as liquefied natural gas (LNG) after minimal modifications. However, the infrastructure to support use of LNG as a shipping fuel is currently limited in both scale and availability.

The upcoming IMO regulations pose a significant challenge for global petroleum refineries: how to increase the supply of low sulfur products for use in marine applications and minimize the output of high sulfur oils.

Residual oil—the long-chain hydrocarbons remaining after lighter and shorter hydrocarbons such as gasoline and diesel have been separated from crude oil—currently makes up the largest component of marine fuels used by large ocean-going vessels, also known as bunker fuel. Removing sulfur from residual oils or upgrading them to more valuable lighter products such as diesel and gasoline can be an expensive and capital-intensive process.

The choice of compliance path for vessels also introduces a risk to refiners: if scrubbers become widely adopted, higher-sulfur residual oils might still be used, potentially reducing the value of existing and new refining units capable of upgrading the residual oils.

One approach refineries could pursue is to divert more low sulfur distillate fuel into the bunker fuel market, which would mean ocean-going ships would be competing with trucks, heavy equipment, trains, and planes for supplies of distillate fuels at a time when global demand for distillate is already high. To respond to added demand for distillate fuels, refineries can increase the rate they process crude oil or invest and build more refinery capacity to produce distillate fuels. Both options would increase demand for crude oil.

Refineries might also choose to process crude oils that are lower in sulfur, yield a greater amount of distillates, and yield lower amounts of residual oils. Changes in the types of crude oil refineries purchase would then change how different crude oils are priced relative to each other and crude prices overall.

The decisions refiners and shippers make in response to the IMO 2020 rules heavily influence one another, adding to uncertainty and complexity. In January 2019, EIA will release the first *Short-Term Energy Outlook* that includes monthly projections through December 2020. This report will discuss short-term implications and uncertainties surrounding the IMO regulations. Later that month, the *Annual Energy Outlook 2019* will describe potential long-term implications of the regulations.

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Independent Statistics & Analysis
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# The Effects of Changes to Marine Fuel Sulfur Limits in 2020 on Energy Markets

March 2019

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Washington, DC 20585

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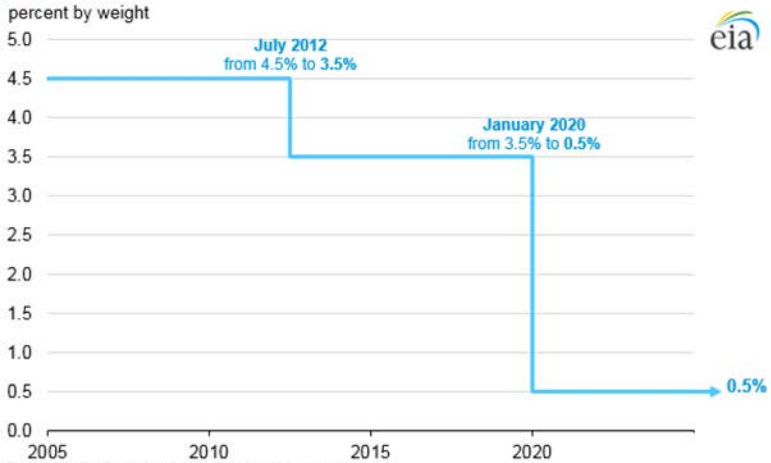
## Introduction

With a planned effective date of January 1, 2020, the International Maritime Organization's (IMO) new regulations (IMO 2020) limit the sulfur content in marine fuels that ocean-going vessels use to 0.5% by weight, a reduction from the previous limit of 3.5% established in 2012. The IMO adopted the plan for this policy change in 2008, and in 2016 reaffirmed an implementation date of 2020. The change in sulfur limits has wide-ranging repercussions for the global refining and shipping industries as well for petroleum supply, demand, trade flows, and prices. The shipping and refining industries have already begun making preparations and investments to varying degrees to accommodate IMO 2020 regulations. As the implementation date for the 0.5% sulfur cap approaches, the U.S. Energy Information Administration (EIA) expects that shifts in petroleum product pricing may begin as early as mid-to-late 2019. EIA anticipates that the effects on petroleum prices will be most acute in 2020, and the effects on prices will be moderate after that. However, the regulations will affect petroleum supply, demand, and trade flows on a more long-term basis.

**Figure 1. Marine fuel sulfur limits**




Source: U.S. Energy Information Administration

EIA shows the effects of these new regulations in both the *Short-Term Energy Outlook* (STEO), published monthly, and the *Annual Energy Outlook 2019* (AEO2019), released in January 2019. Because IMO 2020 will affect petroleum markets across several years, EIA's STEO forecast and AEO2019 projections provide complementary insights into the effects of the regulations.

Both STEO and AEO2019 are based on current laws and regulations. AEO2019 centers around a Reference case based on relationships and general equilibrium models that satisfy projected energy demand under a set of constraints.

STEO provides forecasted data that are updated every month. EIA uses a combination of econometric models based on historical data to forecast where EIA anticipates energy markets will move in the next two years. The STEO relies on historical data, short-term trends, and analyst judgment in creating this forecast. Although the STEO forecasts fewer variables than the Annual Energy Outlook, STEO's publication frequency allows EIA to incorporate developments related to the IMO rule more regularly than AEO2019, which projects variables at an annual frequency through the year 2050. In addition, because the STEO is published monthly, EIA adjust its forecasts continuously to incorporate new information.

Because the current STEO forecasts end in December 2020, the data in AEO2019 provide EIA's projections with insight into how IMO 2020 will affect petroleum markets beyond 2020. In addition, AEO2019 has more detailed data on refinery operations, marine fuel use, and fuel costs than the STEO. Projections in the Annual Energy Outlook are generated from EIA's highly detailed, structured equilibrium models in its National Energy Modeling System.

The first section of this report explains the findings related to IMO 2020 from the STEO and AEO2019 analysis. The second section discusses the uncertainties that might affect the way that actual outcomes deviate from EIA's forecasts and projections.

# Section I: Forecasts and projections of IMO effects

## Demand for marine fuels

Globally, marine vessels are a critical part of the global economy, moving more than 80% of global trade by volume and more than 70% by value. They account for about 4% of global oil demand (about 4.3 million barrels per day (b/d) according to the International Energy Agency). In the United States, consumption of bunker fuel (the fuel mix consumed by large ocean-going vessels) is a relatively small share of total energy demand. In 2018, U.S. bunker fuel consumption represented about 3% of total transportation energy use and just 2% of total U.S. petroleum and liquid fuel use. Of the 4.3 million b/d of global marine sector demand, about 10% of those sales originated at U.S. ports. Those sales of marine fuels at U.S. ports represent the AEO2019 international marine demand projections (Figure 2).

Residual oil—the long-chain hydrocarbons remaining after lighter and shorter hydrocarbons such as gasoline and diesel have been separated from crude oil—currently accounts for the largest component of bunker fuel. Although distillate fuels, the other large component in bunker fuel, have alternative uses and markets outside of marine fuels, residual oils have few other alternative markets. About 80% of total U.S. residual fuel demand is for marine bunkering. Therefore, the steps vessel operators take to comply with the new IMO 2020 sulfur limits have major implications for the use of residual fuel oils in marine fuels, for the price of residual fuel oil and its competitors, and for the refineries that produce residual fuel oil.

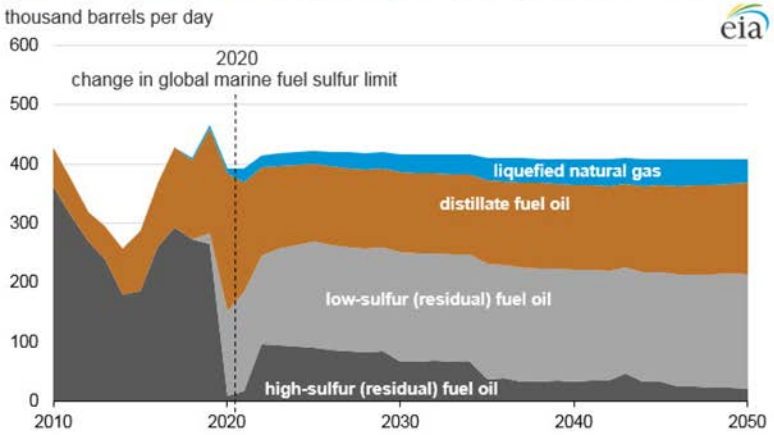
Operators of marine vessels have several options for complying with IMO 2020 sulfur limits. They can switch their ships to a lower-sulfur fuel that complies with the new IMO rules, which would likely increase demand for distillate and low-sulfur residual oils. Another option is to use scrubbers to remove pollutants from ships' exhaust, allowing ships to continue to use higher-sulfur fuels. Vessel operators

can also switch their ships to nonpetroleum-based fuels, such as liquefied natural gas (LNG). In the AEO2019 Reference case projections, the fuel mix of ocean-going marine vessel bunkering in the United States changes significantly because of the new global sulfur fuel limits.

The AEO2019 and STEO projections only consider sales of bunker fuel from ports inside the United States. Because the United States is a member of the IMO and U.S. port and maritime authorities currently enforce all IMO regulations, the implied rate of compliance to the IMO sulfur limits for the United States in the AEO2019 and STEO is 100%. Although the level of compliance with the new IMO sulfur limits may vary globally, the AEO2019 (and the STEO) do not make explicit assumptions about compliance levels beyond the United States.

EIA projects that the share of high-sulfur residual fuel oil consumed by U.S. ocean-going bunker fuel markets drops from 58% in 2019 to 3% in 2020, and then rebounds to 24% in 2022. Despite a recent increase in scrubber installation and orders, the number of vessels installed with scrubbers required to continue using high-sulfur residual fuel oil remains limited. As a result, AEO2019 projects a large but brief increase in the share of distillate fuel oil and low-sulfur residual fuel oil in 2019 and shortly after 2020. A recovery in high-sulfur residual fuel oil consumption driven by scrubber installations does not occur until 2022 but at levels far lower than before the 2020 IMO rule implementation. After 2023, high-sulfur residual fuel oil consumption declines throughout the AEO2019 Reference case projection, down to a 22% share of U.S. ocean-going marine vessel bunker fuel by 2025. In AEO2019, EIA projects that the share of low-sulfur residual fuel oil consumed in U.S. ocean-going marine vessel bunkering will increase from 38% in 2020 to 43% in 2025. Similarly, EIA projects that the need to use distillate in lower-sulfur bunker fuels will increase distillate's share of U.S. bunker demand from 36% in 2019 to 57% in 2020, although this share declines to 29% by 2025.

**Figure 2. International marine shipping consumption by ocean-going vessel bunkering at U.S. ports**




Source: U.S. Energy Information Administration, AEO2019 Reference case

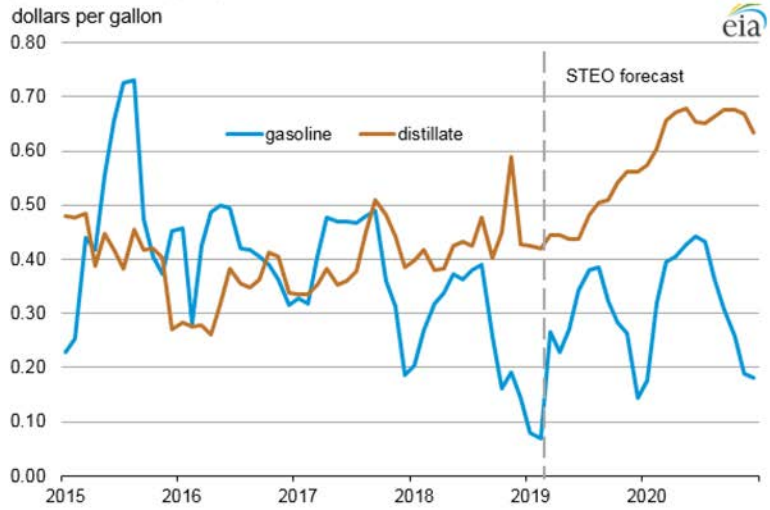
Outside of residual fuel oils and distillate, STEO forecasts that the use of LNG in marine bunkering will be limited through 2020. Similarly, the AEO2019 Reference case projects limited use of LNG in the next five years, reflecting the high initial infrastructure development cost and the limited current infrastructure to accommodate LNG bunkering at U.S. ports. In the medium and long term, this infrastructure barrier decreases, and LNG's share of U.S. bunkering grows to 7% in 2030 and to 10% by 2050.

Despite bunker fuel's relatively small share of both the global and U.S. liquid fuels markets, EIA expects a shift in demand in the global bunker fuel market from high-sulfur fuel oil to low-sulfur distillate fuel and low-sulfur fuel oil. This shift will result in a change in the relative prices of those fuels. EIA expects the demand shift to increase global prices for light- and low-sulfur refined petroleum products such as diesel fuel, gasoline, jet fuel, and low-sulfur fuel oil. This shift, in turn, will lead to a decrease in the prices of high-sulfur refined petroleum products, such as high-sulfur fuel oil. This price premium for lower-sulfur refined products will be most evident at the wholesale (refinery and bulk terminal) level in the form of higher refining margins for low-sulfur products such as diesel.

## Refining margins

The price consumers pay for petroleum products includes three components—the cost of crude oil, the refining margin, and the retail margin (including taxes). The wholesale price of refined product is the cost of crude oil plus the refining margin. The main cause of changes in the price consumers pay for petroleum products are changes in the price of crude oil. Changes to crude oil prices can occur for a wide variety reasons, and any large change in the price of crude oil, either higher or lower, from the levels assumed in STEO and AEO2019 would result in different ultimate wholesale and retail prices of products than EIA projections.

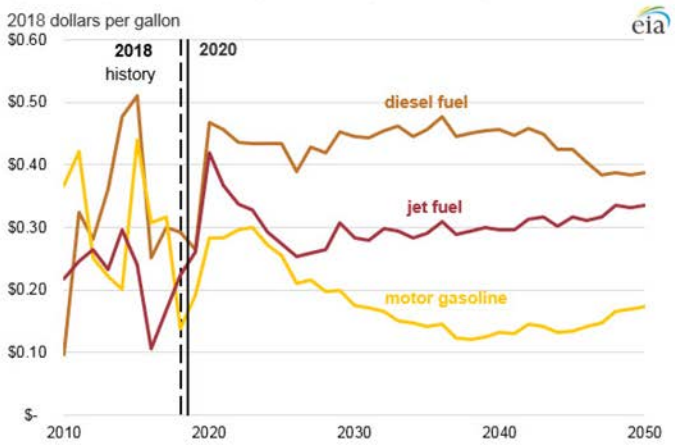
**Figure 3. U.S. refinery margins**




Source: U.S. Energy Information Administration, *Short-Term Energy Outlook*, March 2019

However, in the short-term, refining margins will experience the most price effects because of IMO 2020. Because of an increased premium on low-sulfur fuels, in the STEO, EIA expects that diesel fuel refining margins will increase from an average of 43 cents per gallon (gal) in 2018 to 48 cents/gal in 2019 and to 65 cents/gal in 2020. After 2020, EIA expects diesel fuel prices to moderate as the shipping and refining sectors react to these price signals. In AEO2019, EIA projects that diesel refining margins will gradually decrease after 2020 and will average 39 cents/gal in 2026.

**Figure 4. Projected U.S. diesel, gasoline, and jet fuel crack spreads**



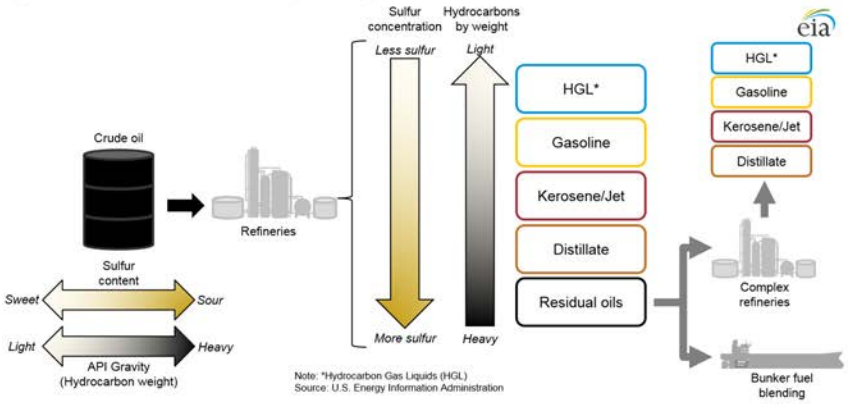

Source: U.S. Energy Information Administration, AEO2019 Reference case

## Refinery operations and production

The increase in diesel refining margins will prompt U.S. refiners to produce more diesel fuel. EIA expects this increase to occur in two ways—an increase in diesel yields and in overall throughput into refineries. Much of U.S. refining capacity, especially on the U.S. Gulf Coast, has downstream units that upgrade residual oils into more valuable and lower-sulfur products such as diesel. These refineries can economically process heavier and higher-sulfur crude oils that yield large quantities of residual oils for further processing, and they will be well positioned to supply the global marine-fuel market with low-sulfur bunker fuel when IMO 2020 goes into effect. As refiners maximize diesel fuel production, STEO forecasts distillate fuel refinery yields will increase from an average of 29.5% in 2018 to 29.9% in 2019 and to 31.5% in 2020. As diesel refining margins decline, EIA projects that diesel yields at refineries will also decline.

The increase in diesel yields in 2020, driven by increased diesel refining margins, largely comes from a shift away from motor gasoline and residual fuel oil. EIA forecasts that gasoline yields will fall from an average of 47.0% in 2018 to averages of 46.6% in 2019 and 45.6% in 2020. In STEO, residual fuel yields decrease from an average of 2.5% in 2018 to an average of 2.2% in 2020. Through 2025, EIA projects some shift back to gasoline production as margin differences between diesel and gasoline narrow and the market returns to historical levels.

**Figure 5. Crude oil and residual oil processing**




Source: U.S. Energy Information Administration

In addition to shifting production toward diesel fuel, refiners are also expected to increase their overall throughput of crude oil. In STEO, EIA expects that gross inputs into refineries will increase from an average of 17.3 million b/d in 2018 to a record level of 17.8 million b/d (up 2.6%) on average in 2020. This increase in gross inputs will result in refinery utilization increasing from an average of 93.2% in 2018 to 93.2% to an average of 95.4% in 2020. If realized, a utilization rate of 95.4% would be the highest for the U.S. refining sectorsince a record of 95.8% in 1998. A utilization rate higher than 95% would likely put stress on the U.S. refining sector and might only be sustainable for about a year. In AEO2019, EIA projects that refinery utilization falls to 93.7% in 2021 and averages 92.9% from 2022–2025. Overall U.S. refining capacity only increases slightly during this timeframe.

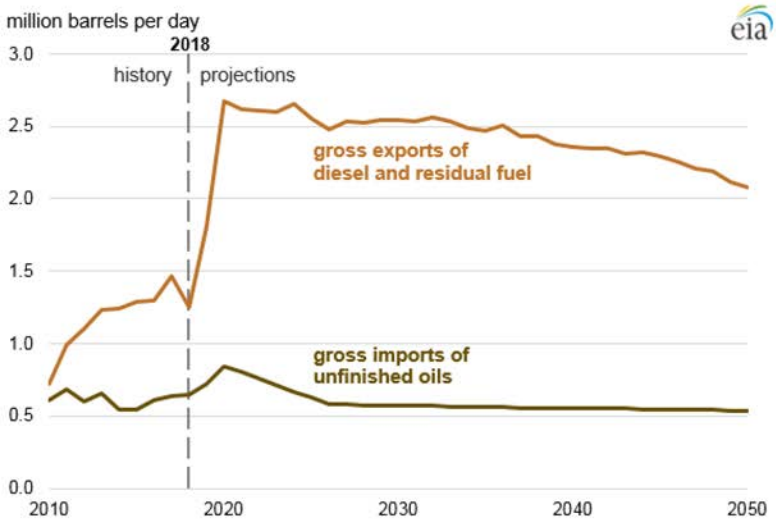
EIA's modeling capabilities do not currently include a detailed, fully integrated global refining model. The Liquid Fuels Market Module in NEMS has a detailed representation of the U.S. refining sector but only a general representation of global petroleum markets through import and export curves. The forecast increase in diesel margins for U.S. refineries from IMO 2020 will likely be replicated, to varying degrees, in diesel margins for refineries in the rest of the world. How refiners in the rest of the world respond to an increase in diesel margins is uncertain, and it is possible that they too would increase utilization, that then would reduce the increase in U.S. refinery utilization that EIA expects to occur. This possibility would reduce the pull on supplies from the United States and cause U.S. refinery utilization rates in 2020 to be lower than EIA's forecast.

## Trade and crude oil spreads

The United States represents a relatively small share of demand in the global bunker fuel market. EIA expects that much of the increase in diesel fuel production and other refined product production resulting from higher refinery runs will be exported. As U.S. refiners export diesel to supply an increasing share of the global demand for low-sulfur bunker fuel, EIA expects gross exports of diesel and residual

fuel to rise from 1.2 million b/d in 2018 to almost 2.6 million b/d in 2020. In AEO2019, EIA projects net exports of diesel will decrease from 2021–2025 as the global shipping industry demands less diesel because of higher scrubber adoption.

**Figure 6. U.S. diesel, residual fuel, and unfinished oils trade**




Source: U.S. Energy Information Administration, AEO2019 Reference case

The increase in net exports of diesel fuel is a key reason why EIA forecasts that the United States will be a consistent net exporter of combined crude oil and petroleum products by the end of 2020. EIA forecasts in the March 2019 STEO that for all of 2020, U.S. net exports of crude oil and petroleum products will average 0.1 million b/d and will average 0.9 million b/d by the fourth quarter of 2020.

Despite this expected increase in overall net exports, EIA expects the imports of unfinished oils (UFO) to increase because of IMO 2020. EIA defines UFO as all oils requiring further processing, except mechanical blending, and they include naphthas and lighter oils, kerosene, light gas oils, heavy gas oils, vacuum gas oils, and residuum. As a result of the IMO sulfur limits, some of the UFO that are lower in sulfur are likely to be used in blending a new compliant low-sulfur bunker fuel or will be directed to other refinery units for additional processing as part of shifting refinery yields. The high sulfur UFO produced by simple refineries—that lack advanced units to process the higher sulfur UFO into finished products—is often sold for use in high-sulfur bunker fuel blending or to more advanced refineries for additional processing. As the demand for high-sulfur UFO as bunker fuel blendstock decreases as a result of the IMO sulfur limits, prices will likely decrease and demand from advanced refineries, such as those on the U.S. Gulf Coast, is expected to increase. The demand for UFO by advanced U.S. Gulf Coast

refineries and higher refinery margins are responsible for the increasing imports of UFO in late 2019 and 2020.

EIA expects IMO 2020 effects on the crude oil market to be less significant than on the product market. Because of the discount that sulfur is expected to receive in global oil markets starting in late-2019 and into 2020, EIA assumes that the price difference between light-sweet crude oil and heavy-sour crude oil will widen. A possible proxy for a light-sweet/heavy-sour spread is the difference between the landed cost of crude oil that is 25 API gravity or less and the WTI spot price. This spread averaged about $12/b in 2018. EIA assumes that this spread has narrowed to about $8/b in the first quarter of 2019, and EIA assumes it will widen by about $5/b to $13/b in 2020. This widening spread can be expected to lower crude oil costs for U.S. refiners, other market factors being equal, because much of the crude oil U.S. refineries import is heavy. EIA expects the cost of imported crude oil to average $5.44/b less than West Texas Intermediate (WTI) spot prices in 2020, compared with $3.50/b less than WTI in 2018.

Similarly, U.S. refineries' average acquisition costs for all crude oil is forecast to be $2.64/b less than WTI spot prices in 2020, compared with 63 cents/b less than WTI in 2018. However, current market developments—including U.S. sanctions on Venezuela and Iran, along with production cuts from the Organization of the Petroleum Exporting Countries (OPEC)—have reduced the amount of heavy-sour crude oil available to the market, narrowing heavy-sour price discounts to light-sweet. To the extent that those factors continue to affect heavy-sour crude oil availability beyond what EIA currently forecasts, the pricing of heavy-sour crude oil could also be affected into 2020.

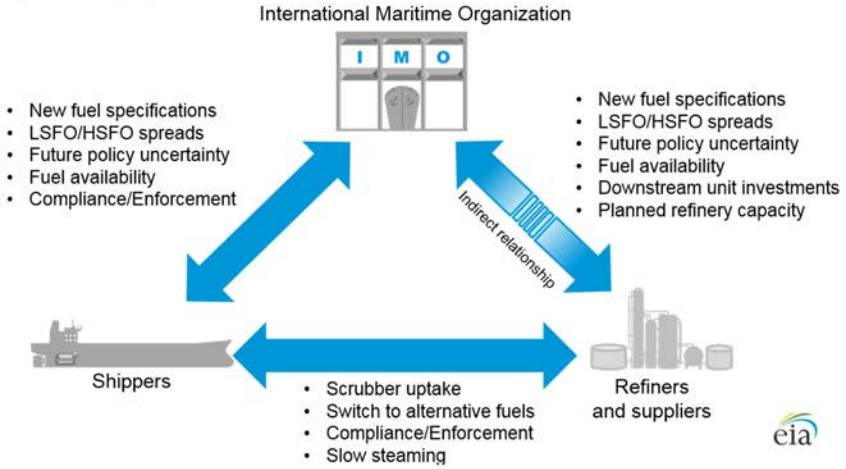
Although EIA expects that the effect on crude oil quality spreads could be relatively significant, EIA does not expect a significant impact on crude oil price levels. In the March 2020 STEO EIA forecasts Brent crude oil prices (the global benchmark for light-sweet crude oil) to average $63/b in 2019 to $62/b in 2020. EIA estimates that about half of the $5/b price spread between heavy-sour and light-sweet crude oils that it forecasts will occur in 2020 comes from higher light-sweet crude oils prices, and half comes from lower, heavy-sour oil prices. EIA assumes IMO regulations put about $2.50/b of upward pressure on Brent crude oil prices as a result of higher demand for light-sweet crude oils. However, EIA expects broader global crude oil market conditions to have more significant effects on Brent prices than IMO regulations.

## Section II: Uncertainties of IMO projections

The effects of implementing the IMO 2020 regulations are highly uncertain. Many policy and technical complications, as well as potential market participant responses, create numerous interrelated factors that will have a significant influence on the eventual outcome. Further, these factors are highly interdependent on one another, making cause and effect difficult to disentangle.

The IMO designed the 2020 sulfur regulation as an open policy without designating one compliance method but instead letting market participants decide for themselves how best to comply. However, this openness, the complexities of implementation, and the number of participants limited the first-mover advantage toward compliance. In the years leading up to 2020, with little to no first-mover advantage, stakeholders have been slow to provide clear intentions of their compliance methods.

Figure 7. IMO projection uncertainties across stakeholders




Source: U.S. Energy Information Administration

EIA's forecasts and projections related to IMO 2020 are a result of detailed insights, modeling, and data on the U.S. refining and shipping sectors and from more general assumptions about how these sectors would react globally. Because the shipping industry and the fuels used in that industry are globally integrated markets, a globally integrated supply and demand model would be required to comprehensively model the effects of the IMO 2020 rule. Although EIA does not currently have such a model, it does employ an integrated supply and demand model for the U.S. petroleum market, which was used to produce many of the results outlined in the first section of this report. The global response of these industries is equally as important as the response in the United States; however, without the same level of modeling globally, the degree of uncertainty in EIA's assessment increases significantly. In addition, the current lack of production, consumption, efficiency, and logistical data for non-U.S. marine fuels and the shipping industry makes this effort more difficult.

EIA will continue to readjust its forecast and projections related to IMO 2020 as more information on these uncertainties become clear, as more data become available, and as newer models are developed.

## Uncertainties for both refiners and shippers

*New fuel specifications:* The IMO set the sulfur limit for marine fuels at 0.5% or lower after January 2020, but the many other specifications needed to establish a uniform fuel specification were left to the International Standards Organization and other industry participants. As of March 2019, a final specification for the new, compliant low-sulfur marine (bunker) fuel is not complete, however ISO has issued a statement that the existing 2017 standard may be used with the lower sulfur requirement.

This lack of certainty means refineries do not know how to optimize their outputs and how much the compliant fuel would cost to produce. Without clear guidance on how much the new compliant fuel would cost and its specifications, ship owners cannot make operational, engineering, and logistical decisions because some compliant fuels may not be compatible with their ships' engines. Once new compliant marine fuel specifications are final, refiners and shippers will be better able to determine the cost to produce it, its price, and how to make it widely available.

***LSFO/HSFO spreads:*** The price discount of high-sulfur fuel oil (HSFO) to either low-sulfur fuel oil (LSFO) or marine distillate oil (MDO) will shape the decisions that refiners and shippers make. Refiners will only invest to produce more low-sulfur fuels if the price difference between low- and high-sulfur fuels covers the associated costs. However, if high-sulfur fuel oil sells at a significant discount to low-sulfur fuel oil or MDO, shippers would be more inclined to install scrubbers to save on fuel costs. As January 2020 approaches, the LSFO, MDO, and HSFO price spread will be more certain , providing clearer signals to market participants on how to react, invest, and plan.

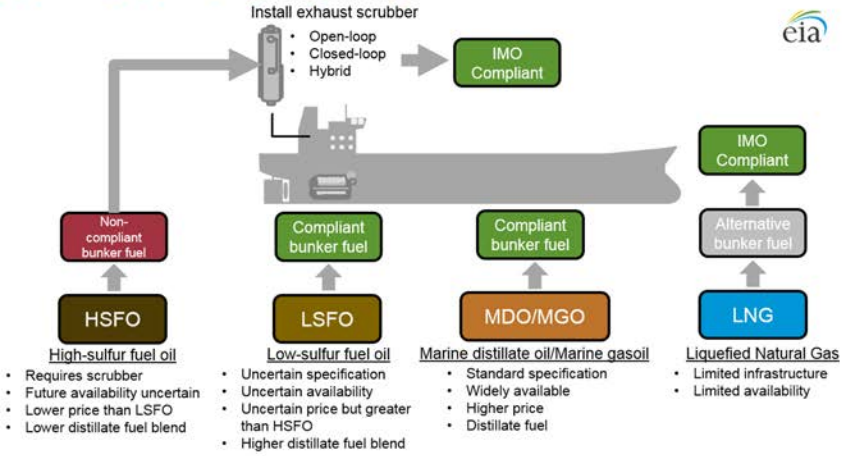
***Future policy uncertainty:*** The IMO has signaled its intention to implement additional controls and regulations on other types of pollution from ships in the future. These future regulations may result in shippers switching to alternative non-petroleum fuels such as LNG. Because of this uncertainty, refiners and shippers may be hesitant to invest in complying with IMO 2020 if additional IMO regulations in the future could cause those investments to lose value or no longer be needed.

***Fuel availability:*** The logistics and availability of marine fuels as part of the IMO 2020 ruling are also uncertain. Vessels visiting ports across the globe require certainty they will be able to acquire the fuel they need wherever they travel. The most common practice is for shippers to sign bunker fuel supply contracts with suppliers that have operations or supply agreements across many ports. However, it is uncertain how much IMO-compliant fuel versus non-compliant fuel will be needed or available in each port after 2020. Although large bunkering ports, such as Singapore, Fujairah in the United Arab Emirates, and Rotterdam in the Netherlands, are likely to have both IMO-compliant fuels and non-compliant fuels, smaller ports and the vessels that visit them may have difficulties. In addition, the potential necessity of commingling IMO-compliant fuel from different producers may present significant problems. A multi-fuel market for bunker fuel creates challenges and logistical problems that result in increased projection uncertainty.

The IMO has also established a system of waivers—if a vessel not equipped with a scrubber visits a port where no IMO-compliant fuel is available, that vessel can apply for a fuel availability waiver. The ease and extent to which these fuel availability waivers will be obtained is uncertain, and these waivers increase the risks for refinery investments related to IMO compliance if they become widely available.

## Uncertainties mainly for shippers

**Figure 8. Shipping industry compliance pathways**




*Scrubber uptake:* A small number of existing marine vessels have already installed scrubbers, and EIA does not expect that number to increase significantly before 2020 because of time constraints and limited installation capacity. Even if scrubbers become widely adopted, which would allow operators to continue to use fuels with higher sulfur content, the price and availability of higher-sulfur fuels after 2020 remains uncertain.

In addition, some maritime and port authorities have regulations in place or may implement regulations that would limit the operation of scrubbers in their waters, depending on the configuration. Open-loop scrubber systems use seawater to remove sulfur from exhaust gas, but they discharge the resulting *wash water* back into the ocean. A closed-loop scrubber system retains the *wash water* onboard for later processing and disposal. A hybrid-loop scrubber system allows *wash water* to be discharged when in the open seas, but the system retains it onboard when in controlled waters. In terms of cost, open-loop scrubber systems are the least expensive, followed by hybrid, and then closed-loop scrubber systems.

Several major ports, including Singapore and large commercial ports in China, have banned open-loop scrubber systems. This ban forces ships equipped with the less expensive open-loop systems to switch to a lower-sulfur marine fuel when operating in certain waters, adding to scrubber uptake uncertainty.

*Switch to alternative fuels:* Another option for vessel operators to comply with the IMO 2020 rule is to switch to non-petroleum based fuels. Marine bunkering using LNG is often considered a potential alternative. In the past several years, many newly built ships were either built with or were offered to be equipped with LNG ready engines—engines that could be configured to run LNG at a later date.

However, very few vessels consume LNG as their primary fuel, and the infrastructure to support LNG as a shipping fuel is currently limited in both scale and availability.

Although numerous petroleum-based and non-petroleum-based marine fuel alternatives would comply with the IMO 2020 sulfur regulations, none are used on a large scale and have limited infrastructure.

*Compliance/enforcement:* The sulfur content of transportation fuels has been declining for many years because of increasingly stringent regulations implemented by individual countries or groups of countries. However, the upcoming IMO 2020 rules apply across multiple countries' jurisdictions to fuels used in the open ocean, and they leave the enforcement up to flag states—or the nation in which a vessel is registered. The capacity and willingness to enforce the IMO 2020 ruling among flag states are uncertain.

However, many large commercial port and maritime authorities have stated they intend to enforce IMO compliance on vessels entering their waters, in a similar way that they enforce local and national regulations on fuel quality, but the penalties or costs of non-compliance vary widely. If the costs of complying exceed the penalty for non-compliance or if the risks of enforcement are low, then use of high-sulfur marine fuels may continue in larger quantities than expected past 2020. Conversely, if the penalties for non-compliance and the risk of enforcement are high, then the continued use of high-sulfur marine fuels may be much lower than expected past 2020. For these reasons, changes in the rate of compliance and enforcement have significant influence on market outcomes because of the IMO 2020 rules.

To increase compliance certainty, the IMO passed a ban on carrying non-compliant high-sulfur bunker fuel on any ship that did not have a scrubber system installed unless the non-compliant fuel was that ship's cargo. This ban is set to go into effect in March 2020. This carriage ban gives port and maritime authorities another method of enforcing compliance with the new sulfur regulations.

*Slow steaming:* If the costs for marine fuels increase, ship owners may try to reduce consumption by reducing a vessels operating speed, a technique called *slow steaming*. This change would, in turn, reduce the overall amount of marine fuels consumed globally, which would alter the amount of marine fuels refineries need to produce and may counteract higher fuel prices. However, many of the efficiency increases possible from slow steaming have likely already been captured in recent years, and how much additional efficiency could be gained is unclear.

## Uncertainties mainly for refineries

*Downstream unit investments:* Removing sulfur from residual oils or upgrading them to more valuable lighter products such as diesel and gasoline can be an expensive and capital-intensive process. The possibility of widespread scrubber installations, which would allow continued use of higher sulfur residual oils, could make refiners hesitant about making large investments to build refining units capable of upgrading the residual oils.

Recently, several plans have been announced to restart portions of idled refineries in both Europe and the Caribbean ahead of or shortly after 2020. These restarted refinery units would process higher sulfur

residual oils and upgrade them into lighter fuels such as gasoline and distillate. This restarted processing capacity would provide a market for higher sulfur residual oils that are no longer used in marine fuels blending and supply more distillate fuels for possible use in low-sulfur marine fuel blending. However, the margins these refinery projects may earn are uncertain and depend on scrubber uptake and other factors, which would affect the price and availability of high- sulfur residual oil feedstock.

***Planned refinery capacity (new/expanded):*** The exact configurations, crude oil feedstocks, and product output profiles of new or expanded atmospheric crude distillation units (ACDU), mostly in Asia and the Middle East, are unknown and contribute to projection uncertainty. New or expanding ACDU capacity projects under construction or planned for construction are assumed to have accounted for IMO 2020 outcomes in their design decisions. As a result, both the market conditions when these new refineries come online and their influence on the market are uncertain. In addition, any changes in the configurations of existing refineries also add to the uncertainty.

The CHAIRMAN. Thank you, Administrator.

Mr. Butler, welcome.

**STATEMENT OF JOHN W. BUTLER, PRESIDENT & CEO, WORLD SHIPPING COUNCIL**

Mr. BUTLER. Thank you, Chairman Murkowski, Ranking Member Manchin, members of the Committee. I appreciate the invitation to testify today.

The World Shipping Council's members carry over 90 percent of the United States' international containerized ocean import and export commerce. Approximately 1,200 oceangoing liner vessels, mostly container ships, make more than 28,000 port calls in the United States in a given year—almost 80 port calls a day. The industry provides American importers and exporters with door-to-door delivery service for almost any commodity to and from about 190 countries around the world. Approximately 35 million 20-foot equivalent units of containerized cargo are imported into or exported from the United States each year.

I have submitted a written statement for the record. This morning, I'd just like to highlight a few points from that longer statement.

First, the implementation of the IMO 2020 Marine Fuel Sulfur Regulation will not disrupt the critical flow of containerized international trade moving into and out of the United States. The international liner shipping industry will function the same next month and the months after as it does today.

Second, as the Chairman has pointed out, this standard that will go into effect on January 1 has been in the works for over a decade. The 0.5 percent sulfur limit was adopted in 2008 by governments working through the International Maritime Organization, or IMO. That limit was subject to a formal review at the IMO in 2016 and the IMO, with the support of the United States, determined that sufficient fuel would be available to meet the 0.5 percent standard by 2020. These global reductions in the sulfur content of marine fuel are anticipated to result in substantial improvements in public health.

My third point and especially because of the long lead time between adoption and implementation, governments, the shipping industry, fuel suppliers and the IMO have had the opportunity to prepare for the clean fuel requirement. Those efforts include regulatory amendments and guidance undertaken by both the IMO and the U.S. Coast Guard as well as extensive preparations across the industry in terms of engineering, crew training and contracting for fuel supplies. All affected parties have been working for the past several years to ensure that the new limits are implemented as smoothly as possible.

Fourth and finally and most important from the ocean carrier perspective, we need a level playing field in terms of enforcement in order for this regulation to work as designed. Although we do not expect major disruptions in broader petroleum markets, there will be a cost differential associated with this cleaner fuel. If everyone is not playing by the same rules, that cost differential can penalize responsible actors and reward bad actors. On this point it is critical that the U.S. Coast Guard and the EPA, the IMO and

governments around the world continue to emphasize that they will consistently enforce this requirement.

I thank you for the opportunity to testify. I welcome your questions.

[The prepared statement of Mr. Butler follows:]

John W. Butler, President & CEO, World Shipping Council


Statement of

**John W. Butler**

President & CEO

**World Shipping Council**

Before the

**Senate Committee on Energy and Natural Resources**

on

**IMO 2020**

December 10, 2019

Chairman Murkowski, Ranking Member Manchin, and Members of the Committee, 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.

Liner shipping is the sector of the maritime shipping industry that offers regular service based on fixed schedules and itineraries. The Council's members carry over 90% of the United States' international containerized ocean export and import commerce and include the full spectrum of carriers from large global lines to niche carriers, offering container, roll-on/roll-off, and car carrier services as well as a broad array of logistics services.

WSC members comprise an industry that has invested over $400 billion 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-

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

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 on-going economic activity. The connection of liner vessels to ports, roads, and rail infrastructure forms an intermodal system that generally operates with such reliability that in most parts of the country the average consumer is unaware of its workings.

My testimony will provide background on the IMO 2020 low sulphur fuel requirement, discuss how the liner shipping industry is prepared to comply with this requirement, and discuss how to ensure the transition to IMO 2020 compliant fuels is executed in a manner that will allow the markets to quickly and efficiently adjust to the new requirement.

**Background of the IMO Regulation**

A global limit on the sulphur content of marine fuel was first established in 1997 when governments, acting through the International Maritime Organization (IMO), adopted regulations for the prevention of air pollution from ships by creating Annex VI to the International Convention for the Prevention of Pollution from Ships, otherwise known as *MARPOL Annex VI*. The requirements of MARPOL Annex VI entered into force in May 2005. The applicable sulphur limits were amended in 2008 as a result of efforts by the United States, Norway, and many other governments that believed lower marine fuel sulphur limits were critical to improving air quality in their own countries as well as around the world. Moreover, global regulations were considered the most effective and efficient mechanism to establish air quality standards while maintaining regulatory consistency in an industry that operates across international borders on a continuous basis.

The 2008 Amendments to MARPOL Annex VI established new sulphur limits. The first limit (0.1%) took effect in 2015 and applies in Emission Control Areas (ECAs) established under the treaty, including the North American ECA established by the United States and Canada.

The second limit (the focus of today's discussion) was adopted in 2008 and will take effect on 1 January 2020. The 2020 0.5% global sulphur limit was subject to a formal review in the IMO to determine sufficient availability of fuel that would meet the 0.5% sulphur limit. The IMO, with the support of the United States, concluded that review in 2016 and determined that sufficient fuel would be available to meet the 0.5% standard in 2020. These global reductions in the sulphur content of marine fuel are anticipated to result in substantial improvements in public health.

**Preparations for the 0.5% Marine Fuel Sulphur Limit**

The IMO, the shipping industry, fuel suppliers, and the United States Coast Guard have all taken measures to prepare for the 0.5% limit. These efforts include regulatory amendments and guidance undertaken by both the IMO and U.S. Coast Guard as well as extensive preparations across the industry in terms of engineering, crew training, and contracting with fuel suppliers. All affected parties have been working for the past several years to ensure that the new limits are implemented as smoothly as possible.

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

IMO guidelines and other actions taken to ensure smooth implementation of the 0.5% sulphur limit can be found at: http://www.imo.org/en/MediaCentre/PressBriefings/Pages/10-MEPC-74-sulphur-2020.aspx.

**The Need for a Level Playing Field**

The marine fuel sulphur limit that will go into effect next month has been in the works for over a decade, so there are no surprises here. Notwithstanding that lead time, there is no doubt that the 2020 sulphur limits will have a significant cost impact on marine carriers. What is less certain is the magnitude of the cost differential that we will see with these fuels, many of which are expected to be blends. In the end, the fuel markets and the markets for marine transportation will find equilibrium and establish cost levels and allocation of those costs across the supply chain.

The one thought that I would leave with you is that the single most important thing that governments around the world can do is to make it clear by words and action that they will require compliance with this new regulation. Markets are already adjusting to the requirement for cleaner fuels, but markets function best when there are clear signals about what the demand will be. Any unnecessary uncertainty in the fuel markets will simply extend the time that it takes for supplies and prices to reach equilibrium. From the perspective of ocean carriers that will purchase this cleaner fuel, it is imperative that we have a level commercial playing field on which all participants are playing by the same rules.

Thank you for the opportunity to testify today.

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The CHAIRMAN. Thank you, Mr. Butler.

Mr. Morgan, welcome.

**STATEMENT OF DERRICK MORGAN, SENIOR VICE PRESIDENT, AMERICAN FUEL & PETROCHEMICAL MANUFACTURERS**

Mr. MORGAN. Thank you, Chairman Murkowski, Ranking Member Manchin and members of the Committee. It's my pleasure to be here today to present AFPM's perspective on the IMO 2020 regulation.

AFPM, the American Fuel and Petrochemical Manufacturers, represents more than 90 percent of the refining and petrochemical capacity in the United States. Our members obtain crude oil and natural gas and manufacture it into the gasoline, diesel, jet fuel, marine fuel, home heating oil and thousands of other products that make modern life possible. The subject of today's hearing, IMO 2020, is nearly 12 years in the making, as you pointed out, Chairman Murkowski.

It is poised to be a tremendous success story for the environment, for American manufacturing jobs and for U.S. energy security. In 2008, the IMO committed to lower sulfur in marine fuels and determined the final timetable and sufficient supplies in 2016. In this way, the world is starting to catch up to the lower-sulfur standards we've already implemented in U.S. waters, starting in 2012 and then rationing down to 0.1 percent in 2015. AFPM fully supports an on-time implementation of IMO 2020 and consistent global enforcement of the new standard.

My written testimony includes some detailed explanations, so I'll just highlight a few major points.

First, our member companies have invested tens of billions of dollars to become the most complex and flexible refining industry in the world. For example, the first chart in the appendix to my written testimony shows refiners in regions such as Russia and the Middle East are simply not as complex as here in the United States and they produce a higher percentage of high-sulfur fuels. Investments in the U.S. have increased the ability to process a wider variety of feedstocks more efficiently and produce cleaner fuels, including for IMO 2020.

Second, the complexity and flexibility of American refineries combined with lower-sulfur crude oils produced domestically should lead to increased exports and an even more positive trade balance on petroleum and petroleum products. This rule will benefit American manufacturers and our employees while reducing sulfur emissions.

Third, although the U.S. is particularly well-positioned for IMO 2020, the global industry as a whole is also ready. AFPM has been a member of a coalition of national refining trade associations from around the world called the Marine Platform 2020. The Platform's goal is to support implementation of IMO 2020 and to advise governments and stakeholders about implementation. And that's just what we've been doing as AFPM.

I had the opportunity and privilege to join the United States delegation to the last two Marine Environment Protection Committee meetings at the IMO, and I can tell you the result of the meetings was an increased understanding by the world governments about

how IMO 2020 will work in practice. The discussion was not if or when the new standards take effect, but the how, a specific detail, such as sampling and enforcement. In the marketplace there is already compliant fuel available at major ports globally and pricing benchmarks have been in place for much of the year already.

As with any new program of this magnitude, there will be bumps in the road and even unforeseen challenges. Local availability and quality in some ports may present challenges for shippers, but these are solvable and will be worked out by the marketplace. Several of our members are working to position themselves and their bunker fuel supply of partners as the ready answer to the question, where can I get quality and compliant fuel?

On a more macro level, I've included some relevant quotes in my testimony referencing analysis at EIA and IEA. These analyses are largely in line with expectation of investment banking community and other independent experts that implementation has already begun and there is sufficient compliant fuel available. The doomsday scenarios of some analysts that grabbed headlines in the last year with predictions of much more expensive crude oil and diesel fuel are just not materializing.

In summary, as a result of years of multinational coordination and planning and investment by the refining and shipping industries and hard work by the professionals at EPA and the U.S. Coast Guard, IMO 2020 is expected to have substantial environmental benefits and promote U.S. energy security.

Again, I appreciate the opportunity to share our views and I look forward to answering any questions you may have.

[The prepared statement of Mr. Morgan follows:]

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**Testimony of Derrick Morgan,**

**Senior Vice President, American Fuel & Petrochemical Manufacturers**

**U.S. Senate Committee on Energy and Natural Resources**

***Full Committee Oversight Hearing of IMO 2020***

**December 10, 2019**

The American Fuel & Petrochemical Manufacturers ("AFPM") appreciates the opportunity to provide testimony on the International Maritime Organization ("IMO") 2020 marine sulfur standard ("IMO 2020"). AFPM's members operate approximately 110 refineries, accounting for more than 90 percent of U.S. refining capacity, that produce the gasoline, diesel, jet fuel, and petrochemical building blocks for the thousands of products that make innovation and progress possible. Marine fuel is approximately 7 percent of global transportation fuel demand.

AFPM supports an on-time and uniform global implementation of IMO 2020, which presents a challenging but unique opportunity to enhance U.S. energy security while delivering substantial environmental benefits. The U.S. refining sector is the most complex and technologically advanced refining sector in the world, having invested nearly $100 billion over the past decade to increase processing capacity, improve operating efficiency, increase crude slate flexibility, and produce cleaner fuels, including low sulfur fuels like those needed for IMO 2020. Despite early concerns about potential impacts on national and local markets, it is increasingly clear that the U.S. refining sector is prepared to deliver IMO compliant fuel to meet not only the needs of U.S. shippers, but also an increasing share of marine fuel globally.

## I. BACKGROUND ON MARPOL, IMO 2020, AND U.S. IMPLEMENTATION

The IMO is an agency of the United Nations that sets global standards for the safety, security and environmental performance of international shipping. The organization provides a regulatory framework for shipping with respect to safety, environment, legal matters, technical co-operation, maritime security and efficiency of shipping. IMO adopted the International Convention for the Prevention of Pollution from Ships, otherwise known as MARPOL, in 1973. MARPOL itself is comprised of a series of annexes that address different pollution concerns. The Marine Environment Protection Committee (MEPC) is the working arm of IMO that "addresses environmental issues under IMO's remit," including "oil, chemicals carried in bulk, sewage, garbage and emissions from ships, including air pollutants and greenhouse gas emissions."[1] The MEPC meets at least once each year to work through issues under its purview.

Regulations for sulfur dioxide, nitrous oxide, and other conventional air pollutants are codified in Annex VI, which was agreed to in 1997 and became effective in 2005. More stringent revisions

[1] Archive of Marine Environment Protection Cmte Meeting Summaries, IMO, http://www.imo.org/en/MediaCentre/MeetingSummaries/MEPC/Pages/Default.aspx (last visited Dec. 8, 2019).

were adopted in 2008, including designation of local Emissions Control Areas ("ECAs") and the worldwide marine sulfur standard for all marine traffic set to take effect in 2020 ("IMO 2020").

The U.S. and Canada requested that IMO establish a North America ECA, effectively requiring a lower sulfur content for ships calling on U.S. and Canadian ports or traveling within 200 nautical miles of most of the gulf, west and east coast of those countries. The first phase of the ECA sulfur standard began in 2012, limiting sulfur content in U.S. waters to no more than 1% and falling to no more than 0.1% starting in 2015. Additional ECAs are in place in the Baltic Sea, North Sea, and elsewhere, with other areas under consideration.

IMO 2020 will cover emissions for ships operating outside the ECAs, in open ocean, and limits sulfur content of ship's fuel oil to no more than 0.5% starting January 1, 2020. The regulation was originally adopted in 2008, with a requirement that IMO review the availability of low sulfur fuel oil to determine whether the effective date would remain January 1, 2020 or be deferred until January 1, 2025. The MEPC met in October 2016 and decided to maintain the 2020 implementation. In October 2018, the MEPC met and approved a carriage ban that becomes effective March 1, 2020. The carriage ban effectively prevents ships from carrying non-compliant fuel in tanks that store fuel for on-board combustion, but does not ban the carriage of higher sulfur fuels as cargo. It also does not apply to ships that use an alternative compliance method, such as an exhaust gas cleaning system, also known as scrubber.

The IMO and MEPC do not have the authority to enforce regulations. That authority rests with flag-state and port-state authorities. In the United States, the MARPOL treaty was accepted, signed, and incorporated into U.S. law by the *Act to Prevent Pollution from Ships*, 33 U.S.C. §§1901-1905 ("APPS"). The U.S. Coast Guard ("USCG") is the primary agency responsible for enforcement of both the U.S. ECA and IMO 2020, and entered into a Memorandum of Understanding with the Environmental Protection Agency ("EPA") that provides that the USGC and the EPA will jointly and cooperatively coordinate inspections, investigations, and enforcement actions if a violation is detected. The efforts to ensure compliance with Annex VI and APPS include oversight of marine fueling facilities, on board compliance inspections, and record reviews.

U.S. regulatory agencies are a world-class model and well-prepared to enforce the IMO 2020 standards. The USCG has an existing inspection and enforcement system for the U.S. ECA and EPA has engaged in a process this year to update its regulations to allow the storage and sale of IMO-compliant fuel. EPA proposed regulations in September to allow for the distribution of diesel fuel that complies with the January 1, 2020 global marine sulfur standard. The final rule is expected by EPA to be promulgated this month.

## II. THE U.S REFINING INDUSTRY HAS A COMPETITIVE ADVANTAGE, HAVING INVESTED $100 BILLION TO INCREASE U.S. COMPETITIVENESS AND PRODUCE CLEANER FUELS IN THE LAST DECADE

As a general matter, compliance with IMO 2020 is the responsibility of ship owners and operators, who can comply by three main methods. First, they may switch to a petroleum fuel

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with a sulfur content of 0.5% or less. That fuel can be a distillate fuel like diesel, or a heavier fuel like very low sulfur fuel oil. Second, they may continue using high-sulfur fuel oil and install an exhaust gas cleaning system, or "scrubber," that will reduce emissions to a level consistent with emissions from a 0.5% sulfur fuel. Finally, they may use alternative low sulfur fuels such as liquified natural gas. AFPM's testimony will focus on the first option and the U.S. refining industry's readiness to meet demand for IMO-compliant fuels.

The U.S. is home to approximately 20 percent of global refining capacity and has the most efficient and complex refining industry in the world. Refinery complexity is a measure of refinery sophistication. More complex refineries are configured to produce more products that are of higher value – and from lower quality crude oils. Higher value products include ultra-low sulfur diesel and gasoline. Lower quality crudes include those that are higher in sulfur and contain a higher fraction of heavy fuel oil. U.S. refiners, on average have the ability to run these higher sulfur crudes to produce substantially more gasoline, diesel, jet fuel, and other high value products. This flexibility is not an accident—according to data tracked by IIR, the U.S. refining industry has invested more than $100 billion over the last decade to make it possible to make cleaner fuels from a range of crude qualities.

For example, PBF Energy is restarting a coking unit at its Chalmette, Louisiana refinery and will build a hydrogen plant at its Delaware City refinery.[2] In February 2019, PBF Logistics LP and Maersk announced an agreement for PBF to make approximately 10 percent of Maersk's annual fuel demand.[3] In June 2019, Phillips 66 announced that it would make modifications to hydrotreaters at its Linden, NJ and Roxana, IL refineries to reduce high-sulfur fuel oil production, and add more storage to its Ferndale, WA refinery to increase capability to process higher sulfur crudes.[4] Marathon Petroleum announced in May 2019 that it would expand its coking capacity at its Garyville, LA refinery to increase capacity to run heavy/sour crude oils.[5] Of course, refiners around the world are finding ways to increase output.[6] BP built an additional hydrotreater at its Whiting refinery in Indiana, enabling it to produce lower sulfur gasoline and

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[2] Argus Media, *PBF Energy Seizing IMO 2020 Opportunities*, WWW.ARGUSMEDIA.COM, Oct. 22, 2019, https://www.argusmedia.com/en/news/2000142-pbf-energy-seizing-imo-2020-opportunities; *see also* Timothy Puko, *Refiners Poised for Boost from Clean-Fuel Rules*, WALL ST. J. (May 26, 2019 5:30 am ET). https://www.wsj.com/articles/refiners-poised-for-boost-from-clean-fuel-rules-11558863000.

[3] PBF Logistics, *Maersk and PBF Logistics LP announce agreement for production and storage of 0.5% sulphur fuel on the U.S. East Coast*, https://www.pbflogistics.com/press-releases/2019/02-14-2019.

[4] Argus Media, *Phillips 66 Modifies Refineries for Marine Fuel Rule*, WWW.ARGUSMEDIA.COM, Jun. 19, 2019, https://www.argusmedia.com/en/news/1924837-phillips-66-modifies-refineries-for-marine-fuel-rule.

[5] Bunker Spot, *Americas: Marathon Petroleum's Coker Expansion Project to Benefit from IMO 2020*, WWW.BUNKERSPOT.COM, May 9, 2019, https://www.bunkerspot.com/americas/48085-americas-marathon-petroleum-s-coker-expansion-project-to-benefit-from-imo-2020

[66] Chen Aizhu et. al, *Fact Box: Global Refiners Raise Cleaner Shipping Fuel Output Ahead of 2020*, REUTERS (Nov. 2019 2:27 a.m.), https://www.reuters.com/article/us-global-oil-imo-factbox/factbox-global-refiners-raise-cleaner-shipping-fuel-output-ahead-of-imo-2020-idUSKBN1XU0RK.

diesel.[7] In addition to overhauling its coker and hydrotreating units at its Beaumont refinery in 2018, ExxonMobil has announced investments in Singapore, Antwerp, Rotterdam, and the UK.[8]

Relatively complex refineries take advantage of these flexibilities in many ways, but the most significant are optimizing crude slates, changing product mixes, increasing utilization, and processing high sulfur fuel oil that less complex refineries cannot further refine. Refineries have been preparing for years, making long-term capital expenditures to increase this flexibility. The refining sector has also planned and executed near-term work to prepare to meet increased demand, including going through major "turnarounds" in fall 2019. A turnaround is a highly intensive maintenance process that involves shutting down a refinery for an extended period of time and bringing in several thousand workers to debottleneck refinery units to increase efficiency, shift product yields, add capacity, and perform required periodic maintenance of refining units to ensure optimal operations. This turnaround procedure allows refineries to increase throughput, efficiency, and utilization, and enhance safety through comprehensive inspection and maintenance.

***Crude Slate Optimization***. The first flexibility available to refiners is the ability to shift and optimize crude slates. Crude oil is classified by physical characteristics, including chemical composition, gravity, and viscosity. For example, low-sulfur crudes common in U.S. shale fields are low density (light) and low in sulfur (sweet), so called "light/sweet" crudes. These light/sweet crudes require less processing to produce clean fuels and as a result are favorable crudes for less complex refineries. All other things being equal, their lower sulfur content will make them higher valued. Brent crude and WTI crudes are light/sweet and both serve as an important global price benchmarks. By contrast, "heavy/sour" crudes are commonly found in Mexico, Canada, Russia, Venezuela, and parts of the Middle East. Heavy/sour crudes are more dense and higher in sulfur content. Common heavy sour crudes are Mexican Maya and Western Canadian Select. Because heavy/sour crudes are optimal in refineries that have made capital investments in complex refining equipment, these crudes typically trade at a discount to their light/sweet competitors.

Crude slate flexibility allows the U.S. refining system to produce IMO compliant fuels from a wider variety of feedstocks. It is widely expected that as IMO 2020 takes effect, less complex

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[7] Erwin Seba, *BP Starts New Whiting Coker to Swap Sweet Crude for Canadian*, REUTERS (Nov. 14, 2013, 5:52 p.m.) https://www.reuters.com/article/us-refinery-operations-bp-whtiing/bp-starts-new-whiting-coker-to-swap-sweet-crude-for-canadian-idUSBRE9AD1DN20131114.

[8] Erwin Seba, *Exxon Beaumont Refinery Overhauling Coker, Hydrotreater*, REUTERS (May 14, 2018, 10:14 a.m.) https://www.reuters.com/article/us-refinery-operations-exxon-beaumont/exxon-beaumont-refinery-overhauling-coker-hydrotreater-sources-idUSKCN1IF1WD; Ship and Bunker, *IMO 2020: ExxonMobil Announces Multi-Billion Dollar Upgrades to Singapore Refinery Complex*, WWW.SHIPANDBUNKER.COM (Apr. 2, 2019) https://shipandbunker.com/news/apac/469033-imo-2020-exxonmobil-announces-multi-billion-dollar-upgrades-to-singapore-refinery-complex; ExxonMobil, *Construction Begins on New Hydrocracker at Rotterdam Refinery*, Jun. 15, 2016, https://www.exxonmobil.com/en/basestocks/news-insights-and-resources/begin-construction-of-new-hydrocracker-at-rotterdam-refinery; ExxonMobil, *ExxonMobil to Expand Ultra-Low Sulfur Diesel Production at Fawley Refinery*, Apr. 24, 2019, https://corporate.exxonmobil.com/News/Newsroom/News-releases/2019/0424_ExxonMobil-to-expand-ultra-low-sulfur-diesel-production-at-Fawley-Refinery.

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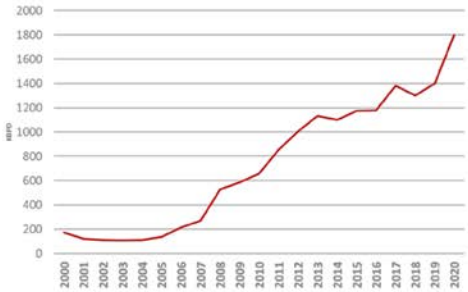
refineries will need to switch to lighter crude slates to minimize production of high sulfur fuel oil, increasing demand for light/sweet crude and widening the discount for heavy/sour crude. Complex U.S. refineries will be competitively advantaged because they will be able to increase their input of unrefined heavy crudes as well as high sulfur residual fuel oil produced by less-complex refineries, increasing utilization of refinery units, like cokers, designed to process heavy crude oil fractions.

In fact, U.S. refinery inputs to coking units have declined in 2019 because of decreased availability of heavy sour crude oil due to sanctions and transportation bottlenecks. The availability of unrefined high sulfur fuel oil and the decrease in demand from less complex refineries for heavy sour crude oil will allow complex U.S. refineries to increase coker utilization. In its analysis of IMO 2020 earlier this year, the U.S. Energy Information Administration, U.S. refiners are expected to increase the processing of unfinished oil inputs from an average of "0.33 million b/d in 2018 to averages of 0.39 million b/d (an increase of 17.5%) in 2019 and to 0.56 million b/d (an increase of 44.6%) in 2020."[9]

For upstream U.S. oil producers, IMO 2020 is expected to increase international demand for light/sweet crude oil.

**Product Optimization.** The second flexibility available to refiners is the ability to shift production of petroleum products. For instance, U.S. refiners have some capability to increase yield of distillate fuels to meet demand. According to the U.S. Energy Information Administration, U.S refineries are expected to "increase distillate fuel refinery yields from an average of 29.5% in 2018 to 29.9% in 2019 to 31.5% in 2020, while motor gasoline yields will fall from an average of 46.9% in 2018 to averages of 46.5% in 2019 and 45.6% in 2020. Residual fuel yields will also decrease from an average of 2.4% in 2018 to an average of 2.2% in 2020."[10]

*Figure 1 U.S. Distillate Exports Expected to Increase*




In total, U.S. refinery production of distillate fuel is expected to "increase from an average of 5.18 million b/d in 2018 to 5.32 million b/d (2.7%) in 2019 and 5.92 million b/d (11.3%) in 2020."[11] This dynamic has already started. Valero Energy and Phillips 66 reported in October

[9] U.S. Energy Information Administration, *Upcoming changes in marine fuel sulfur limits will affect crude oil and petroleum product markets*, THIS WEEK IN PETROLEUM (Jan. 6, 2019), https://www.eia.gov/petroleum/weekly/archive/2019/190116/includes/analysis_print.php.
[10] *Id.*
[11] *Id.*

that they plan to continue running high-sulfur intermediates as part of their crude slate optimization.[12]

As U.S. refinery production of distillate increases, U.S. distillate net exports will increase from an average of 1.2 million barrels per day in 2018 to 1.8 million barrels per day in 2020.[13] U.S. domestic demand for distillate is not expected to be significantly affected by IMO 2020 as much marine fuel consumed in U.S. waters is already low in sulfur (0.1% ECA spec) and U.S. ports are not major bunkering centers for international marine traffic.

**Refinery Utilization**. The final flexibility available to refiners is the ability to increase refinery utilization to meet increased distillate demand. In fact, according to the U.S. Energy Information Administration, gross inputs to U.S. refineries are expected to increase from an average of 17.3 million barrels per day (b/d) in 2018 to a record level of 17.9 million b/d (up 3.6%) on average in 2020.[14] EIA projects "[t]his increase in gross inputs will result in refinery utilization increasing from an average of 92% in 2019 to an average of 96% in 2020."[15]

Refining utilization globally is expected to increase in the fourth quarter of 2019 and through 2020. In its *World Energy Outlook 2019*, the International Energy Agency ("IEA") notes that an expected increase in refining activity in 2020 suggests a smooth implementation in January of IMO 2020.[16]

## III. DESPITE EARLY UNCERTAINTIES, MARKET INDICATIONS ARE THAT REFINERS AND SHIPPERS ARE READY

IMO 2020 has been a focus of analysts for many months given the potential implications for crude and product markets. However, as the transition has started, it is becoming increasingly clear that refining and shipping industries are prepared for IMO 2020.[17] Major bunker fuel refiners and suppliers have been testing fuels for much of the year, and very low sulfur fuel oil ("VLSFO") is already being supplied at major ports around the world. IEA reported that ports, ship owners and refiners have stepped up preparations and major bunkering hubs such as Fujairah, Rotterdam and Singapore are said to have large volumes of compliant fuel available.

Likewise, OPEC, in its *2019 World Oil Outlook* released on November 5th, projects the impact of IMO 2020 will be less severe than previously expected. OPEC attributes this to a lighter global crude slate that will allow refineries to more readily produce compliant fuel. Many

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[12] Janet McGurty, *US Refiners Increase HFSO Throughput as IMO 2020 Nears*, S&P GLOBAL PLATTS, (Oct. 30, 2019 20:51 UTC), https://www.spglobal.com/platts/en/market-insights/latest-news/shipping/103019-imo-2020-tracker-us-refiners-increase-hsfo-throughput-as-imo-2020-nears

[13] EIA, *supra* note 9.

[14] *Id*.

[15] *Id*.

[16] International Energy Agency, World Energy Outlook 2019, https://www.iea.org/topics/world-energy-outlook.

[17] John Kemp, *Fuel Market Calm Ahead of IMO Changeover*, REUTERS, (Dec. 1, 2019) https://www.reuters.com/article/oil-bunker-kemp-idAFL8N2894NJ ("The predicted marine fuel crisis has failed to materialise.").

refiners and ports/blenders that have either started to supply or announced plans to supply 0.5% sulfur fuel.

The U.S. Energy Information Administration reports that heating oil prices at the start of the 2019–2020 winter heating season (October 1 through March 31) were 10% lower than at the start of the previous winter.[18] Although October distillate production declined and distillate inventories fell because of fall refinery maintenance and the loss of supply from the Philadelphia Energy Solutions refinery, EIA nevertheless projects that U.S. average wholesale and retail prices of heating oil and ultra-low sulfur diesel in the fourth quarter of 2019 and into 2020 are expected to be below prices in the fourth quarter of 2018.[19] This is partially due to the fact that EIA expects distillate production to increase in 2020 by 8.1% as compared with 2019, while consumption is expected to increase by 1.2%.[20] In fact, in its November 2019 Short Term Energy Outlook, EIA reported that "[d]espite low distillate fuel inventories, EIA expects that average household expenditures for home heating oil will decrease this winter."[21]

Perhaps the most significant remaining challenges will be for ship owners, including planning to ensure a consistent quality of fuel across all ports of call and navigating port-state enforcement protocols that include standards for reporting the unavailability of IMO 2020 compliant fuels (Fuel Oil Non-Availability Reports or "FONARs") and remedies for non-compliant fuels in port states. AFPM has confidence that the market and cooperation through the MEPC process will effectively address these issues.

## IV. Recommendations and Conclusion

The U.S. refining industry has invested nearly $100 billion over the last decade to increase processing capacity, improve operating efficiency, increase crude slate flexibility, and produce cleaner fuels. As a result of these investments, the U.S. is well-positioned to be a leader in producing and supplying lower sulfur marine fuels to a global shipping fleet and realizing the environmental and health benefits expected from IMO 2020.

AFPM supports maintaining an on-time and consistent adoption of IMO 2020. To continuing facilitating the transition to lower sulfur marine fuels worldwide, policy makers should consider enabling infrastructure to debottleneck light sweet crude oil production. Finally, as with any regulatory program, policymakers should adopt clear guidance for details of regulatory structure and integrate learnings from other fuel programs. AFPM is confident that the U.S. government and industry is ready to meet this challenge.

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[18] U.S. Energy Information Administration, *Winter Fuels Outlook* (Oct. 2019), https://www.eia.gov/special/heatingfuels/resources/winterfuels2019.pdf.
[19] U.S. Energy Information Administration, *Short Term Energy Outlook* (Nov. 2019), https://www.eia.gov/outlooks/steo/pdf/steo_text.pdf.
[20] *Id.* at 10.
[21] *Id.* at 2.

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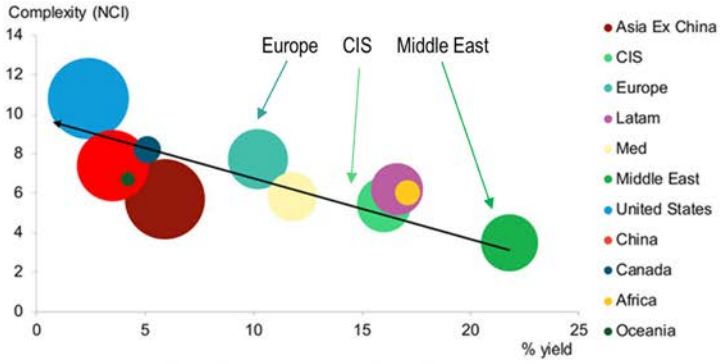
**Appendix**

**Figure 1**: This graphic illustrates the relative complexity of refining capacity around the world. Complexity, in this case based on the Nelson Complexity Index, is a measure of the extent to which a refinery can convert crude oil into high value products, like gasoline and diesel fuel. The higher the complexity score, the higher the value of products that are produced. The industry complexity scores are based on individual complexity scores for each refinery in a region. The U.S. refining industry as a whole, the blue circle in the upper left part of the chart, is the most complex refining system in the world and as a result produces very little low value heavy fuel oil – which is what is measured on the horizontal axis.




*Source: BloombergNEF, Oil & Gas Journal, JODI (JODI<GO> on Bloomberg Terminal)*
*Note: NCI = Nelson Complexity Index. Bubble size indicates total CDU capacity*

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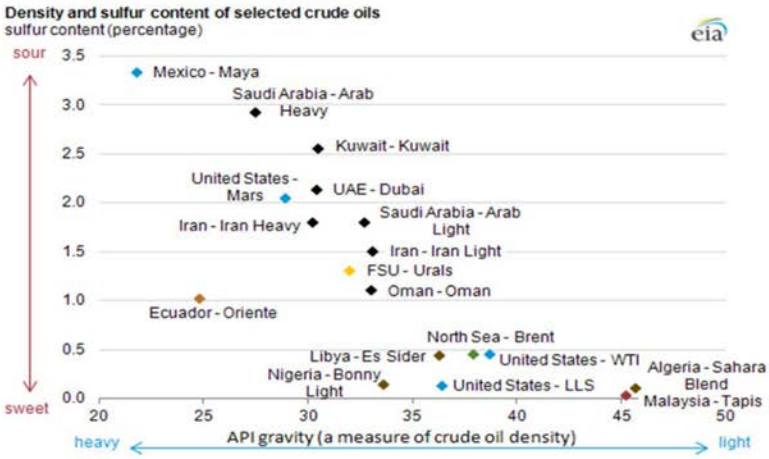
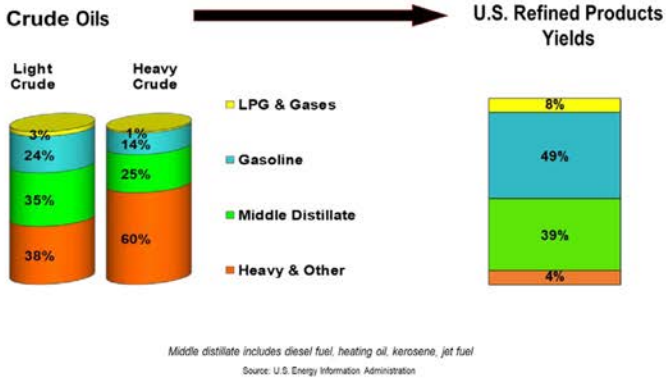
**Figure 2**: This chart compares the sulfur percentage and relative density of various crude oils.




Source: Energy Information Administration

**Figure 3**: EIA estimate of product yield from heavy and light crude oils. The estimates on the left-hand side of the graphic are illustrative of a simple refinery. The U.S. yields are illustrative of U.S. capacity to produce higher-value products from various crude slates.




Source: Energy Information Administration

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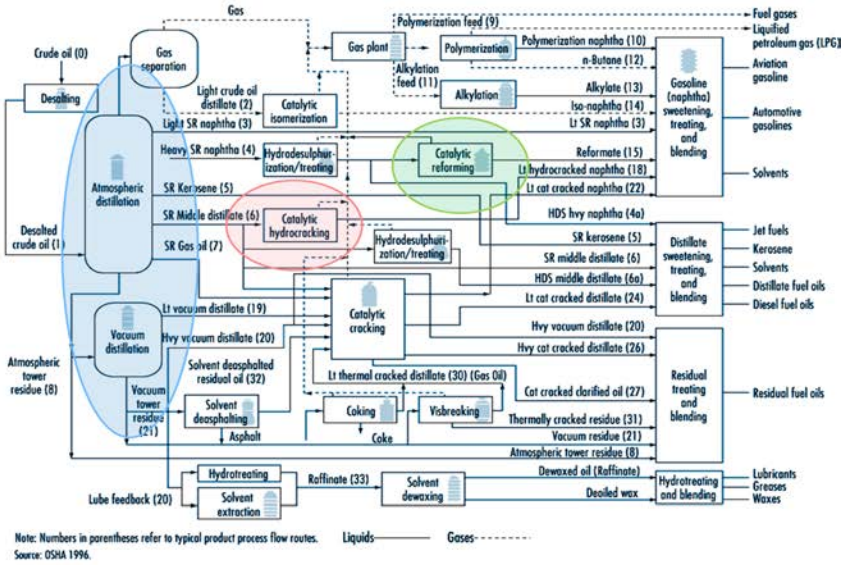
**Figure 4**: A complex refinery schematic. The blue shaded oval highlights distillation, the red, cracking or breaking apart molecules, and the green chemically changing.



The CHAIRMAN. Thank you, Mr. Morgan.

Mr. Nerurkar, welcome.

**STATEMENT OF NEELESH NERURKAR, VICE PRESIDENT, CLEARVIEW ENERGY PARTNERS, LLC**

Mr. NERURKAR. Thank you and good morning, Chairman Murkowski, Ranking Member Manchin and distinguished members of the Committee. My name is Neelesh Nerurkar. I analyze energy and climate policy at ClearView Energy Partners, LLC, an independent research firm that serves institutional investors and corporate strategists. Thank you for having me as part of your conversation today.

Earlier in my career, when I was working at the Congressional Research Service, I considered it a privilege to support this Committee's critically important energy and environmental policy responsibilities. In my current capacity it's an honor to contribute to your discussion.

ClearView's clients look to our firm to provide objective, transparent analysis of market dynamics. Last year, we received many inquiries after media reports of alarming outlooks for the IMO 2020 fuel changeover, including oil market chaos and price spikes for middle distillate fuels like diesel. At the time our firm offered a contrarian perspective. We anticipated a more muted oil market result and our current stance remains consistent with that view.

I'd summarize ClearView's IMO 2020 outlook in three points. First, the IMO adopted the sulfur cap more than a decade ago and remain committed to its implementation; second, the global refining and shipping sectors have taken steps to mitigate potential shortfalls of low-sulfur marine fuel; and third, the change is not taking place in isolation. Trade tensions and global economic slowdown have dampened oil demand growth which may ease the transition. Let me briefly explain the three points.

The IMO sulfur restrictions are intended to produce health and environmental benefits including reductions in cardiovascular disease, lung cancer, asthma and acid rain. The IMO set its 2020 limit in 2008. It officially reaffirmed this deadline in 2016, and it's since focused on sulfur cap implementation and long-term carbon emissions goals.

The global shipping industry uses about 3.4 million barrels a day of high-sulfur fuel oil as of 2018. Our firm looked at nine global fuel production and consumption variables and how they could address the sulfur cap gap, the new demand that the 2020 rules would create. Refiners have many ways to make low-sulfur marine fuel. We modeled a distillate intensive scenario as an acid test to feasibility. In that scenario, 900,000 barrels a day of gap closure could come from distillation, conversion and desulfurization capacity additions, 800,000 barrels a day could come from higher refinery utilization rates and 400,000 barrels a day could come from diesel yield maximization. Refiners could choose other options as well. For example, they can use a broader part of the barrel to make very low-sulfur fuel oil. An early report suggests that many have done so.

The shipping industry also has been preparing. Scrubbers that allow ships to continue using high-sulfur fuel oil could close the

gap by another 500,000 barrels per day. Slow steaming, sailing slower, could cut another 100,000 barrels per day. LNG bunkering could displace around another 50,000 barrels a day. And in our base case, a 20 percent non-compliance rate could amount to another 700,000 barrels per day. Finally, not that it would be good news, but a slowing global economy could weaken non-marine distillate demand growth and a U.S.-China trade war could reduce fuel reused in the shipping sector. Taken together, this implies a 2020 low-sulfur marine fuel shortfall of roughly 100,000 barrels per day.

Our analysis acknowledges several risks. For example, a high compliance scenario might imply a 500,000 barrel per day shortfall. On the other hand, the rapid expansion of very low-sulfur fuel oil production and slower economic growth might lead to no shortfall. Closing a shortfall of 100,000 barrels per day could come out of inventories or it could be a demand response to higher prices. The shortfall, however, looks modest in comparison to the 36 million barrel per day global market for middle distillates which suggests limited price impacts.

We believe the shipping industry may now be approaching the peak of transition. A straightforward metric for market stress in this case is diesel prices, and notably they've remained relatively flat. This is not to minimize the challenge. The maritime refining industry has undertaken vast preparation and considerable investment. Reports of fuel quality and limited—fuel quality concerns and limited fuel availability could still point to challenges, especially at smaller ports and during the early months of transition.

That said, I would suggest that the data thus far does not appear to validate predictions for dramatic widespread dislocations.

Madam Chairman, this concludes my prepared testimony. I look forward to answering questions you or your colleagues may have.

[The prepared statement of Mr. Nerurkar follows:]

**TESTIMONY OF NEELESH NERURKAR**
**VICE PRESIDENT,**
**CLEARVIEW ENERGY PARTNERS, LLC**

**BEFORE THE**
**U.S. SENATE COMMITTEE**
**ON ENERGY AND NATURAL RESOURCES**

**DECEMBER 10, 2019**

Good morning, Chairman Murkowski, Ranking Member Manchin and distinguished Members of this Committee. My name is Neelesh Nerurkar. I analyze energy and climate policy at ClearView Energy Partners, LLC, an independent research firm that serves institutional investors and corporate strategists. Thank you for inviting me to be here today.

Earlier in my career, when I worked at the Congressional Research Service, I considered it a privilege to support this Committee's critically important energy and environmental policy responsibilities. In my current capacity, I am honored to be able to contribute to your discussion today regarding the International Maritime Organization's (IMO's) 2020 sulfur cap.

ClearView's clients look to our Firm to provide objective, transparent analyses of short- and intermediate-term market dynamics. Last year, we received many inquiries in the wake of media reports that cited alarming prognostications regarding the IMO 2020 fuel changeover, including oil market chaos and dramatic price spikes for middle distillate fuels such as diesel.

At the time, our Firm offered a contrarian perspective: we anticipated a more muted oil and products market result, and our current stance remains consistent with that analysis. Indeed, I might summarize the latest IMO 2020 outlook I prepared with my colleague Jacques Rousseau, who leads the Firm's oil and gas fundamentals coverage, by offering three simple points:

- First, the IMO adopted the sulfur cap more than a decade ago and remained committed to its implementation;
- Second, the global refining and shipping sectors have taken steps to mitigate potential low sulfur marine fuel ("bunker fuel") shortfalls; and
- Third, the IMO change is not taking place in isolation. Trade tensions and a global economic slowdown have dampened oil demand growth and offset what might have otherwise been a more significant low sulfur marine fuel shortfall.

## IMO Committed to the 2020 Cap Adopted in 2008

The IMO is an agency of the United Nations, comprised of 174 Member States. The IMO sets safety, security and environmental standards for international shipping. The agency's sulfur restrictions were intended to produce health and environmental benefits, such as reductions in cardiovascular disease and acid rain. A 2018 study in the journal *Nature* estimated that ship emissions contribute to ~400,000 premature deaths from lung cancer and cardiovascular disease and ~14 MM childhood asthma cases a year. The study projected that these premature mortality and asthma rates could fall by 34% and 54%, respectively, after implementation of the 2020 sulfur restrictions.

In 1997, the IMO adopted a marine fuel sulfur content limit of 4.5% that took effect in 2005. It revised the limit in 2008, setting a 3.5% sulfur content threshold beginning in calendar year (CY) 2012 and 0.50% beginning in CY 2020. The IMO also adopted more stringent caps for so-called "emissions control areas" (ECAs), which include the U.S. and Canadian coasts; waters around Puerto Rico and the United States Virgin Islands; the Baltic Sea area; and the North Sea area. The IMO set the ECA sulfur cap at 1.5% until July 2010, when the cap declined to 1%. The ECA cap subsequently fell to 0.1% in CY 2015.

In 2016, the IMO reviewed its 2020 sulfur cap target to consider whether adequate fuel might be available or whether, as an alternative, the organization should delay the 0.5% limit until the start of CY 2025. The organization commissioned a study that found that fuel supplies would be sufficient, and the IMO agreed to proceed with the 2020 date. Last year, the IMO chose not to adopt a proposal for an "experience-building" period submitted by a group of small flag states, which we interpret as a leniency period. Instead, the organization has focused on preparing for 2020 sulfur cap implementation by issuing guidance to ships, fuel suppliers and port-state control authorities that will implement the cap. The IMO has also started planning how it might meet long-term greenhouse gas (GHG) targets.

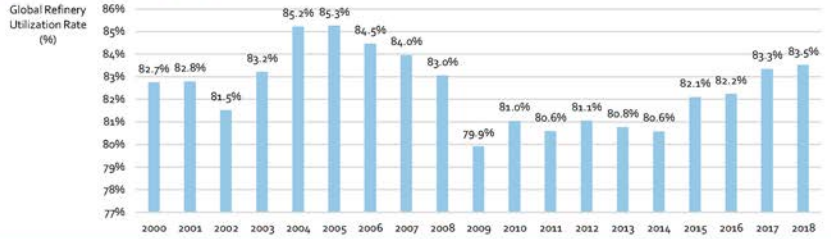
**Refining and Shipping Adjustments**

The International Energy Agency (IEA) estimates that the global shipping industry used ~3.4 MM bbl/d of high sulfur fuel oil (HSFO) during CY 2018. In our analysis, we reviewed nine global refining and shipping variables to assess the potential CY 2020 shortfalls of low sulfur marine fuels; middle distillates and very slow sulfur fuel oil (VLSFO). In our calculations, we compared supply and demand impacts between known CY 2018 data and projections for CY 2020. Let me begin by describing each of these variables. I will then describe how we considered them collectively to arrive at our relatively benign, base-case assessment of potential shortfalls.

*Capacity expansions.* Between CY 2018 and CY 2020, based on IEA and OPEC data, we expect global distillation capacity to increase by ~2.7 MM bbl/d; upgrading capacity to increase by ~2.2 MM bbl/d; and desulfurization capacity to increase by ~2.5 MM bbl/d. We estimate that these global refining industry distillation, conversion and desulfurization capacity expansions could augment low sulfur marine supply by ~0.9 MM bbl/d.

*Capacity utilization.* Data from BP's June 2019 *Statistical Review of World Energy* show that global average refinery utilization rates exceeded 85% in several years during the mid-2000s (Figure 1). Rates averaged 83.5% in CY 2018 and could fall to 82.3% this year. In our view, global refiners could increase low sulfur marine fuel production by ~0.8 MM bbl/d by raising utilization rates to 84.5%.

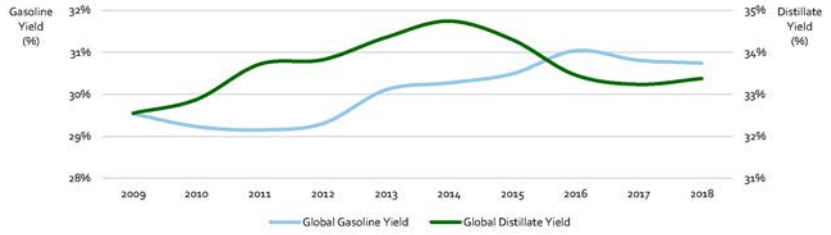
Figure 1 – Global Refining Capacity Utilization Below Peak Levels




*Source: ClearView Energy Partners, LLC, using BP data*

*Maximum distillate.* Global refiners could also slightly adjust their product slates (the mix of the fuels they produce). Our assessment of BP and IEA data indicates that global distillate yields swung by ~2% over the last decade (Figure 2). Were refiners to revert to prior maximum distillate production levels, we estimate that they could increase global distillate supply by ~0.4 MM bbl/d.

Figure 2 – Estimated Global Refinery Distillate Yields Have Varied By ~2% over the Past Decade




*Source: ClearView Energy Partners, LLC, using BP and IEA data*

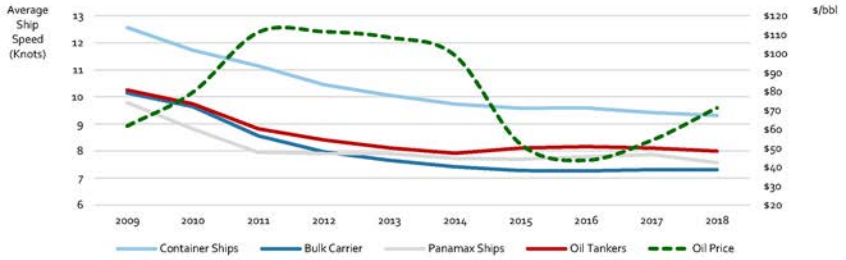
*Scrubbers.* The shipping industry has been preparing for IMO 2020, too. As an alternative to switching to low sulfur marine fuel, ships can install exhaust gas cleaning systems or "scrubbers" so that they can continue using HSFO. Based on data from the Exhaust Gas Cleaning System Association (EGCSA) and the IMO, we estimate that for every 1,000 ships that install scrubbers, another ~0.2 MM bbl/d can remain in the high sulfur fuel oil market.[1]

According to data from consulting firm DNV GL, more than 3,700 ships could install scrubbers by CY 2020. If that projection is borne out, our models imply that ships could continue using ~0.5 MM bbl/d of HSFO during CY 2020.

*LNG.* DNV GL also estimates the delivery of 60 liquefied natural gas (LNG) fueled ships this year and another 44 ships next year. We estimate that this LNG bunkering could displace another ~0.1 MM bbl/d of potential low sulfur marine fuel demand in CY 2020. In the long-run, we believe the shipping industry could expand use of both scrubbers and LNG.

*Slow steaming.* Our understanding is that ships lowered their fuel consumption in response to high fuel prices earlier this decade by reducing speed ("slow steaming"). Bloomberg data suggest that many shippers continued operating at reduced speeds even after fuel prices declined (Figure 3). The IMO has been debating speed limits as part of its maritime GHG emissions reduction protocols, and we think ships could consider slow steaming as a response to fuel market changes. Although our Firm does not model maritime fuel consumption, our literature review and assessment of historical market data suggests that additional slow steaming could cut marine fuel demand by another ~0.1 MM bbl/d from CY 2018 to CY 2020.

Figure 3 – Shippers Reduced Speed to Conserve Fuel When Oil Prices Increased and Maintained Lower Speed Levels




*Source: ClearView Energy Partners, LLC, using Bloomberg and EIA data*

*Noncompliance.* Some ships may not consistently adhere to the IMO restrictions. Using data from the United Nations Conference on Trade and Development (UNCTAD) and other sources, we considered a number of variables that we believe to be associated with compliance, including: shares of international shipments from and/or to advanced economies; the share of trade handled by the largest 10 shipping companies; and container port volumes handled by the 20 largest ports. Based on this assessment, we have assumed a ~20% non-compliance level in our base case, which amounts to about ~0.7 MM bbl/d of bunker fuel demand that remains in HSFO.[2]

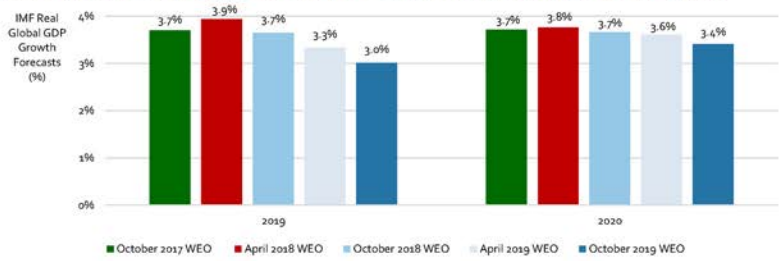
**Broader Market Conditions**

*Economic growth* is a key driver of fuel demand. In April 2018, the International Monetary Fund's (IMF) *World Economic Outlook* (WEO) report predicted global GDP growth of ~3.9% during CY 2019 and ~3.8% during CY 2020. As of the IMF's most recent WEO, published in October 2019 (Figure 4), these forecasts had declined to ~3.0%/CY 2019 and ~3.4%/CY 2020. We think non-marine distillate demand may increase by 0.3 MM bbl/d between CY 2018 and CY 2020, this is down from expectations mid-last year of 0.6 MM bbl/d growth.

[1] Our calculation is based on the average daily fuel usage of the ships types scheduled to install scrubber by CY 2020.

[2] According to media reports, Russian officials said in October that they were considering delaying implementation of IMO requirements for certain regional shipping. Such a development would comfortably fit within our our non-compliance base case.

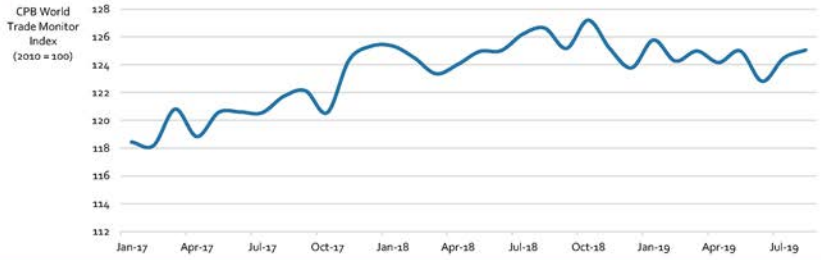
Figure 4 – The IMF Lowered its CY 2019-2020 Global GDP Growth Forecasts in Each of its Last Four WEO Reports




*Source: ClearView Energy Partners, LLC, using IMF data*

***Trade war.*** Furthermore, the October 2019 WEO estimates current trade barriers between the U.S. and China could reduce global GDP in 2020 by ~0.8% relative to the foregoing baseline. As one might anticipate, global GDP growth and global trade correlate closely ($R^2$=0.95, based on IMF data and the CPB World Trade Monitor Index, Figure 5). Based on a strong relationship between trade activity and marine fuel demand, we project that the U.S-China trade war could reduce CY 2020 low sulfur marine fuel demand by ~0.2 MM bbl/d relative to CY 2018 levels.

Figure 5 – The CPB World Trade Monitor Index Peaked in October 2018

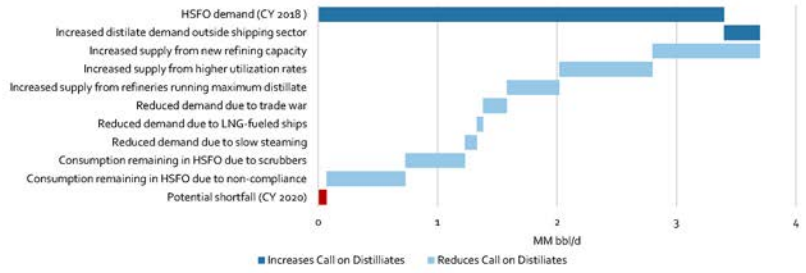



*Source: ClearView Energy Partners, LLC, using CPB World Trade Monitor Index data*

## Synthesis

Adding up our base case assessments of the foregoing nine factors implies a potential CY 2020 low sulfur marine fuel shortfall of ~0.1 MM bbl/d (Figure 6). We would acknowledge several risks to this baseline scenario. In a high compliance scenario, for example, our models imply a ~0.5 MM bbl/d shortfall. By the same token, trade war, greater than expected supply and lower global economic growth could also potentially result in a distillate surplus next year.

Figure 6 – Supply and Demand Factors Likely to Absorb Much of the Shift Away from HSFO

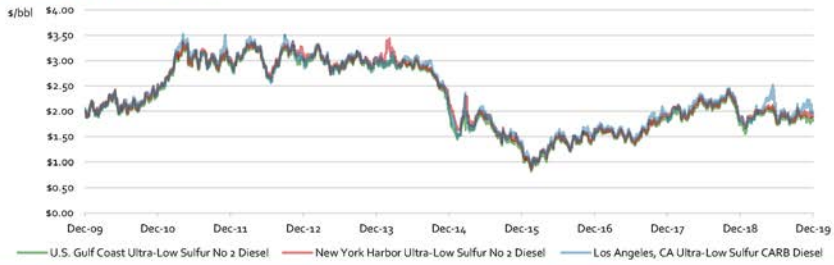



*Source: ClearView Energy Partners, LLC, ClearView Energy Partners, LLC using BP, DNV GL, IEA, IMO, Oil and Gas Journal, OPEC and UNCTAD data*

Missing barrels might come out of distillate inventories. A demand response to higher prices could close the gap, as well. Notwithstanding the tendency of commodities to price at the margin, we would note that our baseline ~0.1 MM bbl/d delta amounts to a mere ~0.3% of the 36 MM bbl/d global market for middle distillates, which suggests limited price impacts, in our view.

This outlook appears consistent with recent change in energy prices. We believe the shipping industry may be approaching the peak of the transition during 4Q2019 as ships convert from HSFO to low sulfur fuel to comply with the requirements that go into force on January 1, 2020. We would therefore look to one of the most straightforward metrics at our disposal for signs of market stress: spot diesel prices, which have remained relatively flat (Figure 7).

Figure 7 – U.S. Spot Diesel Prices




*Source: ClearView Energy Partners, LLC, using EIA data*

This is not to say that the change has been, or will be, easy. The maritime and refining industries have had to undertake vast preparation and considerable investment. Reports of uncertain fuel quality and limited fuel availability could still point to challenges, especially in smaller ports and during the early months of implementation. That said, I would suggest that data thus far do not appear to validate the dramatic dislocations that some market observers predicted last year.

Madam Chairman, this concludes my prepared testimony. I will look forward to answering questions you or your colleagues may have at the appropriate time.

The CHAIRMAN. Thank you.

Mr. Webster, welcome.

**STATEMENT OF JAMIE WEBSTER, SENIOR DIRECTOR, CENTER FOR ENERGY IMPACT, BOSTON CONSULTING GROUP, AND FELLOW AT COLUMBIA UNIVERSITY'S CENTER ON GLOBAL ENERGY POLICY**

Mr. WEBSTER. Thank you, Chairman Murkowski, Ranking Member Manchin. My name's Jamie Webster. I'm with the Boston Consulting Group's Center on Energy Impact. I know we've already had several witnesses, so I don't want to repeat some of the same comments. What I would like to highlight is that despite this clear standard, we're still dealing with significant uncertainty as we roll forward and that uncertainty is likely to last at least through the first half of 2020.

Chairman Murkowski, your letter to the EIA in September, I think, perfectly captured that uncertainty that we're looking at. That said, the clear standard that was put out has really helped both the shipping industry and the refining industry to get ready for this. And I think we're going to be in a much better position as many others have said, relative to some of the, some of the commentary that was made a year or a year and a half ago.

I also think that there's some valuable lessons in this IMO transition. Boston Consulting Group, like many groups, sees that over the next several years and several decades there are going to be significant energy transitions that take place. We've already had some here in the United States, and they're going to continue.

I think the lessons that we've learned here is the importance for industry to have a very clear mandate on what the change is going to be as well as making sure that different industries are able to talk with one another as these changes go forward. I've had the privilege with BCG of being able to sit with both refiners as well as shipping industry, as well as logistics and it was very clear that if there had been some earlier discussions, that would have helped even more with some of this, some of this uncertainty.

I'd also say that for us, as we're looking at the length and magnitude of what this could end up being, I think, a smaller disruption than many people thought. We're looking at a few key measures.

One is the number of scrubbers that are being installed. About a year, year and a half ago, very few ships were showing any real interest in putting in scrubbers. But in the last, less than a year, you've seen a real boost in that interest. And there is now, if you lined it up in a queue, there's a line of approximately 350 miles long of ships waiting to put scrubbers in because they see that that's going to be beneficial for them. The constraints holding back the amount of ships that can actually go in is obviously berthing space as well as talent and some special alloys that need to be put in.

The second thing that we're going to be looking at is we're going to be looking at our friends from AFPM and their members as well as those around the world in terms of understanding exactly how much fuel is able to come on without creating some significant disruptions. While we do see some pricing differentials, obviously,

have already occurred and will continue to occur, we're not overly concerned about that. We're also going to be focused on global economic growth which has already been talked about here, and the odd thing that actually is slower economic growth actually reduces the impact from this.

And finally, it's compliance. Our view on compliance is that it's actually going to be relatively high. I've had a chance in the last couple of months of traveling to Asia and a couple of other countries, countries that had, for a while, were discussing potentially not complying with the IMO and it does seem that at this point almost everybody is on board with that at this point. So I think the compliance is actually going to be relatively high.

We do think that there's going to be a cost of between $25 billion and $30 billion globally for this change. I will also say that there's a lot of uncertainty around that. Other firms have come up with numbers as high as $60 billion, but realize this is not a U.S. number. This is a global number and this is something that is going to be applied over the next couple of years. And so, while we expect that shippers are probably going to be able to pass these costs all the way down to the consumer level, it's unlikely, except in perhaps some remote communities, for it to be a significant, significant change.

Finally, we're looking at, sorry, we are also looking at compliance and how that is going to, going to roll through.

I appreciate the attention of the Committee on this important issue. I do think that there's a lot of lessons as this relates to future energy transitions and look forward to your questions.

Thank you.

[The prepared statement of Mr. Webster follows:]

BOSTON CONSULTING GROUP

Jamie Webster
Senior Director
BCG Center for Energy Impact

*Congressional Testimony of*
**Jamie Webster**
*Senior Director, BCG's Center for Energy Impact*
*Fellow at Columbia's Center on Global Energy Policy*

Before the
**Committee on Energy and Natural Resources**
*United States Senate*
*1st Session, 116th Congress*

Chairman Murkowski, Ranking Member Manchin and Members of the Committee, thank you for inviting me here today to discuss the upcoming implementation of the International Maritime Organization's new global standards for marine fuels.

My name is Jamie Webster, and I am a Senior Director at BCG's Center for Energy Impact. I also serve as a fellow at Columbia University's Center on Global Energy Policy.

On January 1, 2020, new restrictions will reduce the allowable percentage of sulfur in fuel for ships from 3.5% to 0.5%. These global changes are mandated by the International Maritime Organization (IMO), a specialized agency of the United Nations tasked with multiple missions, including managing marine pollution. The IMO does not have any enforcement mechanism, but is instead dependent on its 174 Member States, one of which is the United States, to enforce its rules through its coast guard, environmental agencies and/or port authorities.

This rule was developed and tested over multiple years. In 2008, IMO's revised Annex VI mandated a review and decision to reduce sulfur levels in fuel to 0.5% on a global basis in 2020, with a potential to delay to 2025 if insufficient fuel was available. In October 2016, after an outside review found that enough compliant fuel would be available, the IMO affirmed that the rule would go into effect January 2020. Unlike most other fuel specification changes, the rule will be enforced at the consumer level (ships) rather than the producer level (refiners).

This new rule will reduce ship sulfur emissions by as much as 80%. Sulfur, when combined with air and water, creates sulfuric acid, the primary component in acid rain. The rule will also create pricing impacts on the fuel that ships use, as well as knock-on effects to other companies and consumers dependent on related refined products. BCG estimates that compliance will result in an additional $25-30 billion in fuel costs for liners from 2020 to 2023. These costs will be borne across the ecosystem[1], to include shipping liners, freight forwarders, cargo owners and finally end consumers, as shown in the graphic below.

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[1] See BCG report: "Sharing the Costs of IMO 2020 Across the Ecosystem"

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**Source:** BCG analysis.

[2]

While we anticipate that nearly all costs will eventually be borne by global consumers, this increase will not be meaningful given it will be spread over several years and across all purchases.

The length and magnitude of this disruption will be influenced by several factors[3], to include:

- **Compliance with the mandate.** At present, BCG anticipates high compliance, likely in excess of 90%. This is driven by the consolidated nature of the shipping industry (8 companies operate 78% of ships) and the fact that 85% of global trade involves a participant from a developed market, markets that have clearly shown a willingness to enforce compliance. The IMO's carriage ban, which prohibits non-compliant fuel to be onboard a ship that does not have a scrubber, will limit opportunities for switching between compliant and non-compliant fuel as of March 1, 2020. According to Argus Media, as of November, IMO compliant fuel sales were already at 65%. **The less compliance, the less prices will react from the changed supply/demand balance.**

- **Number of installed scrubbers.** Scrubbers are equipment fitted on ships that allows sulfur in high-sulfur fuel oil to be stripped out before the fuel is used. This incurs a capital cost to install, but allows the shipping company to continue to use high-sulfur fuel oil at a discount to low-sulfur fuel oil. After relatively little interest from ship owners, this option is now increasingly sought out. It was estimated that the queue for ships interested in a scrubber would stretch in excess of 300 miles if the ships were laid end to end. At present, BCG expects about 4,000 ocean-going vessels (out of ~60,000) to be fitted with scrubbers by January 1. Constraints on installing scrubbers include berthing space, specific metal alloys needed for the containment vessels, and available qualified personnel. **The more scrubbers are installed, the less 0.5% sulfur fuel will be needed, reducing pricing impacts.**

[2] The reference to "BAF" in the graphic is referring to a "Bunker Adjustment Factor" – a mechanism to adjust pricing based on a formula that takes into account bunker fuel prices
[3] See BCG's report: "Just how disruptive will IMO 2020 be?"

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- **Available fuel from refiners.** BCG forecasts that approximately 3 million barrels per day (mmb/d) of compliant 0.5% sulfur fuel will be needed in 2020 vs 2019, as high sulfur fuel oil demand declines by the same amount. This compliant fuel will be made up of approximately 1.5 mmb/d of middle distillates (to include diesel) and the remainder will be very low sulfur fuel oil. To make this fuel, refineries have increased capacity in desulfurization and sweet crude topping units, as well as shifting yields, increasing utilization and expanding facilities. **Refiners are working to ensure fuel is available volumetrically as well as in the right locations, but pricing effects will still occur as supply/demand balances shift.**

- **Global economic growth.** The pace of global GDP growth impacts global trade volumes. Should the global economy speed up or slow down markedly, this will impact the volume of compliant fuel oil needed, impacting pricing spreads.

Shipping companies have 3 primary methods to comply with the new rules.

- **Maintain current equipment and use newly available low sulfur fuels**
  - Capex impact: none
  - Opex impact: 1.5 to 1.8 times the 2018 high sulfur fuel oil cost[4]
- **Install scrubber**
  - Capex impact: $4-7 million installation cost per scrubber[5]
  - Opex impact: ~25% savings from 2018 high sulfur fuel oil cost
- **Use an alternative fuel (LNG or other)**
  - Capex impact: $20 million for a retrofit, new ship is 20-40% more than conventionally fueled ship
  - Opex impact: ~60% of the 2018 high sulfur fuel oil cost

Using new compliant fuel will be the option most ships use in 2020, with an estimated 92% of ships taking this option. Scrubbers are expected to be approximately at 7% of the fleet at the beginning of 2020, but this could feasibly double if price spreads encourage more retrofits. LNG-fueled ships are currently less than 1% of the global fleet. In the future, the number of ships may increase as the IMO examines options to reduce greenhouse gases. With current technology and costs there are few cases that are economic for companies to use LNG ships.

This fuel spec change on close to 4% of global demand is a significant challenge for both refiners and ship owners. But it also provides useful learnings as the industry faces other energy transitions in the future, particularly as this one should be one of the easiest, with its clear standard and date set out plainly more than 3 years ago[6]. Even now, less than 30 days before the switch, uncertainty on its impact continues and shows the scale of the challenge. Industries will need to communicate more with one another to better understand actions as well as impacts to those actions across sectors. Governments and policymakers will best serve their aims with consistent clarity on their policies.

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[4] Unless stated otherwise, BCG used an assumption of $60/b for oil prices for all IMO analysis
[5] As scrubber installation capacity is installed and installers go down the experience curve, BCG expects this cost to fall in subsequent years. The $4 million figure is for a scrubber on a new ship, while $7 million is a retrofit.
[6] See also FT article; "What we can learn from the 2020 shipping fuel switch"

The CHAIRMAN. Very good, thank you, Mr. Webster.

Thank you, each of you, for your comments this morning. This is actually very encouraging to hear that you feel that we are in a pretty good place and that the United States is leading for lots of good reasons—the environment, the jobs that are created and the energy security initiatives.

My colleague has another appointment very shortly, so I am going to defer to Senator Cassidy to begin the round of questions.

Senator CASSIDY. Thank you, Madam Chair.

Dr. Capuano, of course, all politics is local. I am hearing about how Louisiana Light Sweet is going to have a $2 differential upon that sour crude from elsewhere. But you said it is going to last for two years. When I look on Wikipedia though, there are a lot of countries with light, sweet oil which, I presume, is if already not in compliance inherently is soon to be.

So it seems like, is there not enough of the light, sweet in the distillates worldwide to meet demand? Because you mentioned there will be a shortage of demand.

Dr. CAPUANO. So, to be more specific, we're seeing that you'll see a price differential initially in 2020 which will dissipate as you move out of 2020. It's being offset by the fact that the lower demand globally for energy fuel oil will compensate for that. It really becomes more of a question of getting the right fuel to the right place at the right time. And there's some adjustment——

Senator CASSIDY. So the Gulf Coast, where we have Louisiana Light Sweet off the coastline——

Dr. CAPUANO. Yeah.

Senator CASSIDY. ——with our refineries right there, that is one more reason to make New Orleans and Lake Charles your hub for international shipping. Is that a fair statement?

Dr. CAPUANO. Correct. Yeah.

And so, what'll happen is there'll be some, some shipping routes will adjust over time and that's, I think, where the focus would be.

Senator CASSIDY. You threw in LNG as part of the mix, I think, you or Mr. Butler. How quickly will people transition because it seems like the price differential is even more favorable for liquefied natural gas?

Dr. CAPUANO. You bring up a really good point. So, the decision that, the decision that needs to be made, which I cannot answer how the businesses will make that decision, is you can either buy light, sweet crude. You can buy the low-sulfur fuel. You can buy a scrubber and buy high-sulfur fuel and reduce the sulfur yourself or you can go to LNG, an LNG ship.

Like I said, we have done long-term projections, and you'll see in our AEO that we do see growth in the LNG shipping.

Senator CASSIDY. Now, growth could be—or growth can be——

Dr. CAPUANO. Yeah. And over time will tell, time will tell. And we, again, look at data and project forward. I might, and some other, the—some other people have mentioned decision, the decision-making that might go on in choosing between an LNG and a scrubber. Can someone make a comment?

Senator CASSIDY. Mr. Webster, a thought on this?

Mr. WEBSTER. Thank you for your question, Senator.

So we do anticipate that LNG shipping is going to grow over the next couple of years. Some of the decisions——

Senator CASSIDY. But quickly or modestly?

Mr. WEBSTER. I think it's actually going to be relatively slow. It's starting from a very low base. I don't see it as something where it's going to be some giant amount. There's approximately 60,000 ships that, kind of, traverse the international——

Senator CASSIDY. How much does it cost to retrofit?

Mr. WEBSTER. If I recall, it's around a 30 to 30 percent increase and you also have to deal with, which I think my colleague from the Shipping Council can discuss, is there's an impact in terms of how much you can actually ship on the ship because, of course, the LNG material takes up more space in the ship.

Senator CASSIDY. Got it, okay.

And then the local, Mr. Butler, you mentioned about the local and country enforcement. But I am presuming that there is a whole set of countries that we know that are going to enforce. The U.S. is going to enforce. France is going to enforce. Germany is going to enforce. Australia. Japan.

Shipping routes are typically not going to be between, you know, they are international. How likely is it that a ship would not eventually go to a country that, by golly, we know is going to enforce? Do you follow what I am saying? Can we rely upon this network of countries that we trust to enforce to capture all of the shipping just because it is international and, by definition, sooner or later they go through a jurisdiction which does enforce?

Mr. BUTLER. Senator, I mean, this is probably the most critical question with respect to this regulation at this point because both from the standpoint of sending the right signals to markets—the more people that comply, the higher the compliance rate, the more clear signal you'd get from the demand side and the better response you'd get from the supply side.

Speaking of the IMO——

Senator CASSIDY. Well, I have limited time. My specific question with international shipping routes being what they are, what is the likelihood that any ship could escape the jurisdiction of a country that, by golly, we know is going to enforce this standard?

Mr. BUTLER. The likelihood of escape, so long as the signatories to this convention enforce, the likelihood that a ship can escape is quite low.

Senator CASSIDY. Now some of those countries may have signed, but we don't trust them. Just the countries that we trust, how much do we think that they are going to be able to enforce this?

Mr. BUTLER. Well, I have to ask you to define that universe, but this is where I was going a minute ago which is, it's critical that countries like the United States and other developed countries that already have experience in enforcing the emission control areas the way we do in the U.S. and Canada, that we keep this enforcement issue on the front burner.

Senator CASSIDY. Great, thank you.

Thank you, Madam Chair.

The CHAIRMAN. Thank you, Senator Cassidy.

Senator Manchin.

Senator MANCHIN. Thank you, all. I appreciate very much you enlightening us on this matter. We discussed there are three main methods the marine fleet can utilize to meet the new IMO regulations, including switching to lower-sulfur fuels, using cleaner alternative fuels and LNG or biofuels. Which one do you think is the most cost-effective and what adjustments will need to be made?

I have a follow-up question to you, you might want to think about. I am old enough to remember when basically unleaded gas came on to the market. All the engines had to be, kind of, retrofitted, catalytic converters, not that they even talked about biofuels and ethanol and all that.

What adjustments, I mean, what cost of adjustments are there? Are they going to be fighting back, pushing back? Have they made those adjustments? Looked into what engine adjustments are needed rather than retrofitting? A gasoline engine can be retrofitted to LNG. Can a diesel fuel engine be retrofitted to LNG? Does anybody know those answers? Do we have any engine experts here?

Mr. MORGAN. I believe that LNG would require a new engine.

Senator MANCHIN. A new engine.

Mr. MORGAN. Yeah. But the, I think, you know, every harbor will have a competitive marketplace for the fuels. We're seeing an introduction in a lot of these ports of a very low-sulfur fuel oil.

Senator MANCHIN. Which one do you think they are going to switch to?

Mr. MORGAN. I think a lot of it will be very low-sulfur fuel oil and that will be green gas oil which is more akin to like a diesel.

Senator MANCHIN. That would be the cheapest way——

Mr. MORGAN. So there would be some that go a more diesel-like route and some that go to a fuel oil route that's just lower-sulfur that, I think, we've seen a number——

Senator MANCHIN. And we touched on the enforcement, you know.

Mr. MORGAN. Yeah, I think——

Senator MANCHIN. The only thing we can enforce is what is coming into our ports, correct?

Mr. MORGAN. That's right. Each country is responsible for enforcing it in their ports.

Senator MANCHIN. Their ports.

Mr. MORGAN. In their ports or that and the flag state also. So if a ship has a flag of a certain country, that flag state can also enforce the measure. So it's both port states and flag states that enforce the measure.

Senator MANCHIN. And you believe that we will be prepared starting next month?

Mr. MORGAN. Yes. The professionals at the U.S. Coast Guard have already been enforcing the ECA, so the Emission Control Areas, that's actually much lower than this new proposal in our waters and their enforcement is world class and is looked at as a model around the world. So we will definitely be ready.

Senator MANCHIN. I had one other question. The emissions, EIA reported emissions from 2018 went up for the first time since 2014. It is primarily due to higher natural gas emissions from more extreme summer and winter weather and transportation-related petroleum emissions. Does the EIA expect high emissions to continue

in 2019 as they have in 2018, and can you discuss the outlook for natural gas deployment and what implications that might have for emissions?

Dr. CAPUANO. You're referring to the fact that EIA had forecasted rising emissions of 2.7 percent in 2018?

Senator MANCHIN. Yes.

Dr. CAPUANO. We expect that U.S. energy-related carbon dioxide emissions will decline by 1.7 percent in 2019 and 2 percent in 2020.

Senator MANCHIN. That is attributed to what?

Dr. CAPUANO. That lower forecast energy consumption in 2019 and the demand, lower demand, in space cooling and the weather. Those are the major factors.

Senator MANCHIN. Okay.

Of course, we talked about the refineries. You think there is not going to be a shortage? You think we are able to meet those demands——

Mr. MORGAN. Yes, indeed.

Senator MANCHIN. ——and be able to ship this low-sulfur fuel that is basically refined in America right now, the United States, to these other ports?

Mr. MORGAN. Yes, I think on two fronts the United States is well-positioned. On the upstream side for crude oils, the crude oils produced in the United States are lower in sulfur and so, all things being equal, will be more valuable on the world market for refiners that are not as complex and need to start with the lower-sulfur level in order to make the products that are in demand.

And then also on the refining side, because our refining sector is so complex and flexible, we can take a variety of feedstocks, including higher-sulfur fuels and we can turn that into lower-sulfur products.

Senator MANCHIN. Have you seen any movement whatsoever? Have they stockpiled right now so some of the countries in some of the ports which have a lot of activity from importing and exporting, have they started bringing in this lower-sulfur fuel to meet this type of demand? Have you seen that type of transaction?

Mr. MORGAN. Yes.

Senator MANCHIN. Going back to the United States because we are the one main supplier right now, correct?

Mr. MORGAN. We are a very important supplier in the world market, certainly. And exports have been increasing, especially distillate fuels and ports are getting prepared to have the stockpiles on hand of both low-sulfur fuel oil and in some cases, marine gas as well.

Senator MANCHIN. Thank you, Madam Chair.

The CHAIRMAN. Thank you. I appreciate the discussion about the enforcement piece of it, because while we have had these ECA standards in place and, as you point out, the U.S. Coast Guard has been good, as they are, in making sure that those standards are being met. I do appreciate that this is now going to be a step up, whether for the U.S. Coast Guard or for EPA on enforcement.

I wrote a note to myself making sure that we are checking in with the Administration to make sure that from a budget planning perspective going forward they are factoring this in to that expanded mission set there.

I appreciate, again, I think the, not the optimism, but, kind of, the reality check that the sky is not falling. We are moving forward. The clarity of these standards has been very, very important, not only here in this country but around the world, globally. We are going to see better, greater environmental positive impact and that is very, very important. But it seems that every one of you has had, kind of, little asterisks about the overall negative impact. It is going to be fine, except for those, perhaps, remote locations.

Director Capuano, you mentioned the smaller more remote ports might have logistical issues. It has been suggested that in some of the areas, such as Alaska or Hawaii, that rely more on diesel, you know, and if we're not, if it is not maritime fuel, it is aviation fuel for us. And so, a couple questions, and this is directed to you, Administrator.

You have mentioned that you are going to be doing continuous monitoring on this which we appreciate. I think you actually said, monthly, which is great. I am curious to know to what extent you actually narrow it down to focus on some of these more remote and rural areas in the country—Alaska, Hawaii—that have the potential to be more negatively impacted because of our high transportation costs that will be impacted?

Dr. CAPUANO. The current EIA data collection does not go down to the state and the port level, to the smaller ports. However, we do monitor the trade press. As I said, we will be, we pay attention to the IMO each month now. And so, if we start to see something changing within a specific area as a result of communications through the trade press, we will then go investigate it and it would be something that we could talk about as a special issue. But it's not something that we routinely collect.

The CHAIRMAN. Well, we want to really try to understand. And again, the reason I raise this, the reason I am asking is not because we want to back off of this, but again, we have some very, very challenged parts of the country and we want to be able to figure out how they move forward in a way that is not going to damage their very, somewhat fragile economies.

Mr. Morgan, let me ask you. Have you assessed the regional refining capacities individually, the refineries that supply places like Alaska and Hawaii and other remote and rural parts of the country? Are you convinced that they too are ready for the implementation?

Mr. MORGAN. As you mentioned, there are some challenges, especially getting fuel into Interior Alaska. It's an expensive proposition. Alaska has five refineries and produces the bulk of the needs for Alaska. Some additional fuel is imported, especially from Washington State and some other locations. I don't believe that the IMO specification will present a significant additional challenge to the challenges that already exist.

One factor is that home heating oil sulfur specifications in Alaska are actually, haven't been reduced like they have been, for example, in the Northeast United States where it's on par now with on-road diesel. And so, actually, the sulfur in home heating oil in Alaska will allow a little bit more flexibility in the short-term. And so, I think that the challenges that have always been there will

continue to be there, of course, but Alaska's five oil refineries are prepared for this.

The CHAIRMAN. We are actually not at five anymore, but that is, kind of, a sad story.

What about AV gas, aviation?

Mr. MORGAN. Same. The refineries in Alaska produce the bulk of the aviation fuel. It's actually higher than the gasoline fuel demand, as you know, there, and diesel is higher still. So I assume that that product mix, of course the individual companies will make those decisions, but I assume it'll continue to remain at the same level to meet the demands in Alaska.

The CHAIRMAN. Let me ask a question to you, probably, Mr. Butler. The considerations that a shipping company would make in determining do we install the scrubbers? Do we move to an LNG retrofit? And I appreciated your example, your visual, Mr. Webster, about 350 miles of ships waiting to have scrubbers installed. That says to me that we have a backlog here in terms of our capacity, whether it is to build out LNG vessels and we know that we have some that are being built for the Alaska trade. We have seen one, a couple, that have gone out to Puerto Rico. We would love to see more of these coming on, but we have shipbuilding capacity that, I think, is limited.

How much of a factor is the capacity to do the build-out to more LNG-powered vessels, the ability to move quickly with the scrubber installation or the factors that are under consideration by the shipping companies?

Mr. BUTLER. So there are quite a number of factors with respect to each of those decisions. Maybe I'll cut to the end first and then work backward.

The CHAIRMAN. Nice.

Mr. BUTLER. And that is, we expect that well over 80 percent of the compliance will come from burning one type of low-sulfur fuel oil or the other.

The CHAIRMAN. Okay.

Mr. BUTLER. As Senator Manchin said, he had a couple of statistics on projections with respect to scrubbers and LNG and there will be increased penetration of those technologies in the short-term, but they're not going to make up anything like the bulk of the compliance option. It's simply a matter of what's available and the cost and the disruption involved with retrofitting to some of the other technologies.

Some folks like scrubbers. Some folks don't. There are some operational challenges associated with scrubbers and then a lot of people are looking at this and saying, well, I see a cost benefit if the spread between low-sulfur and high-sulfur fuel oil stays high for a long time. I get a payout from the scrubber, but if that differential shrinks in a fairly short order, maybe it's not worth taking that step.

The CHAIRMAN. Thank you.

Let me turn to Senator Heinrich.

Senator HEINRICH. Ranking Member Manchin asked a good question which is, can you convert diesel over to liquid natural gas? And the answer is, yes. There are some complications there because diesel uses compression ignition whereas liquid natural gas

does not so you have to introduce some sort of an ignition source or you can just use a very small amount of diesel which then, it will compression ignite.

The CHAIRMAN. It is so good to have an engineer on the Committee.

Senator HEINRICH. You can convert those things over. And I think it is important for this discussion because we have to realize, sort of, where we——

Senator MANCHIN. [off mic]

Senator HEINRICH. ——uh, no, but if you look it up on MIT Technology Review, you can read all about it.

It is important for this discussion because we have been burning tar for a long time for maritime applications. When we talk about fuel oil, bunker fuel, 3.5 percent sulfur, none of us would allow a power plant in our hometown to burn this product because it is, kind of, what is left over after all the other good stuff comes out of the refinery process.

It is helpful to understand in context that makes international maritime shipping the sixth largest emitter of greenhouse gas as if it were a country. It is a bigger source of greenhouse gases than Germany. That doesn't take into account carbon black or black carbon which we used to call soot. Sounds a little fancier, black carbon, but that has an incredibly disproportionate impact on things like snowpacks in the West and melting sea ice in the Arctic.

So we have a long way to go here beyond just looking at the 0.5 percent. But I am curious, Mr. Butler, what the World Shipping Council is doing, in addition to the work on sulfur that we are discussing today, to reduce your $CO_2$ pollution levels and to look at the impact of black carbon in shipping?

Mr. BUTLER. Starting with the $CO_2$ question. This is following the carbon, or the sulfur discussion at the International Maritime Organization. The Marine Environment Protection Committee at IMO is, they can "walk and chew gum." They do a lot of things but carbon emissions is very much top of the agenda right now.

Senator HEINRICH. What are, specifically, your trade organizations? What are you doing to lead upfront?

Mr. BUTLER. Well, next week we're going to be, along with most of the other trade associations that have observer status at the IMO as we do, we're going to be making a quite detailed lengthy proposal urging the IMO to set up a new research and development body to—funded by a fee on each ton of fuel burned—to look at the question of what are the fuels of the future because, as I'm sure you know, we have an IMO standard that calls for a 50 percent absolute reduction in carbon emissions by 2050.

Senator HEINRICH. 2050.

Mr. BUTLER. We can't get there with existing technology.

Senator HEINRICH. What is the differential in terms of carbon emissions from bunker fuel today switched over to natural gas?

Mr. BUTLER. Well, there's a lot of debate about that. At the point of combustion there is a benefit to natural gas. There is a debate going on about the life cycle emissions of greenhouse gases with respect to those two fuels.

Senator HEINRICH. With respect to methane? Is that what you are referring to?

Mr. BUTLER. That's part of it, yup.

Senator HEINRICH. Yes, well that is an issue of whether or not we capture methane. So we need to start capturing methane. But within the shipping industry what is the increment from bunker fuel down to natural gas?

Mr. BUTLER. Well, I think it's looked at, at point of combustion, as probably 25 percent improvement.

Senator HEINRICH. Okay.

Mr. BUTLER. If you have efficient combustion.

Senator HEINRICH. Right.

Mr. BUTLER. Because there's a question there.

Senator HEINRICH. It is also worth noting that liquid natural gas emits almost zero black carbon. So that is an additional benefit to getting some of these conversions in the pipeline.

Ms. Capuano, do you, or actually, Mr. Webster, what do you estimate is a current payback period for conversion from fuel oil to liquid natural gas? Do you know what those figures are?

Mr. WEBSTER. Yeah, we didn't look at that. We looked at how much it would be for a scrubber at current rates.

Senator HEINRICH. Okay.

Mr. WEBSTER. Which is between two and three years, depending on what the spread is, but the spread right now, it's quite short. So, going back to Senator Manchin's question, so if you wanted to pick the best, kind of, option today——

Senator HEINRICH. It would be?

Mr. WEBSTER. ——the scrubber in many ways is that best option and then longer-term——

Senator HEINRICH. And scrubbers would remove black carbon as well as sulfur, correct?

Mr. WEBSTER. I believe so. You said that, Senator, yeah, yeah.

The CHAIRMAN. Thank you, Senator Heinrich.

Senator Hirono.

Senator HIRONO. Thank you, Madam Chair.

For Mr. Butler, Hawaii depends on international maritime shipping to meet our needs more than any other state. So in Hawaii the two largest shipping companies have both announced a three percent fuel surcharge to their shipping customers to cover the costs of the change to lower-sulfur fuel which is lower than what some consumers in Hawaii had feared earlier this year. The companies are investing in new ships as well as scrubber systems for their older ships that will let the older ships continue to use the higher-sulfur fuel.

What has guided the decisions by your member shipping companies decisions on whether to use low-sulfur fuels in their ships versus installing a scrubber to continue burning high-sulfur fuels? Is——

Mr. BUTLER. Well, again, a lot of it depends on, there are any number of factors that go into it. Some folks, as an operational matter. I mean, scrubbers, depending on the size of the ship, they can take up a significant amount of space on the ship. So, as an engineering matter, if you have room in the engine room and engineering spaces, that's always a question as to whether you can actually do it.

And then there are questions of cost tradeoff. And I think, you know, that's always, as with any technological bet, that's always an educated guess because we don't know in the future what the cost of the low-sulfur fuel is going to be. You talk to folks like those to my left, you get their best opinion about what the markets are going to do and then you make that cost decision based on what your ships look like, what your trading profile looks like.

Senator HIRONO. I think you testified that most of your memberships will burn the lower-sulfur fuels rather than going to scrubbers.

Mr. BUTLER. Everything we see is that the vast majority of the vessels will indeed comply——

Senator HIRONO. Using the——

Mr. BUTLER. ——by using the lower-sulfur fuel.

Senator HIRONO. And then, I had a subsequent question, which I think Mr. Webster may already have responded to. How long are your members expecting to need to recoup the investments that they are making to comply with the rule? I suppose an investment is installation of scrubbers.

Mr. Webster testified that it would maybe, it would take two to three years to recoup the investment in a scrubber which doesn't seem that long a timeframe to recoup.

Mr. Butler, would you like to comment?

Mr. BUTLER. Well, I think maybe those—as a trade association we don't have specific analysis on that. A lot of it depends on the individual situation, but I have heard that sort of a number based on certain assumptions about a continued spread between high-sulfur and low-sulfur fuel. But again, at the end of the day it depends on, in two or three years, what that spread is.

Senator HIRONO. So, for Mr. Butler, again. Do you agree with Mr. Webster that price increases for consumers will likely not be significant given the small share of shipping in the total product price?

Mr. BUTLER. I think, as a broad matter, that's probably correct. When you look at the price increase directly to the vessel operators, the carriers, it's substantial because it hits in one place. By the time that increase is spread out across the value of the cargo on that ship, it's quite diffused.

Senator HIRONO. So, Mr. Webster, do you think that because you can spread out the cost of compliance to the total, you know, products being shipped, would that apply to a place like Hawaii that has a particularly high reliance on shipping to meet our needs?

Mr. WEBSTER. Senator, thank you for the question.

We haven't examined Hawaii, specifically, but our view on a global basis is that it should be quite small in terms of how that goes across. There was one analysis by Flexport which stated that each television would be, at even a large spread, would be about $0.50 more per television next year. Obviously televisions also go down about 17 percent a year. So it's quite small.

Senator HIRONO. That is good to hear because there have always been concerns that somehow or other the shipping to Hawaii and the Jones Act adds so much to the cost to consumers and, frankly, it does not. And so neither will this particular change.

So, for Mr. Nerurkar, I think you talked a little bit about the public health benefits and environmental benefits of this 2020 rule. Could you just talk a little bit more about the benefits to both health and environmental benefits of this lower-sulfur fuel?

Mr. NERURKAR. Sure. There was a study in the Journal of Nature last year that shipping emissions contribute to about 400,000 premature deaths and also 14 million cases of asthma and that the implementation of the 2020 standards would reduce that by 34 percent and 54 percent respectively.

Senator HIRONO. What is the study you are referring to?

Mr. NERURKAR. It's in the Journal of Nature.

Senator HIRONO. Journal of Nature.

Mr. NERURKAR. Yeah.

Senator HIRONO. What issue?

Mr. NERURKAR. In my prepared comments link.

Senator HIRONO. Oh.

Mr. NERURKAR. And I'm happy to send——

Senator HIRONO. Thank you. Thank you very much.

Thank you, Madam Chair.

The CHAIRMAN. Thank you, Senator Hirono.

Senator King.

Senator KING. I apologize for being late. I think I may recover some ground. I hope not to take too much time.

I guess one question, Mr. Butler, is there sufficient refining capacity to produce the amount of low-sulfur fuel that we are going to see demanded within the system?

Mr. BUTLER. The short answer is yes. I would defer to Mr. Morgan on the refining capacity, but whereas and this was brought up earlier in the hearing, whereas a couple of years ago there were real questions, I think, about whether refiners in the end would step up with the investments necessary to produce this fuel, what we're seeing now is much more encouraging.

The other thing I would mention that hasn't come up yet today is that there are already ships on the water burning the low-sulfur fuel today because it's, you know, you don't fill up every three days at the gas station with these vessels.

Senator KING. Right.

Mr. BUTLER. So we're already in the implementation phase.

Senator KING. Mr. Morgan, you concur that there is not going to be a bottleneck here?

Mr. MORGAN. Yes, I do. The United States, in particular, has some room, as Administrator Capuano has talked about, to increase utilization rates. In addition, because our refineries have additional complexity, they'll be able to use those complex pieces of the refinery to produce more low-sulfur fuel.

Senator KING. Mr. Butler, and I think Senator Cassidy may have touched on this, you are expecting international compliance as well as the U.S.? You don't see this as us doing something that nobody else is doing?

Mr. BUTLER. No, Senator. I don't see us as being the only ones enforcing. With that said though, the U.S. has in the past had a leadership role in terms of enforcement and with this regulation perhaps more than many others that we have seen coming out of the IMO, that enforcement piece is simply critical.

This is not a situation where regulation says to a ship owner, you have to install a particular piece of equipment, something like that. This is 24/7/365. It's an operating requirement. And so, it will require diligence by governments around the world.

Senator KING. And do these regulations apply to cruise ships as well as transport?

Mr. BUTLER. They do.

Senator KING. All major shipping.

Mr. Webster, can you give us a, sort of, percentage or technology breakdown between low-sulfur fuel scrubbers and LNG? Which is best? Forget about price for a minute, but just what do the technologies tell us?

Mr. WEBSTER. Um, so, in terms of best, that's a difficult question, as has been highlighted by some of the other witnesses.

I would say for installing a scrubber, it's around, right now, around $4.7 million, approximately. That number has been coming down, but your operational——

Senator KING. But low-sulfur fuel requires no new equipment, is that correct?

Mr. WEBSTER. That is correct.

So it's effectively a choice between do I want to spend CapEx or do I want to have a higher operating expense with the addition——

Senator KING. The assumption is the low-sulfur fuel will cost more, is that correct, Mr. Morgan?

Mr. MORGAN. Yes, it typically has, historically and requires additional, usually it requires additional processing in a refinery.

Senator KING. Can you give us a—it will increase the price that is being paid now by five percent? Ten percent? Two percent?

Mr. MORGAN. Well, the current, there are current spreads on the market and the low-sulfur fuel oil has trended above marine gas oil which would be, kind of, the two low-sulfur varieties and both of those are above what the high-sulfur fuel oil is now.

Senator KING. Right.

Mr. MORGAN. The way——

Senator KING. Can you give me a number, I mean, I am just trying to get a ballpark. Is it——

Mr. MORGAN. I'll be happy to provide that to you afterwards, yes.

Senator KING. Thank you.

Mr. MORGAN. They definitely change daily and in different locations are different prices for sure, but they are a bit more expensive. There are environmental benefits, obviously, that come along with that, but definitely having cleaner air does cost money.

Senator KING. Sure. And we didn't get Mr. Webster to LNG. I take it that would, well, I know you had the discussion with our resident engineer, Senator Heinrich. What kind of conversion requirements would be necessary to use LNG?

Mr. WEBSTER. So we think a retrofit would cost around $20 million and a new ship about 20 to 40 percent more than a, kind of, conventionally-fueled ship, at present. I will say as you go down the experience curve, those numbers will, of course, come down.

And you mentioned cruise ships before. So cruise ships have been the ones that have shown the most interest in both scrubbers and looking at LNG, obviously, as they go into ports that are monitoring those sorts of emissions.

Senator KING. Thank you. Very informative hearing. I appreciate all of you being here.

Thank you, Madam Chair.

The CHAIRMAN. Thank you, Senator King.

It has been. It has been very interesting. You know, I think about what we are seeing in our state and I listened to Senator Hirono's questions. I mean, we are two states that are certainly entirely reliant on shipping and air. We do get some that is across the Canadian border after a couple thousand miles, but the vast majority of what we receive in our state comes to us through shipping. And it's not just our fuels, it is the plywood that you build with and it is our food source, 85 percent of our food to the state.

Senator KING. Well, if you tip the globe just right and draw the map, you are not remote at all, necessarily.

The CHAIRMAN. We are not remote. We are in the center of the universe and you know that.

Senator KING. Yes.

The CHAIRMAN. But it is that center that is still surrounded by a great deal of water. We have watched with great interest as the industry has changed. The requirements that we saw through the ECA requirements and the standards for the cruise ships that were coming in. We have seen companies, Saltchuk has been a very early leader in terms of working to do LNG conversion. That is going to be significant for us.

But when you still have so many communities that are reliant on diesel generation for the operation of their communities and that diesel has to come up from the Lower 48—it has to be transferred to a barge that goes upriver several hundred miles and you are hoping that the water is high enough because otherwise you might only be able to get a barge in there once a year. The logistics that you speak to that we worry about, that could take what was otherwise just modest price increases and, in a region, have impact that is more than just modest. These are the things that I am interested in following and understanding and we appreciate, again, the level of monitoring.

The issue that was raised about compliance. Global compliance is something that, I think, we all should be attentive to as well.

I want to ask one last question, and I will throw it out there to any one of you.

So when we had this, some of this discussion in February, there was a great deal more concern and I think it was you, Mr. Nerurkar, who said that ClearView had not been as concerned as some of the others in terms of what the potential price impacts may be. So we are sitting here now. This is December. Did the others just misread it? Have the refineries been working double time to get ready for this? Has there just been an awareness that, look, there are not going to be any waivers granted so we better get into the game here? What has happened between February and now that allows you to have this level of certitude with what you are sharing with us?

And I throw that out to any of you.

Mr. Nerurkar.

Mr. NERURKAR. I think there have been two main factors that have caused this dynamic. The first is that we were looking at the

broader oil market picture and some concerns about global economic growth and trade tensions that might slow oil demand and make the transition easier. The second factor is that we were looking at the capacity for the refining sector to adjust, and that might have been underestimated.

And so, what we're seeing now is the transition is, kind of, getting to its peak is that, if anything, refiners are providing more of this very low-sulfur fuel oil than might have been expected and things are going more smoothly than people might have thought a year, two years ago.

The CHAIRMAN. And I think one of you mentioned that one of the things that has helped has been the clarity of the standard, the certainty that this is the standard that we are going to, this is the date that we are going to and this is it. There is not a lot of grey or nebulous matter there. I am assuming that has helped. Sometimes we don't set standards with very clear certainty.

Any other comments on what has changed between February and now?

Mr. Webster.

Mr. WEBSTER. One other that I would say, Senator, is the amount of scrubbers that are getting put in. There really has been this real interest in suddenly putting them in and lots of companies looking at that are looking at, kind of, a hedging mechanism and saying, we're not quite sure what the prices are going to be so we're going to put in say, 10 or 15 percent of our ships with scrubbers. And that's why you're seeing so much of a backlog of those that are getting scrubbers. And of course, if you have a scrubber you don't need to have this new compliant fuel.

The CHAIRMAN. Right, right.

Mr. Butler, were you going to weigh-in there?

Mr. BUTLER. The only thing that I would add is I think it's, part of it, is simply a function of as you get closer to a deadline like this, the commercial negotiations really kick into high gear. And so, you have a lot more information flowing in the market about supply and demand.

Two years ago, we were hearing that it was hard for our members to get good information from their fuel suppliers about what this might look like because everyone was still trying to figure it out. When you get to the point of saying, well, I'm going to start needing deliveries in Q4, Q3/Q4 of 2019 and you have to talk about price and where is this fuel going to be, it's a much more concrete discussion and I think that's also been part of it.

The CHAIRMAN. Yes, it becomes real.

Mr. Morgan.

Mr. MORGAN. Yeah, I would echo a lot of what has been said and the refining industry has really positioned itself well, I think, here with the complexity for sure and also the competition. We, there is competition between and among the different companies that are members, for example, to provide that best solution and to provide it on a scale that is helpful for, you know, some of John's members and other shippers as well.

And a lot of that can't really be discussed in a public and open way because people are competing against each other to provide that need. And once again, the engineers and professionals in the

refining industry, I think, have done a good job to make sure that the fuels that are needed are gonna be there.

The CHAIRMAN. Very good.

Senator King, any follow-up?

Thank you very much. We appreciate the discussion here this morning and your very sound efforts to make sure that we are current and up-to-date with this as we go into this new year with these new standards that, I believe, will be the right thing from an environmental perspective, certainly, and it sounds like it is not going to hurt the jobs and the economic benefits that we will see here in this country. We want to keep an eye on price because at the end of the day that is what really matters to a lot of those folks that are in some pretty remote areas and are paying high costs anyway.

So we will keep an eye on this, but thank you for what you are doing to help educate and inform the Committee.

With that, we stand adjourned.

[Whereupon, at 11:20 a.m. the hearing was adjourned.]

## APPENDIX MATERIAL SUBMITTED

**U.S. Senate Committee on Energy and Natural Resources**
**December 10, 2019 Hearing: To Examine the Upcoming Implementation of the International Maritime Organization's New Global Sulfur Standard for Marine Fuels, Which is Set to Take Effect on January 1, 2020**
**Questions for the Record Submitted to the Honorable Linda Capuano**

QUESTIONS FROM SENATOR JOHN HOEVEN

Q1. Dr. Capuano, you refer to the capabilities of U.S. refiners to meet increasing global demand for low-sulfur bunker fuels, and the potential export opportunities.

Unfortunately, the State of Washington recently enacted legislation which requires crude oil unloaded in the state to meet a 9 psi Reid Vapor Pressure, starting in 2020, which effectively blocks the Pacific Northwest as a market destination for Bakken crude oil.

Furthermore, Sandia National Laboratories concluded that Bakken crude is not more volatile than other crude oil produced in the U.S., demonstrating the Washington State law has no basis for targeting Bakken crude.

How does the Washington State de facto crude-by-rail ban impact U.S. refining operations in the Pacific Northwest?

A1. There are five refineries in the Pacific Northwest, all of which are located in the State of Washington, with a total atmospheric crude distillation capacity of about 650,000 barrels per calendar day. EIA's latest available data indicate that between January 2018 and September 2019, West Coast refinery utilization averaged about 90%, implying that refinery inputs in the Pacific Northwest averaged about 585,000 barrels per calendar day over that time.

Crude by rail movements from the Midwest to West Coast averaged 156,000 barrels per day (b/d) from January 2018 through September 2019. Most of this was Bakken crude oil shipped to refineries in Washington State, and represented about 25% of Pacific Northwest refinery runs. Crude by rail between the two regions is a recent trend. Prior to 2010, there were very few crude by rail shipments between the Midwest and West Coast.

Q2. Additionally, how does this de facto ban impact consumers if U.S. refiners are forced to replace lower-cost domestic crude, such as Bakken crude produced in North Dakota, with more expensive foreign crude oil?

A2. EIA believes that the potential higher price for crude oil would affect the refinery operators and owners more than consumers. An increase in crude oil price would reduce refinery margins, however consumer prices for petroleum products are set on the global market and tend to reflect the price of

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the Brent crude oil benchmark. For example, in a 2014 analysis of what drives U.S. gasoline prices, EIA found that the price of Brent crude oil, an international benchmark, is the key for determining gasoline prices globally, and therefore in the United States. The report cited considered gasoline prices in four U.S. regions: East Coast, Gulf Coast, Midwest, and West Coast.

Q3. Which countries would most likely backfill Bakken crude if this de facto ban remains in place?

A3. API gravity is one of the key characteristics of crude oil that, along with other characteristics such as sulfur content, is used by refiners when evaluating different crude streams for processing into petroleum products. About 90% of North Dakota's oil production is light with an API gravity of 40.1–50.0 degrees.

EIA data show that during 2018, refineries in Washington State imported crude oil with API gravity around 40 degrees from both Canada and Saudi Arabia. Refineries in other parts of the country imported crude oils with a similar API range from countries such as Angola, Argentina, Belize, Indonesia, Nigeria, Russia, and Vietnam.

# World Shipping Council Responses to Questions from Senator Maria Cantwell from December 10, 2019, Energy and Natural Resources Committee Hearing on IMO 2020

9 January 2020

**Question 1:** What are the relative pros and cons of using LNG to power ocean-going vessels versus lower sulfur fuels currently being used in an ECA area like Puget Sound?

**Answer:** LNG offers significant reductions in oxides of nitrogen and offers additional improvements in SOx and particulate matter (PM) emissions compared to lower sulfur fuels currently in use in the North American Emission Control Area (ECA). Depending on life-cycle emission factors, and local practices with respect to transport and fueling, LNG may offer some improvement in GHG emissions from vessels using LNG. More significant reductions in vessel GHG emissions will require the use of low carbon or zero carbon fuels and technologies that are not yet developed for use on large ocean-going ships.

**Question 2:** A report last year found that maritime-related sulfur dioxide emissions in the Puget Sound airshed plummeted by 96 percent between 2011 and 2016. That's great, but unfortunately, we have seen very minor decreases in maritime-related greenhouse gas emissions. What more can the shipping industry be doing to reduce their contribution to climate change and ocean acidification? How could a U.S. price on carbon or greenhouse gas emissions impact shipping fueling decisions?

**Answer:** The World Shipping Council, with the support of numerous maritime industry associations across the world, has in December 2019 made a comprehensive proposal to the International Maritime Organization (IMO) for the IMO to create an new international body to undertake the substantial technical research and development work necessary to enable the introduction of zero-emission ships, especially in the large trans-oceanic ships that constitute the majority of carbon emissions generated by maritime shipping. Such an R&D effort is critical if we are to see the maritime industry move to alternative, zero-carbon fuels in the foreseeable future. The proposal includes a funding mechanism, based on a contribution per ton of fuel consumed, that would generate roughly 5 billion USD over a 10-year period. The industry proposal to the IMO is attached as well as a supporting study undertaken by Ricardo that outlines the scope of research that could be done under the proposal.

The maritime industry is also working through the IMO to identify appropriate legally binding obligations applicable to the existing fleet that can be expected to improve the overall carbon efficiency of the existing fleet by at least 40% by 2030 (compared to 2008 levels).

With respect to carbon pricing, the theory behind that mechanism is that a sufficiently high price will drive migration to less polluting alternatives. In order for that mechanism to result in emissions reductions, there must be alternative fuels and related technologies (specific to marine applications) available to vessel operators. Those technologies do not yet exist for trans-oceanic vessels. Thus, an international price on carbon or greenhouse gas emissions could be useful in the future to transition the world's fleet to zero-carbon fuels (once those systems are available), but stipulating an international carbon price today would have little positive impact because the technical pathways to use zero-carbon fuels for the vast majority of ships are not yet developed. The recent proposal made by WSC and others to the IMO is designed to address this critical need to identify and develop those new fuels to which the fleet could move.

A U.S. (as opposed to international) price on carbon or greenhouse gas emissions in the maritime sector would effectively penalize U.S. domestic vessel operators (which, because of their trading profiles, buy fuel in the U.S.) without making any improvement in global marine GHG emissions. This is the case because the market for marine fuels is global with respect to vessels that operate internationally. A carbon tax on marine fuels imposed by one country would simply cause international vessels to obtain fuel in ports outside of the taxing country. The result would be to damage the fuel suppliers in the taxing country, but there would be very limited, if any, change in the amount of fuel burned or overall GHG emissions generated from ships.

**Question 3:** While I appreciate that it took many years to reach the international consensus necessary to make IMO 2020 possible, do you believe the IMO can and should do more to do shipping emissions in the future?

**Answer:** Yes. The most pressing environmental issue facing the IMO is the reduction of GHG emissions and other air emissions from shipping. As referenced in the answer to Question 2, the proposal by the World Shipping Council and other maritime industry groups to establish an *International Maritime Research and Development Board* is focused on the fuels and technologies necessary to introduce low carbon and zero carbon ships and is a critical step if the IMO is to achieve dramatic reductions leading to a zero-carbon emission fleet.

Current discussions within the IMO are expected to result in legally binding measures to reduce emissions from the existing fleet as well as development of the policy measures necessary for achieving absolute reductions of GHG emissions by 50% in 2050 with the objective of eliminating GHG emissions as soon as possible thereafter; these target reductions have already been set by the IMO.

INTERNATIONAL MARITIME ORGANIZATION

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MARINE ENVIRONMENT PROTECTION COMMITTEE
75th session
Agenda item 7

MEPC 75/7/4
18 December 2019
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**REDUCTION OF GHG EMISSIONS FROM SHIPS**

**Proposal to establish an International Maritime Research and Development Board (IMRB)**

**Submitted by ICS, BIMCO, CLIA, INTERCARGO, INTERFERRY, INTERTANKO, IPTA, and WSC**

**SUMMARY**

| | |
|---|---|
| *Executive summary:* | This document proposes the establishment of an IMO GHG reduction research and development programme to accelerate the introduction of low-carbon and zero-carbon technologies and fuels as identified in paragraph 4.7.9 of the *IMO Initial Strategy on the Reduction of GHG Emissions from Ships*. The proposed action is considered critical to achieving the levels of ambition for 2050 and beyond set forth in the IMO Initial GHG Strategy. The co-sponsors propose that core funding would be provided via a mandatory R&D contribution per tonne of fuel oil purchased for consumption, which will be necessary to maintain an appropriate level of funding and to maintain fair competition between shipping companies. The co-sponsors propose that core funding of approximately five billion US dollars over the life of the programme would fundamentally alter the current level of investment in maritime R&D focused on the development of low-carbon and zero-carbon technologies. An effort of this scale is expected to be successful in identifying one or more technical pathways that can lead to the introduction of zero-emission ships across the maritime sector by 2030 and beyond. |
| *Strategic direction, if applicable:* | 3 |
| *Output:* | 3.2 |
| *Action to be taken:* | Paragraph 67 |
| *Related documents:* | Resolution MEPC.304(72); ISWG-GHG 5/4/4; MEPC.1/Circ.885 and MEPC 71/7/4 |

**Introduction**

1 This proposal is intended to serve as one component of an integrated IMO strategy to phase-out greenhouse gas (GHG) emissions, consistent with the Initial Strategy on the Reduction of GHG Emissions from Ships (hereafter referred to as the IMO Strategy) that was adopted by IMO in 2018 (resolution MEPC.304(72)). 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 2008.

2 To reach the 2050 ambition and to realize the full vision of the IMO Strategy, it will be necessary to develop a suite of low-carbon and zero-carbon technologies and fuels that will be the basis of the next maritime technology transition. The technologies necessary to achieve these ambitious goals do not yet exist in a form or scale which is commercially viable for widespread use by international shipping, especially for transoceanic voyages. But the co-sponsors are confident that these ambitions can be realized if the necessary research and development investments in developing low-carbon and zero-carbon propulsion systems and technologies are incorporated as part of an integrated IMO strategy.

3 The IMO Strategy calls, inter alia, for consideration of *'research and development activities addressing marine propulsion, alternative low-carbon and zero-carbon fuels, and innovative technologies [with] an International Maritime Research Board to coordinate and oversee these R&D efforts'* as one of the candidate short-term measures (see paragraph 4.7.9 of the IMO Strategy) to be considered by the Committee. Note that the above mentioned International Maritime Research Board in the IMO Strategy is the same as the International Maritime Research and Development Board (IMRB) proposed in this document.

4 The development, scaling and application of new technologies are probably the most important steps needed to deliver the levels of ambition set by the IMO Strategy. The IMRB and its coordinated R&D programmes would help accelerate the development of low-carbon and zero-carbon emission technologies and fuel systems that are specifically tailored for maritime application, especially larger transoceanic ships. The IMRB and the specific R&D programmes it could support would be expected to help deliver substantial GHG reductions in the mid to long term, but discussions to establish the IMRB will need to occur in the short term if the expected benefits are to be achieved in the time period consistent with the IMO Strategy.

5 The co-sponsors recommend that one of the specific research items to be undertaken through the IMRB (in addition to its work on low-carbon and zero-carbon technologies) would be work to identify technical and operational innovations that may be undertaken to address and reduce the high transportation costs that exist for many Small Island Developing States (SIDS) and other remote locations.

6 This document has been developed by the co-sponsors as a follow-up to document ISWG-GHG 5/4/4. The ideas proposed in this document are intended to facilitate discussion about the IMRB concept which, if adopted, would allow the maritime sector to take collective responsibility for decarbonising international shipping. The concept outlined in this document is intended to provide the necessary structure, direction and funding for successful development of low-carbon and zero-carbon technologies and fuels that may be used across the world fleet to achieve the vision and objectives of the IMO Strategy. The amount of funding to be applied is specifically intended to help accelerate the necessary research and development work that will be critical to delivering this. Notwithstanding the concept outlined in this document, it is emphasized that responsibility for decarbonisation of the sector as a whole is not the sole responsibility of shipping companies, and must ultimately be driven by a broad set of stakeholders.

**Proposed IMRB Concept**

7 The IMRB would play a critical role in accelerating the development of low-carbon and zero-carbon emission $CO_2$ fuel systems and technologies for international shipping, with a negligible impact upon trade or the economic interests of IMO Member States.

8 With the support of the industry, the IMRB could be established by IMO relatively quickly, as a non-governmental research and development organisation which would report to IMO, together with a mechanism for providing the necessary core funding from *shipping companies* via a mandatory system of R&D contributions per tonne of marine fuel oil purchased for consumption by ships. To facilitate the involvement and active participation of other important stakeholders, the co-sponsors invite Member States to encourage and/or require other relevant stakeholders to participate and contribute to the International Maritime Research Board and its work. The IMRB may also require some grant recipients to contribute a defined percentage of funds (e.g. co-funding of a specific proposal) as a condition of grant approval, thereby expanding the pool of total resources available.

9 The IMRB would report to a body of representative IMO Member States established by the MEPC in order to provide oversight of its activities, including approval of the IMRB's budget. The supervisory body would report to the MEPC.

10 The IMRB concept would include three functional components:

.1 International Maritime Research and Development Board (IMRB);

.2 IMO 'supervisory body' (reporting to the MEPC) to provide oversight and approve the IMRB budget; and

.3 International Maritime Research Fund (IMRF) that would provide industry financing for the IMRB and the research and development programmes it would undertake.

11 The IMRB would consist of two main elements, both financed from the budget set for the IMRB:

.1 an IMRB Board of Directors that would oversee the work of the IMRB; and

.2 a Secretariat, led by an Executive Director, that would include both professional and administrative staff to manage the substantive work of the IMRB, implementing its strategy and R&D programmes, and providing financial oversight and administration of the IMRF and the R&D contribution system.

12 It is envisaged that the IMRB and the IMRF might have a life of between 10 and 15 years. Once the MEPC has concluded that the IMRB has fulfilled its objectives, the IMRB and IMRF would be formally dissolved.

13 The co-sponsors do not consider the proposed IMRB concept to be a market-based measure (MBM). Neither is this proposal intended to frustrate or delay the development of an MBM should there be consensus for this among Member States. The intention is simply to accelerate development of low-carbon and zero carbon technologies and fuels for use in the commercial maritime sector. However, if this IMRB concept is taken forward by the Organization, it could potentially provide some of the architecture for the possible future development of a levy-based MBM for shipping, in a manner that would reduce the possibility of market distortion.

14 Most importantly, this proposal is considered an essential step in developing the necessary fuels and technologies that are critical to achieving the introduction of zero-carbon vessels (ZEVs) across the commercial maritime fleet, especially with regard to large transoceanic ships. If the IMRB concept is taken forward, the Committee would subsequently need to consider what regulatory measures or economic instruments may be appropriate to facilitate the transition from the carbon-based fuels and ships in today's fleet to a fleet made up of low-carbon and zero-carbon ships.

15 It is emphasized that a mandatory contribution system for shipping companies, established via amendments to MARPOL or another appropriate mechanism, will be vital for this concept to work. This is to ensure a level playing field and the maintenance of the necessary funding for the IMRB and its programmes. Without a mandatory mechanism, there would be no guarantee that every shipping company worldwide would contribute on a fair and equal basis.

16 Should the Committee choose to further consider and develop this proposal, the Committee would need to carefully consider what legal mechanism would prove most practical to establish and finance the IMRB. The co-sponsors believe that the IMRB may be established by adopting a new Chapter 5 outlining regulations for greenhouse gas reduction research and development under MARPOL Annex VI, but we also recognize that the Committee will want to carefully consider what mechanism is most appropriate.

**International Maritime Research and Development Board**

17 The objective of the IMRB would be to accelerate 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 achieve the levels of ambition for 2050 and beyond set by the IMO Strategy. The IMRB would perform the necessary management responsibilities involved with directing an international research and development programme of this scale.

18 The IMRB would operate under a Charter approved by the MEPC that would set out the primary research and development objectives to be pursued and achieved, as well as critical principles, operating parameters and expectations for the IMRB. The Charter would also include the procedures for selecting the members of the IMRB Board of Directors and the Secretariat. Annex 1 of this document sets forth a possible draft Charter to provide an indication of what such a document may include, recognizing that the Charter would subsequently need to be further developed should Member States decide that this IMRB concept should be taken forward.

19 Consistent with the agreed Charter, the IMRB would undertake a broad spectrum of activities and management functions. Specific responsibilities would include:

.1 development, direction, management and administration of an 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 and fuels suitable for application in transoceanic commercial shipping;

.2 identification, definition and ongoing refinement of the specific research priorities consistent with the mandate and Charter of the IMRB;

.3 development of specific R&D programmes and request for proposals, review of proposals received, and decisions concerning specific project approval and funding;

.4 consideration of changes and modifications to specific research and development objectives in light of project results, technology developments, and experience gained;

.5 preparing a detailed budget and report each year for review and approval by IMO;

.6 administering the collection of R&D contributions to the IMRF and the issuance of evidence of contributions having been made by shipping companies, both annually and immediately via an automated payments system;

.7 management and administration of the IMRF including all relevant fiduciary responsibilities associated with the management, accounting, and investment of IMRF funds; and

.8 providing regular progress reports, assessments, and recommendations to the new IMO supervisory body (reporting to the MEPC) that might be established for this purpose.

20 The IMRB would direct and manage research and development projects consistent with its mandate. Actual research projects would be undertaken through qualified third-party research institutions and other qualified entities. The research and development work would be subject to specific deliverables and constraints as per contract or specific binding grant conditions. In particular, these would require recipients of any funding to comply with appropriate intellectual property principles that would be developed as a guide for work undertaken as part of IMRB programmes or grants.

21 For the purpose of the proposal, "development" is intended to mean 'applied research' only. Although this work would include the development of working prototypes or, for example, addressing technical and safety issues associated with the bunkering, use and storage of new fuels, this would not include commercial development of relevant technologies and fuels, or taking new technologies to market. Commercial development of relevant technologies, fuels, and related infrastructure would be the responsibility of other stakeholders such as energy producers, ports, engine manufacturers and shipbuilders.

22 The composition of the IMRB Board of Directors will have to be agreed by the MEPC, with specific procedures to prevent potential conflicts of interest. It is envisaged that the IMRB Board of Directors would include non-governmental professionals with experience, inter alia, in research and development, shipping, shipbuilding, zero-carbon fuels, environmental energy policy, and other expertise relevant to the mandate of the IMRB.

**IMO supervisory body**

23 IMO oversight of the IMRB and its work would be achieved through the establishment of a new IMO supervisory body composed of an appropriate number of IMO Member State representatives with support from the IMO secretariat.

24 The details concerning the composition of this IMO supervisory body and its relationship with the MEPC would be determined by IMO Member States. While the IMO supervisory body may be composed of a defined number of IMO Member State representatives, it could be open to participation by any Party to MARPOL Annex VI that wishes to contribute views and information relevant to the work of the IMRB.

25 The IMO supervisory body would meet on a periodic basis to perform its functions and provide oversight and advice to the IMRB.

26 Specific responsibilities of the IMO supervisory body would include:

.1 general oversight and advice to the IMRB and its Board of Directors on the strategic direction and annual budget of the IMRB;

.2 ensuring that the IMRB performs its duties and responsibilities consistent with the objectives set forth in the IMRB Charter;

.3 approval of the overall annual operating budget for the IMRB after considering recommendations and other relevant information provided by the IMRB and its Board of Directors;

.4 reviewing, or if necessary undertaking, independent financial audits of the IMRB concerning the management and administration of the IMRF and related investments to ensure that the IMRB fully meets its fiduciary responsibilities in managing the IMRF, including the accounting of funds expended for specific research and development programmes, grants, and other funding provided by the IMRB using IMRF funds; and

.5 advising upon recommendations made by the IMRB to modify and adjust the IMRB research strategy and budget as appropriate in light of technological, scientific, and research developments.

27 While the IMO supervisory body would approve the annual operating budget of the IMRB and provide advice on its overall strategy, decisions on the funding of individual R&D projects should be the sole responsibility of the IMRB and its Board of Directors. This provision is intended to avoid potential politicization of project specific funding decisions, and to allow the IMRB to focus on achieving the specific technical objectives as defined by its Charter. The suggested draft Charter set out in annex 1 further elaborates on the role of the IMO supervisory body.

**Funding the IMRB**

28 The funding of the IMRB would need to be sustainable with recurring income on an annual basis until the objectives of the IMRB have been met. This would be achieved through the establishment of an International Maritime Research Fund (IMRF) under the auspices of the IMRB.

29 The core funding of the IMRF would be provided via mandatory R&D contributions per tonne of fuel oil purchased for consumption. As noted in paragraph 8 of this document, the co-sponsors also invite Member States to encourage and/or require other relevant stakeholders to participate and contribute to the International Maritime Research Board and its work. Relevant stakeholders may include energy suppliers, marine engine companies, specialized research and development institutions, foundations, and other entities with substantial expertise relevant to the development of low-carbon and zero-carbon fuels and technologies in the commercial maritime sector.

30 Member State efforts to encourage or require other relevant stakeholders to participate in the formal work of the IMRB and to contribute to the financing of the IMRF would be expected to significantly expand the substantive expertise and financial resources available to the IMRB. Member State actions taken to expand involvement of key stakeholders can be expected to accelerate the ability of the IMRB to reach the goals set forth in the IMO Strategy and the objectives set forth in the draft Charter (see annex 1, Article 3 of this document).

31 All funds received would be held 'in trust' by the IMRF in order to conduct maritime R&D projects and would no longer belong to the individual companies or entities that had made the R&D contributions. As noted in paragraph 8, the IMRB may also require some grant recipients to contribute a defined percentage of funds (e.g. co-funding of a specific proposal) as a condition of grant approval, thereby expanding the pool of total resources available.

32 In order to expedite establishment of the IMRB and IMRF, the co-sponsors would be willing to help develop a fully automated system, allowing ships to make R&D contributions directly to IMRF accounts established for each ship (matching their IMO number).

33 There would need to be a brief trial period following the official establishment of the IMRF and before evidence of shipping companies having made R&D contributions became mandatory, in which monies were not actually transmitted, in order to identify and address any potential problems with the functioning of the system.

34 It is also anticipated that the IMRF would accrue interest which would be used to support the work of the IMRB.

35 To achieve the goals established by the IMO Strategy, the IMRB would require significant funding capable of supporting numerous research and development projects to be undertaken by multiple research institutions and other qualified entities around the world. While a substantial sum of money would be necessary to support the R&D projects of the IMRB, the quantum of the R&D contribution per tonne of fuel oil required could be relatively

modest and would be approved by the MEPC. This should ensure that any impacts on trade and the economic interests of Member States are negligible. Annex 2 of this document provides an initial impact assessment on States for this proposal consistent with the guidance contained in MEPC.1/Circ.885.

36 The co-sponsors estimate that roughly five billion US dollars in core funding is needed over the life of the IMRB and IMRF to fund the necessary research and development work supported by the IMRB. The five billion US dollar figure is based on a preliminary analysis of what research and development work activities could be undertaken at this level of funding. See document MEPC 75/INF.5 for a copy of the relevant study. Over a 10-year period, this means that approximately five hundred million US dollars per year would be needed to fund the IMRB.

37 Based on the assumption that the total fuel consumption of international shipping, before the introduction of zero-carbon fuels, will continue to be at least 250 million tonnes per annum, the co-sponsors propose that the quantum of the R&D contribution would be set by the MEPC at two US dollars per tonne of marine fuel purchased for consumption.

38 As a matter of principle, a lower R&D contribution per tonne would be set for alternative low-carbon fuels and energy sources, or those with lower GHG emissions than conventional fuel oil.

39 Figure 1 provides a short graphic illustration of how the IMRB and IMRF contribution system would work. Further detail is provided in paragraphs 40 – 64 of this document.

**How the mandatory R&D contribution system would work**

40 Mandatory statutory certification would be used to demonstrate compliance. A ship would be required to demonstrate that the necessary R&D contributions had been made to the IMRF, commensurate with the ship's annual fuel purchased for consumption, as verified by the flag State. The existing IMO Fuel Oil Data Collection System (DCS) could be used to verify the amount of this contribution. The co-sponsors recognize, however, that ships below 5,000 GT are not currently required to report data to the IMO DCS and it may therefore be necessary to consider how to verify contributions from ships below 5,000 GT.

41 Each shipping company would be required to make the necessary contribution directly to the IMRF for each ship it has assumed responsibility for under the International Safety Management (ISM) Code, regardless of the flag State. In the case of ships registered with non-Parties, the principle of 'No More Favourable Treatment' would need to apply, with flag State certificates of all visiting ships checked by port State control authorities.

42 Each shipping company would be responsible for transmitting the R&D contributions to the IMRF for its ships on a mandatory basis as required by an amendment to Annex VI of MARPOL or other legal mechanism deemed appropriate by the Committee. The co-sponsors emphasize that the R&D contribution per tonne of fuel oil must be regarded as an integral part of the cost of any fuel purchased for consumption. This is to ensure that if an entity other than the shipping company (such as a charterer) is responsible under commercial contract or charter party for paying or reimbursing the cost of fuel this entity shall also be responsible for the cost of the contribution to the IMRF. In order for the IMRB concept to be taken forward, the importance of addressing this issue is strongly emphasized.

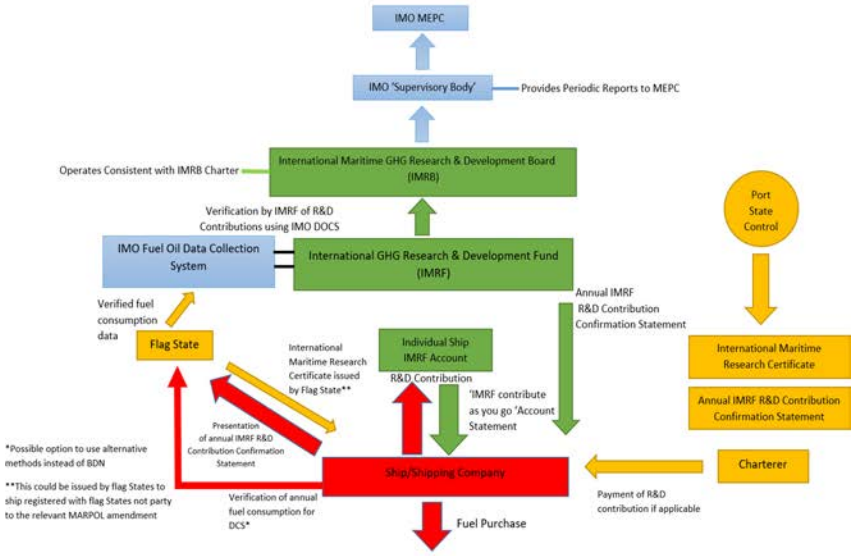


Figure 1 Graphic illustration of how the IMRB and IMRF contribution system would work

43 The shipping company (as defined by the ISM Code) would have the responsibility for providing evidence to the flag State of transmitting the required R&D contributions to the IMRF for its ships.

44 The IMRF would use data submitted to the IMO Fuel Oil Data Collection System (IMO DCS) to verify the R&D contributions to the IMRF made for individual ships were correct, while maintaining the confidentiality of individual ships' data.

45 The IMRF would issue documentary evidence to the shipping company that the required contribution has been made for the ship. Upon receipt from the company of an Annual IMRF R&D Contribution Confirmation Statement, the flag Administration (or authorized Recognised Organization) would issue an official International Maritime Research Certificate to the ship confirming that required R&D contributions had been made during the previous calendar year.

**Transmission of R&D contributions to the IMRF**

46 Every ship (including ships registered with non-Parties to MARPOL Annex VI) would have an IMRF Account provided by the IMRF, identified by the ship's IMO number. Safeguards would be developed to prevent accidental double payment.

47 On receipt of an R&D contribution, an automated IMRF system would immediately provide an IMRF Account Statement to the shipping company.

48 The IMRF Account Statement would show the R&D contributions against the amount of fuel purchased, corresponding to the Bunker Delivery Note (BDN) for the fuel purchased. This would also serve as evidence of transmission of the R&D contribution to the IMRF by the shipping company if it needs to be recovered from another commercial entity such as a charterer.

49 R&D contributions would need to be transmitted by the shipping company directly to the IMRF either:

.1 on a 'contribute as you go' basis (i.e. within three months of the bunker fuel purchased for consumption as shown on the BDN), or

.2 on an annual basis.

The main benefit of contributing on an 'as you go' basis is that this will facilitate reimbursement to the shipping company from third parties, such as charterers, that might ultimately be contractually responsible for paying for the cost of the fuel and the required R&D contribution.

50 Direct R&D contributions by the shipping company to the IMRF are essential for the concept to work and to minimize inefficiencies within the system for transmitting all of the R&D contributions to the IMRF for use by the IMRB. R&D contributions cannot be made via bunker suppliers or with the involvement of non-maritime authorities, as this would lead to significant complications and difficulties in enforcement and administration of the system. It could also lead to market distortion in the case of bunker suppliers located within countries which were not Parties to the new IMO regulation. Requiring R&D contributions to be made to the IMRF via flag States would also be too complex and could potentially lead to taxation and hypothecation issues with national administrations. For these reasons, the proposed funding mechanism is premised on R&D contributions being transmitted directly by shipping companies to the IMRF.

**Verification of R&D contributions**

51 Ships would be required by a new regulation to hold a flag State certificate confirming that the necessary R&D contributions had been made. In addition, the IMRF itself would verify that required contributions had been made, using data within the IMO DCS.[1] This should simplify the necessary regulations by building on the existing responsibilities of flag States with regard to the IMO DCS.

52 The IMRF would prepare an Annual IMRF R&D Contribution Confirmation Statement which would be sent directly to the shipping company for each of its ships. This would confirm that the R&D contributions made by the shipping company during the previous calendar year correspond with the verified fuel oil consumption data submitted to the IMO DCS by the flag Administration. The Annual Statement would only be issued after the IMRF has confirmed that the contributions are commensurate with the data recorded by the IMO DCS.

53 In the event of any discrepancy with the IMO DCS, the IMRF would either issue a rebate or invoice the shipping company for any shortfall and collect the outstanding amount before issuing the Annual IMRF R&D Contribution Confirmation Statement.

[1] The IMO Fuel Oil Data Collection System allows Bunker Delivery Notes, received at the time of purchase, to serve as a proxy for recording consumption, although other methods can also be used.

54 Allowing time for the resolution of any discrepancies, the Annual IMRF R&D Contribution Confirmation Statement could be issued to the shipping company for each of its ships within an agreed period (e.g., before 1 June each year) and presented by the shipping company to the flag State. However, most of these statements could be issued earlier in the year to facilitate issuance of flag State certificates and avoid logjams.

55 The flag Administration (or delegated Recognized Organization) would then issue an official International Maritime Research Certificate to the ship, confirming that required R&D contributions had been made during the previous calendar year. Allowing time for the verification process by the IMRF, this flag State certificate might normally be valid for the same 12-month period (e.g. 1 September to 30 August).

56 The flag State International Maritime Research Certificate would form part of the ship's statutory certification.

57 To ensure uniform global implementation and compliance, the system would need to be overseen by flag State administrations, supported by port State control (PSC) authorities when carrying out inspections. PSC authorities could then check that the ship has an up-to-date International Maritime Research Certificate issued by the flag State confirming that required contributions have been made during the previous calendar year.

58 PSC authorities would be entitled to check that R&D contributions have been made regardless of whether the ship is registered with a flag State Party to MARPOL Annex VI, consistent with the principle of 'No More Favourable Treatment'.

59 Applicable guidance for the new regulations would need to include appropriate provisions for instances where ships change flag State or company during the annual verification period.

**Ships registered with Non-Parties**

60 Shipping companies with ships registered with a non-Party would need to be able to transmit the necessary contributions to the IMRF. In the case of ships registered with flag States that are not Parties to MARPOL Annex VI, IMO has agreed that Recognized Organizations can verify and submit fuel oil data to IMO for inclusion in the DCS on behalf of such ships.

61 Such ships should be allocated an IMRF Account and be issued by the IMRF with 'contribute as you go' statements of receipt, and an Annual IMRF R&D Contribution Confirmation Statement in the same way as other ships. The status of the IMRF as a non-governmental research and development fund should help to facilitate the participation of all ships in the system regardless of the flag State.

62 It should be noted that IMO Member States which have ratified the IMO liability Conventions have been willing to issue certificates to ships registered with flag States that have not ratified these Conventions. This should also be possible with respect to issuing the International Maritime Research Certificate.

**Implementation of the IMRB**

63 Implementation of this proposal would be done through amendments to MARPOL Annex VI or another legal mechanism as deemed appropriate by the Committee. The Committee would also develop accompanying resolutions and/or guidelines that are deemed necessary. These instruments would need to address the following:

.1 establishment of the IMRB and the IMRF and their relationship with IMO;

.2 the quantum of the *mandatory* R&D contribution by ships per tonne of fuel oil purchased for consumption;

.3 the expectation that contributions would be made by other stakeholders and ensuring a means for facilitating such contributions to the IMRB;

.4 arrangements for approval by IMO of the budget for the IMRB, based on data for total fuel consumption by the world fleet provided by the IMO DCS[2] and additional contributions by other stakeholders;

.5 a mandatory requirement for ships to carry a valid International Maritime Research Certificate, issued by, or on behalf of, the flag State, confirming that required R&D contributions have been made to the IMRF during the previous calendar year;

.6 provisions for ships entering or leaving service part way through the year;

.7 a mechanism for IMO to transfer individual ships' annual fuel oil consumption data to the IMRF, as recorded in the IMO DCS, whilst preserving the confidentiality of such data;

.8 a stipulation that although the shipping Company (as defined by the ISM Code) would be legally responsible for transmitting the R&D contribution to the IMRF, the R&D contribution per tonne of fuel oil must be regarded as an integral part of the cost of any fuel purchased for consumption and that it is the commercial entity responsible for paying for the fuel which is responsible for the cost of the R&D contribution;

.9 port State control measures and provisions regarding application of the 'No More Favourable Treatment' principle to ships registered to non-Parties to the new regulation;

.10 treatment of ships of under 5,000 GT (depending on the nature of the provisions which may need to be developed for smaller ships); and

.11 provisions that enable the IMRB and IMRF to be phased down and dissolved once the MEPC has concluded that the IMRB has fulfilled the objectives set forth in its Charter.

64 Those elements listed above which are not included in the IMO legal text should be addressed in an MEPC resolution or guidelines, as may be appropriate.

**Conclusion and proposed way forward**

65 This proposal is intended to facilitate discussion among governments and other stakeholders about the development of a measure that could prove to be one of the most critical actions in the IMO GHG strategy, enabling the IMO and industry to meet the 2050 GHG reduction target established in the IMO Strategy and to move as soon as possible to low-carbon and zero-carbon fuels and technologies. This proposal outlines a possible

[2] This would need to take account of what might be decided regarding the treatment of ships below 5,000 GT which are currently not covered by the IMO DCS.

framework for how an *International Maritime Research and Development Board* (IMRB) could work to achieve that objective, recognizing that the details would inevitably require further development should these ideas be taken forward by the Committee.

66 In order to ensure that essential research and prototype development of low-carbon and zero-carbon fuels and technologies commences as soon as possible, the co-sponsors are of the view that this programme would need to be in place by 2023. Therefore, to achieve this objective, the co-sponsors suggest that the International Maritime Research and Development Board proposed in this document be discussed at MEPC 75 with a view toward providing comments and views on the general acceptability of the concept of the IMRB/IMRF. The co-sponsors fully recognize that MEPC 75 will appropriately devote considerable attention to agreement on appropriate measures to reduce emissions in the existing fleet. Recognizing the critical need to accelerate the development of low-carbon and zero-carbon technologies and fuels, the co-sponsors also believe that the Committee should provide time for an initial, general discussion of this proposal at MEPC 75 with a view to more detailed, substantive discussions at MEPC 76.

**Action requested of the Committee**

67 The Committee is invited to consider this document, in particular, the conclusion and the proposed way forward in paragraphs 65 and 66, and take action as appropriate.

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## ANNEX 1

### Possible draft Charter

### Applicable to the International Maritime Research and Development Board (IMRB) and the International Maritime Research Fund (IMRF)

**Introduction/Preamble**

Whereas:

- The *Initial International Maritime Organization (IMO) Strategy on Reduction of Greenhouse Gas (GHG) Emissions from Ships* calls for GHG emissions from international shipping to peak as soon as possible and to reduce the total annual GHG emissions from shipping by at least 50% by 2050 when compared to 2008 levels, while phasing out GHG emissions as soon as possible in this century on a pathway consistent with the Paris Agreement temperature goals.

- The *Initial IMO Strategy on Reduction of GHG Emissions from Ships* explicitly recognizes the need for new research and development activities addressing marine propulsion, alternative low-carbon and zero-carbon fuels, and innovative technologies to further enhance the energy efficiency of ships, and recognizes the concurrent need to establish an *International Maritime Research and Development Board* to coordinate and oversee these R&D efforts.

- These ambitious goals will require the accelerated development and deployment of low-carbon and zero-carbon fuels, propulsion systems, and related technologies specifically to meet the unique power demands that make up the broad spectrum of shipping activity in the commercial maritime sector.

- Consequently, this document sets forth the mandate, responsibilities, and associated provisions necessary to establish an *International Maritime Research and Development Board* (IMRB) whose purpose is to establish an international maritime research and development programme specifically devoted to research and development of low-carbon and zero-carbon technologies suitable for application in the commercial maritime sector as well as proper administration of all available funds. It is emphasized that responsibility for decarbonisation of the maritime sector as a whole is not the sole responsibility of shipping companies and must ultimately be shared by other stakeholders.

*Article 1*
**Establishment**

1. The *International Maritime Research and Development Board* is established in [*insert relevant geographic location*] and is registered as ... consistent with the [insert *relevant legal authorities governing the establishment of a non-profit organization in the relevant jurisdiction]*.

2. An International Maritime Research Fund (IMRF), specifically created for the collection of funds for the IMRB, and to be overseen by and subordinate to the IMRB, shall be established.

3. The IMRB and the IMRF are established pursuant to regulations ..., as amended and adopted. [*This particular provision will be dependent on what specific legal mechanism the Committee deems appropriate to establish the IMRB and IMRF.*]

*Article 2*
**Mandate**

1. The mandate and purpose of the *International Maritime Research and Development Board* (IMRB) is to establish, oversee, and fund an international research and development programme designed to identify low-carbon and zero-carbon fuels, propulsion systems, and related technologies for use in commercial maritime service.

2. The IMRB and its programme shall support research and development projects that accelerate the development and deployment of low-carbon and zero-carbon fuels, marine propulsion systems, and related technology and design advancements. Low-carbon and zero-carbon fuels and technologies are non-fossil-based fuels and technologies that produce near-zero or zero-carbon emissions when evaluating the full life cycle production of a given fuel or technology.

3. The IMRB and its programme shall develop a portfolio of research and development projects that pursue low-carbon and zero-carbon fuels and technologies that reflect the differing demands that are inherent to a broad spectrum of shipping activity including large transoceanic ships, smaller short-sea ships, passenger ships, and the major ship types that constitute commercial maritime trades. This portfolio shall include research, development, and demonstration projects that seek to identify and develop low-carbon and zero-carbon fuels and technologies which are not yet available for commercial deployment on most ship types.

4. While the primary mandate of the IMRB is focused on identifying low-carbon and zero-carbon fuels and technologies, the IMRB shall also consider co-benefits. Consequently, the IMRB will consider and encourage development of fuels and technologies that also minimize harmful emissions such as oxides of nitrogen, SOx, particulate matter, black carbon, and other emissions and discharges considered harmful to the environment.

5. The IMRB may exercise its discretion to also pursue mixed-fuel (e.g., hybrid fossil and non-fossil fuel) projects if such projects are considered to be important pathways in facilitating the transition to low-carbon and zero-carbon fuels and technologies.

6. The IMRB's research and development efforts may include field demonstrations of promising technologies, fuels, and marine propulsion systems with the aim of catalyzing the conditions that will lead to low-carbon and zero-carbon systems that are commercially available and economically and technically viable for use across a wide range of ship types used in the commercial maritime sector.

7. When the IMRB determines and IMO agrees that low-carbon and zero-carbon fuels, propulsion systems, and technologies can be made available across the maritime sector, the mandate shall be considered to have been met.

*Article 3*
**Objectives**

1. The primary objective of the IMRB is to meet the above mandate through the funding and management of research and development projects that support development of low-carbon and zero-carbon fuels, marine propulsion systems, and related technologies for use in the commercial maritime sector.

2. The IMRB shall pursue the most cost-effective low-carbon and zero-carbon fuels and technologies.

3. The IMRB shall also seek to foster international cooperation and collaboration among the recipients of its grants and contracts and other interested parties to maximize the productivity and progress of research and development projects. In this context, the IMRB shall work to disseminate knowledge gained from funded projects to assist global efforts to decarbonize shipping and help support the transition from fossil fuel use in shipping in both developed and developing countries, particularly SIDS and LDCs.

4. The IMRB shall promote, fund, and evaluate low-carbon and zero-carbon fuels and technologies that can be applied in different ship types to ensure that research and development investments are made in those areas of commercial maritime shipping that are critical to achieving the objectives outlined in the IMO GHG Strategy. In this context, the IMRB work programme needs to give appropriate priority to identifying low-carbon and zero-carbon fuels and technologies that are workable for transoceanic ships.

5. The IMRB shall include a research work stream that will explore technical and operational innovations that could contribute to reducing transport costs to Small Island Developing States and other remote locations.

6. Among its research and development initiatives, the IMRB shall include funding to develop and construct fully functioning prototypes. The IMRB may also fund projects to develop prototype ship-to-shore infrastructure designs to facilitate practical and economical fueling of ships. Such projects will be limited to prototype development and shall not be expanded to include commercial infrastructure construction and shipbuilding.

7. The IMRB shall achieve these objectives in a manner that is transparent, credible, and trusted, while remaining aligned with the Objectives of the IMO GHG Strategy.

*Article 4*
**Management and Organization of the IMRB and IMRF**

1. The IMRB shall be composed of the IMRB Board of Directors, an Executive Director, Chief Financial Officer, Technical Research Officer, General Counsel, and other professional and administrative staff to perform the managerial functions and responsibilities necessary to the successful operation of the IMRB and the IMRF (see figure 1 which is appended to this document).

2. The IMRF will provide the financial resources necessary to support the programmatic work of the IMRB including grants and contracts to qualified research and development institutions and other qualified parties performing work as directed and authorized by the IMRB. The IMRF will also provide the necessary financial resources to support the IMRB Secretariat including salaries, office space, and all other related expenses. The management of the IMRF and related fiduciary responsibilities will be conducted by the Chief Financial Officer (CFO). The CFO and financial staff managing the IMRF, as well as the IMRF itself will be an integral component of the IMRB Secretariat.

3. The Board of Directors shall consist of [11] individuals, including a Chairperson, who are non-governmental professionals with extensive experience and recognized expertise in one or more of the following fields: research and development, shipping, shipbuilding, low and zero-carbon fuels and technologies, environmental policy, energy policy and other expertise relevant to the mandate of the IMRB.

4. The term lengths for the Board of Directors shall be initially staggered, with four members serving one-year terms, four members serving two-year terms, and three members serving three-year terms. The standard term length after each initial term shall be three years, and Board Members will be able to serve a maximum of two terms. To serve a second term a Board Member must again be nominated and selected via the same process that a new nominee would face. Using this process, each year, approximately one-third of the Board's seats shall rotate to new nominees, or in some cases, will be retained for a Board Member's second term. Consequently, the Board of Directors will always have members with sufficient IMRB-specific experience.

5. The initial Chairperson of the Board will be selected by the IMO Secretary General from a list of candidates provided by the IMRB Nominating Committee. The remaining [10] initial IMRB Board Members will then be selected by the Chairperson from a list of candidates named by the IMRB Nominating Committee.

6. The IMRB Nominating Committee shall be composed of [13] members. Of these [13] members, [7] shall be from the shipping industry, [3] shall be government representatives, and [3] shall be from academia and environmental NGOs. The IMRB Nominating Committee may utilize professional assistance for nominating prospective Board Members consistent with paragraph 7 below. Once the IMRB Board of Directors has been established, subsequent nominations to ensure continuity of the Board (consistent with the term lengths outlined in paragraph 4) shall be made by the IMRB Nominating Committee with the approval of the IMRB Board of Directors. Interviews and other evaluations may be performed as the IMRB Nominating Committee, Executive Director, and IMRB Board of Directors deem appropriate.

7. The IMRB Nominating Committee shall ensure that nominees for the IMRB Board of Directors are non-governmental professionals with experience, inter alia, in: research and development, shipping, shipbuilding, low-carbon and zero-carbon fuels and technologies, environmental policy, energy policy and other expertise relevant to the mandate of the IMRB. Specific criteria and guidance outlining expertise and experience are set forth in Appendix [*to be developed*].

8. The Board of Directors shall be responsible for making high-level decisions concerning strategy and management of the IMRB. These responsibilities shall include: development of specific R&D needs, providing guidance to the Executive Director, and identification, definition, and ongoing refinement of the specific research priorities consistent with the mandate of the IMRB.

9. The IMRB Board of Directors shall have the authority to set its own processes and procedures for reviewing and evaluating proposals on an individual and/or group basis, and shall have the final say on approval of grants and contracts that have been recommended to it by the IMRB staff.

10. The Board of Directors may, if appropriate, recommend an increase or decrease in the funding of the IMRB should the Board of Directors conclude that the amount of funding currently authorized warrants adjustment.

11. The Chairman of the Board shall rotate every [2-4] years. The initial term of the inaugural Chairman should be [...] years.

12. The Chairman of the Board's responsibilities shall include convening and leading meetings of the IMRB Board of Directors and assisting the Executive Director in communications with the IMO Oversight Body and other parties as appropriate.

13. With respect to the initial establishment of the IMRB, the Board of Directors shall select an IMRB Executive Director and Chief Financial Officer from a list of candidates provided by the IMRB Nominating Committee. Following a rigorous interview process, the Board of Directors shall select the most qualified person for the respective positions. Subsequent Executive Directors and Chief Financial Officers will be chosen by the IMRB Board of Directors.

14. The responsibilities of the IMRB Executive Director shall include overall management and direction of the IMRB and the IMRF. The Executive Director and Chairman of the Board of Directors shall be responsible for presenting the annual operating budget to the IMO Oversight Body and reporting on the IMRB's work and progress to the IMO Oversight Body, MEPC, and other bodies, as appropriate.

15. The Chief Financial Officer (CFO) shall oversee the management of the IMRF, the operating budget of the IMRB, and financial management of the programmatic contracts and grants, and all related fiduciary obligations consistent with the budget approved by the IMRB Board of Directors and the IMO Oversight Body. The CFO reports to the IMRB Executive Director and shall regularly advise on the management of the IMRF, contributions to the IMRF, and other aspects of the IMRF and IMRB as the Board of Directors sees fit.

16. The IMRB Executive Director shall hire a Technical Research Director to administer and oversee the strategic research initiatives of the IMRB and provide technical advice to the Executive Director and the IMRB Board of Directors. The Technical Research Director shall report to the Executive Director.

17. The IMRB Executive Director, with the approval of the Board of Directors, shall consider qualified candidates and make a selection for the position of General Counsel. The General Counsel will provide legal counsel to the Executive Director, Technical Research Director, and the IMRB Board of Directors. In addition, the General Counsel will be responsible and have authority to oversee all matters where a conflict of interest may arise. In this context, the General Counsel shall review and have access to all administrative and managerial reports regarding the IMRF, funding awards, hiring procedures, hiring decisions, nominations and appointments to the IMRB Board of Directors, and other areas of the IMRB as necessary to ensure that there are no conflicts of interest. Any conflicts of interest identified shall be reported to the Board of Directors by the General Counsel in a timely manner.

18. The IMRB Chairman of the Board of Directors, Executive Director, Technical Research Director, and Chief Financial Officer, as appropriate, shall present regular reports on the management and status of the research and development programme, the IMRF, and related matters to the IMO Oversight Body.

19. The IMRB Executive Director [with the approval of the Board of Directors] shall have the authority to hire professional and administrative staff as is necessary to ensure the smooth and efficient operation of the IMRB and IMRF. The Executive Director shall also have the authority to delegate specific managerial authorities as he or she deems necessary.

*Article 5*
**Conflict of Interest Provisions**

1. The selection of the IMRB Board of Directors, Executive Director, Chief Financial Officer, the Technical Research Director, and the General Counsel (hereafter referred to as the IMRB Officers) shall be subject to strict conflict of interest provisions to ensure that the management, direction and decision-making within the IMRB and IMRF are undertaken in a manner that is free of political and commercial conflicts of interest or the appearance of such conflicts. It is critical that nominees for IMRB Officers are free from notable conflicts of interest, both commercial and political. Therefore, any nominee should be vetted in light of specific criteria identified in Appendix [ ], and subject to review and approval of the IMRB General Counsel.

2. The IMRB Officers and the performance of their responsibilities shall be subject to a defined set of conflict of interest provisions as set out in Appendix [ ] of this document.

*Article 6*
**Acquisition and Management of Resources**

1. The International Maritime Research Fund (IMRF) shall be financed via mandatory contributions, on the basis of fuel oil purchased for consumption by each ship subject to the regulation[s] as approved by IMO. The fee per tonne of fuel oil purchased for consumption shall be established in consideration of the needs of the IMRB, while taking into account the total fuel consumption of the world fleet as determined by the IMO Data Collection System (DCS). The specific fee shall be subject to IMO approval.

2. A process for submitting both required and voluntary contributions as well as a detailed accounting system shall be created and maintained by the staff of the IMRB.

3. IMRF accounts shall be created for individual ships subject to the regulation, identified by the ship's IMO number. Contributions shall be paid to their respective accounts directly via an automated system for increased efficiency.

4. The IMRB staff shall use the existing IMO Fuel Oil Data Collection System to verify that the contributions have been made as required.

5. The IMRB shall issue documentary evidence in the form of quarterly and annual IMRF contribution statements to Flag states, with a copy sent to each respective shipowner, as evidence that the required contributions have been made for every ship. Upon receipt of this statement, Flag states can then issue the required *International Maritime Research Certificate*, valid for the next year.

6. Issuance of the certificate for each year shall be subject to a ship fully meeting its required contributions for the previous year.

7. The contributions to the IMRF should be treated as a component of the cost of marine fuel, and thus the commercial entity ultimately paying for the fuel should also pay for the cost of the contribution, although the responsibility of transmitting payment to the Fund itself and maintaining compliance so as to receive an annual certificate rests with the shipowner.

8. Ships registered with non-parties will also have an IMRF Account linked to their IMO number, and will be required to contribute along with all others, per the principle of 'No More Favourable Treatment'. Non-party ships shall carry a statement of compliance by their Administration/RO that they have contributed full and final for the previous year.

9. Payment may be made on a 'contribute as you go' basis (submitted within three months of purchasing fuel) or through a single annual payment for the preceding year.

10. Interest gained from the IMRF being held in trust shall be used to support the work of the IMRB.

11. The IMRF shall be managed by the Chief Financial Officer.

12. Consistent with the budget approved by the IMRB Board of Directors and the IMO Oversight Body, the IMRB Executive Director shall possess the authority to approve contracts, purchases, and other actions necessary for the effective operation of the IMRB and IMRF. Contracts and grants relating to specific research and development projects require approval of the IMRB Board of Directors and are subject to the provisions specified under Article 7.

*Article 7*
**Administration of Grants and Contracts**

1. A system shall be established and put in place by the IMRB, in which qualified applicants may submit proposals for research and development projects as requested by the IMRB through a "*Request for Proposal" (RFP),* solicitation of contract proposals, or through other mechanisms as deemed appropriate by the IMRB Executive Director. The IMRB will also develop a process and criteria for reviewing unsolicited proposals consistent with *Article 3* of this document.

2. The IMRB professional staff shall review proposals based on their merit, feasibility, proposed cost, and scientific and technical potential.

3. In reviewing proposals, as well as research and development work performed or currently in progress, the IMRB staff may utilize appropriate peer review measures and engage external consultants with appropriate technical expertise to determine the scientific merit and feasibility of proposals, and to assess progress made in the case of existing work projects.

4. Those proposals considered to have the most merit shall be recommended to the IMRB Board of Directors for final review and determination of whether to approve the work, the duration of the work project, and the specific level of funding to be approved. Decisions concerning grants and contracts made by the IMRB Board of Directors shall require the affirmative support of a majority of the Board Members that are eligible and participating when voting on a given motion. If a given Board Member or Members have been determined to have a potential conflict of interest on a specific proposal, that Board Member(s) will be excluded from voting or otherwise participating in the Board's discussion of the specific proposal under consideration.

5. The IMRB and its Board of Directors shall consider, inter alia, the following criteria during its evaluation and assessment of specific project proposals:

- potential to meet the low-carbon and zero-carbon objectives identified in Article 3 of this Charter;
- energy density, feasibility, and potential to be applied in specific maritime ship types and trades, including the spatial and energy demands of transoceanic voyages;
- safety considerations that examine risks to the ships' crew, shore-side personnel, and relevant risks to the general public;

- co-benefits with respect to other important air emissions such as NOx, SOx, PM, BC, VOCs, etc.;

- can the specific fuel or technology be used with existing internal combustion two-stroke, slow speed engines? If not, does the project provide an appropriate evaluation of the relevant considerations for ship design, materials science, and the overall engineering of relevant systems as applicable to one or more ship types;

- potential to be used in conjunction with existing bunkering infrastructure;

- impacts on competition and maintenance of a level playing field, in particular, avoidance of grants being made directly to shipowners, shipyards, energy producers, or other parties that might cause market distortion; and

- specific project proposal criteria as specified by the IMRB.

6. All research and development grants and contracts shall be subject to the grantee's acceptance of specific terms to be established by the IMRB, including, but not limited to:

a. The intellectual property policy for all grants and contracts shall be as follows: All research and development grants and contracts shall be subject to the grantee's acceptance of specific terms concerning intellectual property rights associated with inventions arising from the grant or contract. These terms, which shall be determined by the IMRB, shall be designed to further two equally important purposes:

   - to encourage broad participation in the work funded and directed by the IMRB by providing grantees an opportunity to obtain intellectual property rights in the results of work funded by the IMRB, and

   - to ensure that the intellectual property associated with discoveries and knowledge created by work funded by the IMRB is available for incorporation into inventions and derivative works created by parties other than the grantees performing the work leading to such discoveries and knowledge.

b. The objectives specified in 6a shall be fulfilled by the IMRB through grant conditions that may include, inter alia, a requirement that all utility patents and utility patent applications claiming inventions made pursuant to an IMRB grant or contract shall be licensable to anyone in the world on Fair, Reasonable, and Non-Discriminatory (FRAND) terms, so that such inventions can be widely adopted by the international community.

c. Grantees or contractors shall provide regular updates on substantive progress made and use of funds provided to date.

d. Grantees or contractors shall return unused funds (if any remain) at the completion of the proposed project to the IMRB, which shall then deposit such remaining funds back into the IMRF, and

e. The IMRB shall be authorized to terminate a given work project and its funding if in the judgement of the IMRB Board of Directors the recipient has failed to satisfactorily perform the stipulated work in a timely manner or has failed to properly account for or manage IMRB funds. The IMRB will hold the sole authority to terminate funding of a given work project.

7. Contracts and other payments (e.g. salaries, office space, and other expenses) that are primarily related to internal management and administrative responsibilities of the IMRB may be approved by the Executive Director. The Executive Director may also delegate such approvals to the Chief Financial Officer.

*Article 8*
**Supervision and Oversight by IMO**

1. IMO shall have oversight authority, via a specific entity to be created for such a purpose, over the IMRB.

2. The oversight body shall meet on a periodic basis to perform its functions and provide supervision and direction to the IMRB. Its responsibilities shall include:

a. providing general oversight and advice to the IMRB and its Board of Directors on the strategic direction and budget of the IMRB;

b. ensuring that the IMRB performs its duties and responsibilities consistent with the objectives and mandate set forth in this Charter;

c. advising upon recommendations made by the IMRB to modify and adjust the IMRB research strategy and budget as appropriate in light of technological, scientific and research developments;

d. reviewing and approving the IMRB's annual operating budget after considering recommendations and other relevant reports and information provided by the IMRB and its Board of Directors. In the event that the IMO Oversight Body does not approve the proposed annual operating budget, the IMRB shall prepare a modified budget within 45 days of the initial decision; and

e. reviewing, and, if necessary, undertaking independent financial audits of the IMRB concerning the management and administration of the IMRF and related investments to ensure that the IMRB fully meets its fiduciary duties in managing the IMRF, including the accounting of funds expended for specific research and development programmes, grants, contracts and other funding provided by the IMRB using IMRF funds.

3. The IMO Oversight Body shall receive regular reports on project progress and updates, as well as reports on the IMRF and its stability, performance, and any other related issues.

4. The IMO Oversight Body shall not have the authority to make decisions on the funding of individual R&D projects; rather, these decisions will be the sole responsibility of the IMRB and its Board of Directors.

*Article 9*
**Dissolution**

1. As stipulated in regulation [ ], and after an operational period of twelve years, beginning on the date that this [Chapter] enters into force, mandatory contributions to the IMRF shall cease. Once mandatory contributions cease, the IMRB shall continue to oversee all planned and approved projects through completion, and may plan and approve new projects, subject to availability of funds. All new and ongoing work projects shall be completed in a period of five years once mandatory contributions have ceased.

2. Upon completion of the IMRB's work programme and with the approval of the MEPC, the IMRB and IMRF shall cease operations. Upon such a determination, the IMRB and IMRF and its requirements shall be dissolved, unless the parties determine otherwise.

**Appendix**

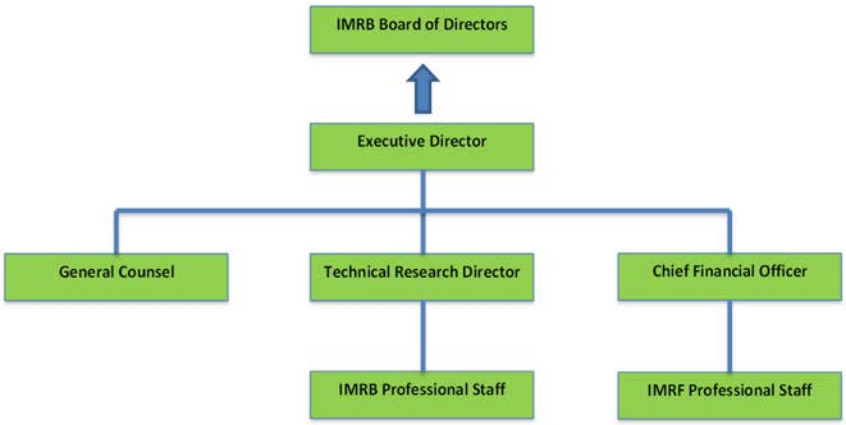


**Figure 1 Management and Organization of the IMRB and IMRF**

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## ANNEX 2

## INITIAL IMPACT ASSESSMENT ON STATES

**1 Measure:**

**Establishment of an International Maritime Research and Development Board (IMRB) to accelerate the development of low-carbon and zero-carbon emission ships**

**1.1 Proposals**

.1 To establish an International Maritime Research and Development Board (IMRB) to accelerate the development of low-carbon and zero-carbon emission ships in order to achieve the 2050 levels of ambition of the Initial IMO strategy on reduction of GHG emissions from ships (MEPC.304(72)) (the Initial Strategy). The objectives and activities of the IMRB would be governed by a Charter that would be approved by the Organization and overseen by a 'supervisory body' reporting to the MEPC.

.2 The research and development programmes of the IMRB would be funded by an International Maritime Research Fund (IMRF), which would itself be funded by the shipping industry in the form of direct mandatory contributions, via an automated payment system into the IMRF, for each tonne of fuel oil purchased for consumption on board ship. This mandatory contribution would be fixed at two US dollars per tonne of fuel oil, sufficient to raise around five billion US dollars over a 10-year period. Member States may also require or encourage other stakeholders to contribute into the IMRF.

.3 Ships would be required to carry an International Maritime Research Certificate demonstrating compliance with required contributions to the IMRF, verified using the existing IMO Fuel Oil Data Collection System. This would be a statutory certificate issued by the ship's flag Administration and subject to examination by port State control. This would provide an effective means of enforcing mandatory contributions that will minimize the administrative burden on Administrations which would not have any direct role in the collection of contributions from shipping companies.

.4 The IMRB and its coordinated R&D programmes would accelerate the development of low-carbon and zero-carbon emission technologies and fuel systems that are specifically tailored for maritime application, especially for larger transoceanic ships. The IMRB and the specific R&D programmes it would support are expected to help deliver substantial GHG reductions from international shipping in the mid to long-term.

**1.2 Assessment of impacts on Member States**

**.1 Geographic remoteness of and connectivity to main markets**

The proposed contribution level of two US dollars per tonne of fuel oil is within the daily variability of fuel oil bunker prices and would be a marginal component of marine fuel oil cost (less than 1%). The proposal includes specific research aimed at identifying technical and operational innovations to reduce the transport cost to Small Island Developing States and other remote locations. Consequently, the proposal can be expected to undertake work that may lead to the reduction of transport costs to SIDS and other remote locations.

**.2 Cargo value and type**

As the proposals would apply to all ships (at least 5,000GT and above) it would not discriminate between different cargoes. As the additional cost of fuel would be marginal and within the daily variability of marine fuel costs, it would not impact the shipping costs of low value cargoes.

**.3 Transport dependency**

The proposals will not disproportionately impact Member States which are dependent on maritime transport.

**.4 Transport costs**

The proposal is not expected to adversely impact transport costs beyond any impacts which might already result from daily volatility of fuel oil prices. The work undertaken in the IMRB is designed to identify potential mechanisms for reducing the cost of transportation to Small Island Developing States and other remote locations.

**.5 Food security**

The proposals will have no adverse impact on food security.

**.6 Disaster response**

The proposals will have no adverse impact on disaster response.

**.7 Cost-effectiveness**

The proposals would impose a marginal cost on individual ships whilst creating a multi-billion-dollar fund to accelerate research and development of low-carbon and zero-carbon fuels and technologies. Therefore, the proposed IMRB is considered to be an extremely cost-effective measure which will facilitate successful delivery of the 2050 levels of ambition of the initial strategy.

**.8 Socio-economic progress and development**

The proposal is expected to have no adverse impact on socio-economic progress and development.

**1.3 Justification**

.1 Delivery of the initial strategy, in particular providing a pathway to deliver the 2050 level of ambition of the initial strategy and the introduction of low-carbon and zero-carbon fuels and technologies. Specific development of one of the candidate short-term measures identified in the Initial IMO Strategy on Reduction of GHG Emissions from Ships. See paragraph 4.7.9 of the Initial IMO GHG Strategy.

.2 Accelerating the development of low-carbon and zero-carbon fuels and technologies suitable for maritime application to mitigate climate change.

.3 Low-carbon and zero-carbon fuels and technologies are expected to offer significant co-benefits in terms of reducing or eliminating emissions of local pollutants such as particulate matter, with positive impacts for local eco-systems and public health.

.4 The proposals will ensure that the shipping industry collectively provide the core funding which will be required to undertake the necessary research and development effort.

**1.4 Number of ships affected and impact on GHG emissions**

.1 All ships subject to MARPOL Annex VI (at least 5,000GT and above).

.2 Successful delivery of the 2050 levels of ambition of the initial strategy.

**1.5 Impact on seafarers**

.1 The proposals will have no impacts for seafarers.

**1.6 Positive Impacts**

.1 Accelerated development of low-carbon and zero-carbon fuels and technologies, facilitating reduced GHG emissions from ships and successful delivery of the 2050 levels of ambition of the initial strategy.

.2 Timely identification of low emission pathways which will mitigate the risk that resources are wasted developing measures which are later found to be ineffective whilst giving industry confidence to invest in measures which are identified as having a high emissions reduction potential.

.3 Provision of a multi-billion-dollar fund which would be available to support a wide range of research and development projects, many of which are expected to provide significant co-benefits such as improved public health and reduced local pollution.

.4 The proposals will be cost effective and will minimize the financial burden on individual shipowners, with no anticipated adverse consequences for trade or the economic interests of member states. No other potential proposals are considered able to match the effectiveness of this proposal for decarbonising shipping or this proposal's negligible negative impacts.

.5 Accelerated development of commercially viable low-carbon and zero-carbon emission ships, including ships engaged in transoceanic voyages.

.6 Positive cost reductions are anticipated in association with a specific research work stream focused on technical and operational innovations to lower the cost of transportation to Small Island Developing States (SIDs) and other remote locations.

**1.7 Negative Impacts**

.1 There would be a marginal increase in the cost of purchasing fuel oil for ships. The proposed mandatory contribution of two US dollars per tonne of fuel oil purchased for consumption is within the daily variability of marine fuel prices and would not significantly affect fuel cost. Therefore, the proposal will not impact the cost of maritime transport beyond existing exposure to daily fuel price variability.

.2 The IMRB has been designed to minimize administrative burden for both industry and member states, therefore the costs of establishing and maintaining the IMRB and IMRF, and costs of enforcement will have no negative impacts for member states.

**1.8 Quantification of Impacts**

.1 GHG reductions at least in line with the 2050 level of ambition of the initial strategy.

.2 Shipping transport cost impacts are expected to be within normal levels of commercial variability.

.3 There is expected to be no significant adverse impact on trade with significant positive impacts on maritime transportation as a result of the work undertaken through the IMRB.

.4 Potential benefits through reduction of transport costs to SIDs and remote locations as a result of specific research work stream.

**1.9 Will the measure result in any disproportionately negative impacts?**

.1 No.

**1.10 Expected workload for IMO**

.1 Development of an amendment to the MARPOL Convention or an alternative legal mechanism deemed appropriate by the Committee.

.2 Establishment of the necessary IMO oversight function to oversee the IMRB.

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# ZERO CARBON FUELS ACCELERATION

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## VERSION HISTORY, STUDY BOUNDARY CONDITIONS & DISCLAIMER

| Reference Number | Issued Date | Revision |
|---|---|---|
| RD19-003074-1 | 23 August 2019 | First issue. Unapproved draft for discussion. |
| RD19-003074-2 | 30 August 2019 | Second issue. Unapproved draft for discussion |
| RD19-003074-3 | 07 October 2019 | Third issue. Formally approved. Feedback included where appropriate. |

**Study boundary conditions:**

- Ricardo has prepared this concise report, within a 3 week time window, using their existing technical, environmental and market knowledge. No further quantitative analysis or predictions (either technical or financial) have been undertaken for this report beyond Ricardo's existing knowledge. Consequently, the forward-looking statements in this report are informed hypotheses and not expectations based on detailed forecasts or modelling.
- The report only considers technology aspects, not political aspects.

## EXECUTIVE SUMMARY

It is understood that the proposed 'International Maritime Research and Development Board' (IMRB) and its associated fund would collect Research and Development (R&D) contributions from shipowners globally and distribute the monies collected to activities which will meaningly contribute towards the development and deployment of zero carbon vessel power systems on board commercial ships. **A number of international shipowner associations have jointly commissioned this document as an initial independent high-level review covering only the technological aspects of the proposed fund.** This includes how the envisaged income, of around US$500 million per annum over a 10 to 12 year period, could hypothetically be utilised to accelerate the application of zero carbon technologies, consistent with the Initial IMO GHG Strategy, and what the potential benefits could be. It focuses on transoceanic shipping which presents the greatest challenge.

This document introduces some of the technical issues associated with the move to zero carbon considering battery and hybrid, hydrogen and ammonia technology. It explains the typical R&D process including Technology Readiness Levels (TRLs), provides example R&D case studies of projects which could be required, and it illustrates the breadth of projects the fund could support. Finally, the implications for vessel owners and operators are discussed.

The key technical issues with the three technologies are discussed:

- Battery hybrid systems suitable for transoceanic marine vessels are not yet commercially produced, so a significant number of R&D projects would be required to accelerate their development.
- The big challenges associated with hydrogen are around the safety of the fuel and the systems to store it on vessels. Further engine and fuel cell development would be required too.
- Ammonia has issues around its toxicity and emissions, whether used in reciprocating internal combustion engines or solid oxide fuel cells. Work is required to develop these technologies for ammonia and marine use respectively.

The potential to reduce $CO_2$ emissions is believed to be greatest for the transoceanic vessel sectors emitting the largest proportion of $CO_2$: the container, bulk carrier and liquid bulk tanker sectors. While much of the R&D is expected to be applicable across many sectors, there are expected to be some different solutions for each sector. These differences include vessel layouts to accommodate the zero carbon technologies, vessel sizes as well as different voyage power requirements.

It is hypothesised that the IMRB fund could support the development of approximately 200 technology and vessel sector combinations, which would be expected to reduce to approximately 20 on vessel demonstration projects as the technologies advance into the systems which are the most suitable solutions.

The IMRB fund benefits for vessel owner and operators would lie in the reduced risk of zero carbon technology adoption and accelerated pathways to commercial implementation. Similarly, ensuring that the solutions with good technical merit prevail, which should minimise future fuel or energy and maintenance costs.

This document suggests how the proposed fund could make a significant contribution towards accelerating the deployment of zero carbon propulsion systems and the achievement of GHG reduction targets for 2050 set by IMO.

  

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# ZERO CARBON FUELS ACCELERATION

## 1 INTRODUCTION

The proposed 'International Maritime Research and Development Board' (IMRB) and its associated fund is intended to collect funds and distribute these to activities which will contribute towards the development and deployment of zero carbon vessel power systems. This document discusses how the fund could be utilised to overcome the many vessel challenges associated with the deployment of zero carbon fuels for transoceanic shipping.

The IMO has set forward an ambition to reduce total annual GHG emissions by at least 50% by 2050 compared to 2008. To achieve this, given typical transoceanic vessel and power system lifetimes together with an anticipated continued growth in transoceanic shipping demand, will require the mainstream commercial deployment of zero carbon vessel power systems by around 2035. As such, the proposed fund would consider projects to be undertaken in the timeframe 2023 to 2035, which would then become available for mainstream deployment from around 2035.

It is understood that the fund would consider R&D of relevance to the application of new power system technologies to transoceanic ships. It would not consider funding of port bunkering infrastructure or any form of carbon offsetting. The development of new energy storage methods such as fundamental fuels or battery cell chemistry are not expected to be a focus for the fund so are not discussed in this report. The total fund is expected to be approximately US$5bn, generated by total contributions from shipowners of approximately US$500m per year.

**A number of international shipowner associations have jointly commissioned this document as an initial independent high-level review covering only the technological aspects of the fund, including how the fund could hypothetically be spent on transoceanic shipping and what the potential benefits could be.**

Ricardo is a global multi-industry and multi-discipline consultancy with over 100 years of experience in helping clients define the future. Its broad expertise includes developing power systems, environmental consulting and market and socioeconomic analysis.

## 2 VESSEL TECHNOLOGY AND TECHNOLOGY READINESS LEVELS

To develop zero or near zero carbon power systems for transoceanic shipping there are many possible technology pathways. These range from renewable fuels such as green hydrogen or ammonia through to alternative energy storage and power systems such as batteries, hybrid-electric and fuel cells provided they all utilise renewable energy. Fundamentally, for transoceanic shipping all these pathways require an energy dense method of storing renewable electricity. The alternative power systems either enable the use of these energy storage methods or the opportunity to improve power system efficiency. This document will focus on those solutions which are 'zero carbon' throughout their use and do not use carbon-based molecules as the fuel. Alternative carbon neutral technologies, such as Renewable Natural Gas (RNG) or methanol fuels that remove carbon from the atmosphere to manufacture fuels synthetically or from biomass sources, could also be capable of achieving the GHG reduction targets and might usefully also be the recipient of R&D Funds, but are not considered in this document. Similarly, the use of on-board Carbon Capture and Storage (CCS) using existing fossil fuels and power systems is not considered in this report.

  

Technology Readiness Levels (TRLs) are a standard method of estimating technology maturity, see Figure 2-1. TRL 1 is the initial scientific research, while TRL 9 is fully operational deployment of the technology on commercial shipping. The fund will concentrate on the development, demonstration and deployment phases (TRL 4 to TRL 8).

| TRL | Explanation | |
|---|---|---|
| 1 | **Basic principles** of scientific research observed and reported | Basic research, minor focus |
| 2 | **Invention and research** of practical applications | |
| 3 | **Proof of concept** with analytical and experimental studies to validate the critical principles of individual elements of the technology | |
| 4 | Development and validation of component in a **laboratory** | Development, major focus |
| 5 | **Pilot scale** testing of component in a simulated environment to demonstrate specific aspects of the design | |
| 6 | **Prototype system** built and tested in a **simulated environment** | |
| 7 | **Prototype system** built and validated in a **marine operational environment** | Demonstration, major focus |
| 8 | **Active commissioning** where the actual system is proven to work in its final form under expected marine operating conditions | Deployment, major focus |
| 9 | **Operational application** of system on a commercial vessel | |

**Figure 2-1: Technology Readiness Levels (TRLs)**

To develop a complete zero carbon vessel would require a significant number of new and adapted technologies, which are currently at different TRLs. Even technology used commercially in adjacent industries, such as electrical grid power generation, will have a low TRL for transoceanic shipping. As such development of multiple technologies would be required up to TRL 5, with some of these being combined into systems for TRL 6 and above. The complete zero carbon vessel will require many of these systems.

## 2.1 Battery and hybrid

Battery and hybrid vessels are already in commercial operation on some ferry routes (Ship Technology). The largest has a battery with a capacity of 5 MWh weighing 65 tonnes (Electrek, 2019) (Ulstein, 2019). However, transoceanic shipping's power requirements are vastly different.

A pure battery electric transoceanic ship would require an energy storage system of up to circa 15 Gigawatt hours (GWh) to complete a single transoceanic crossing depending on the vessel tonnage (Ricardo estimation). Using current battery cell technology this equates to a battery array of tens of thousands of tonnes, severely limiting the vessel's cargo carrying capacity. As of 2019, the largest battery array installation has an energy storage capacity of only 129 Megawatt hours (MWh), which is much less than 15 GWh, and is used to supplement an onshore wind farm (Hornsdale Power Reserve, 2019).

A hybrid vessel offers good fuel consumption improvement for applications with variable power demands. They can also offer the potential for zero non-carbon emissions from ship operation, which could be a legislative requirement in some ports by 2050. For transoceanic shipping a likely application would be entering and leaving ports.

Battery arrays are comprised of battery packs which are manufactured from modules containing individual cells. A battery management system would be required together with consideration of cell thermal management and ageing. While all these elements can be scaled, there will be considerable challenges developing a battery system of enough capacity to meet the requirements of a hybrid transoceanic vessel. A significant improvement in battery cell energy and power density would improve pure battery electric viability. This is an area of active research currently driven by the automotive industry.

The direct engine to propeller drive arrangement should be maintained with a hybrid system to preserve propeller and drive efficiency. This could require the development of low speed motors to match the speed of the two-stroke engines; technology could be used from the generators in direct drive wind turbines which are circa 10 MW (Siemens Gamesa, 2019).

Current TRLs for hybrid electric transoceanic shipping are estimated at between 4 to 6, although much of the technology is mature in other smaller applications. The vessel challenges are the scale of the electrical systems and the durability required. Additionally, the batteries must be mechanically robust in a harsh environment. TRLs are lower for alternative battery chemistry cells with improved energy density.

## 2.2 Hydrogen

Hydrogen produced using electrolysers powered by renewable electricity (as opposed to that derived from fossil fuels) or "green hydrogen" is considered zero-carbon. It can either be burnt in a reciprocating internal combustion engine or used in fuel cells. Spark ignited or dual fuel two stroke and medium speed engines are capable of operating on hydrogen with some modifications. There are several types of fuel cells which can operate using hydrogen, including proton exchange membrane fuel cells (PEMFCs) used in automotive applications and solid oxide fuel cells (SOFC) currently used for industrial stationary applications. Currently the largest have power outputs of a few MW (E4tech, 2018). Marine fuel cell systems are expected to involve hybrid designs to manage variations in load. Hydrogen ferries are currently under development using fuel cells and are expected to enter service in the early 2020s (DNV-GL, 2019).

Hydrogen can be transported as either a compressed gas or in liquid form. The former at pressures, typically in excess of 300 bar and the latter at cryogenic conditions (below -253 °C); both have a significant cost. Large scale storage of hydrogen on ships would require development of new vessel storage systems. The relatively low energy density of hydrogen compared to traditional fuel oils will make this more challenging.

Hydrogen safety poses significant vessel challenges where development and demonstration projects will be required. Other vessel challenges include determining which fuel cell type is most appropriate and scaling these to the transoceanic vessels' power demands, together with changes to standard vessel configuration to allow the storage of hydrogen. Due to flammability characteristics and the explosive nature of hydrogen, additional safety measures in a vessel must be deployed. Measures include hydrogen sensors, additional ventilation and electrical equipment that does not arc when switched.

Current TRLs for using hydrogen fuel in transoceanic shipping are estimated at between 3 and 5 for the various new technologies. The deployment of hydrogen fuels in other industries is modest.

## 2.3 Ammonia

"Green ammonia", which is produced using "green hydrogen", can either be directly burnt in a reciprocating engine or used in SOFCs. Indirectly it can be cracked to hydrogen for use in any hydrogen fuel cell. Ammonia typically needs a supporting fuel for use in reciprocating engines due to its combustion instability and high ignition temperature. For compression ignition this would be a typical dual fuel arrangement similar to current dual fuel LNG engines (for example HFO or renewable synthetic diesel as the supporting fuel). For spark ignition a proportion of hydrogen is expected to be required, which could be cracked from the ammonia upstream of the engine (Ash & Scarbrough, 2019). Leading engine manufacturer MAN has stated that their dual fuel two-stroke engines will be able to operate using ammonia once they have completed the engine development work. In total up to 3000 existing engines could be converted. (MAN Energy Solutions, 2018)

Compared to hydrogen, ammonia can be stored more easily and with less energy as it liquifies at a pressure of only 10 bar or at a temperature of -33 °C at atmospheric pressure. Bulk transport of liquid ammonia is already established using transoceanic gas carriers. It does not pose the same flammability concerns as hydrogen, although it is toxic. The marine industry would need to address this major toxicity challenge using the knowledge and experience of the chemical industry.

Ammonia can also be used as a refrigerant, meaning a possible synergy for vessels refrigerating their cargos.

Current TRLs for ammonia fuel in transoceanic shipping are estimated to be between 2 and 5. The current large-scale shipping of liquid ammonia together with more favourable storage capability than hydrogen compensate for the engine or fuel cell development required, the toxicity of the fuel, and the lack of technology available from other industries.

## 3 VESSEL SECTORS

The latest available $CO_2$ emissions by ship sector produced by the IMO are for 2012 (IMO, 2015). Figure 3-1 shows the range of $CO_2$ emissions for each vessel sector. The relative proportion will have changed since 2012 due to the relative growth or decline in different vessel subsectors. However, they are an indication of current $CO_2$. These are for international shipping, but removing ship types which are not transoceanic, such as ferries and the smaller 'general cargo vessels' (below ~15,000 dwt) results in the estimated split shown in Figure 3-2. This is a representation of expected transoceanic $CO_2$ emissions. The relative financial contributions to the fund from different vessel sectors are expected to be similar to these $CO_2$ estimates.

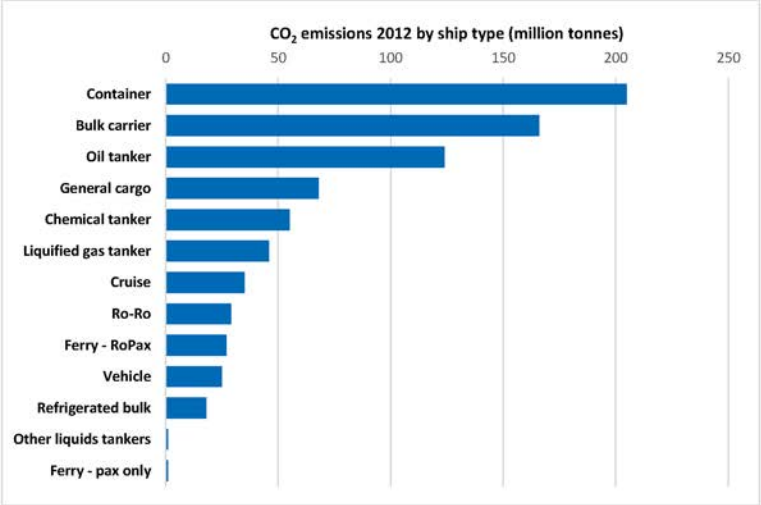


**Figure 3-1: Ship type $CO_2$ emissions 2012 (latest IMO data available) (IMO, 2015)**

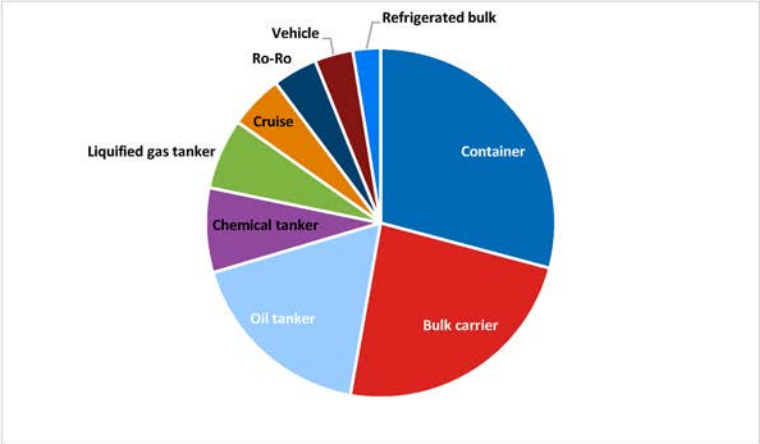


**Figure 3-2: Estimated distribution of transoceanic shipping $CO_2$ emission by ship type 2012**

The potential to reduce $CO_2$ emissions is greatest for the sectors emitting the greatest $CO_2$: the container, bulk carrier and liquid bulk tanker sectors.

Much of the R&D anticipated to be undertaken is expected to be applicable across these three sectors. Different solutions may be required for other sectors such as cruise, vehicle carriers and refrigerated bulk.

Differences between sectors are likely to be related to the vessel layout configuration to accommodate the zero carbon power and energy systems around the cargo types.

Variations within each sector, such as vessel sizes and operational routes, may cause variations in technological solutions, and therefore differences in R&D projects. Differences in operation, such as speed and routes, depend not only on the vessel type, but whether a vessel is engaged in the liner or tramp trade.

## 4 POTENTIAL R&D AND CASE STUDIES

To determine which technologies are most appropriate for different vessel types and operation, it is expected that it will be necessary to progress development with hybrid battery, hydrogen, and ammonia energy simultaneously. For each zero carbon energy storage method, a wide range of new vessel-based technologies and systems will be required. Each of these technologies and systems will require project(s) to progress their technology readiness. Some of these projects may be relatively small, especially at the mid TRLs of 4 and 5 where simulation tools can be used; a fund contribution of circa US$1m or less per project is likely to be appropriate. However, at later TRLs where full transoceanic demonstrators and full sea trials are required, a fund contribution in excess of US$20m per project is likely to be appropriate, considering only the cost of the new equipment and excluding the ship cost. It is assumed that the fund contributes between 30% to 50% of the R&D costs. Therefore, a project with a fund contribution of US$1m could have a total cost of US$2-3m and a fund contribution of US$20m could have a total cost of US$40-60m.

Where there are gaps in the technology required to enable a concept zero carbon energy storage system to safely and reliably function, low TRL research projects may be required which would be carried out as applied research typically by a university. These projects may not become apparent until sufficient development of other technologies.

It is anticipated that at least circa 200 projects would be required to enable widespread deployment of zero carbon transoceanic vessels (this is explained in Section 5). To illustrate, six case studies are presented covering possible example projects which could be funded. (The example case studies are provided for indication only and do not imply that these are viable or justifiable projects, without further detailed appraisal.) These cover projects with fund contributions of both circa US$1m and greater than US$20m for the three zero carbon energy solutions.

### 4.1 Case study 1: Maintenance of battery systems (circa US$1m)

Battery systems installed on transoceanic shipping are likely to require ongoing maintenance and replacement of battery modules to enable the full range to be utilised. This will include replacement when at sea by the ship's crew. The development of equipment and procedures are expected to be required to allow this to be carried out safely. While equipment to replace battery modules exists in other sectors, a different approach may be needed given the size of the battery installations.

| **Maintenance of battery systems** | | |
|---|---|---|
| *Vessel system:* | Energy storage | *Project deliverables:* |
| *Vessel sector:* | All | Design and development of equipment for safe removal of battery modules at sea, including an on-ship battery systems workshop |
| *TRL estimate:* | 4 to 7 | |

### 4.2 Case study 2: Battery array design and analysis (greater than US$20m)

Battery systems require bespoke development for the specific application. This is needed to account for the expected power draw over the operational duty cycles and the battery state of charge, as well as other factors such as shock loading, vibration and cell temperature management. As part of the design and development, these factors will need to be modelled to ensure sufficient durability of the battery pack. Development of a single, large battery pack design is typically in the order of US$10m. While a modular approach is expected, there may need to be several different base battery pack designs to ensure maximum utilisation and durability of the battery array system.

The battery arrays will also need design and development to package within the vessel without compromising significant cargo capacity as well as further considerations including sufficient thermal management and design for maintenance.

Follow on projects will include the manufacture and testing of the battery pack, including a vessel demonstrator.

  

| **Battery array design and analysis** | | $$$$ |
|---|---|---|
| *Vessel system:* | Energy storage | *Project deliverables:* |
| *Vessel sector:* | Array specific to each vessel class<br>Pack applicable across classes | Design and analysis of a transoceanic battery array for a hybrid power system in a specific vessel class.<br>Design and analysis of modular base battery packs for transoceanic hybrid requirements |
| *TRL estimate:* | 5 to 6 | |

### 4.3 Case study 3: Safe engine room concept with hydrogen (circa US$1m)

Safe engine room (or 'fuel cell machinery' room), including fire suppression systems, will be needed throughout any vessel operating on hydrogen. These systems will need to be developed and proven by rig demonstration.

This project would consider methods for hydrogen detection and prevention of hydrogen build up by trialling different sensors and engine room designs through modelling. A scale model of the chosen design would be built to prove the concept. Further projects would be required to consider engine room fire suppression systems.

| **Safe engine room concept with hydrogen** | | $H_2$ $ |
|---|---|---|
| *Vessel system:* | Engine room | *Project deliverables:* |
| *Vessel sector:* | All | Proven guidelines to ensure safe ventilation of hydrogen with transoceanic shipping |
| *TRL estimate:* | 5 to 7 | |
| *Other:* | SOLAS | |

### 4.4 Case study 4: 50 MW hydrogen fuel cell system manufacture, testing and development (greater than US$20m)

Current fuel cell systems are available up to several MWs in power. These systems will need to be scaled up to provide the required power of a transoceanic ship. Whether the actual fuel cells are arranged as modules, or designed as fewer larger fuel cells, projects are required to manufacture and validate the full fuel cell system design through testing. The testing is likely to reveal areas which will require further development.

The system to be tested would likely include a fuel delivery system, heat transfer system, power electronics and control systems. If larger fuel cells are required for a modular array, significant work will also be required to test the fundamental fuel cell design.

Following iterations of development, further projects will be required to test these fuel cell systems on vessels.

| **50 MW hydrogen fuel cell system, testing, validation and development** | | $H_2$ $\$\$\$\$$ |
|---|---|---|
| *Vessel system:* | Power system | *Project deliverables:* |
| *Vessel sector:* | All | 50 MW fuel cell system manufactured and then tested on-shore over a range of different operating and ambient conditions |
| *TRL estimate:* | 4 to 7 | |

### 4.5 Case study 5: Ammonia cold start emissions strategy, (circa US$1m)

When starting the power system of an ammonia power system, the exhaust gas and aftertreatment system will start cold. During this phase conventional ammonia slip catalysts and selective catalytic reduction (SCR) systems will not be effective at reducing ammonia and $NO_x$ emissions to acceptable levels respectively. Therefore, a solution needs to be developed to prevent release of ammonia droplets into the air, which as toxic, could potentially harm anyone in the vicinity such as residents local to a port or any crew on deck. The solution could be an ammonia storage catalyst specifically designed for low temperatures.

This project is required to develop a control strategy and / or technology to reduce ammonia emissions to acceptable levels to meet various national emissions limits. Further projects are required to develop a demonstration of the strategy on board a vessel with emissions monitoring equipment.

This technology is applicable to both ammonia reciprocating internal combustion engines and ammonia SOFCs, the latter which typically emit some ammonia during the fuel conversion process.

| **Ammonia cold start emissions strategy** | | $NH_3$ $\$$ |
|---|---|---|
| *Vessel system:* | Power system | *Project deliverables:* |
| *Vessel sector:* | All | Development of a strategy and technology system to prevent release of ammonia into the atmosphere |
| *TRL estimate:* | 4 to 5 | |
| *Other:* | Environmental | |

### 4.6 Case study 6: Waste heat recovery demonstration in vessel with ammonia fuel cell (greater than US$20m)

SOFCs (and to some extent internal combustion engines) using ammonia will have a different temperature grade of waste heat to that of current fuel oil or natural gas internal combustion engines. A system developed to optimise the waste heat recovery for ammonia will require testing on a transoceanic ship. This project is to verify the previous design, analysis and simulation projects to ensure that the system functions reliably and provides the required power and heat under commercial vessel operating conditions.

| **Ammonia cold start emissions strategy** | | $NH_3$ $\$\$\$\$$ |
|---|---|---|
| *Vessel system:* | Power system | *Project deliverables:* |
| *Vessel sector:* | All | On vessel demonstration system for use under commercial shipping activities |
| *TRL estimate:* | 7 to 8 | |

## 5 IMPACT OF THE R&D FUND

### 5.1 Potential for comprehensive R&D of multiple technology paths

Considering battery, hydrogen, and ammonia energy storage alone, this document has highlighted a number of possible projects and technologies. These are a small example of the overall number of projects required; Ricardo has identified over 50 different technologies, systems and problems requiring development to support the application of ammonia alone. Taking an ammonia powered reefer (refrigerated container vessel) as an example the following need to be considered, and each of these have many systems and sub-systems which will need to function reliably:

- Fuel storage
- On vessel fuel transportation
- Propulsion
- Auxiliary power
- Waste heat recovery
- Refrigeration
- Emissions
- Engine room safety
- Wider vessel safety
- Vessel configuration
- Voyage adjustments and more

Considering battery, hybrid and hydrogen as well as other possible zero carbon fuels across multiple vessel sectors, it could be plausible to investigate in excess of 200 different technologies.

Each of these technologies would need to be progressed to a level to determine whether they are applicable for transoceanic marine applications. Figure 5-1 illustrates the possible number of projects which the fund could support at each TRL. A typical project would be similar to those identified in the case studies in Section 4 and would advance the technology

readiness. Figure 5-2 illustrates a possible fund contribution for each type of project; for simplicity these are the contributions assumed to progress a technology by one TRL. Combining the number of projects and the estimated project costs results in an estimated total fund contribution of approximately US$5bn plus administration costs. Development of each TRL would be expected to take between 6 months and 2 years, requiring the fund to operate for at least circa 12 years (to advance TRL 4 to 9). Therefore, a fund, with an income of circa US$500m per annum operating between approximately 2023 and 2035, could make a significant contribution towards accelerating the development and deployment of new zero carbon technologies.

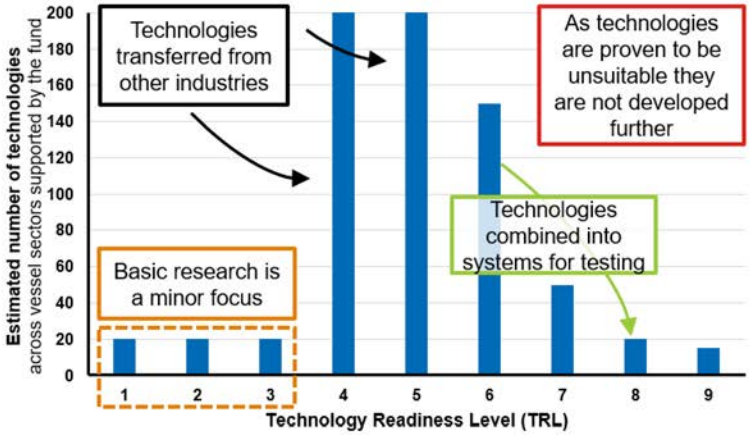


**Figure 5-1: An example of the estimated number of projects the fund could support as technologies develop through the TRLs (Ricardo)**

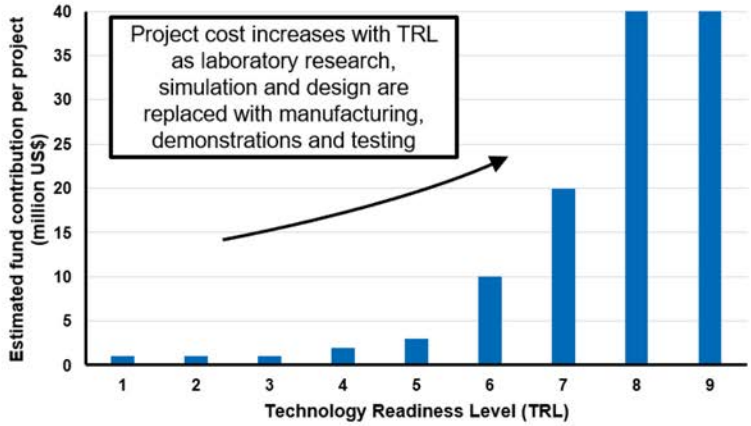


**Figure 5-2: Example of the estimated average fund contribution to projects (at 30% to 50% funding) to develop a technology through one TRL (Ricardo)**

### 5.2 Impacts on ship development

While the fund will only apply to vessel technology, it is expected that it will have a "pull" effect on investment in zero carbon technologies by other parties, multiplying its impact. One example being that fuel companies and engine manufacturers will often not seriously invest in developing fundamental novel technology until a demand exists. The shipping industry will often not develop vessels until the technology exists. Therefore, using the fund to develop demonstrator vessels should help overcome this impasse by creating a situation where zero carbon technologies are under development thereby expanding the level of activity and investment in maritime technologies.

### 5.3 Impacts on shipping companies

The fund would be expected to reduce the impact of the complex transoceanic transition to zero carbon fuels. While naval architects, ship yards and other manufacturing and research companies will benefit, there is expected to be a long-term benefit to the vessel owners and operators. These include:

- **Reducing the impact of the complex transition process:** Documented trials with the technologies should enable more of the issues to be fixed prior to commercial use, meaning more robust technology applied to commercial vessels.
- **Giving opportunities for the solutions with good technical merit to prevail:** The size of the fund means that a range of technologies can be properly assessed by ship owners and operators, so informed decisions can be made by the shipping industry and used as a market "pull".
- **Inclusion of owners and operators in R&D:** It is normal for projects supported by funds to require the inclusion of end users in the projects at later TRLs. This should allow the owners and operators an opportunity to influence the technology direction.
- **Whole ship optimisation:** R&D is split across engine OEMs, naval architects, ship builders, owners and operators. An R&D fund should respond to bids for the funding which are from integrated collaborations, so the marine industry should end up with more optimum ship-level zero carbon solutions.
- **Lower overall industry R&D costs:** Other industries are spending more on R&D. As an example, German automotive manufacturers collectively spent circa US$12bn on R&D for transitioning to zero carbon energy products in 2018 alone (Ricardo analysis, 2019). A marine R&D fund should also help avoid costly company competitive R&D replication, which in turn should help limit the R&D costs passed on to those purchasing zero carbon ships and in turn those chartering. Deciding on a technology path more quickly can also have the same impact.
- **Accelerated capital cost reduction:** The R&D acceleration provided by the fund should also accelerate the reduction in manufacturing costs, particularly for the relatively immature high power fuel cells and to some extent battery arrays too. This in turn should be reflected in the capital costs of technologies.
- **Quicker transition to zero carbon technology:** The fund should allow technology to be introduced into the fleet in a managed and structured way. This should reduce the risk of imposition of punitive measures for failing to meet targets as well as lowering the total $CO_2$ released into the atmosphere.
- **Quicker elimination of unsuitable technology:** The fund could accelerate a conclusive assessment of which fuels and energy storage are not suitable, and

therefore narrow the range of possible technologies for further development. This will help prevent uncertainty among shipping companies as to which technology to invest in. It will reduce the risk of adopting such a large step change in propulsion and energy storage technology.

## 6 CONCLUSIONS

The 'International Maritime Research and Development Board' (IMRB) and its associated fund could support the vessel development of a range of zero carbon fuels and energy storage such as ammonia, hydrogen, and batteries. It would help determine which methods are suitable for different vessel types, and which methods are unsuitable for any transoceanic vessel. This would narrow the range of possible technologies which should reduce the risk of investment in R&D for the industry towards 2035.

Each zero carbon fuel or energy storage method will require many different supporting on-vessel technologies. Battery and hybrid technologies are mature in other markets, but significant development is required to transfer these to marine applications. Ammonia and hydrogen are less mature and again significant marine development is required. The fund could support the development of new transoceanic technologies through TRL 4 to 9. Approximately 200 technologies could be supported through TRLs 4 and 5, which would be expected to reduce to approximately 20 on vessel demonstration projects as the technologies advance into systems in TRLs 8 and 9.

The fund's investments are expected to create a pull effect on investment in zero carbon technologies by other parties, multiplying its total impact to transoceanic shipping. It should give an opportunity for the energy and power systems solutions with good technical merit to prevail, while considering the whole vessel through structured collaboration.

The fund benefits for vessel owner and operators lie in this reduced risk of zero carbon technology adoption, which should limit the vessel purchase cost through reduced competitive R&D spend and accelerated manufacturing cost reductions. Similarly, ensuring that the solutions with good technical merit prevail should limit fuel or energy and maintenance costs.

A fund, with an income of circa US$500m per annum operating between approximately 2023 and 2035, could make a significant contribution towards accelerating the development and deployment of new zero carbon technologies for transoceanic vessels.

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**U.S. Senate Committee on Energy and Natural Resources**
**December 10, 2019 Hearing: To Examine the Upcoming Implementation of the International Maritime Organization's New Global Sulfur Standard for Marine Fuels, Which is Set to Take Effect on January 1, 2020**
**Questions for the Record Submitted to Mr. Derrick Morgan**

**Questions from Senator John Hoeven**

***Question 1:*** *Mr. Morgan, your testimony mentions "For upstream U.S. oil producers, IMO 2020 is expected to increase international demand for light/sweet crude oil." North Dakota is an energy powerhouse. Our state's total energy production is 6 times greater than our energy consumption, and we have abundant reserves of light-sweet crude oil. Having the necessary infrastructure to transport energy from where it's produced to where it's consumed is critical.*

*Would you agree that we will need more energy infrastructure, including pipelines, to take advantage of this increased demand?*

AFPM has been and continues to be a vocal advocate for U.S. energy infrastructure and the development of policies which encourage its growth to meet increased energy needs and consumer demand. In June 2018 AFPM released a report entitled "Fuel & Petrochemical Supply Chain Report" highlighting the importance of increased investment in energy infrastructure, particularly pipelines. There report can be accessed at: https://www.afpm.org/system/files?file=attachments/Supply-Chain-Report-2018.pdf.

Growing domestic production of crude oil and natural gas, expanding capacity at refining and petrochemical facilities, and higher manufacturing utilization rates have increased our energy security, supported robust economic growth, spurred job creation, enabled access to affordable energy and improved the quality of life for all Americans.

U.S. crude oil, and natural gas production (as well as associated Natural Gas Liquids, an important petrochemical feedstock) have surged in recent years and the Energy Information Administration projects continued growth in U.S. production in the coming decade. U.S. refineries and petrochemical facilities, which are among the most sophisticated and efficient in the world, are taking full advantage of increasing U.S. crude oil and natural gas production. These industries are expanding capacity, optimizing operations and increasing utilization rates to meet growing global demand for fuels and petrochemical feedstocks.

Bringing the benefits of this energy renaissance to U.S. consumers requires "midstream infrastructure" – the integrated system of pipelines, ports and waterways, railroads, roadways, and storage facilities that support moving America's energy supplies from producer to consumer. Midstream infrastructure is the essential link between upstream production fields where oil, natural gas and NGLs are produced, to refineries and petrochemical manufacturing facilities where raw materials are turned into fuels and other essential goods. Midstream infrastructure also links refineries and petrochemical plants to consumers, moving fuels from refineries to regional storage terminals to retail outlets, and petrochemical products from the plants that produce them to the manufacturing facilities that turn them into myriad everyday consumer products that make modern life possible.

For this energy renaissance to continue, crucial new infrastructure investments are essential. Expanded investment in America's petroleum and petrochemical midstream infrastructure is essential to fully capitalize on America's energy renaissance.

**U.S. Senate Committee on Energy and Natural Resources**
**December 10, 2019 Hearing: To Examine the Upcoming Implementation of the International Maritime Organization's New Global Sulfur Standard for Marine Fuels, Which is Set to Take Effect on January 1, 2020**
**Questions for the Record Submitted to Mr. Derrick Morgan**

***Question 2:*** *What are some of the existing barriers to constructing new pipeline capacity?*

Energy infrastructure developments (particularly pipelines) often face numerous challenges, including lengthy and duplicative permitting processes with multiple federal, state and local agencies; legal challenges by project opponents designed to block or delay construction from moving forward; an uncertain regulatory environment; and even attempts by project opponents to physically damage infrastructure or hinder construction.

AFPM acknowledges the need for robust analyses of infrastructure projects to ensure that environmental impacts are appropriately considered. Yet, the current permitting processes and regulatory requirements often hinder needed infrastructure developments. Efforts to reform permitting processes should promote accountability for reviews and ultimately reduce the costs and burdens of delayed infrastructure projects by eliminating duplicative actions, ensuring consistency in reviews and providing timely and predictable review schedules

**U.S. Senate Committee on Energy and Natural Resources**
**December 10, 2019 Hearing: To Examine the Upcoming Implementation of the International Maritime Organization's New Global Sulfur Standard for Marine Fuels, Which is Set to Take Effect on January 1, 2020**

**Questions for the Record Submitted to Mr. Neelesh Nerurkar**

**Questions from Senator Maria Cantwell**

**Question 1:** *What are the relative pros and cons of using LNG to power ocean going vessels versus lower sulfur fuels currently being used in an ECA area like Puget Sound?*

Response: Our Firm does not address marine fuel issues specific to Puget Sound, but we can describe key issues that stakeholders could consider regarding LNG as a marine fuel in ECAs. LNG has lower sulfur and nitrogen oxide emissions than petroleum fuels.[1] LNG can also cost less. On an energy-equivalent basis, the price of LNG was ~39% lower than marine gasoil (MGO) and ~9% less than heavy fuel oil (HFO) in the U.S. Gulf Coast based on October 2019 data reported by the Energy Information Administration (EIA) and Bloomberg.[2]

Key challenges for LNG as a bunker fuel include the higher up-front costs for LNG-fueled ships and the limited availability of LNG fueling infrastructure. A January 2019 study by LNG bunkering trade association Sea\LNG found that a new LNG-fueled container vessel may cost $9-15 MM more than a similar petroleum-fueled ship. According to a February 2019 Congressional Research Service report, two U.S. ports have LNG bunking facilities, Jacksonville, Florida and Port Fourchon, Louisiana, and firms have proposed LNG bunking projects for Tacoma, Washington and Port Canaveral, Florida.

**Question 2:** *A report last year found that maritime-related sulfur dioxide emissions in the Puget Sound airshed plummeted by 96 percent between 2011 and 2016. That's great, but unfortunately, we have seen very minor decreases in maritime-related greenhouse gas emissions. What more can the shipping industry be doing to reduce their contribution to climate change and ocean acidification? How could a U.S. price on carbon or greenhouse gas emissions impact shipping industry fueling decisions?*

Response: In 2018, the International Maritime Organization (IMO) adopted an initial greenhouse gas (GHG) reduction strategy that sets long-term targets for the intensity and level of emissions from ships. The IMO aims to reduce the $CO_2$ intensity of shipping by 40% from 2008 levels by 2030 (in shorthand, 40%/2008/2030) and 70%/2008/2050. It also aims to cut the level of GHG emissions by 50%/2008/2050. The organization is in the process of developing measures by which the industry could meet these targets. The IMO last convened members to discuss options at an Intersessional

[1] Whether LNG emits fewer greenhouse gas (GHGs) may depend on analytical parameters. As part of ongoing IMO discussions on how to meet GHG targets, the Clean Shipping Coalition, a group of environmental NGOs, submitted a paper to the IMO last year challenging the GHG benefit of LNG for marine use versus MGO or heavy fuel oil (HFO) due to methane leakage:

> *[...] LNG has substantial methane emissions throughout the supply chain (well-to-wake), which means that even with the use of high-pressure engines, with lower methane slip, the overall life cycle analysis would show little or no carbon savings and, in many cases, worse performance compared to HFO/MGO.*

[2] MGO meets ECA requirements. HFO can be used in ships with exhaust gas cleaning systems. Gulf Coast HFO prices have fallen since October but remain above October LNG prices, the latest month we have EIA reported LNG prices.

**U.S. Senate Committee on Energy and Natural Resources**
**December 10, 2019 Hearing: To Examine the Upcoming Implementation of the International Maritime Organization's New Global Sulfur Standard for Marine Fuels, Which is Set to Take Effect on January 1, 2020**

**Questions for the Record Submitted to Mr. Neelesh Nerurkar**

Working Group on Reduction of Greenhouse Gas Emissions (ISWG) session in November 2019, where it focused on short term measures to reduce GHGs. The ISWG is receiving and deliberating on emissions reductions proposals before making a recommendation to the Marine Environment Protection Committee, the IMO's decision-making body on emissions issues. The ISWG plans to take up short-term measures again at its next meeting, March 23-27.

A price on carbon or GHGs in the United States that applied to maritime fuels could create a disincentive for ships fueling in the United States to use hydrocarbon fuels. MGO combustion emits ~3,206 $kgCO_2$ per metric ton (Mt) according to the IMO's Third GHG Study. For example, a $20/$MtCO_2$ surcharge would correspond to ~10% of the 2019 average spot price of MGO in Houston of $615/Mt reported by Bloomberg.

**Question 3**: *While I appreciate that it took many years to reach the international consensus necessary to make IMO 2020 possible, do you believe the IMO can or should do more to reduce shipping emissions in the future?*

Response: As mentioned above, the IMO set long-term climate targets, and the organization is working to develop measures by which the international shipping industry can meet them. The 2020 sulfur cap transition provides some context for GHG reductions. Shipping and energy industries tend to use long-lived, capital-intensive assets, which can make transitions costly and slow. The 2020 sulfur cap process required immense change within a short interval, despite more than a decade of lead-time. Much of the new marine fuel needed to meet the 2020 sulfur cap comes from the same refineries and move via the same transportation infrastructure as fuel prior to its implementation. Cutting the shipping industry's GHG footprint in half would very likely require significant use of new low carbon marine fuels. Industry appears to be considering long-term options such as advanced biofuels, hydrogen and ammonia. These fuels would probably be produced at different types of facilities, and they are likely to require alternative transportation infrastructure. Consequently, meeting the IMO's GHG targets seems more challenging than meeting sulfur targets. In this context, quick, clear and resolute agreement at the IMO on measures to reach GHG targets may be more likely to attract needed investment in a timely manner. A graduated approach to GHG emissions reductions ahead of 2050 may reduce concerns around abrupt market dislocations.

**U.S. Senate Committee on Energy and Natural Resources**
**December 10, 2019 Hearing: To Examine the Upcoming Implementation of the International Maritime Organization's New Global Sulfur Standard for Marine Fuels, Which is Set to Take Effect on January 1, 2020**
**Questions for the Record Submitted to Mr. Jamie Webster**

**Questions from Senator Maria Cantwell**

**Question 1:** What are the relative pros and cons of using LNG to power ocean going vessels versus lower sulfur fuels currently being used in an ECA area like Puget Sound?

**Response:** The pros of using LNG as a ship fuel include lower emissions from sulphur and nitrogen oxides, as well as reduced carbon dioxide, a greenhouse gas.

The cons include a significantly higher capital cost, and the size of the engine and fuel tanks is substantially larger, reducing the amount of cargo that can be carried.

**Question 2:** A report last year found that maritime-related sulfur dioxide emissions in the Puget Sound airshed plummeted by 96 percent between 2011 and 2016. That's great, but unfortunately, we have seen very minor decreases in maritime-related greenhouse gas emissions. What more can the shipping industry be doing to reduce their contribution to climate change and ocean acidification? How could a U.S. price on carbon or greenhouse gas emissions impact shipping industry fueling decisions?

**Response:** As a new resident to the Pacific Northwest that is great news. The shipping industry is on a path to further reduce greenhouse gas emissions through the IMOs plan to reduce greenhouse gases by at least 50% by 2050. BCG analysis indicates that the world shipping fleet reduced CO2 emissions 10% from 2011-2016, with emissions per ship falling 20%. Additional steps that can be taken include:

- Slow steaming (a process of slowing the vessel down, reducing fuel burn and emissions but in exchange for a longer transit time), which the industry has applied since the late 2000's in response to high oil prices.
- Improved hull design, the use of advanced paints to reduce drag, as well as propeller optimization
- Using shoreside electrical power while at berth, allowing engines to be turned off as the ship is run off the grip.

**Question 3**: While I appreciate that it took many years to reach the international consensus necessary to make IMO 2020 possible, do you believe the IMO can or should do more to reduce shipping emissions in the future?

**Response:** I believe the IMO's successful implementation of IMO 2020 is likely to give it confidence that it can implement further measures to improve shipping emissions in the future.


Honorable Lisa Murkowski
Chair, Committee on Energy and Natural Resources
United States Senate
304 Dirksen Senate Office Building
Washington, DC 20510

December 9, 2019

Dear Chairman Murkowski:

ConservAmerica represents thousands of conservatives and other citizens who are dedicated to creating and supporting practical solutions for today's environmental, energy, and conservation challenges. Our core belief is that a strong economy and a clean environment go hand-in-hand.

We write to offer our views in connection with the Committee's December 10, 2019, hearing on the International Maritime Organization's (IMO) new global sulfur standard for marine fuels, which is set to take effect on January 1, 2020, and is informally known as IMO 2020.

As you know, IMO 2020 will require the reduction of sulfur content in maritime bunker fuel to 0.5%. ConservAmerica has monitored developments regarding IMO 2020 and while we have expressed reservations in the past, we recognize that significant progress that has been made to prepare for this rule. Therefore, we support its timely implementation.

Refiners and shippers have been aware of the required changes related to IMO 2020 for over a decade. Experts have found that changes in fuel should not affect U.S. supply chains, meaning that IMO 2020 can be implemented on time with little to no impact on consumers. Actual petroleum product prices are far more sensitive to crude market developments than to anything related to IMO standards. Indeed, the timely implementation of IMO 2020 is one of the few initiatives with the strong support of the environmental community, refiners, and the shipping industry.

ConservAmerica believes that market-based solutions are an important element of environmental compliance. In the case of IMO 2020, meeting the deadlines long envisioned under this program allow for the regulated community to realize the full potential of significant investments in enhanced flexibility at refineries. In addition, IMO 2020 can stimulate the development of new markets for other clean maritime fuels like liquefied natural gas. As a recent analysis from


Lazard Asset Management stated that the U.S. "is very well placed" to take advantage of "big emerging markets" for cleaner maritime fuels resulting from IMO 2020.

The significant benefits for American energy markets described above can be realized while slashing marine-sector air emissions in international waters, thereby constituting the largest reduction in the sulfur content of fuel undertaken at one time. IMO estimates that this new standard will prevent over 570,000 premature deaths between 2020 and 2025.

As we have stated before, we endorse the IMO goals, as maritime sulfur pollution presents a threat to human health and the environment. We look forward to the timely implementation of IMO 2020 and all the benefits that it will provide.

Sincerely,

Jeffrey Kupfer
President
ConservAmerica

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