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

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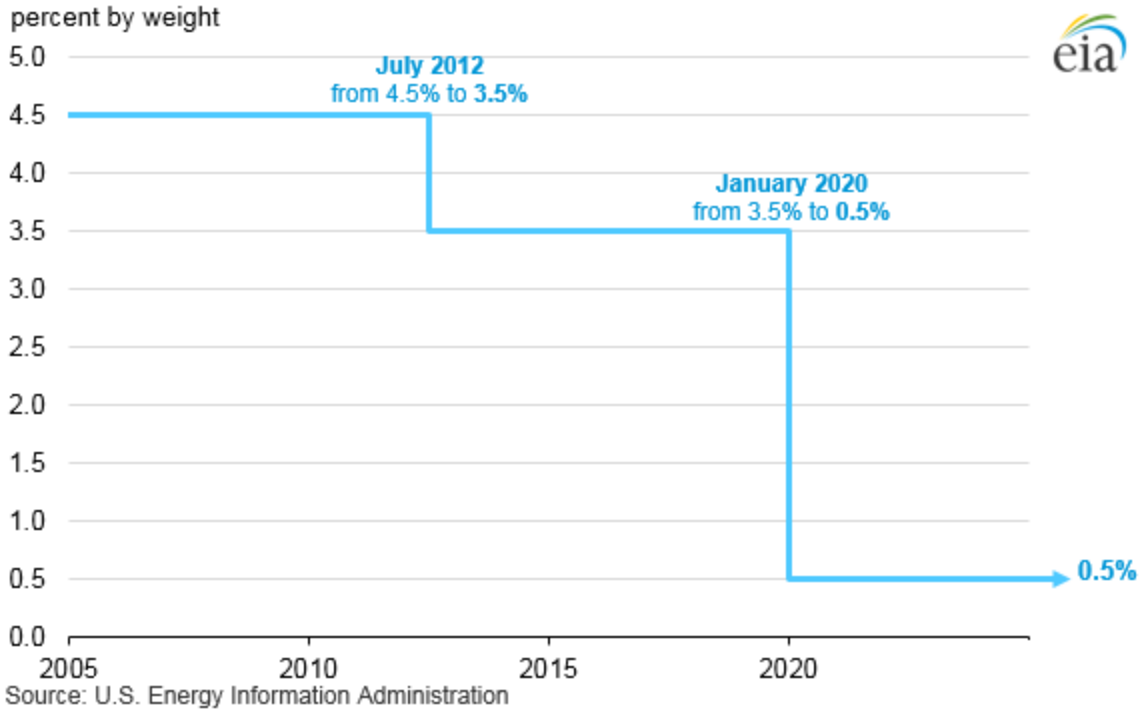
Introduction

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.

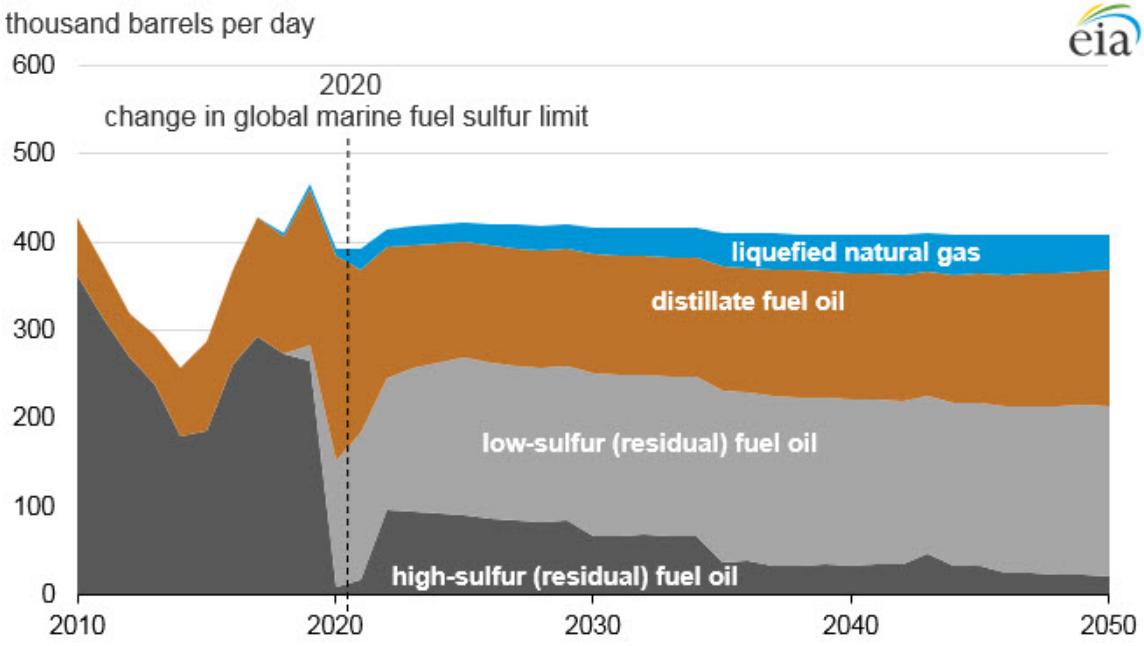
Operators of marine vessels have several options for complying with IMO 2020 sulfur limits. They can switch their ships to a lower-sulfur fuel that complies with the new IMO rules, which would likely increase demand for distillate and low-sulfur residual oils. Another option is to use scrubbers to remove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

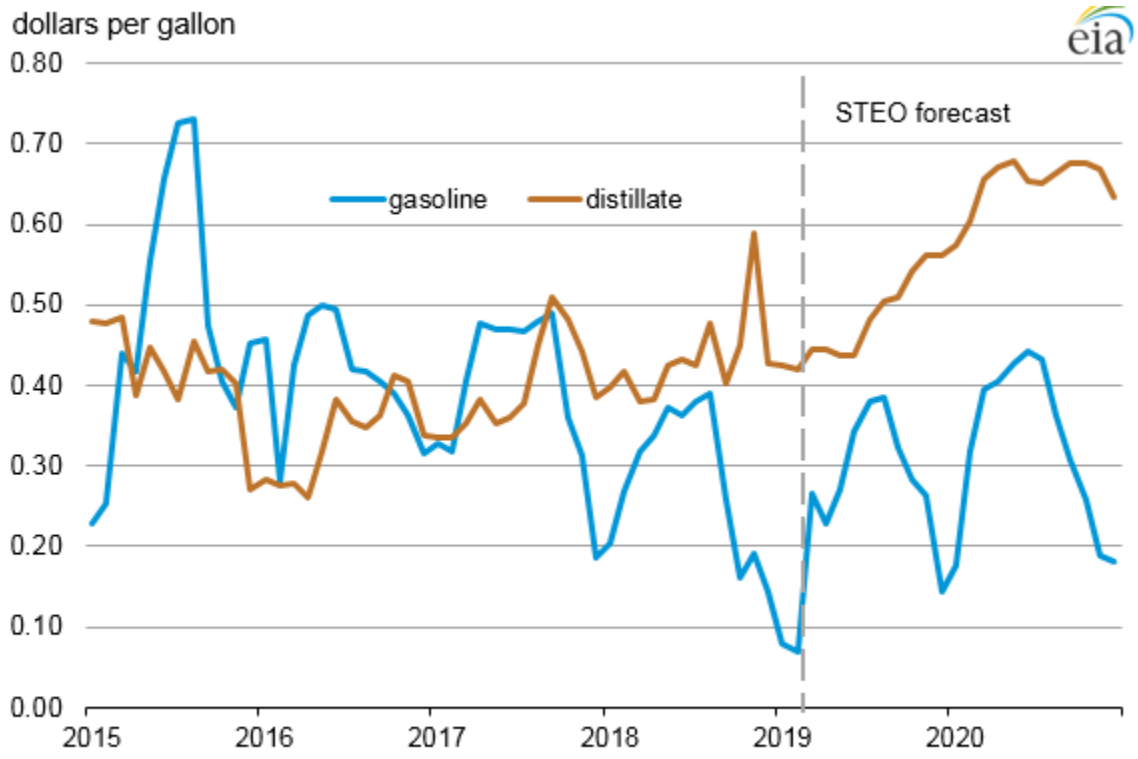
Outside of residual fuel oils and distillate, STEO forecasts that the use of LNG in marine bunkering will be limited through 2020. Similarly, the AEO2019 Reference case projects limited use of LNG in the next five years, reflecting the high initial infrastructure development cost and the limited current 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.

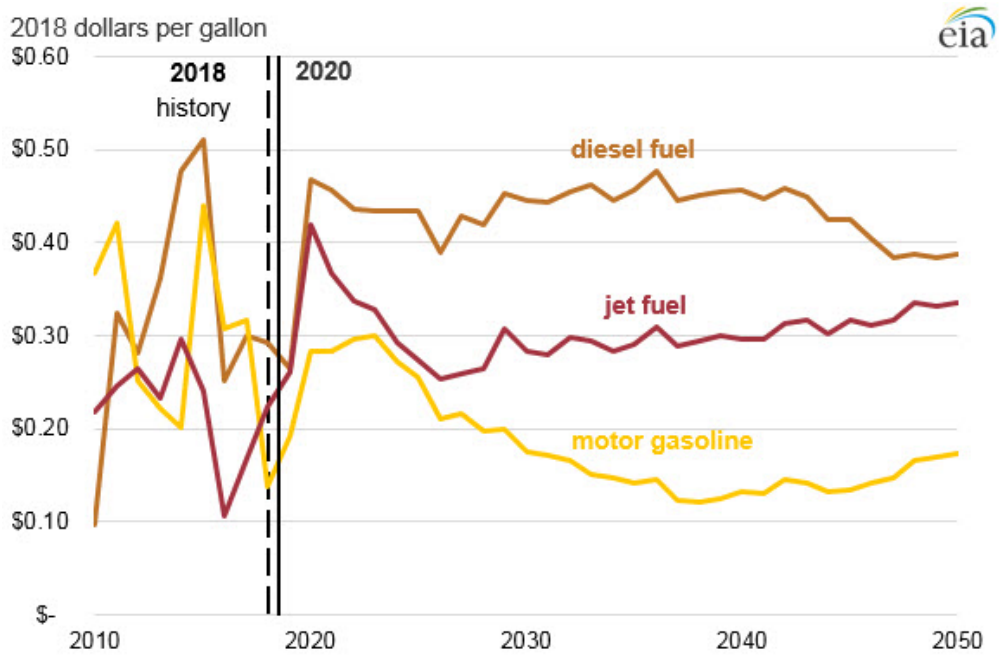
Figure 3. U.S. refinery margins



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



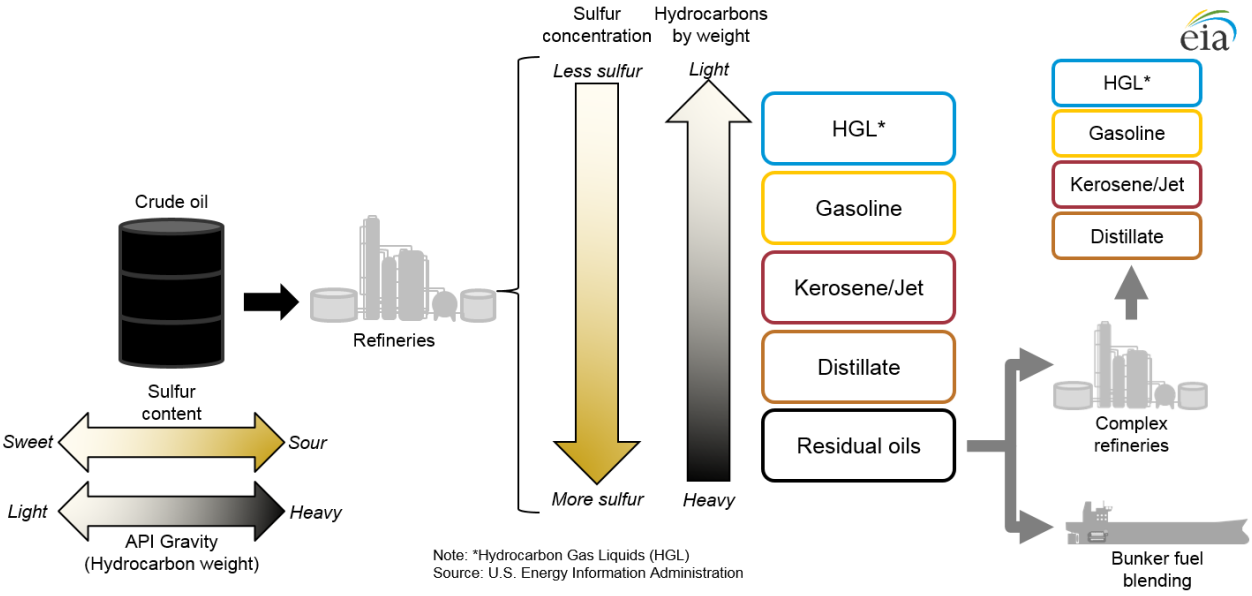
Source: U.S. Energy Information Administration, AEO2019 Reference case

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.

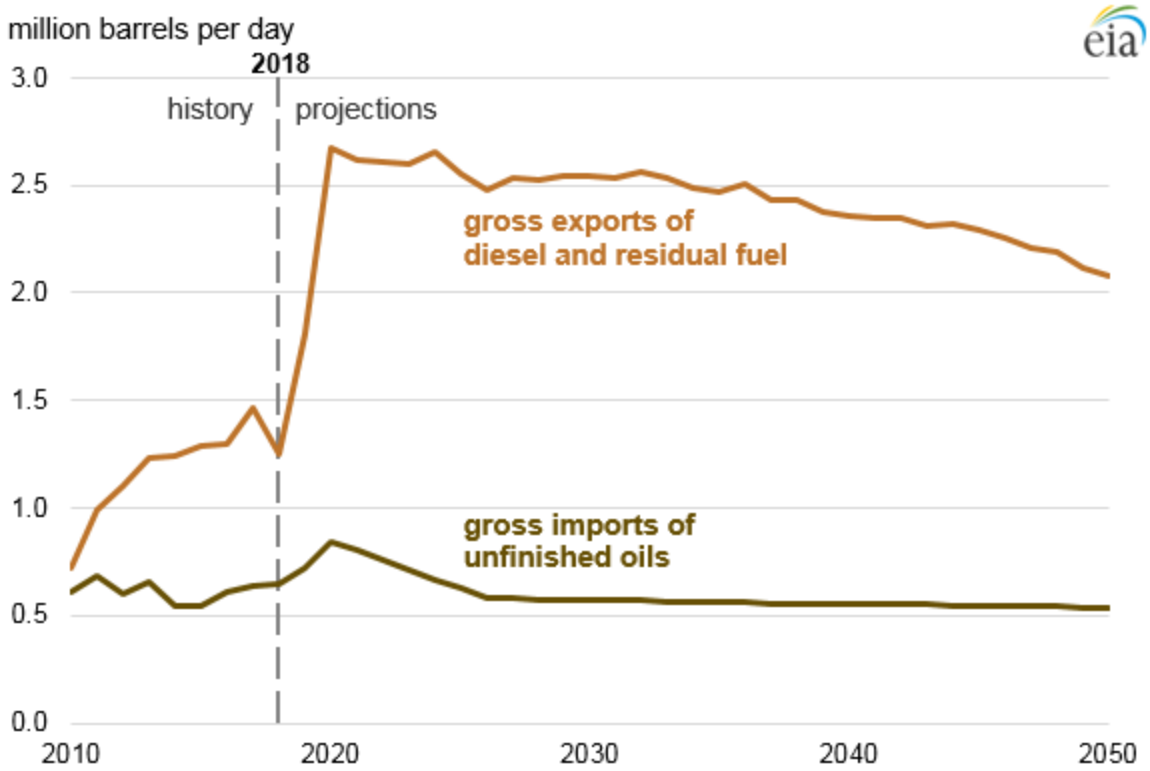
EIA's modeling capabilities do not currently include a detailed, fully integrated global refining model. The Liquid Fuels Market Module in NEMS has a detailed representation of the U.S. refining sector but only a general representation of global petroleum markets through import and export curves. The 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.

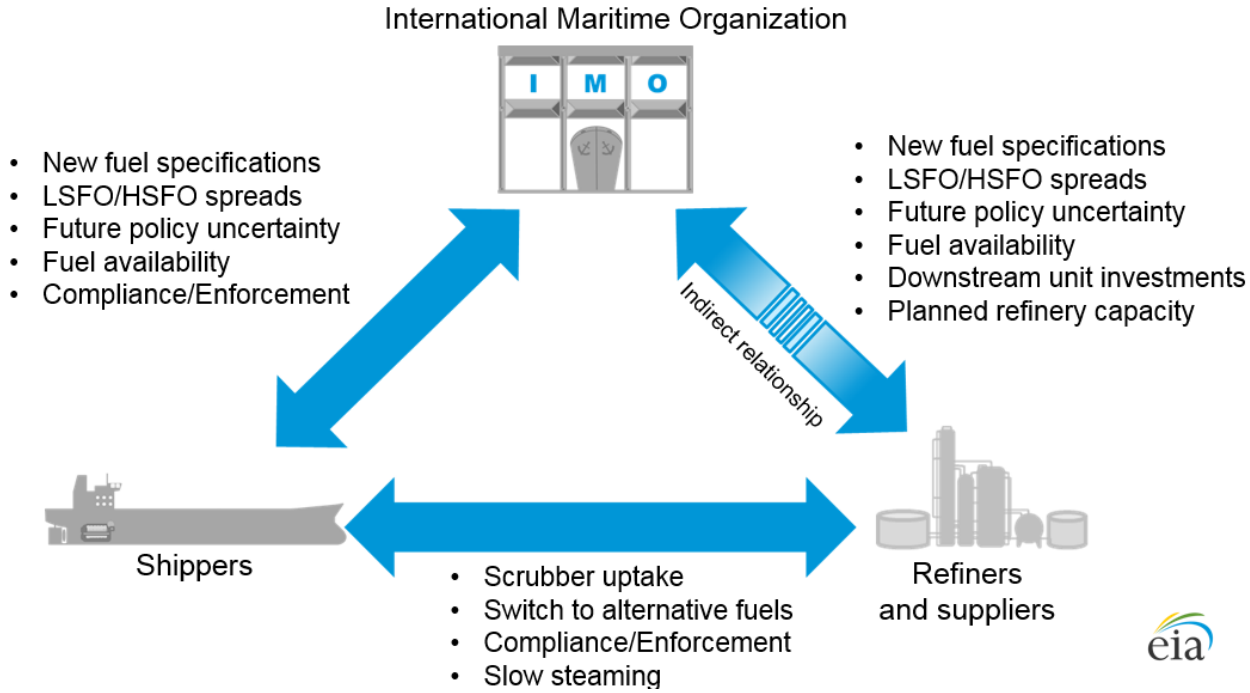
Although EIA expects that the effect on crude oil quality spreads could be relatively significant, EIA does not expect a significant impact on crude oil price levels. In the March 2020 STEO EIA forecasts Brent crude oil prices (the global benchmark for light-sweet crude oil) to average $63/b in 2019 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.

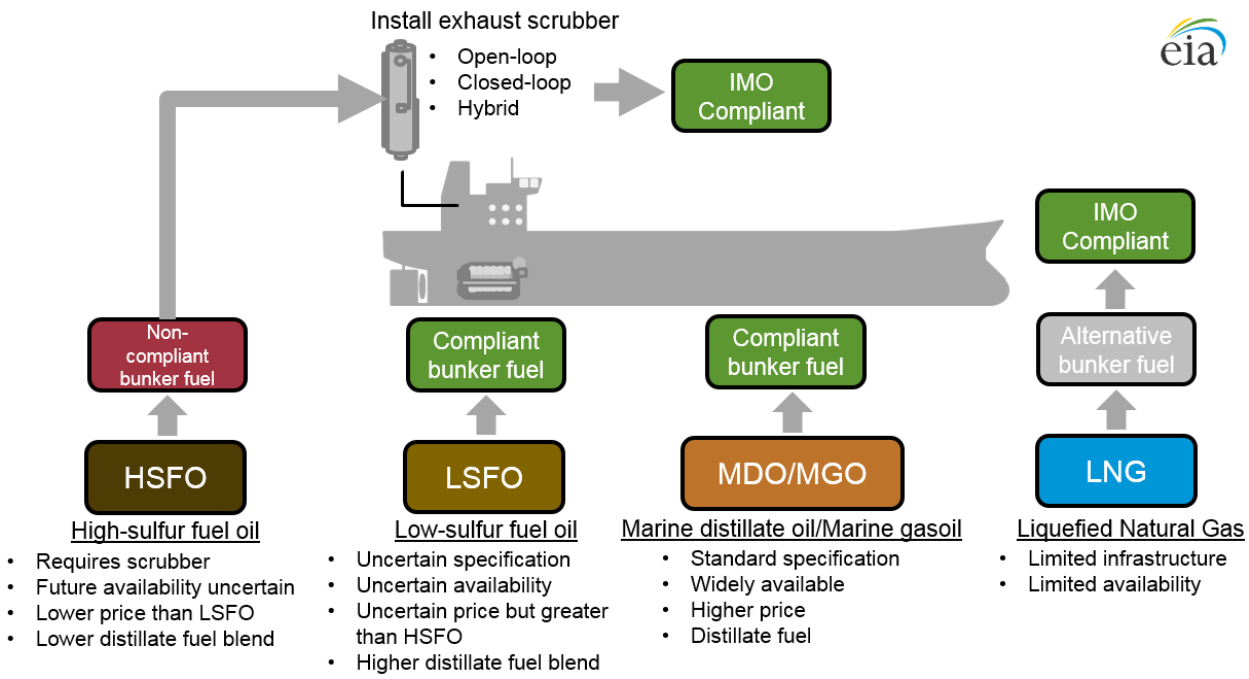
Future policy uncertainty: The IMO has signaled its intention to implement additional controls and regulations on other types of pollution from ships in the future. These future regulations may result in shippers switching to alternative non-petroleum fuels such as LNG. Because of this uncertainty, refiners 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.