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Oil and Gas Industry – Global

Global oil refining faces weakening demand, tighter regulation due to carbon transition

» **Carbon transition poses significant business and credit risk for global oil refiners, especially after the Paris Agreement of 2016.** Oil consumption is responsible for more than 30% of carbon emissions globally, making oil refineries and the consumption of refined products key targets for carbon reduction. Our baseline assumption for carbon emissions indicates decarbonization will likely disrupt consumption patterns for refined products. While we expect global oil demand to continue growing through 2040, demand in the OECD will peak much sooner, with fuels for passenger fuel vehicles coming under greatest pressure. Refiners that produce fewer distillates, and low complexity refineries that cannot easily adjust product slates, particularly those unable to reach more attractive markets, will be most disadvantaged.

» **Emissions regulation for refineries and refined products will increase variously by jurisdiction.** Many governments will likely implement carbon-pricing mechanisms, or expand existing programs, aimed at carbon emissions both from refining operations and refined-products consumption. Refiners in more lightly regulated jurisdictions may generate higher operating margins, and the lack of consistent prices on carbon, or agreement about who pays, add to refiners' uncertainty, particularly for exporters. Tighter regulations in China and India will challenge smaller refiners there.

» **Changing consumption patterns will likely worsen overcapacity.** As OECD nations push to reduce carbon emissions and their demand for refined products declines, Asian and Middle Eastern refining capacity will likely expand significantly. Under our base case, more than 10% of existing global throughput capacity is at risk of closure by 2025. Although not our baseline assumption, an oil demand peak by 2020 consistent with a two-degree pathway would render up to 25% of existing global refining capacity unnecessary by 2035.

» **Changes in consumer preferences, technological advances substantially increase transition risks.** Advances in automotive and energy storage technology and development of cleaner transportation fuels threaten demand for oil as gasoline demand peaks. Rising consumer interest and regulatory pressures are increasing demand for alternative fuel vehicles, leading both nations and automakers to target electrification of the transportation sector even more rapidly, which could result in oil demand peaking sooner than expected. Lower-complexity refineries in the import-saturated European and US East Coast markets face particular risk of diminishing utilization rates and even closure.

Carbon transition poses significant business and credit risk for global oil refiners

Carbon transition will challenge refiners to keep pace with evolving regulatory environment and competitive landscape in the coming decades. Oil refineries accounted for about 1 gigatonne of carbon dioxide (CO2) emissions globally in 2016, a small fraction of the 11.2 gt of oil-related CO2 emissions and about 3% of total worldwide CO2 emissions of 32 gigatonnes. However, efforts targeted at greatly reducing emissions caused by refined products will materially change crude and product flows and pressure refinery utilization, placing 10% of existing throughput capacity at risk of closure by 2025.[1]

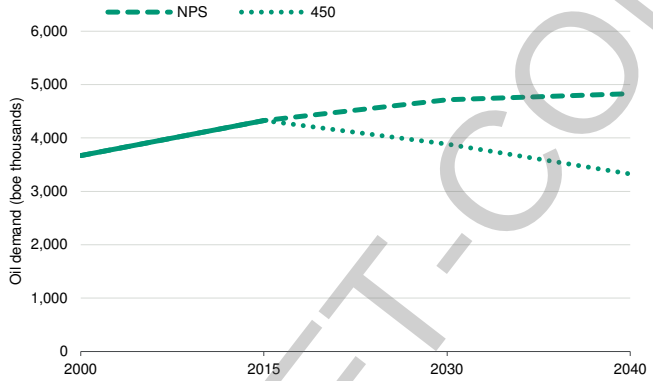
Who refines oil?

While integrated oil companies, nationally owned oil companies and independent refiners all refine oil, this report focuses specifically on the carbon transition exposure faced by independent refiners. (See Appendix A for commentary discussing the Refining and Marketing Industry Rating Methodology, written specifically for independent refiners, and Appendix B for a full list of independent refiners.) We discussed carbon transition risk for integrated oil companies and many nationally owned oil companies in our April 2017 report "Oil and Gas Industry Faces Significant Credit Risks from Carbon Transition."

Carbon transition risks facing refiners include lower demand for refined products over time due to policy initiatives, vulnerability to changing consumer preferences and disruptive technological shocks, especially in the transportation sector. Still, under our base case scenario we expect oil's incumbency, particularly as a fuel for heavier forms of transportation, to lead to continued demand growth through 2040 and that transition to alternative fuels will be gradual (see Exhibit 1).

Exhibit 1

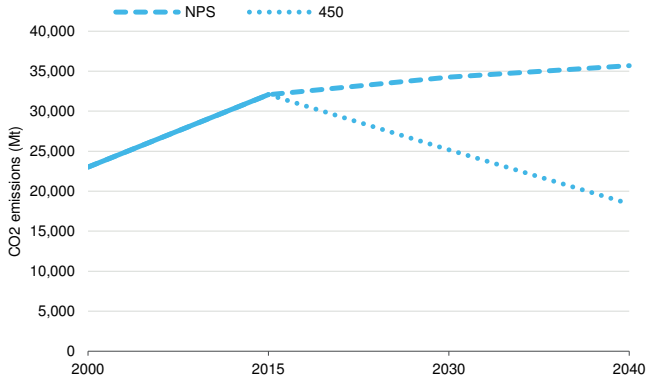
Oil demand likely to stabilize around 2040...



Source: IEA (World Energy Outlook 2017)

Exhibit 2

...while carbon emissions continue to rise



Source: IEA (World Energy Outlook 2017)

We assess carbon transition risk using our central emissions scenario consistent with the nationally determined contributions (NDCs) agreed under the Paris Agreement, a scenario that the International Energy Agency's (IEA) New Policies Scenario (NPS) estimates will raise global temperatures by 2.5°C-3.0°C above preindustrial levels by the end of this century.[2] NPS represents our base-case assumption, while the IEA's 450 Scenario—which would limit concentration of greenhouse gases in the atmosphere to around 450 parts per million of CO2—helps show how a much more accelerated decarbonization would affect refiners.[3]

Although the world is not currently on a path to limit warming to 2°C, the Paris Agreement aims for nations to continue strengthening their pledges in order to keep warming "well below two degrees." The IEA's 450 Scenario helps us assess what a 2°C pathway would mean for future demand for refined products. The NPS points to a steady rise in carbon emissions through 2030 (see Exhibit 2).

Although the NPS is insufficient to limit global warming to less than 2°C, it represents a plausible central scenario, based on its broad support and policy commitments from governments, as well as technology trends.

Carbon transition risks' potential impact on R&M company ratings

Credit ratings for the refining and marketing (R&M) industry express opinions on the relative risk of default and credit loss. As such, ratings incorporate our forward looking view of all material risks, including carbon transition risks. Since our current view of carbon transition risks for the sector and each company is already reflected in our ratings, publication of this report has no immediate impact on ratings.

Carbon transition risks are considered part of our overall integrated analysis of credit risk for the R&M industry. As is the case for most risks that affect credit quality, carbon transition is not scored on a granular level in the R&M industry rating methodology. Examples of the multitude of other important risks that are not scored individually in methodology scorecards include management; labor relations; litigation; changes in technology, customer preferences and market structure; supply and demand dynamics; and competitors' strategies. Our view of the impact of such risks, including carbon transition risks, are incorporated in ratings through impacts on broad factors in the methodology scorecards and in our additional assessment of outside-the-scorecard rating considerations.

The R&M industry methodology scorecard is included in the appendix (see Exhibit 3 and Appendix A). These show scorecard measures that will be affected by carbon transition, which, for example, could lead to lower scoring for factors such as predictability of cash flow, competitiveness and regulatory support, technical and operating risks/vendor profile, and key financial metrics. For reasons that include false precision, we do not publish scorecards extending multiple years into the future. However, ratings are intended to be forward-looking and to incorporate relevant credit considerations as far into the future as possible. When we believe that an emerging risk is highly likely to result in weaker scorecard outcomes in the future, we incorporate this expectation into ratings. Consistent with this long-standing approach, when our evolving understanding of the credit impacts of carbon transition leads us to believe that it is highly likely that scorecard outcomes for a particular issuer will materially worsen, we expect to incorporate this into its rating well before deterioration is fully evident in the issuer's financial and operating results.

For a list of R&M issuers worldwide and their capacity, see Appendix B.

Exhibit 3

Carbon transition risk's effect on R&M methodology scorecard

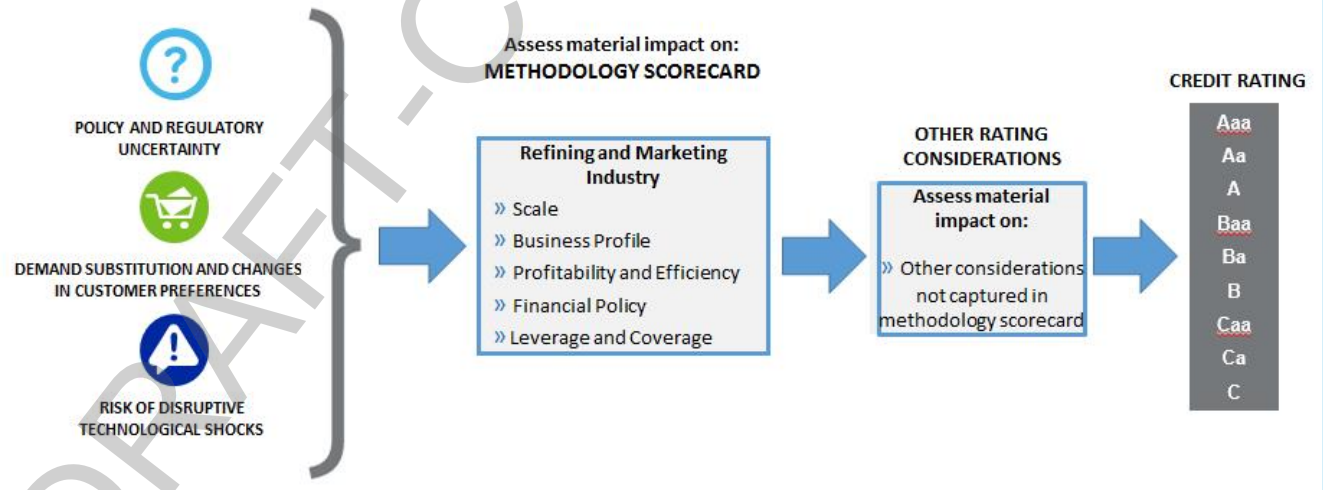


Exhibit 3 is a stylized representation of our approach to incorporate ESG considerations into ratings. The scorecard provides summarized guidance for the factors that are generally most important in assigning ratings to companies in the R&M industry. However, the scorecard, or grid, is a summary that does not include every rating consideration. For more information, readers should refer to the Refining and Marketing Industry Rating Methodology.
Source: Moody's Investors Service

Carbon transition heightens refiners' risk of fuel substitution, technological disruptions

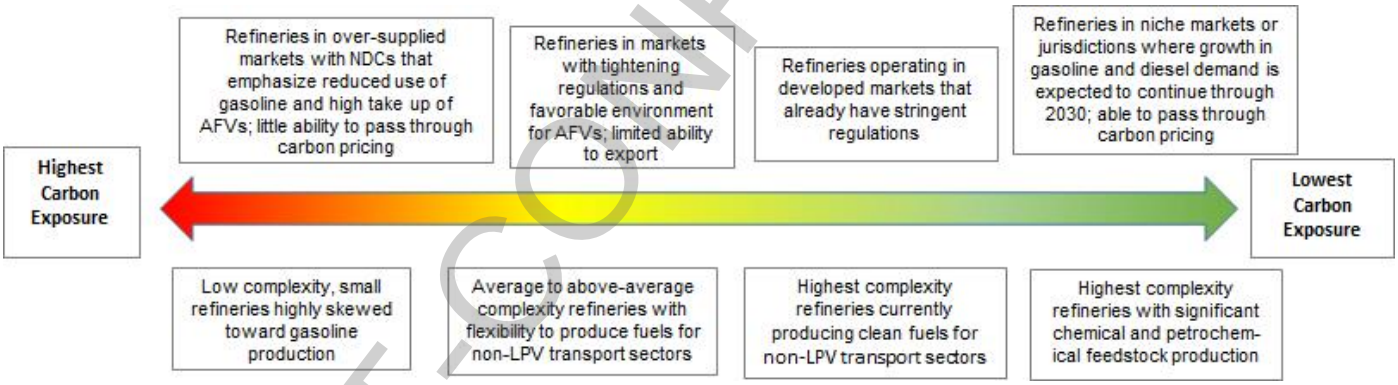
We examine three transmission pathways in assessing a company's carbon transition exposure within components of our Global Refining and Marketing Industry rating methodology: policy and regulatory risk; substitution and changing consumer preferences; and risk of disruptive technological shocks. For refiners, the risk of substitution and changing consumer preferences overlaps substantially with disruptive technological shocks; technological advances in other sectors are creating more options for consumers of gasoline and diesel, among the highest-value refined products.

These trends will lead to reduced demand for refined products over time, although the timing and rate of demand destruction will vary among products. Reduced demand will diminish profitability and cash flow for refiners, but those with stronger business profiles—greater refining complexity, size, geographic diversity and advantaged locations—will initially weather weaker demand more easily. We incorporate the risks assessed through this framework directly into our scoring of rating methodology factors for R&M companies.

While all refiners face increasing risk from these trends, those with low refining complexity, with products more skewed towards gasoline production and limited ability to export face the greatest risk—particularly those with refineries in historically lightly-regulated jurisdictions where policies for reducing greenhouse-gas emissions are tightening (see Exhibit 4).[4]Should oil demand peak sooner -- if policy initiatives to reduce emissions follow the 2°C pathway, or if low-emissions technological advances in other sectors such as automotive, freight, aviation, and batteries accelerate faster than IEA expects today – less competitive refiners would face a steeper challenge to remain viable. Under a 2 Degree Scenario, overcapacity would accelerate much more quickly than under the NPS, rendering as much as 25% of 2016 global refining capacity unnecessary by 2035.[5]

Exhibit 4

Low-complexity refiners in oversupplied markets face greatest risk from carbon transition



Source: Moody's Investors Service

Increased regulation of refining will vary geographically

Emission-related regulations for refineries and refined products will increase noticeably in coming decades, but their effects will depend on jurisdiction. Regulators throughout most of the OECD have imposed standards on refinery emissions for several decades, targeting the removal or substantial reduction of lead, sulfur, nitrogen oxides, volatile organic compounds and particulates. Over time, most of these standards have been adopted throughout much of the rest of the world. The success of these efforts, especially fuel efficiency standards, has caused demand for oil to decline in many OECD countries. The IEA projects overall OECD oil demand will peak by the early 2020s.

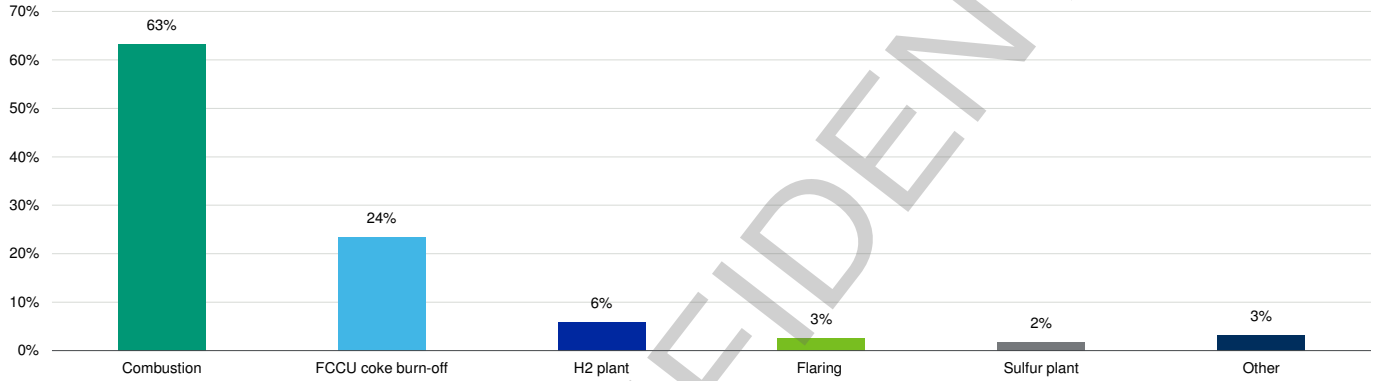
With the notable exception of the US, we expect that governments will keep implementing policies that further reduce carbon emissions generated by refining operations, known as Scope 1 emissions, as well as emissions from the combustion of refined products, or Scope 3 emissions, primarily through carbon-pricing mechanisms that will expand in scale and price. The Paris Agreement aimed to tighten NDCs over time, which increases the likelihood that carbon-pricing schemes will be unveiled in more regions and at higher levels. Since most existing carbon pricing schemes are set at low levels today, we expect them to rise gradually over time.

Scope 1 emissions

The petroleum refining sector has the largest process-heating energy demand of all manufacturing sectors, and is also the largest generator of onsite greenhouse-gas combustion emissions. Almost 90% of onsite fuel use is consumed in process heating and steam generation.[6] But opportunities to reduce greenhouse-gas emissions within refineries are limited; about two-thirds of refinery fuel demand in a refinery is supplied by byproduct fuels derived from feedstock in the production process (see Exhibit 5).[7] Comprehensive emission-remediation systems for refiners, such as carbon capture and storage, are still in early development, and we believe they are at least a decade away from widespread adoption, if at all.

Exhibit 5

Refining Scope 1 emissions by source



Source: US Environmental Protection Agency

The biggest variable in a refinery's carbon footprint is the type of crude being processed. Heavier crudes require more processing at higher temperatures, generating greater greenhouse-gas emissions than lighter crudes. The heavier the oil, the more heat, steam, and hydrogen needed to extract, transport, and transform it into high-value petroleum products such as gasoline and diesel. These high-carbon oils also yield higher shares of bottom-of-the-barrel products like petcoke that sell at deep discounts on an energy-equivalent basis to gasoline, diesel and other distillates. The heaviest oils have total carbon footprints that can be 60% greater than lighter oils.[8]

Scope 3 emissions

Future policy efforts to reduce greenhouse-gas emissions from oil will focus more on fuel consumers than fuel refiners. We estimate that petroleum refineries accounted for only about 1.0 gigatonne of CO2 emissions globally in 2016,[9] [10] 3% of total CO2 emitted, which pales in comparison to the 9.7 gigatonnes emitted through the combustion of refined products.[11] Fuel combustion's outsized contribution to global emissions, and the refiners' dependence on petroleum to fuel operations, make it likely that future greenhouse-gas policy will focus on influencing fuel consumption through fuel-efficiency standards, electrification requirements, and the elimination of subsidies, among other means.

Japan's experience highlights the effectiveness of targeting Scope 3 emissions. A 2009 regulation encouraged refiners to improve efficiency and shutter uncompetitive refineries (Scope 1 emissions) resulted in about 10% of the country's refining capacity closing in early 2017, following a similar reduction in 2014. However, a major cause of the significant excess refining capacity that led to these closures was continuously tightening transportation fuel efficiency standards (Scope 3) initiated in the 1980s.[12]

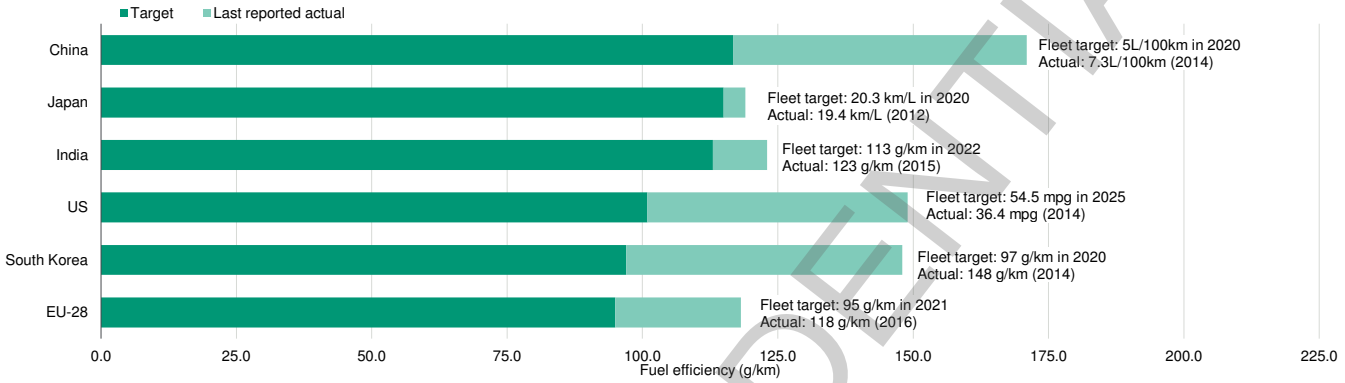
Sulfur reduction, fuel efficiency standards and many of the carbon-pricing systems have emphasized the emissions or consumption primarily of transportation fuels. Fuel-efficiency standards have had a significant effect on gasoline and diesel demand, prompting automakers to pursue battery/internal combustion hybrid engines, electrification and lighter-weight materials in an effort to meet increasingly stringent thresholds. These standards will continue to rise (see Exhibit 6).[13]

Greenhouse-gas and fuel-efficiency regulations for heavy transport/freight vehicles, the maritime industry, and aviation industries have lagged those of light passenger vehicles (LPVs). Only four countries—Canada, China, Japan and the US—have implemented fuel-economy standards for heavy trucks, while about 40 countries have implemented them for LPVs.[14] Unlike for electric vehicles, there are

few existing tax policies that would encourage the purchase of trucks powered by alternative fuels.[15] However, we expect regulations to expand over time in these industries as well. The EU is seeking to regulate emissions in the heavy transport sector, including proposed legislation that would require monitoring of CO2 emissions from heavy duty vehicles.[16]

Exhibit 6

Fuel efficiency standards to keep rising



Note: Fuel efficiency targets and actual values have been converted into g/km for comparison purposes in this graph. Labels contain units as per actually announced targets.
Sources: European Commission; US Environmental Protection Agency; UN Economic Commission for Europe; International Council on Clean Transportation; TransportPolicy.net; US National Highway Traffic Safety Administration; Moody's Investors Service

Environmental policies and regulations on refining operations and refined products, including those for carbon reduction, have gradually dampened profitability for an industry that struggles with overcapacity. The expense to reduce refiners' greenhouse gas emissions comes on top of ongoing regulatory efforts to limit other pollutants. ExxonMobil (Aaa stable) estimates that EU regulations from 2010-20 will add $2.50-$4.00/barrel (bbl) to refiners' operating costs.[17] Added costs have increased the pressure to rationalize; 16 EU refineries with aggregate throughput capacity of about 1.9 million barrels per day (bpd) have shut down since 2009.[18]

Significant ongoing emissions-driven compliance efforts for refiners in the OECD include the EU's Fuel Quality Directive, which mandates a 6% reduction in greenhouse-gas emissions from 2010 levels by 2020,[19] and a push by the International Maritime Organization limiting sulfur content allowed in marine bunker fuel to 0.5% by 2020, reduced from 3.5%.[20] The IMO is also set to announce in April 2018 its plan for lowering shipping CO2 emissions, to be implemented by 2023.[21] Desulfurization will be disruptive to both the shipping and refining industries since low-sulfur gas oil capacity is limited. In addition, high sulfur bunker fuel has served as a sulfur sink for refiners. Without bunker fuel production, refining profitability will suffer and the burden of sulfur disposal will increase.

Sulfur reduction has been a priority throughout the refining sector for the past two decades, primarily in Europe and North America initially, but now worldwide. China accelerated sulfur reduction targets for gasoline and diesel in 2016, and India did so in 2017, in both cases to combat historically poor air quality. Chinese refiners have invested heavily in desulfurization capacity since 2006, increasing the share of distillation capacity with desulfurization to 35% in 2016 from 15% in 2006, although still well below the global average of 51%. Additional investment may lag, given China's overcapacity and the effect that could have on raising capital, especially for the smaller independent refiners.[22]

Carbon pricing to vary by jurisdiction

The timing and costs of carbon-pricing regulations will vary considerably by nation, allowing refiners in lightly (or more slowly) regulated jurisdictions to generate higher operating margins. Pricing system designs vary; some target refiners, other assess prices on the consumer. But nations that export large volumes of oil and refined products are less likely to assess a substantial carbon price on petroleum, giving their domestic refiners a competitive advantage worldwide.

The NPS, which we use as a base case in assessing carbon transition risk for refiners, assumes that carbon pricing systems will vary significantly by region—ranging from a low in 2040 of about $25/tonne in South Africa, to highs of almost $50/tonne in Korea and the EU's Emissions Trading System (ETS). These levels are markedly below the 2°C pathway under the IEA's 450 Scenario, in which carbon

would be priced at $125-$140/tonne.[23] A move toward higher carbon pricing than currently anticipated would lead to even greater variations in the competitive landscape for refiners.

The EU's ETS is in its third phase, which expires at the end of 2020. The EU ETS is quite extensive in its coverage, but the high number of allowances granted to energy-intensive industries such as refining and steelmaking have kept the price of carbon very low—less than $10/tonne of mid-January 2018. Allowances are intended to combat competition from imports. Current proposals for Phase IV, set to begin in 2021, would have fewer allowances. As a result, refiners could face about €15 billion in total costs over the course of Phase IV, assuming a CO2 price of €30/tonne, which would represent more than 10% of average refinery margins.[24]

EU regulators have also discussed a carbon border adjustment to help mitigate potential competitive disadvantages that European emitters might face in their home countries. While the ETS targets refining emissions, many EU member states have added carbon prices on refined products in their own countries. Without either continued liberal allowance provisions or a carbon border adjustment, European refiners could lose significant market share to imports once Phase IV begins in 2021. (See Appendix C for a full list of carbon pricing plans covering refineries and refined products.)

Among other countries with ETS proposals, Korea and several Canadian provinces have added carbon pricing systems in the past few years, with prices generally ranging between $15-$25/tonne. Phase 2 of Korea's ETS, set to begin in 2018, will introduce auctioning for a small amount of carbon allowances, which should increase prices. China introduced its national ETS program in December 2017. This program follows regional pilot programs in seven Chinese provinces and major industrial cities. The initial implementation will only cover the power sector before likely adding other polluting industrial sectors later, but China has not announced pricing or many of the structural details.

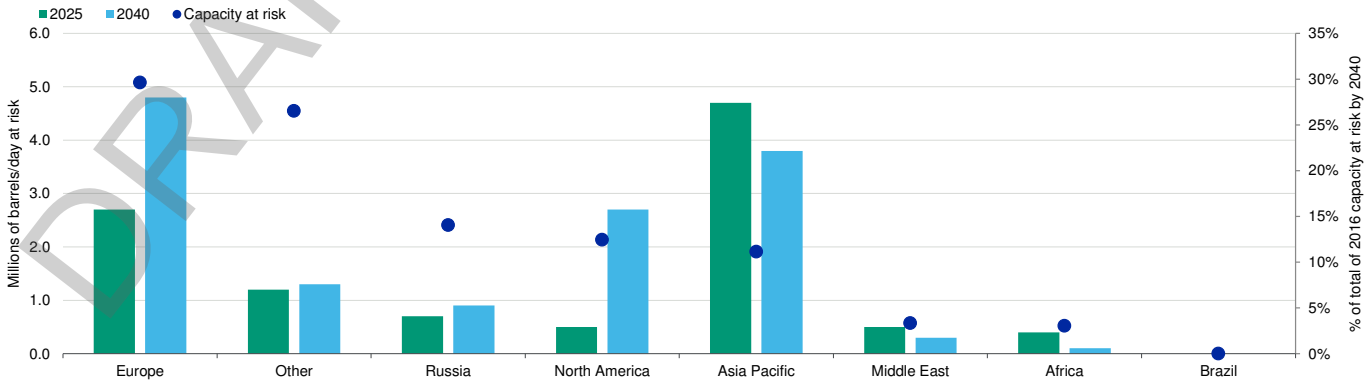
Carbon-pricing effects will likely be unevenly distributed; however, fuel produced primarily in export markets with higher carbon prices would face competitive disadvantages against products with lower or zero carbon prices. For example, Singapore-based refiners export most of their products and will be unable to pass through to consumers a carbon tax that goes into effect in 2019.[25] Wood Mackenzie estimates a $0.40-$0.70/bbl carbon-pricing cost for refiners overall, representing about 10%-15% of the barrel's typical operating margins.[26]

Changing regional consumption patterns likely to exacerbate overcapacity

At the same time policies designed to reduce oil consumption begin to bite in the OECD, Asia will likely add significant capacity, both to meet its own growing energy appetite, and to offer a destination for Middle Eastern oil producers seeking to capture more of the value chain for their crude. Together, these developments will worsen overcapacity (see Exhibit 7), which has accelerated over the past decade as stricter fuel-efficiency standards and fuel switching have curtailed demand in many OECD countries. Under the NPS, increased Asian demand will absorb most of the new capacity. OPEC forecasts that the Middle East and Asia will host 75% of a roughly 7.6 million bpd global refining capacity expansion through 2022.[27]

Exhibit 7

Europe faces brunt of risk from refining capacity closures by 2040

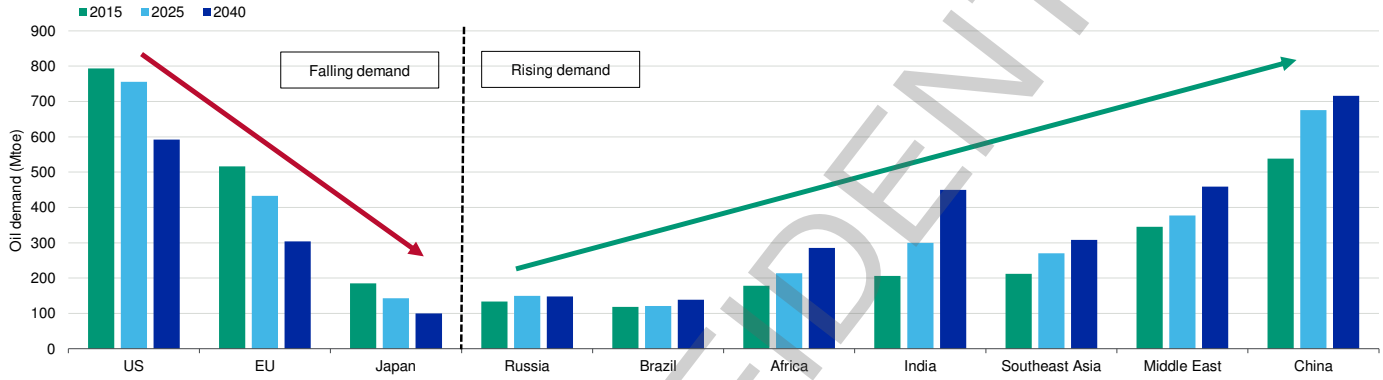


Source: IEA (World Energy Outlook 2017)

The highly complex facilities that will come onstream in Asia and the Middle East should operate at high utilizations, forcing reductions at the lower-complexity refineries now serving those markets. Declining OECD demand for LPV fuels (see Exhibit 8), the highest value and largest portion of the refining barrel (see Exhibits 9 and 10), will force refiners in western Europe and the US East Coast to become competitive in distant export markets or face the possibility of closure. As US demand wanes, Gulf Coast refiners will look to serve growing Latin American markets and Asian markets, since the Gulf Coast crude and energy cost advantages make shipping competitive with Asian and Middle Eastern products, though shipping will also eat into profitability.

Exhibit 8

Falling oil demand in US and EU offset by growth in most of rest of world through 2040

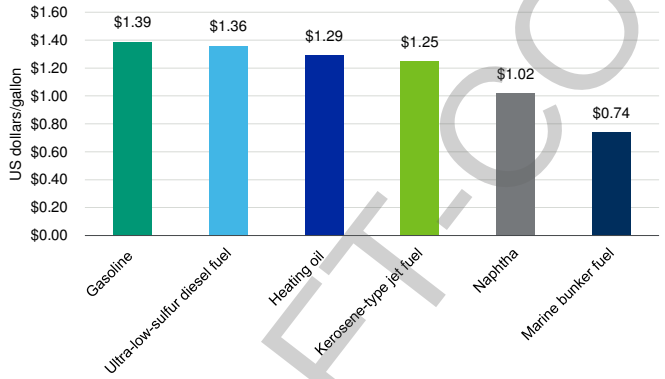


Source: IEA (World Energy Outlook 2017)

exhibit Exhibit 9

Gasoline and diesel have historically priced higher than other refined products

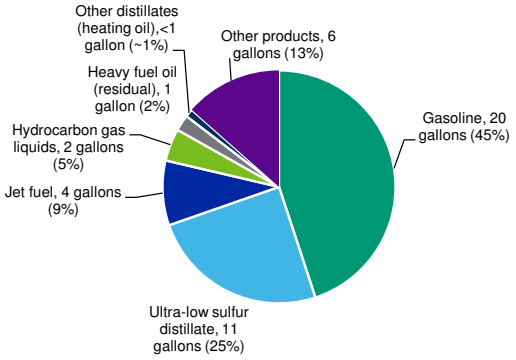
Average product prices for 2016



Note: Gasoline, heating oil, and ultra-low-sulfur diesel fuel are spot prices at NY Harbor; kerosene is the spot price at the US Gulf Coast; and naphtha and 3.5% marine bunker 180 cst sulfur fuel oil are Singapore spot prices. Prices converted to US dollars/gallon for comparison purposes.
Source: EIA; Bloomberg

Exhibit 10

Petroleum products produced from one barrel of crude, 2016



Source: EIA

Crude supply patterns are also likely to shift in a decarbonizing world to the detriment of heavy crude oils and relating refining capacity. Recent investment in the refining industry has focused on increasing upgrading capacity to enable conversion of low-value products, such as residue and petcoke, into higher-value products such as gasoline and distillates. Most of the new capacity that has come onstream in Asia and the Middle East in recent years has had coking or cracking capacity that allows refiners to process dirtier heavy crudes that sell at significant discounts to light crudes.[28] Many large US refiners added cokers and catalytic cracking units beginning in the 1990s to capitalize on the advantaged economics of Canadian oil-sands crude and heavy Venezuelan and Mexican crudes that were readily available. Decarbonization could cause these crudes to fall out of favor, however; their transformation process requires extensive

processing, takes higher energy inputs, yields more residual fuels, and results in greater carbon emissions. Growing light crude supplies, led by US shales, and the carbon burden of heavy crudes will dissipate the cost advantage of upgrading and coking the dirtiest crudes.

Electric vehicles will hasten peak gasoline demand well before oil demand crests

Global gasoline demand will peak much sooner than oil demand, in part because of increasing national and automaker efforts to electrify LPVs. Although fuel efficiency gains have already slowed growth for LPV fuels, accelerating growth in alternative fuel vehicles and electric vehicles through the 2020s will exacerbate demand destruction in countries where gasoline and diesel demand are already declining. (See our report, .).)Automakers Fully Engaged on Battery Electric Vehicles, but the Transition Will Pressure Returns, January 23, 2018.)

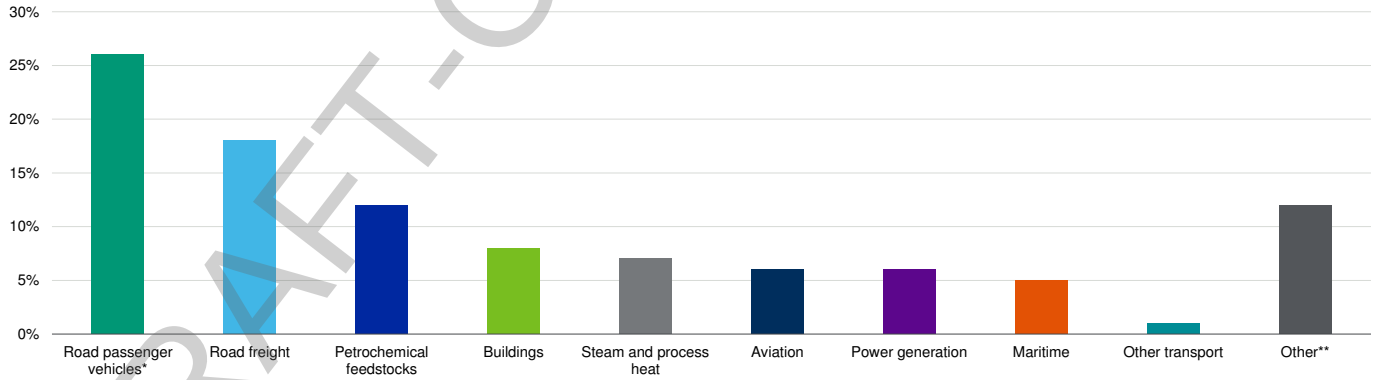
Changes in consumer preferences and technological advances will threaten demand for gasoline worldwide by the late 2020s. IEA expects that demand for ride sharing, driverless cars, electric vehicles, and other alternative fuel vehicles will continue to grow amid technological advances and efficiencies in scale improve battery life and reduce costs. Additionally, if refining companies can successfully transfer regulatory costs and carbon taxes to the consumer, we would expect higher fuel prices to accelerate consumer demand for lighter and more efficient vehicles, electric vehicles, and driverless cars.

The mere difficulty of predicting the degree and speed of rising popularity for alternative fuel vehicles, including electric vehicles, poses significant challenges in itself. Alternative fuel vehicles require changes to the auto manufacturing process, heightened coordination with auto-parts suppliers, improvements in battery life and costs, and the spread of such infrastructure as power-charging stations. Government mandates to transform vehicle fleets to electric and hybrid is likely to spur additional investment into battery technologies and the related infrastructure needed to support electric vehicles, such as charging stations with higher-speed chargers. (See our report, Environmental Risks: Automotive Sector Faces Rising Credit Risks from Carbon Transition, September 20, 2016.)

The NPS assumes that gasoline demand will peak in the early 2030s, while the use of diesel in passenger vehicles will grow until the early 2020s. However, a spate of recent announcements regarding electric vehicles by countries and automakers point to the possibility of a faster transition that could cause demand for refined products in the LPV segment to peak sooner, pressuring margins and cash flow. Still, even as gasoline demand falls, petroleum-based transportation fuels are likely to remain necessary for many decades to come, and that the decline will be gradual.

Exhibit 11

Transportation uses dominate petroleum end markets



Notes: * includes buses and two-/three-wheelers; ** includes agriculture, transformation and other non-energy uses, mainly bitumen and lubricants
Source: IEA

Demand for heavy transportation fuels, petrochemical feedstocks props prop up growth

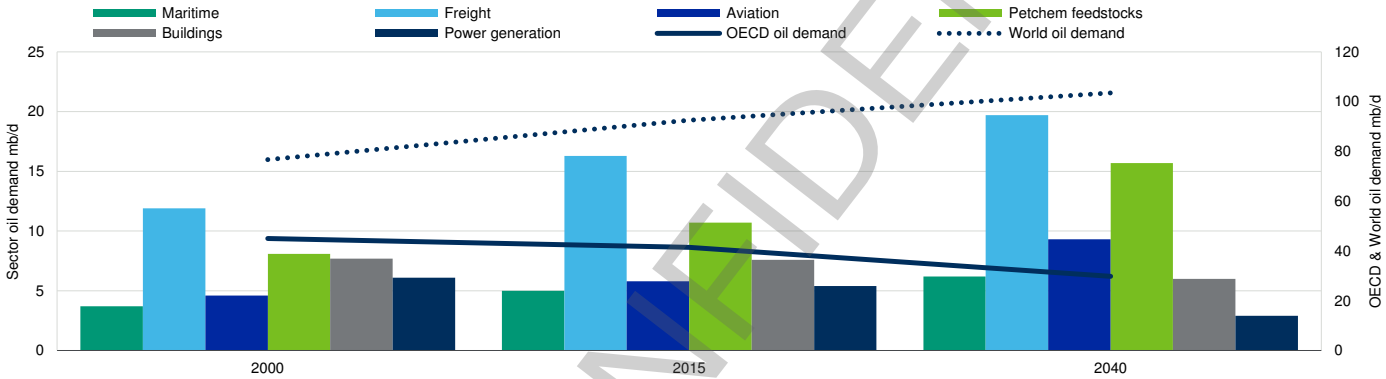
Although the transport sector consumes 56% of petroleum globally, it is only the 26% that powers passenger vehicles that is most at risk, given the steep challenges in electrifying heavy-duty engines (see Exhibit 11).[29]continues For example, the IEA's NPS assumes demand for refined products among non-LPV transportation sectors will continue to grow through 2040. The NPS indicates rising oil demand through 2040 on the back of strong energy demand in Asia and healthy growth in heavy transportation fuels and petrochemical feedstocks.

Lagging electrification and limited availability of alternative fuels for medium- and heavy-duty trucks, ships and aircraft should ensure oil's primacy in these sectors through at least 2030. Technological advances in batteries, engine efficiency, and alternative fuels and a continued focus on lighter-weight materials will eventually reach the heavy duty transport, aviation, and shipping industries, but their electrification readiness lags that of passenger vehicles considerably. Transport fuel demand outside of LPVs will continue to grow at significant rates as a result.

Our baseline assumption as modeled in the NPS is that demand for oil in the aviation, maritime, and freight sectors combined will increase by almost 30% by 2040 from current levels, and exhibit that demand for oil for petrochemicals will grow by over 45% by 2040 (see Exhibit 12),[30] given the more limited range of options for alternative fuels and the expectation for strong activity growth in those segments.

Exhibit 12

Oil demand for aviation, maritime, and petrochemicals will rise significantly under baseline IEA scenario



Note: Demand figures are from the IEA WEO 2016 given the availability of data at the sector level. Total world oil demand is about 1.5 mb/d higher in the NPS in the WEO 2017. The difference is driven by increases in the forecasts for demand for industry, petrochemicals, buildings, and power generation, which are somewhat set off by lower oil demand for transport.
Source: IEA WEO 2016

Growth within these segments will probably more than offset efficiency gains stemming from lighter materials, fuel diversification (liquefied natural gas in maritime), and engine improvements.[31] The trucking industry may transition to alternative fuel vehicles more rapidly than currently forecast. Efforts toward electrification are further along for trucking than other heavy transport sectors, and fleet managers seeking to manage high fuel costs are motivated to electrify fleets.[32]

Maritime greenhouse-gas emissions will eventually recede based on several factors, including a longer-term emphasis on efficient ship design, improvements in onboard systems to reduce power usage, and the rise of alternative fuels such as liquefied natural gas and wind and solar assistance, in conjunction with bunker fuel. Although national of the aviation industry aviation regulations have been somewhat limited so far, the global airline industry has adopted a voluntary fuel-efficiency goal of cutting both fuel consumption and CO2 emissions by 25% of their 2005 levels on a revenue tonne-kilometer basis by 2020.[33]. The International Air Transport Association has set out targets to improve fuel efficiency by 1.5% annually from 2009 to 2020, cap net CO2 emissions in 2020 despite growing aviation demand, and reduce net CO2 emissions by 50% from 2005 levels by 2050.[34]

The NPS assumes use of refined products for power generation and in buildings will drop significantly, although these segments are considerably smaller than the transport sectors. Improved access to natural gas, electricity and renewables will likely curb the use of oil in power generation and industrial boilers, cutting oil's share of power generation almost in half from 2015 to 2040. Natural gas and electricity will largely displace liquefied petroleum gas for heating and cooking in within the OECD, although liquefied petroleum gas for cooking will rise in developing countries seeking to switch from solid biomass. Kerosene consumption will continue to decrease as electricity access increases in developing countries. Still, the petrochemical industry's likely roughly 5 million bpd increase in oil consumption by 2040 would likely more than offset the nearly 4 million bpd decrease in petroleum demand from buildings and power generation.[35]

Appendix A: How carbon transition risk flows through refining methodology

Exhibit 13

Refining and Marketing Industry			
Broad Rating Factors	**Factor Weighting**		**Impact of NPS Scenario**
Scale	25%	Crude Distillation Capacity (mbbls/day) Number of Large-Scale Refineries	Falling demand for light passenger vehicle fuels is likely to exacerbate overcapacity in the sector, which could lead to the highest cost and least complex plants being under-utilized and ultimately stranded. As the costs of compliance with stringent regulations increase, plants with high scope 2 emissions or burdensome costs to comply with these regulations could face closure.
Business Profile	20%	Business Profile	Weakening demand over time will force management teams to assess the competitiveness of their refineries and whether to invest in upgrades or diversify outside of refining. High complexity refineries, particularly those with petrochemical operations, are better positioned to weather falling gasoline and diesel demand. Companies that undertake rigorous scenario testing and use the findings to guide strategy are likely to more quickly adapt to carbon transition.
Profitability and Efficiency	15%	EBIT / Total Throughput Barrels EBIT / Average Capitalization	Risk that metrics will deteriorate for high cost, high emitting refining companies as demand for high value LPV fuels falls amid rising costs for regulatory compliance. Debt / Capitalization will increase for refiners with assets that are written down or off altogether.
Financial Policy	20%	Financial Policy	
Leverage and Coverage	20%	EBIT / Interest Expense Debt / EBITDA RCF / Debt Debt / Capitalization	

Source: Moody's Investors Service

Appendix B: Refining capacity for rated R&M companies

Exhibit 14

Total refining capacity for rated R&M companies
as of January 26, 2018

Issuer/entity	Outlook	Long-term rating	Country	Capacity b/d
Administracion Nacional de Combustibles-ANCAP	Stable	Ba2	Uruguay	50,000
Alon US Partners, LP	Stable	B2	US	73,000
Andeavor	Stable	Baa3	US	1,157,000
Bharat Petroleum Corporation Limited	Stable	Baa2	India	670,000
Calumet Specialty Products Partners, L.P.	Negative	Caa1	US	136,300
CITGO Petroleum Corporation	Negative	Caa1	Venezuela/US	749,000
CVR Refining, LLC	Stable	Ba3	US	185,000
Deer Park Refining Limited Partnership	Negative	N/A	US	340,000
Empresa Nacional del Petroleo	Stable	Baa3	Chile	230,000
Flint Hills Resources, LLC.	Stable	A1	US	620,505
Formosa Petrochemical Corporation	Stable	Baa1	Taiwan	540,000
GS Caltex Corporation	Positive	Baa2	South Korea	790,000
Hindustan Petroleum Corporation Ltd.	Stable	Baa2	India	498,000
HollyFrontier Corp.	Negative	Baa3	US	457,000
HPCL-Mittal Energy Limited	Stable	Ba1	India	225,000
Indian Oil Corporation Ltd	Stable	Baa2	India	1,600,000
IRPC Public Company Limited	Stable	Ba1	Thailand	215,000
JXTG Holdings, Inc.	Stable	Baa2	Japan	1,930,000
Marathon Petroleum Corporation	Stable	Baa2	US	1,881,000
Motiva Enterprises LLC	Stable	Baa1	US/Saudi Arabia	1,073,000
Par Petroleum, LLC	Stable	B1	US	112,000
PBF Holding Company LLC	Stable	Ba3	US	884,000
Petroleum Co.of Trinidad & Tobago (Petrotrin)	Stable	B1	Trinidad	190,000
Phillips 66	Negative	A3	US	2,116,000
Polski Koncern Naftowy ORLEN S.A.	Stable	Baa2	Poland	710,000
Raffinerie Heide GmbH	Stable	B3	Germany	92,000
Reliance Industries Limited	Stable	Baa2	India	1,240,000
SK Innovation Co. Ltd.	Stable	Baa1	South Korea	1,115,000
S-OIL Corporation	Stable	Baa2	South Korea	669,000
Thai Oil Public Company Limited	Stable	Baa1	Thailand	275,000
Turkiye Petrol Rafinerileri A.S.	Positive	Ba1	Turkey	611,000
Valero Energy Corporation	Stable	Baa2	US	2,600,000

Source: Moody's Investors Service; company information

Appendix C: Partial list of carbon pricing plans, by government

Exhibit 15

Carbon pricing plans covering refineries, refined products, and petrochemicals, by jurisdiction

Jurisdiction	Price type	Started	Price per tCO2e	Date of price	Sectors covered
Alberta province, Canada	carbon tax	2017	$24	1-Jan-18	Combustion of all fuels that emit GHG (including transport fuels)
Beijing municipality, China	pilot ETS	2013	$8	20-Sep-17	Electricity providers, heating, cement, petrochemicals, manufacturers, service sector, and public transport
China	ETS	start date to be confirmed	n/a		First phase will cover the power sector. Other sectors likely to be covered in future phases include: petchem (including refining), chemicals, iron and steel, non-ferrous metals, building materals, pulp and paper, aviation
Denmark	carbon tax	1992	$27	1-Aug-17	Consumption of fossil fuels (natural gas, oil, and coal); sectors covered by EU-ETS, energy-intensive processes, exported goods, fuels in refineries and many transport-related activities are partially exempt
EU	ETS	2005	$9	9-Nov-17	Power stations, oil refineries, coke ovens, iron and steel plants, cement, glass, lime, bricks, ceramics, pulp, paper, board, intl; aviation (in the EEA), CCS, petchem, ammonia, non-ferrous and ferrous metals, gypsum, aluminum, nitric, adipic, and glyoxylic acid
Finland	carbon tax	1990	$69 (other fossil fuels); $73 (liquid transport fuels)	1-Aug-17	Heat and electricity production and heat and transport fuels
France	carbon tax	2014	$36	1-Aug-17	Fossil fuel consumption not covered by the EU ETS; transport fuels and heating oil
Fujian province, China	pilot ETS	2016	$3	20-Sep-17	Electricity, petchem, chemicals, building materials, iron and steel, nonferrous metals, paper, aviation, and ceramics
Guangdong province, China	pilot ETS	2013	$2	20-Sep-17	Power, iron and steel, cement, petrochemicals, aviation, paper, and white cement
Hubei province, China	pilot ETS	2014	$2	20-Sep-17	Power and heat, iron and steel, non-ferrous metals, petrochemicals, chemicals, chemical fiber, cement, glass and other building materials, pulp and paper, cermaics, auto and equipment manufacturing, food, beverage, medicine production
Iceland	carbon tax	2010	$12	1-Aug-17	Importers of liquid fossil fuels (transport incl; aviation) for retail or private use
Ireland	carbon tax	2010	$24	1-Aug-17	Transport fuels (including petrol, heavy oil, auto-diesel aviation fuels), LPG, fuel oil, natural gas, coal, peat; excludes sectors covered under EU-ETS
Japan	carbon tax	2012	$3	1-Aug-17	Use of fossil fuels
Kazakhstan	ETS	upcoming (expected 2018)	n/a		Likely to cover energy sector (including oil and gas), mining, and chemicals
Korea	ETS	2015	$18	21-Sep-17	Steel, cement, petro-chem, refining, power, buildings, waste and aviation (23 sub-sectors from these sectors)
Mexico	carbon tax	2014	<$1-$3	1-Aug-17	Tax on use of fossil fuels that emit more CO2 than natural gas; Tax is equal to the additional amount of emissions released given that this fuel was used in place of natural gas
Norway	carbon tax	1991	$4-$56	1-Aug-17	Transport fuels, heating, and petroleum activities; sectors covered under EU ETS are mostly exempt except offshore oil and gas and aviation
Ontario province, Canada	CaT	2017	$15	1-Aug-17	Manufacturing, base metal processing, steel, pulp and paper, food processing, electricity, transportation fuel distributors, natural gas distributors
Poland	carbon tax	1990	<$1	1-Apr-17	Transport fuels and electricity (some industries exempt from electricity taxes
Quebec province, Canada	CaT	2013	$15	12-Aug-17	Electricity, industry, and distribution of fuels
Shanghai municipality, China	pilot ETS	2013	$4	20-Sep-17	Airports, aviation, chemical fiber, chemicals, commercial, power and heat, water suppliers, commercial, hotels, financial, iron and steel, petchem, ports, shipping, non-ferrous metals, building materials, paper, railways, rubber, textiles

Note: CaT is a cap-and-trade pricing scheme; tCO2e is tonnes of CO2 equivalent

Carbon pricing plans covering refineries and refined products, by jurisdiction (continued)

Jurisdiction	Price type	Started	Price per tCO2e	Date of price	Sectors covered
Shenzhen province, China	pilot ETS	2013	$4	20-Sep-17	Power, water, gas, manufacturing, buildings, port and subway, public buses
Singapore	carbon tax	upcoming	n/a		Power generation and large industrial sectors incl; refining
Slovenia	carbon tax	1996	$20	1-Aug-17	Transport sector; fossil fuel combustion, EU ETS sectors are exempt
South Africa	carbon tax	upcoming	n/a		Likely to cover all direct GHG emissions from fuel combustion and non-energy industrial process emissions; In the draft legislation, refining, iron and steel, and food processing indusstries will receive an additional 10% allowance know as a "trade exposure allowance"
Sweden	carbon tax	1991	$140	1-Aug-17	natural gas, gasoline, coal, light and heavy fuel oil, LPG, and home heating oil; industries under EU-ETS are exempt from CO2 tax
Switzerland	carbon tax	2008	$87	1-Aug-17	All fossil fuels unless they used for energy generation; companies are exempt if they participate in the ETS
Switzerland	ETS	2008	$7	1-Aug-17	Will merge with the EU-ETS in the future
Tianjin municipality, China	pilot ETS	2013	$1	20-Sep-17	Heat, electricity, iron and steel, petchem, chemicals, oil and gas exploration

Note: Some of the listed jurisdictions exempt particular entities or facilities from listed carbon taxes based on size or amount of emissions. Some jurisdictions provide exemptions to particular industries based upon carbon leakage or other factors.
Sources: World Bank Group; International Carbon Action Partnership; IETA; European Commission; Sub-sovereign announcements; Media reports; Moody's Investors Service

Appendix D: Partial list of government and corporate alternative vehicle goals

Exhibit 17

Alternative vehicle goals, by country

Country	Announcement
India	Annual sales of electric and hyrbid cars to hit 6 million-7 million by 2020; goal for all vehicles sold in country to be electric-powered by 2030
France	Ending sales of gasoline and diesel cars by 2040; hybrids will be permitted
UK	Starting in 2040, banning sales of new gasoline and diesel cars; starting in 2050, all cars on the road must be zero-emission
Norway	Starting in 2025, requiring that all new passenger cars and vans sold must be zero-emission
China	Auto fleets must have a CAFE of 42 mpg by 2020 and 54.5 mpg by 2025, with a goal of more than 5 million new AFVs by 2020; planned phase-out of EV subisidies by 2021; ban on sales of new gasoline and diesel cars, no timeframe set yet
Poland	1.0 million electric vehicles by 2025
Thailand	1.2 million electric vehicles by 2036
Netherlands	Ban on sales of new fossil fuel-buring cars by 2040

Source: Media reports; Moody's Investors Service

Exhibit 18

Alternative vehicle goals, by automaker

Date	Company	Announcement
Jan-17	Ford	Plans to introduce 13 new electrified vehicles (hybrid and fully electric) in the next five years, including a hybrid pickup truck in the US, a plug-in hybrid van in Europe, and a fully electric SUV globally
Mar-17	Honda	Hybrid, plug-in hybrid, battery electric and fuel cell cars to make up two thirds of European sales by 2025; also announced it would introduce first two-motor hybrid model in Europe in 2018
Apr-17	GM	Plans to have 10 new-energy vehicles (plug-in hybrids and battery-electric cars) and annual sales of 150,000 units in China by 2020; annual sales of 500,000 units by 2025
Jul-17	Volvo	All new models introduced starting in 2019 will be fully electric, plug in hyrbid, or mild hybrid cars; will no longer introduce new models that contain internal combustion engines; plans to introduce five fully electric cars during 2019-21
Jul-17	Toyota	Building electric car that will use an all-solid-state battery, with aims to begin selling it in Japan in 2022
Jul-17	Daimler and BAIC Motor	Announced they would joinly invest about €655 million to make battery electric vehicles under the Mercedes-Benz brand in China by 2020
Aug-17	GM	Started selling its fully electric Baojun E100 in China for about $5,300 after subsidies ($14,000 before subsidies)
Sep-17	Toyota	New investment in five US manufacturing plants to support production of first American-made hybrid powertrain
Sep-17	Volkswagen	Plans to invest more than €20 billion in zero-emissions vehicles by 2030; plans to introduce 80 new electric vehicles by 2025; hopes to offer electric option for each of its 300 group models by 2030
Sep-17	Nissan, Mitsubishi and Renault	Joint plan to introduce 12 new all-electric vehicles by 2022; also plan joint release for fully autonomous vehicle by 2022
Sep-17	Daimler	The company will electrify its portfolio of Mercedes vehicles, offering at least one electrified option in each segment from smart cars to large SUVs by 2022
Oct-17	GM	Introducing two new all-electric vehicles by April 2019, and at least 20 new all-electric vehicles by 2023; will focus on both battery-electric and hydrogen fuel cell-electric

Source: Media and company reports; Moody's Investors Service

Moody's related publications

Sector in-depth reports:

» Oil and Gas Industry – Global: Oil industry will focus on disciplined spending and M&A opportunities in 2018, January 2, 2018

» Cross-Sector: Energy prices remain subdued, making strong returns difficult for producers, October 30, 2017

» Environmental Risks: Oil and Gas Industry Faces Significant Credit Risks from Carbon Transition, April 26, 2017

» Environmental Risks: Automotive Sector Faces Rising Credit Risks from Carbon Transition, September 20, 2016

Outlooks:

» Oil & Gas - Global: 2018 Outlook, December 7, 2017

» Refining and marketing – North America and EMEA: Distillates will lead way for higher refining margins through 2018, October 10, 2017

» Refining and marketing - Asia: Outlook stable on modest EBITDA growth and firm refining margins, October 3, 2017

Rating methodology:

» Refining and Marketing Industry, November 2016

To access any of these reports, click on the entry above. Note that these references are current as of the date of publication of this report and that more recent reports may be available. All research may not be available to all clients.

Endnotes

1 IEA *World Energy Outlook* 2017

2 IEA *World Energy Outlook* 2017. The NPS provides a useful proxy for future NDC-based greenhouse-gas emissions. The NPS begins with the individual NDCs and incorporates the policies and measures that are already in place as well as targets and intentions that have been announced in line with these national commitments, even if these have yet to be enshrined in legislation or the means for their implementation are still taking shape if there is a reasonable expectation they will be adopted. The NPS also contemplates uncertainties related to meeting NDC targets; where timing is deemed to be too ambitious, implementation delays are modeled.

3 The 450 Scenario was last updated in the 2016 World Energy Outlook (WEO). The 2017 WEO provided a Sustainable Development Scenario (SDS) in place of the 450 Scenario, reflecting the UN's 17 Sustainable Development Goals. While limiting global temperature increase to 2°C is one of the goals, other goals act to increase oil and natural gas demand and render the SDS ineffective in analyzing decarbonization and its effect on future oil demand. While the SDS decarbonizes, it does not reach the 450 Scenario's level of decarbonization.

4 A refinery's level of complexity is often based on how much secondary conversion capacity it has. The Nelson Complexity Index is one measure of refinery complexity. The index measures the complexity and cost of each major type of refinery equipment. The larger the Nelson index of a refinery, the more complex it is. The IEA considers a complexity score greater than 9.0 to be "high"; examples of highly complex refineries are Valero Energy's St. Charles, LA plant (17.1) and Turkiye Petrol Rafinerileri's Izmit, Turkey refinery (14.5).

5 Carbon Tracker Initiative's analysis "Margin Call: Refining Capacity in a 2°C world" uses the IEA's 450 Scenario for oil demand.

6 US EPA

7 DOE: Petroleum Refining Sector (NAICS 324110) Energy and GHG Combustion Emissions Profile, November 2012.

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9 https://www.shell.com/sustainability/sustainability-reporting-and-performance-data/performance-data/greenhouse-gas-emissions.html;

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13 The 54.5 miles-per-gallon US target is in doubt following statements and actions by the Trump administration that indicate a desire to scrap the 2025 standard.

14 https://www.iea.org/newsroom/news/2017/july/iea-study-unveils-key-role-for-trucks-in-global-oil-demand-growth.html; https://www.iea.org/publications/freepublications/publication/TheFutureofTrucksImplicationsforEnergyandtheEnvironment.pdf, p. 9

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16 https://ec.europa.eu/clima/policies/transport/vehicles/heavy_en

17 http://www.exxonmobil.eu/en-eu/policy/refining-competitiveness/challenges-facing-european-refining-today/challenges-facing-eu-refineries-overview

18 FuelsEurope: https://www.fuelseurope.eu/wp-content/uploads/2015/06/Graphs_FUELS_EUROPE-_2017_-36.pdf

19 https://ec.europa.eu/clima/policies/transport/fuel_en

20 http://www.imo.org/en/MediaCentre/HotTopics/GHG/Documents/FAQ_2020_English.pdf

21 IHS Markit: Refining and Marketing Insight, August 4, 2017

22 IEA *WEO 2017*, p. 583

23 IEA *WEO 2016 & 2017*

24 FuelsEurope: https://www.fuelseurope.eu/policy-priorities/climate-energy/eu-ets/

25 https://www.woodmac.com/news/editorial/singapore-carbon-pricing/

26 https://www.woodmac.com/analysis/singapore-carbon-pricing

27 *World Oil Outlook 2017* Organization of the Petroleum Exporting Countries, p. 206

28 In December 2017, Western Canadian Select crude, which suffers from limited market access, traded at more than a $24/bbl discount to West Texas Intermediate. Other heavy crudes typically trade at $5-$10/bbl discounts to light crudes.

29 https://www.iea.org/publications/freepublications/publication/TheFutureofTrucksImplicationsforEnergyandtheEnvironment.pdf

30 *IEA WEO 2016*

31 IEA *WEO 2016*, p. 117

32 McKinsey & Company: "What's sparking electric vehicle adoption in the truck industry?," September 2017

33 http://www.iata.org/whatwedo/ops-infra/Pages/fuel-efficiency.aspx

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