Sustainability shift

Oil’s future in the energy transition

February 2020

Refining in transition
Industry adapting to meet future demand

Rules of the road
Governments push for cleaner, greener fuels

Biofuels blending
Sustainability to benefit non-crop feedstocks

CEO interviews
Nayara Energy, Renewable Energy Group
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Executive summary

Energy markets are awakening to climate risks. The debate around the energy transition has shifted from whether one will occur to when it will happen and what it will look like.

Sustainability risks have come under heavy investor scrutiny. “In the near future — and sooner than most anticipate — there will be a significant reallocation of capital,” Larry Fink, CEO of BlackRock, the world’s largest asset manager, said in January.

And yet global energy demand continues to grow. Oil remains essential to the economy and is becoming further embedded into everyday life through petrochemical products, despite the rapid acceleration in the public’s ambitions around climate policy.

While oil demand might peak in the next decade, it will continue to meet a significant share of total energy demand for decades to come.

“The challenge for the industry going forward is to find a way to recognize what might happen if you no longer need oil as a fuel, but you increasingly need it as a building block,” said Madhav Acharya, technology-to-market adviser for the US Department of Energy’s independent Advanced Research Projects Agency - Energy. “All of the molecules in oil end up in products all around us. How oil is perceived has to change. The industry has to come to terms with that shift as well.”

Future of refining

Oil refiners will see slower demand growth for gasoline and diesel as a result of changing consumer habits, electric vehicle adoption, increased biofuel blending and other factors. But oil will be challenging to displace in aviation and shipping.

As investor concern builds around future decarbonization of transportation fuels and stranded asset risk from standalone oil refineries, refiners like India’s Nayara Energy show the sector’s increasing shift toward petrochemical demand.

Under a rapid energy transition scenario, sharply lower rates of demand growth for oil products derived from crude in the late 2020s and 2030s could trigger a profound rationalization in the global refining system, with winners and losers in a characteristic “survival-of-the-fittest” race.

But even in this rather gloomy scenario, do not be tempted to write off the refining industry. The sector has proved to be particularly resilient in the past four decades, by shutting off inefficient units in unprofitable markets and investing in new opportunities and markets.

Rules of the road

Sulfur content in gasoline is falling globally as more countries adopt specifications similar to the Euro 5 standard, with a sulfur limit of 10 ppm, 35% aromatics and 1% benzene.

US refiners reached a hard deadline for Tier 3 standards, resulting in fuel with less sulfur and lower exhaust emissions.

Future of flight, shipping

Aviation will be one of the toughest sectors to decarbonize, as weight, distance and safety concerns limit the alternative fuel options available to other transportation sectors.

While drop-in biofuels are advancing, the ultimate solution to reducing jet fuel emissions might rely on continued aircraft efficiency gains, together with the exploration of alternative and lower-carbon transport modes for both passengers and freight — particularly for shorter haul trips.

With the International Maritime Organization’s marine sulfur cap in place, a more protracted battle begins for shippers over which cleaner fuels can cut the sector’s emissions in half by 2050. No clear replacement has yet emerged, with options like LNG, methanol, hydrogen and ammonia all facing challenges.
Feeling the heat

Global energy demand continues to rise as public pressure mounts on governments and companies to adopt stronger environmental and social policies.

Climate concerns reached a fever pitch last year as teen activist Greta Thunberg warned a “change is coming, whether you like it or not.” Change has certainly happened when it comes to the public’s desire for sustainability – awareness of the impact of carbon emissions on health and the environment, willingness to adopt new technologies that use energy more efficiently, and ambition to find radical new solutions to fuel the modern economy.

Change has also happened in boardrooms, as socially conscious investors increasingly demand to know that company profits are not coming at the expense of the environment, workers’ well-being or the overall health of society.

But these growing ambitions have not changed the trajectory of global energy demand or the desire of developing countries to improve living standards.

If the world is, in fact, set to make the massive shift that Thunberg warns about, it will not be the oil sector’s burden to bear alone. The reverberations will be felt in every sector of the global economy, as overall demand for energy shows no signs of slowing in the coming decades, and petrochemical products become further embedded into everyday life.

“Oil is unique because it’s both a source of energy — it embodies a huge amount of energy — and increasingly it’s a building block,” said Madhav Acharya, technology-to-market adviser for the US Department of Energy’s independent Advanced Research Projects Agency-Energy. “All of the molecules in oil end up in products all around us.”

“The challenge for the industry going forward is to find a way to recognize what might happen if you no longer need oil as a fuel, but you increasingly need it as a building block,” said Acharya, a chemical engineer who spent 17 years at ExxonMobil. “How oil is perceived has to change. The industry has to come to terms with that shift as well.”

Turning the supertanker

Oil companies have started responding to calls for more sustainability with measures such as tying executive pay to emissions reductions, writing off long-cycle assets and setting targets for reaching carbon neutrality.

Spain’s Repsol became the first large oil company to promise to reach that goal by 2050, while Shell aims to cut its net carbon emissions in half by the same year. US independent driller Occidental Petroleum is striving for carbon neutrality through its extensive work on carbon capture and sequestration technology, although it has not set a deadline.

While global coal use has peaked, oil and natural gas will remain central to the energy sector for the foreseeable future, said Roman Kramarchuk, S&P Global Platts Analytics’ head of energy scenarios, policy and technology. Despite a relatively rapid shift in rhetoric and ambition surrounding environment and sustainability, peak oil demand is not expected anytime soon.

“To get there, they have to start turning the supertanker,” Kramarchuk said. “It’s going to take a while for the momentum to shift.”

The future of oil refining

Huge uncertainties loom if an energy transition is to be carried out. Refiners will have one of the hardest puzzles to solve: how to produce more jet fuel and petrochemical feedstocks to meet rising demand for those products while curtailing gasoline and diesel output, as demand for those mainstream fuels is on track to slow with the rise of electric vehicles, biofuels and other alternative transportation fuels.

“When you’re converting oil, you’re producing all these other products,” Acharya said. “The main challenge the industry needs to confront is: how do I continue to make some of these other products that I would argue are equally important — maybe even more valuable than gasoline and diesel — but do it in such a way that I’m not left behind with all of this product that I can no longer sell?”

Tighter fuel specifications around the world have already forced the refining sector to evolve, with many smaller, simple refineries being forced to close while more complex plants tailor their output to the new standards. Further consolidation is inevitable as governments tighten regulations and demand patterns shift.

“If there’s not as much fuel needed to come from refineries, then it becomes more of a low-cost provider, survival-of-the-fittest analysis,” said Jacques Rousseau, managing director of ClearView Energy Partners in Washington. “You’re going to see a number of refineries end up closing down because they won’t be profitable.”

ARPA-E’s Acharya said transforming the energy economy would also disrupt how markets price commodities.

“Right now, everything relies on crude pricing and the pricing of fuels,” he said. “All of those prices get set in the marketplace. If you have a very different ecosystem where you have a smaller number of products, but they have very different end-uses, how the market prices those to enable them to be made will also be part of this shift.”

Investor pressure

Demand for energy may continue to rise, but demand for oil may not, said Andrew Logan, senior director for oil and gas at Ceres Investor Network, whose 170 institutional investors manage more than $26 trillion.

“While nobody has a crystal ball, and every forecast about this sector has no doubt been wrong, it is a real shift for the industry to move from 125 years of more or less being able to bet with some certainty that demand will grow over time — to now it being much more of a mixed picture,” Logan said. “If you’re doing
strategic planning as an oil and gas company, you have to at least consider the idea that demand for your product may peak in the mid-to longer term.”

Logan said that possibility has all sorts of implications for how companies invest capital. “It argues against long-lived resources like the oil sands or some offshore projects,” he said, adding “it makes shorter-lived assets a bit more attractive. It maybe makes you less likely in general to invest more money in growing production, and that’s been a trend that’s been encouraged by other factors as well,” including the recent Wall Street pressure on US shale drillers to return capital to shareholders rather than increasing production at any cost.

Optionality of US shale

In a sense, the shale boom gives the US more optionality during a potential energy transition, Logan said.

“If you’re investing in a shale well, you’re not making a bet on oil demand in 2040, which is very different from if you’re investing in an Arctic drilling platform or the oil sands,” he said. “There’s a way in which shale becoming the swing producer, or at least the marginal producer, is helpful. It gives the US and the broader global economy the ability to ramp down demand if need be.”

New technologies will be critical to an eventual energy transition, but those that can operate within the existing liquid fuel supply chain stand the best chance in the medium term. In the power sector, batteries have succeeded because they operate on the existing electricity grid.

“We tend to overlook the fact that getting oil from all across the world is an enormous business in its own right,” said ARPA-E’s Acharya. “If you can find a way to produce the same kind of fuel with the same properties that we’re using right now, it will allow you to use the same infrastructure and not have to worry about building all of that out.”

Role for biofuels

This challenge of infrastructure gave biofuels early potential, as it is a liquid fuel that can, to some extent, be shipped, stored, and used like conventional fuels. While the sector continues to confront questions of land use and lifecycle carbon emissions, researchers are pressing on to find next-generation biofuels and innovative new feedstocks.

The Mariner project at ARPA-E, for example, is examining the potential to grow algae in the open ocean as a feedstock for biofuels. “If you were going to scale biofuels and do it on a scale of 100 million b/d, you would need a game changer like that where you would harvest biomass in enormous quantities, because you’re out essentially in free space,” Acharya said.

Biofuels’ future in the energy mix may depend on demand from aviation, shipping and long-haul trucking. “Those are areas that are going to be very challenging to either electrify or switch over to hydrogen and fuel cells,” said John Field, a Colorado State University engineer who collaborates with ecologists to study the lifecycle sustainability of different biofuels.

“It’s impossible to rule out dramatic technology improvements in batteries, hydrogen storage and things like that,” Field added. “But at the moment, based on where the technology is and where it might go in the next couple of decades, there’s a lot of thinking that biofuels just fills that niche better and more cost effectively than some of these other alternatives.”

Field said biofuels research also could contribute to finding systems for removing carbon dioxide from the atmosphere, if the world overshoots warming limits like the Paris Accord’s 2 degree Celsius target. While the area of research is still speculative, he said one of the front-runner technologies would separate the CO2 produced from converting biomass feedstock into fuels, compress it, and store it underground.

‘Waddling’ into the future

Acharya predicts that something bigger and more intangible will be needed than new technologies: willingness and readiness by a wider swath of society.

“It’s up to societies as a whole around the world to accept that that kind of a shift is both necessary and possible,” he said. “The possibility will not simply be a magical technology that gets dropped from above. It will require adjustments along the way. There will be a shift, then there will be a response, then another shift.”

“You’ll be waddling your way into this future. It’s not going to be a sprint. It’s certainly not going to be without challenges. But eventually it’s something where you decide on the most likely path to success, and then focus on taking the best technologies with the best deployment pathway to putting those investments in place,” Acharya said.
Global refiners are facing a tricky balancing act as oil supplies become lighter, while their customers demand ever increasing volumes of diesel and petrochemical feedstocks. At the same time, growing levels of oil demand are being met by fuels such as ethanol.

**Refiners facing lighter oil supplies (million b/d)**

The graphic below shows expected growth in global crude by API gravity and liquid supplies from 2018 to 2030.

**Crude oils**

- Extra Light/Cond.
- Light
- Medium
- Heavy

**NGLs, condensates, other**

- Butanes, Ethylenes, LPG, etc.
- NGLs

**Middle distillates push out gasoline refining volumes (million b/d)**

Expected change in global refining yields from 2018-2030:

<table>
<thead>
<tr>
<th>Product</th>
<th>2018</th>
<th>2030</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoil/Diesel</td>
<td>3.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gasoline</td>
<td>9.41</td>
<td>9.62</td>
<td>0.21</td>
</tr>
<tr>
<td>Residual fuel oil</td>
<td>1.76</td>
<td>1.79</td>
<td>0.03</td>
</tr>
</tbody>
</table>

**Rising global plastics and chemical demand to see petchem feedstocks absorb 5 million b/d of additional oil by 2030.**

**Petrochemicals, middle distillates to capture most demand growth (%)**

Percent of expected demand change 2018-2030:

- **Gasoline:** 38%
- **Diesel:** 19%
- **Jet:** 15%
- **Oil:** 14%
- **Ethanol:** 8%
- **Fuel oil:** 6%

**Change in transport fuel demand (million b/d)**

The four major transport sectors face different paths in terms of demand growth and fuel mix as the transition to lower carbon energy gains pace. While electrification and alternative fuels are expected to increasingly sap demand for oil to power passenger cars, oil-based fuels for trucks, marine and aviation are likely to be displaced at a much slower pace.

**Passenger cars**

- **Gasoline:**
  - 2018: 20 million b/d
  - 2030: 25 million b/d
- **Diesel:**
  - 2018: 5 million b/d
  - 2030: 10 million b/d

**Trucks/buses**

- **Gasoline:**
  - 2018: 20 million b/d
  - 2030: 25 million b/d
- **Diesel:**
  - 2018: 20 million b/d
  - 2030: 25 million b/d

**Aviation**

- **Aviation gasoline:**
  - 2018: 10 million b/d
  - 2030: 15 million b/d
- **Jet fuel:**
  - 2018: 10 million b/d
  - 2030: 15 million b/d

**Marine**

- **Fuel oil:**
  - 2018: 20 million b/d
  - 2030: 25 million b/d

Source: S&P Global Platts Analytics

Infographic
Time to turnaround

Global oil demand will undergo significant disruptive changes over the next decade and refiners will need to invest and adapt to remain competitive.

The refining industry has shown itself to be adept and flexible in the past, reacting to and overcoming whatever market conditions it confronts. The last few decades have brought remarkable changes operationally as the industry has striven to cut costs and remain profitable, while at the same time investing in increased complexity.

There have been periods of upheaval as weaker operations were closed and as new entrants came into the business. Indeed, larger multinational refiners closed or sold facilities and, in turn, helped create quite large independent refining businesses. Companies have tended to exhibit more operational flexibility, with a focus on meeting market needs, while at the same time complying with ever more restrictive government regulations on product quality and other requirements, all of which necessitated significant stay-in-business capital investment.

Each year has seen its challenges and the response has, in most cases, varied regionally. The US has become a major supplier of refined products to Latin America and other parts of the world thanks to its aggressive competitiveness, which has been reinforced by its access to increasingly low-cost feedstocks, low energy costs and high complexity – often integrated with petrochemical units. Europe, faced with dwindling local demand, has become a key gasoline supplier to the US, Latin America and Africa. China has overbuilt its refining system, while continuing to battle high energy costs and a lack of indigenous feedstocks, leaving it with excess volumes for exports.

Refiners have seen demand continually increase at a global level, although some sectors, such as residential and industrial, and a few regions, like Europe, Japan and Australia, have seen rather consistent periods of decline or flat growth since the start of the century. Between 1990 and 2009, global refined products demand rose nearly 19.7 million b/d, largely in terms of distillates and gasoline.

The pace of change was even more rapid over the following decade, with consumption of the key transportation fuels jumping an additional 8.6 million b/d. Petrochemical feedstock demand surpassed even that, rising more than 3% a year, or about 3.6 million b/d, and the sector’s share of overall oil demand rose to nearly 13% in 2019 from roughly 7% in 1990.

This will help set the future direction for the industry as petrochemical feedstock demand growth will continue to outpace that of transportation fuels, as well as other refined products.

In response to such developments, a number of refiners have been gearing and will continue to gear their refinery configurations toward the production of more petrochemicals, turning crude into chemicals, rather than traditional refined products.

The change is already underway, as the refining industry demonstrates its ability to successfully adapt to a changing market environment, even though another challenge looms large: natural gas liquids’ relentless growth, primarily from US shale formations — produced from y-grades fractionation — which bypasses the refining system and accordingly reduces crude demand and refining utilization.

Claudio Galimberti
Head of Demand, Refining & Agriculture
S&P Global Platts Analytics

Evolving product demand

World oil product demand has now reached 102 million b/d, after growing by an average of nearly 1.6 million b/d per year since 2009. The pace of the increase has, of course, varied by year and across regions. In 2010, the traditional Organization for Economic Co-operation and Development nations represented about 40.7 million b/d of oil demand, around 45% of the world total. By 2019, the share of oil consumption for the major...
industrialized nations dropped to around 40%. More importantly, the growth in demand in the OECD nations over that period only amounted to around 1 million b/d, while the rest of the world saw a gain of 14.6 million b/d. Almost all of that occurred in non-OECD Asia.

Technological advancements in electric mobility, efficiency improvements in almost all oil sectors and regulatory tightening in carbon dioxide emissions will create the perfect storm, which will significantly slow the pace of oil demand growth starting in 2025-2030. But it’s too early to call for a plateau. Demand is expected to increase to around 114 million b/d by 2030, or around 1% a year. The fastest growth is expected to occur in petrochemical feedstocks demand, which leads to new types of chemical refineries.

The other significant growth will occur in the transportation sector, albeit at a far slower pace. Gasoline demand is set to slow in US, although it will continue to grow in non-OECD countries for at least the next 10-15 years. Diesel demand will be robust for the next two decades globally as there appears to be little threat from fuel substitution in heavy-duty freight, a major source of transportation diesel demand. Jet fuel demand is projected to be strong due to a lack of fuel substitutes and strong underlying growth in consumption of air transport, fueled by the swelling middle classes in emerging markets. It is noteworthy that transportation fuels account for over 50% of overall oil product demand, with much of the regulatory environmental pressure continuing to focus on this sector.

Non-OECD Asia represented around 30% of overall demand in 2019, which is expected to grow to an estimated 34% by 2030. Additional key growth areas include Latin America and the Middle East. On the other hand, Europe, Japan, Australia and potentially some regions in the US, such as the West Coast, will see demand declines, due to a combination of heavier regulation of fossil fuels and changing consumer preferences favoring alternative fuels.

As with ethanol, biodiesel is a supplement to hydrocarbon-based diesel that has seen rapid growth over the past decade, but from a low base level. Over the past 10 years, the growth has been supported by government mandates in many parts of the world, including the US and Western Europe.

Refineries have already been adapting to the loss of market position for traditional hydrocarbon-based gasoline. But the pressure on refineries will only increase as overall gasoline consumption growth is expected to slow quite significantly in the years ahead, while the usage of ethanol continues to grow, albeit at a slower pace.

Competition from biofuels

Biofuels have played an increasing role in meeting transportation sector needs, as part of clean and renewable fuel programs. The biofuels have played an increasing role in meeting transportation sector needs, as part of clean and renewable fuel programs. The

As the product, regional mix and growth rates change, refineries will adapt their systems to meet the requirements.

Refiners have already been adapting to the loss of market position for traditional hydrocarbon-based gasoline. But the pressure on refineries will only increase as overall gasoline consumption growth is expected to slow quite significantly in the years ahead, while the usage of ethanol continues to grow, albeit at a slower pace.

Over half the growth in volumetric gasoline demand is expected to be absorbed by ethanol over the 2019-2025 period, while virtually all of the gains will be taken by ethanol from 2025-2030. Consequently, in general, refineries will not see an incentive to invest in new facilities, clearly limiting new investment in gasoline production capability, except for perhaps octave generation and ultra-low sulfur gasoline.
increase in world usage has amounted to over 8% a year, but just around 800,000 b/d, or roughly 3.5% of the world transportation sector’s diesel use. That share is expected to grow to 5-6% during the course of the next decade.

Biodiesel has been and will continue to be most actively used in Western Europe. Other key markets will include the US, Latin America and Southeast Asia. Unlike for gasoline, Platts Analytics expects growth in hydrocarbon-based diesel demand over the course of the next decade, although the pace of change is set to slow.

Refiners expand outside OECD

Refining margins will remain cyclical and essentially revert to the mean, with the potential for elevated profitability at complex refineries in 2020, the year of the International Maritime Organization’s marine fuel sulfur cap change. Between 2000 and 2019, over 19 million b/d of net new refinery capacity was added, with nearly 80% of that occurring in Asian markets. Not surprisingly, most of the additions occurred in China or about 11.6 million b/d. While there were also significant additions in East Asia and South Asia, there were net closures of almost 2 million b/d in 2020 to 20.7 million b/d in 2035, at a compound annual growth rate of 2.8% per year. The demand projection includes propane dehydrogenation processes. Without PDH, petrochemicals demand will rise to 17.8 million b/d in 2035 from 11.7 million b/d in 2020.

Looking ahead, investment in Asian refineries will still be dominant, amounting to just under 40% of the planned firm plus probable additions between 2019 and 2025. Once again, China will see the largest share within Asia at over 1.2 million b/d. East Asia and South Asia will continue to grow their refining capacity.

In addition, the Middle East will see further significant capacity growth, even after the addition of capacity between 2010 and 2019. About a quarter of the net new additions between 2019 and 2025 – 1.7 million b/d – are expected to occur in the Middle East, Africa, which, saw a net decrease between 2010 and 2019, is expected to add more than 1 million b/d in the coming five years. Much of this involves the 650,000 b/d refinery being built by Dangote Group in Nigeria, which is expected to start up in 2022.

This scale of capacity addition is becoming more commonplace as several new mega-refinery additions are coming to fruition in the next few years. The commissioning of Dangote will make Nigeria’s local products markets almost self-sufficient, depriving European refineries of a key outlet for their high sulfur fuel exports. This could have far-reaching effects for Northwest European refining in particular, due to its reliance on medium sour Urals crude from Russia.

Saudi Aramco’s 400,000 b/d Jizan refinery will start up in 2020, as will the second phase of the Zhejiang (Rongsheng) refinery with a 200,000 b/d crude distillation unit, after the first 200,000 b/d of capacity began operations in late 2019. Kuwait is also in the construction phase for a long-delayed 615,000 b/d refinery that is now due online in early 2021. These projects follow the 400,000 b/d Hengli refinery in Dalian, which commenced operations in 2019.

Increasing focus on chemicals

What is notable about several of these projects, aside from their size, is their added capability for producing large volumes of on-purpose chemicals on top of traditional hydrocarbon-based refined products, including at Zhejiang and Hengli.

These are geared to making substantial volumes of chemicals such as ethylene and paraxylene. The chemical yield for these and several other newer facilities could be over 70%, as opposed to a more typical yield of up to 20%. More such refineries will be coming online over the next several years and such a trend is expected to continue well into the 2030s.

Platts Analytics expects the world to need the equivalent of 63 Worldscale ethylene crackers of 1.5 million mt/year capacity between 2020 and 2035 to satisfy growing demand for petrochemical products, which in turn is going to raise petrochemical feedstock demand from 13.7 million b/d in 2020 to 20.7 million b/d in 2035, at a compound annual growth rate of 2.8% per year. The demand projection includes propane dehydrogenation processes. Without PDH, petrochemicals demand will rise to 17.8 million b/d in 2035 from 11.7 million b/d in 2020.

Refiners face multiple challenges over the next decade, including recent and imminent specification changes to marine and road fuels across the globe. The decrease in the sulfur content in fuels will result in higher refining costs, but will also unlock opportunities for innovative refineries willing to invest in the most efficient kit to produce clean fuels and process discounted sour crudes.

The global crude slate will continue to get lighter, at least until the mid-2020s, according to S&P Global Platts Analytics’ latest estimates, on the back of US shale production growth, potentially putting complex refineries’ margins under pressure. Yet this trend could reverse by the mid-2020s, if not earlier, as Iranian and Venezuelan barrels potentially return to the market, providing much-needed heavier crude to tankers in the US, China and India.

Refining margins will remain cyclical and essentially revert to the mean, with the potential for elevated profitability at complex refineries during the first year of the International Maritime Organization’s marine fuel sulfur cap transition. Lower margins will likely follow in the subsequent two to three years due to the vast additional capacity being added, especially in China and the Middle East, which will reduce utilization rates for crude distillation units and for some downstream units.

The commissioning of the Dangote refinery in Nigeria will structurally change crude and refined product trade flows, depriving mostly Northwest European refineries of a key outlet for their high sulfur products exports. The US refining system will likely remain resilient due to its underlying competitive advantage of its high complexity, although there is some vulnerability based on the availability of discounted heavy crude. The Middle East will finally establish itself as an important refining center, capable of competitively exporting oil products, thus threatening less dynamic refining systems in contiguous regions, such as the Mediterranean.

Under a rapid energy transition scenario, sharply lower rates of demand growth for oil products derived from crude in the late 2020s and 2030s could trigger a profound rationalization in the global refining system, with winners and losers in a characteristic “survival-of-the-fittest” race. But even in this rather gloomy scenario, do not be tempted to write off the refining industry.

In fact, it has proved to be particularly resilient in the past four decades already, by shutting off inefficient units in unprofitable markets and investing in new opportunities and markets in a timely fashion. One of these opportunities in the coming years appears to be the increasing integration between trading and refining, whereby trading effectively takes advantage of refineries’ high optionality, both on the crude and on the refined product side, which tends to be very lucrative in periods of high price volatility. Recently, vast investment in the establishment of trading desks by large integrated oil companies and, at the same time, numerous acquisitions of refining assets by traditional trading companies is evidence of this trend.

Despite the many challenges refineries will face in the coming decades, there is no reason to doubt they will find a way to compete and prosper. But the road will surely be bumpy.
A clean slate

Refiners plan for changing oil demand

The global refining landscape is changing to meet new complexities, with expected changes to oil products consumption over the next decade. While oil demand is still expected to grow, at least over the coming years, what makes up that demand and where that demand comes from is becoming ever more important. The push to meet environmental goals has seen shippers switch to cleaner marine fuels and road users re-evaluate what they put in their automobiles. But a bet on the rise of petrochemical demand despite the backlash against single-use plastics, means a surge in complex mega-refineries ready to handle this downstream dynamism. Asia, Africa and the Middle East will be the driving forces as they seize on their roles as key demand and supply hubs amidst questions over how different fuels may power different sectors in different parts of the world.

A closer look at the most important and sizable refining capacities coming online over the next decade (capacity increases of 200,000 b/d or more).

**Capacity additions**

- **Scenario: firm & probable**
  - **+ 7.5 MILLION B/D**
  - **Distillation capacity (million b/d)**
    - 8,000
    - 4,000
    - 2,000
    - 1,000
    - 100

- **Scenario: Less likely**
  - **+ 30 MILLION B/D**

**Downstream’s big hitters:**

**key capacity additions**

A closer look at the most important and sizable refining capacities coming online over the next decade (capacity increases of 200,000 b/d or more).

**2020**

- **Jazan** (Saudi Aramco) 400,000 b/d
- **Zhanjiang** (Sinopec) 250,000 b/d
- **Guangdong** (PetroChina) 400,000 b/d
- **Dangote** (Dangote Group) 650,000 b/d
- **Shenhong** (Shenhong Group) 320,000 b/d
- **Papan** (IOCL) 200,000 b/d
- **Duqm** (Oman Oil Company and Kuwait Petroleum International) 230,000 b/d

**2021**

- **Jazan** (Saudi Aramco)
- **Dangote** (Dangote Group)
- **Guangdong** (PetroChina)
- **Ducim** (Oman Oil Company and Kuwait Petroleum International)

**2022**

- **Jazan**
- **Dangote**
- **Guangdong**
- **Al Zour (Kuwait Petroleum)** 615,000 b/d

**2024**

- **Jazan**
- **Dangote**
- **Guangdong**
- **Al Zour**
- **Maharashtra (ADNOC)**

**2025**

- **Jazan**
- **Dangote**
- **Guangdong**
- **Al Zour**
- **Maharashtra**

**2030**

- **Jazan**
- **Dangote**
- **Guangdong**
- **Maharashtra**
- **Jamanagar** (Reliance Industries) 600,000 b/d

**Source:** S&P Global Platts Analytics
A refiner’s view

B. Anand, CEO of Indian refiner Nayara Energy, speaks with Sambit Mohanty about what the future oil refining sector might look like in a decarbonized world

India is one of the last countries still building mega-refineries, with capacity of 247 million mt/year expected to grow by 113 million mt/year in brownfield expansions and 78 million mt/year of new capacity by 2030.

Nayara Energy operates the 20 million mt/year Vadinar refinery, India’s second-largest private refinery. The former Essar Oil was taken over in 2017 by a consortium of Rosneft, Trafigura and United Capital Partners.

As investor concern builds around future decarbonization of transportation fuels and stranded asset risk from standalone oil refineries, Nayara illustrates the sector’s increasing shift toward petrochemical demand.

In 2019, Nayara signed agreements with the state government in the western Indian state of Gujarat as part of plans to build petrochemical units, including a 450,000 mt/year polypropylene plant and a 200,000 mt/year MTBE plant. Construction of the units is expected to be completed by the end of 2022.

The proposed investment would contribute significantly toward the development of the Dehokhi Dwarika district, where the existing refinery at Vadinar is located.

Nayara aims to eventually double its refining capacity in the longer term, although no concrete plans have been firmed up yet.

To keep up with the demand for energy, the government of India is undertaking several forward-looking policy initiatives across the value chain to enhance oil and gas production, develop infrastructure and improve efficiencies within the downstream sector.

At Nayara Energy, we have invested in building capacity for cleaner and better fossil fuels such as BS VI (or Euro 6-equivalent fuels), solar power plants in our depot and other infrastructure, etc. and that plays a pivotal role in decarbonization. In addition to this, we are also diversifying our energy basket by building an integrated petrochemical complex, making it among the world’s largest integrated sites.

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The refiner also wants to play a bigger role in pushing cleaner forms of energy, including solar energy and biogas, in the future. S&P Global Platts’ Sambit Mohanty sat down with the company’s top executive, B. Anand.

How is global refining technology evolving to accommodate demand trends?

Technology is at the core of our business. Today, we have the distinct advantage of being one of the few refineries in the country that can process the most diversified crude from around the world.

The evolving refining technology and digitization of processes is helping drive improvement in reliability, efficiency and capacity, backed by an agile and nimble supply chain. This is also marked by an enhanced capability to process cleaner fuels that have low sulfur content.

Will refiners be able to adapt to expected long-term declines in gasoline and diesel demand and focus on other products where demand is not projected to fall, like petrochemicals and jet fuel?

As one of the fastest-growing economies in the world, India’s energy demand is rising. Moreover, India is expected to witness the fastest growth in oil and gas demand in the world, largely driven by industrialization and urbanization. Gasoil and gasoline will continue to be important to meet the growing demand. We believe cleaner and high-quality transportation fuel will play a significant role.

What does the future refining sector look like in a decarbonized world?

Conventional fossil fuels and new generation alternatives will coexist in the future. It is economic returns and energy security that will drive growth for each of them. While there is an increased focus on renewables, oil and gas will continue to remain essential components of the energy mix for many years to come.

To keep up with the demand for energy, the government of India is undertaking several forward-looking policy initiatives across the value chain to enhance oil and gas production, develop infrastructure and improve efficiencies within the downstream sector.

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Rising supply of US light sweet crude oil is helping less complex refiners in Europe and Asia remain competitive as they work to meet tighter limits on sulfur in gasoline.

An increase in the global supply of light sweet crude oil has been a boon to most refiners around the world, particularly those less complex plants lacking the deep conversion capacity necessary to handle heavier, more sulfurous and cheaper grades. As US oil output continues to rise, with exports of light sweet crude growing, refiners in Europe and, to a lesser extent, Asia, are benefiting from the growth.

US crude exports topped 3 million b/d for the last four months of 2019, according to US Census Bureau data. September marked the first time on a monthly basis the US was a net oil exporter — with total exports of crude and refined products exceeding imports by 90,000 b/d, in part, to the ramping up of light sweet crude exports. S&P Global Platts Analytics forecasts US production will grow about 770,000 b/d in 2020 to 12.94 million b/d, while the US Energy Information Administration sees it growing 930,000 b/d to 13.18 million b/d.

With momentum shifting toward lower sulfur fuels, including the International Maritime Organization’s 0.5% marine fuel sulfur cap that went into effect January 1, the increase in supplies of lighter, sweeter crude helps less complex refiners in Europe and Asia stay competitive by reducing sulfur through sweeter crude feed slates.

European cracking margins for refiners running WTI MEH — US benchmark West Texas Intermediate priced at Magellan’s East Houston terminal on the US Gulf Coast — averaged $5.89/b in November, according to Platts Analytics margin data, a 95-cent premium over running local North Sea Forties crude.

In Asia, WTI MEH cracking margins for Southeast Asian refiners averaged $1.33/b in November, compared with a minus $6.41/b monthly average for Forties. Increased popularity and supply of US crudes in the global marketplace has created concern about crude quality, particularly for Permian Basin barrels, where specification quality depends on barrel provenance. To support the growth of the US crude export industry, both producers and exporters have seen the need for the same price transparency and quality control for US grades that domestic refiners enjoy.

The US makes, the world takes

“The US is the fastest-growing exporter of crude and NGLs,” Phillips 66 CEO Greg Garland said at a company analyst day November 6. “We expect domestic growth to be relatively flat, so the majority of this is going to need to be exported. The shale crude quality is light and sweet and attractive in a low-sulfur IMO environment, especially in Asia and Europe for low complexity refining.”

Phillips 66 is just one of several refiners and midstream companies who are actively engaged in supporting the US crude export market, as US Gulf Coast refiners are reaching their limits for running light sweet crude in their sophisticated coking plants.

Phillips 66 expects to increase its current 400,000 b/d of crude export capacity to 1.8 million b/d in 2022. In November, Phillips 66 started limited service on its Gray Oak Pipeline, which, when in full service early in 2020, will carry 900,000 b/d of Midland crude to the port of Corpus Christi. The line will connect with the South Texas Gateway Terminal, due online in mid-2020, allowing partial loading of VLCCs.

All crudes are not created equal

As new pipelines coming online have alleviated export constraints, quality-control issues have arisen. This is, in part, because of the lightening of the barrel from some parts of the Permian. As a result, many barrels from the Permian have a higher API than the standard 39 API, which has created challenges for refiners looking to run lighter barrels in their plants.

US refiners with operations in the Permian, like Delek US Holdings, have touted their ability to have “quality” barrels — such as WTI with an API gravity between 37 and 42 from the heart of the Permian in Midland, Texas — at their disposal.

In an effort to alloy the concerns of importers of US crude that the API quality of WTI falls within that scope, controls have been put into place at the point of delivery for barrels from Midland, with pipeline provenance clearly delineated.

As a result, S&P Global Platts’ assessments for WTI FOB from the US Gulf Coast were recently expanded to include Midland barrels from six pipelines: BridgeTex, Cactus I and Cactus II, Lenghorn and Midland-to-echo I and II. Platts offers a WTI FOB-to-Rotterdam assessment, as well as delivered price assessments to Augusta, Singapore and Yeosu.

Besides WTI export assessments, separate assessments for Bakken, Eagle Ford, and Eagle Ford condensate have been created, reflecting loadings from USGC ports including Houston, Corpus Christi, Nederland and Port Arthur.

As demand rises, more Permian crude pipelines are expected online, including the 1 million b/d Wink-to-Webster pipeline scheduled to start in the first half of 2021, backed by ExxonMobil and Plains All America, among others.
Rules of the road

Road fuels are evolving across the world as countries target air pollution by setting tougher sulfur standards for gasoline and looking to blend in more renewable fuels.

The road fuel market is set to evolve as refiners adapt to optimize gasoline production and meet increased demand for higher octane fuels, and governments require lower sulfur content and higher biofuel blending.

The transition to cleaner road fuels is evident in Europe’s gasoline market as nations move toward 10% ethanol content in gasoline.

The EN228 gasoline standard, which is widely adopted across Northwest Europe and became an EU directive, contains up to 5% ethanol, maximum 10ppm sulfur and minimum 95 RON. The market is moving to E10, driven by EU-wide targets under the Renewable Energy Directive and Fuel Quality Directive, but it is implemented differently in each member state.

The Netherlands — the largest gasoline-exporting nation in Europe with over 1.29 million b/d of capacity — introduced gasoline blended with 10% ethanol in October, joining Finland, Belgium, France, and Germany in the higher-ethanol blend at the pump.

Concerns about higher ethanol blends persist, particularly among Germany’s car enthusiasts, but the consensus is that E10 can be used in around 90% of gasoline-powered vehicles in Europe and in 99.7% of the gasoline-powered vehicles produced since 2010.

European consumers are becoming more conscious about environmental protection as well as vehicle efficiency.

The growth of the electric vehicle fleet will rise in importance in 2020, with countries such as the UK boosting both the number of cars on the road and the charging infrastructure. The UK offers grants of up to £3,500 for new electric cars, but the subsidy’s future is uncertain.

Another topic closely being monitored is the growth in sales of higher-octane, or premium, gasoline in Europe, which commands a higher price at the pump. Sales of higher-octane fuel have grown steadily in recent years, with a more advanced vehicle fleet across Europe’s more developed economies, although consumers’ environmental concerns have somewhat capped the increase.

US hard deadline for Tier 3

US refiners face challenges ahead for both major road fuels, diesel and gasoline. Diesel cracks climbed above five-year average levels ahead of the January 1 debut of the 0.5% sulfur limit for marine fuel the International Maritime Organization mandated.

Overshadowed by the whirlwind challenge of IMO 2020, US refiners faced another major sulfur cut January 1 with the US Environmental Protection Agency’s Tier 3 gasoline specifications — requiring US refiners to reduce the amount of sulfur in gasoline to 10 ppm from 30 ppm — going into full force.

Under the 2014 law, refiners had six years to phase in capital investments to be able to make enough low-sulfur gasoline to meet demand. In the interim, refiners have been able to fill the gaps with credits while making Tier 2 gasoline.

As the deadline neared, the price of Tier 3 credits spiked, while expiring Tier 2 sulfur credits “are nearly worthless,” said George Hoekstra, independent oil consultant and expert on Tier 3 gasoline. In August, S&P Global Platts Analytics pegged Tier 3 credits at about $1,990/credit.

Hoekstra estimates that about 70% of US refiners are not making 10 ppm sulfur gasoline required by the Tier 3 gasoline specs.

“All refiners are compliant,” he said. “But not all refiners are making compliant gasoline. Most refiners who say they are Tier 3 compliant mean they will be shipping off-spec barrels with the intent to comply by buying credits later at unknown future prices.”

NATIONS TIGHTEN GASOLINE STANDARDS TO CURB AIR POLLUTION

Source: Stratas Advisors, S&P Global Platts

Maximum sulfur limits in gasoline, 2020

<table>
<thead>
<tr>
<th>ppm sulfur</th>
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</thead>
<tbody>
<tr>
<td>0-10 ppm</td>
</tr>
<tr>
<td>11-50 ppm</td>
</tr>
<tr>
<td>51-150 ppm</td>
</tr>
<tr>
<td>151-500 ppm</td>
</tr>
<tr>
<td>Over 501 ppm</td>
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</tbody>
</table>

No information/ Not regulated

Over 501 ppm

Hoeekstra estimates that Tier 3 credit supply is “minuscule compared to likely demand,” which means prices will rise further.

“Tier 3 credits will go high enough that some refiners will pay hundreds of millions of dollars for them in 2020, 2021, and 2022. It will be similar to how the RINs issue played out,” he said, referring to US renewable fuel credits.

But sources with knowledge of the situation said most of the major refiners, like Chevron, Valero, and Marathon, are already complying with Tier 3 gasoline requirements, and are building up Tier 3 credits as a result.
One conundrum these refiners face is that reducing the amount of sulfur in gasoline also reduces the octave level, at a time when car manufacturers are making cars with higher-performance engines that require more octave.

While increased hydrotreating will reduce the sulfur content in gasoline, it also strips out more octave. New hydrotreating catalysts that minimize octave loss have been installed in many refineries and will help staunch the octave loss, according to Platts Analytics.

Platts Analytics estimates that cat gasoline hydrotreaters to do more desulfurization, but again we believe octave loss will be manageable,” according to Platts Analytics.

Asia tightens sulfur limits

In Asia, developing economies’ embrace of lower sulfur limits will have a major impact on trade flows. China adopted the Euro 6-equivalent China VI standards in 2019, placing the region’s biggest exporter of gasoline among the top five countries in Asia with strict emission standards, such as neighbors South Korea and Japan. Historically, China plays a large role in the gasoline market, with 2020 exports expected to surpass the 2019 average of around 380,000 b/d.

Gasoline-hungry India is set in April to adopt the Bharat VI standard, which is similar to Euro 6 specifications and limits sulfur content to 10 ppm from the current 50 ppm. The market impact of India’s shift to lower-sulfur gasoline started appearing months before the deadline. Major turnarounds at Indian refineries boosted demand for spot gasoline imports to plug supply gaps, which raised prices and caused new trade flows to emerge.

New refining capacity is making the Asian gasoline pool lower in sulfur, with integrated refineries such as Malaysia’s RAPID plant and Brunei’s Hengyi, among others, having the capability to make lower-sulfur fuels. Chinese state-owned refiners are increasing their focus on India as an outlet for gasoline. For example, Petrochina sent its first MR-sized cargo to Indian state-owned Hindustan Petroleum Corp. Ltd. in October.

Asia’s gasoline demand growth weakened sharply to below 190,000 b/d in 2018 from close to 500,000 b/d in 2015, and it is expected to fall to 150,000 b/d in 2019, mainly from the slowdown in China amid trade tensions with the US and a slump in vehicle sales. India’s gasoline demand rose to 700,000 b/d in 2019, from 688,000 b/d in 2018. But higher taxes and insurance costs have dampened vehicle ownership in India amid a slowing economy, and the pace of decline in auto sales has accelerated as a liquidity crunch in the shadow banking sector has dried up lines of credit to both auto dealers and potential car buyers.

India’s implementation of Euro 6-equivalent gasoline specifications could dampen gasoline demand, as happened in China last year.

Sulfur shift seen in Africa

Expanding Asian refining capacity has also opened opportunities for cargoes to move to West Africa, which historically have been very rare. West Africa is a major gasoline importer that still allows a sulfur content of up to 1,000 ppm — 100 times the limit of Europe, the US, China, and soon, India — although it too is feeling global pressure to curb emissions.

A recent Nigerian National Petroleum Corp. tender sought gasoline with 500 ppm maximum sulfur. Nigeria is the leading importer of European gasoline, taking about 281,000 b/d, typically from the Amsterdam-Rotterdam-Antwerp hub.

Changing benchmarks

Recognizing the need to stay relevant in the increasingly cleaner gasoline space, S&P Global Platts undertook several changes in 2019 in its ongoing commitment in providing robust price assessments that reflect regional trade flows. Platts amended the specifications for the benchmark FOB Singapore 92 RON unleaded gasoline, 95 RON unleaded gasoline and 97 RON unleaded gasoline on July 1, 2019, following a prolonged consultation with market participants.

The change dropped the sulfur content for all three gasoline grades to a maximum of 50 ppm from 350 ppm, as well as lowering the maximum limits of several other specifications, such as final boiling point, aromatics limit, olefins limit, and Reid Vapor Pressure.
Expanding markets

CJ Warner, CEO of Renewable Energy Group, North America’s top biodiesel producer, speaks with Meghan Gordon about the role of advanced biofuels in a future energy transition.
Finding a better blend

Non-crop feedstocks stand to benefit from governments’ shift towards carbon-intensity targets, while traditional crop-based biofuels are expected to continue to play a role.

Carbon-reduction targets are taking center stage in government discussions about the future of biofuels policy around the world as volumetric goals seem to be a thing of the past. This is changing feedstock supply and demand trends.

Biofuels programs have historically focused on spurring higher blending into transportation fuels. But as more countries pledge to meet climate accords, newer programs are agnostic toward biofuel and feedstock, as long as the finished products meet or beat requirements.

California’s Low Carbon Fuel Standard, and other programs like it, have changed the game, according to Corey Lavinsky, global biofuels analytics adviser with S&P Global Platts Analytics. Such programs assign a carbon-intensity score to every gallon of fuel — be it plant-based or derived from fossil fuel — depending on how it and its feedstocks were produced. The approach attempts to consider a fuel’s full lifecycle emissions and converts it to a carbon dioxide-equivalent.

Supply and demand of both ethanol and biodiesel will continue to rise to meet emissions targets and climbing volumetric mandates, but feedstocks for those biofuels will keep evolving as new mandates favor alternative or next-generation processes.

“Carbon intensity values have added a new dimension to biofuels that was not overly important when the Renewable Fuel Standard was created,” Lavinsky said, referring to the US’ volume-based federal blending program that started in 2006.

Focus on new feedstocks

California’s LCFS is one of the longest-running programs, containing a robust dataset that lends itself to analysis. In 2011 through 2013, conventional ethanol accounted for more than 69% of the carbon credits generated, according to California Air Resources Board data. But climbing credit costs have spurred investment in alternative fuels.

From January 2018 through the second quarter of 2019, renewable diesel accounted for over 32% of credit generation, just shy of ethanol’s 34%.

“On the world stage, corn-based ethanol is much less desirable than ethanol made from sugarcane or molasses,” Lavinsky said. “It’s good for meeting volumetric mandates, but not as good for meeting [greenhouse gas] reduction targets. As for biodiesel, there will be less demand for biodiesel made from soy and canola in GHG-reduction areas, and more demand for biodiesel and renewable diesel made from used cooking oil, corn oil and tallow.”

The European Union has also passed regulations that cap the use of biofuels with the highest risk of changing land to agricultural use at 2019 levels. That’s left market participants searching for alternatives that meet blending mandates while also hitting GHG emissions targets.

“Road vehicles have an average 10-year lifecycle so widespread electrification of transportation is some distance off,” said Angel Alberdi, secretary general of the European Waste-to-Advanced Biofuels Association.

In Europe, biodiesel made from used cooking oil counts for double the volume of biodiesel made from conventional crop feedstocks when it comes to GHG targets. A market participant needs to blend one liter of biodiesel, they could blend half a liter of used-cooking-oil-based biodiesel and meet their requirement.

“Low carbon liquid fuels are the best renewable option for road transportation for the foreseeable future, and waste-based biodiesels are preferred, given their comparatively higher GHG savings,” Alberdi said. “Road, heavy duty and marine use will be important uses of waste biodiesel in the future.”

Securing waste feedstocks will be an ongoing challenge, but supply...
Evolution of biofuels

has become more consistent thanks to increased demand, Alberdi said.

“Promotion of waste biodiesel in Europe is helping develop collection networks in the EU and in third countries, and we see a steady increase of available resources,” he said.

The logistics of gathering small volumes of a product like used cooking oil from restaurants and other scattered locations have kept costs high compared with conventional, virgin vegetable oils.

To achieve low carbon-intensity scores, some producers have poured money into developing hydrotreated vegetable oil, or renewable diesel. Originally using conventional vegetable oils, producers can now hydrotreat a variety of feedstock oils to produce the same product.

Neste is currently the largest HVO producer in the world, but rising demand has driven plant expansions in Europe, Brazil and the US, with Asia already serving as a production hub.

While renewable diesel and some biodiesel have similar carbon-intensity scores, data from California’s LCFS shows why renewable diesel has been increasingly favored over biodiesel made from conventional feedstocks.

Renewable diesel certified under the LCFS averages 32.05 carbon intensity, compared with 54.13 for soybean oil-based biodiesel. Soybean oil is the most common feedstock for biodiesel produced in the US.

Space at the table

Since the 1970s, Brazil has required the blending of an increasing amount of ethanol into gasoline, with the current target at 27%.

The program has long been hailed as supporting the Brazilian sugarcane industry, with almost 390 million mt of sugarcane being crushed in 2019 for ethanol use.

Brazil launched a new biofuels program in 2019 aimed at helping the country meet international climate agreements. RenovaBio sets carbon-intensity targets that would reduce GHG emissions over 10 years.

Brazil’s overlapping targets represent the future of biofuels policy, according to Platts Analytics.

“In many cases these programs are not substitutes but complementary to volumetric mandates or targets,” according to Patricia Luis-Manso, head of sugar and biofuels with Platts Analytics. “This means a lot of the growth will be in alternate feedstocks like used cooking oil — but the majority of the feedstocks used will remain the more traditional ones.”

That bodes well for countries that have structured policies to create volumetric targets. Farmers in Brazil and the US both have looked to their ethanol industries as important sources of demand for their crops.

In the US, ethanol production consumed 37% of corn supply in the 2018-19 marketing year, according to the US Department of Agriculture.

China likewise turned to ethanol production to attempt to consume its high corn inventories after years of stockpiling.

And even as nations focus on programs that will reduce carbon emissions through carbon intensity targets, China continues to try to implement a nationwide mandate to blend 10% ethanol into the gasoline pool, which would create around 17.1 billion liters of ethanol demand in 2020.

Full implementation, however, remains unlikely.

Platts Analytics expects demand for both ethanol and biodiesel to rise in 2020 as governments seek to meet GHG emissions targets, with biodiesel rising 7.2% and ethanol 2.1%.

Still, countries are increasingly rethinking the effects of crop-based biofuels and encouraging investment in feedstocks that can sequester carbon without converting land to agricultural use.

“Otherwise the challenge of biofuels will always be linked with how land is used,” said Madhav Acharya, technology-to-market adviser at the US Department of Energy’s Advanced Research Projects Agency—Energy.

“And increasingly with using land as a way to store carbon, the industry will be challenged to explain why land that can otherwise be sequestering carbon should instead be converted to producing crops that can then produce biofuels,” he added.

“Road vehicles have an average 10-year lifecycle so widespread electrification of transportation is some distance off”

— Angel Alberdi, secretary general of EWABA
Get the balance right

The emergence of new fuel sources will depend on the right market conditions, as well as having the right technology – as the slow adoption of gas-to-liquids technology shows.

The adoption of new fuel sources depends not only on proving the technology, but having the right market conditions. The slow progress of gas-to-liquids technology, once heralded as a solution for monetizing stranded reserves of natural gas, shows what happens when those two forces are not aligned.

GTL has had to compete with the rapidly expanding LNG export market and remains prohibitively expensive for all but the largest market players. In the US, GTL technology has not yet reached commercial viability, except for a limited number of small-scale projects. However, a number of smaller companies are working to develop cheaper technologies that might one day be put to use in niche markets in the US and across the globe.

GTL relies on a chemical process to convert natural gas to liquid fuels such as gasoline, jet fuel and diesel, while liquefaction is a physical conversion that makes natural gas more easily transportable. The most common technique used at GTL facilities is Fischer-Tropsch synthesis, which converts natural gas to syngas, which is then converted to synthetic crude oil, or F-T syncrude. That can then be refined into synthetic diesel fuel and other products.

Although the process has been around for about a century, only in recent years have several largescale GTL projects been constructed “because of the growing spread between the value of petroleum products and the cost of natural gas,” according to the EIA.

Advocates have also promoted the use of GTL technology as a way to monetize stranded gas and reduce flaring of associated gas volumes in predominantly US oil-producing provinces, such as the Permian Basin and Bakken Shale plays. But the oil and gas industry has been slow to adopt the technology for these applications, largely as a function of its cost and the growth of alternative methods of bringing gas to market, such as liquefying it for shipment as LNG to gas-hungry nations.

Today, the GTL world is dominated by a handful of “world-class” plants in Malaysia, Qatar and South Africa. The largest is the 260,000 b/d Pearl GTL facility, a joint development by Qatar Petroleum and Shell that processes gas from the giant North Field in the Persian Gulf.

In recent years, the growth of international GTL mega-projects has slowed, Nicholas Skarzynski, an EIA natural gas analyst, said in an interview.

In its 2017 International Energy Outlook, EIA predicted two large-scale GTL projects would come online in the next decade, a 37,600 b/d facility in Uzbekistan in 2021, and a 160,000 b/d plant in South Africa in 2025 that would be converted from a coal-to-liquids facility.

However, Skarzynski said EIA no longer believes the South African plant will be converted fully to GTL production, leading EIA to expect growth in the global GTL market will flatten out over the next several years.

He attributed the slowdown in global GTL growth to the rise of the LNG market. “In some ways it competes with LNG. Qatar has announced they’re going to build more LNG,” he said.

In the US, which has no largescale GTL plants, the technology largely has failed to take hold, despite the efforts of some smaller companies to promote the construction of small-scale projects. “We haven’t really seen too much movement in the US,” Skarzynski said. “If there’s movement on any front, it’s the very small ones, but even that is kind of slow moving.”

The few GTL projects that have been built in the US have consisted of micro-sized plants with capacity of 100 b/d to 200 b/d, not big enough “to move the needle,” for the EIA, he said. Yet, several small development companies are hoping to use the latest GTL technology to create a thriving industry.

“There’s been a new breed of technology coming into the market over the last 10 to 15 years, that is trying to make these systems cheaper, smaller and modular,” Walter Breidenstein, CEO of Michigan-based Gas Technologies, said in an interview.

Rather than producing synthetic diesel, Breidenstein’s company uses a GTL process to convert associated gas that would otherwise be flared or natural gas from a pipeline to methanol and ethanol. He added that the process is much simpler and cheaper than that used in even the most economic traditional F-T GTL plant.

“I’m only in about the $5 million to $10 million in price range, not $80 million to $100 million, because I’m a single-step process, not a three-step process,” Breidenstein said.

And yet, even at the bargain-basement price, he said few big integrated oil and gas companies are willing to take a risk on a new technology for monetizing gas assets that has not been proven to be viable on a commercial scale.

“They would rather flare the gas with a $100,000 flare, than they would be willing to spend $5 million to take a risk on a new technology,” he said. “We’re all sitting, waiting patiently for somebody to be the first mover.”
Not all biofuels are created equal

The sustainability credentials of biofuels have always been disputed. Production of food crops as biofuel feedstock has been linked to deforestation and volatility in cereal prices. However, biofuels’ potential to reduce GHG emissions in the transport and energy sectors has made it an important part of climate policy in many countries.

The use of biofuels in the transportation sector needs to increase from around 2% of the transport sector mix to about 15% by 2050 to meet the 1.5 degrees Celsius warming target in the Paris Agreement, according to a 2017 report by the IPCC.

Recognizing this ambition, regulators have started to introduce rules to regulate the sustainability credentials of biofuels to ensure they become an effective climate policy tool. For example, carbon intensity scores are being used in California’s new fuel standards and there are restrictions on biofuel coming from high “land use change” risk sources in the EU’s Renewable Energy Directive.

Today, there are multiple methods to assess the environmental impact of biofuel, but carbon intensity is the metric adopted by most policymakers. However, the environmental impact of biofuels is not just about GHG emissions. In addition, the type of crop, place of origin and farming practices are all important factors that could enhance or tarnish the fuel’s sustainability credentials.

The importance of land

Carbon intensity, measured in grams of carbon dioxide equivalent per megajoule of energy in the fuel, captures the greenhouse gas emissions from the production of the feedstock, the fuel conversion process and the combustion of the fuel. In theory, biofuels are carbon-neutral at the point of use, meaning the amount of carbon emitted from their combustion would have been balanced by the carbon absorbed during the growth of the feedstock. The reality is a little more complicated.

To begin with, conversion of feedstock into fuel requires energy, usually generated from fossil fuels. Also, to achieve the balance, the speed at which the feedstock is regrown has to match the rate of biofuel consumption, which might not always be the case.

Despite that, the scientific consensus is that biofuels produced from feedstock grown on existing cropland are less carbon-intensive than fossil fuels such as diesel and petrol.

Biofuels made from conventional food crop feedstocks such as corn, sugarcane or oilseeds generally have higher carbon intensity than their lignocellulosic counterparts made from switchgrass or straw. For instance, the carbon intensity of bioethanol produced from switchgrass is less than two-thirds that of fuel produced from corn. The extra carbon in corn-based biofuel comes from the GHG emitted during the manufacturing and application of nitrogen-based fertilizers, an essential ingredient in the industrial production of most food crops.

The picture is rosey until we take into account “land use change” – in other words, the clearing of native forests or grasslands. This is what critics of biofuels usually cite as the unintended consequence of biofuel production. The increased demand for biofuels drives prices higher, and farmers respond by converting forests to cropland to expand production.

Carbon dioxide equivalent per megajoule

AVERAGE CARBON INTENSITY OF SELECTED BIOFUEL, FROM PRODUCTION TO COMBUSTION

Source: Royal Academy of Engineering

WATER STRESS INDEX

Source: World Resources Institute

Native ecosystems, such as tropical rainforests, are natural stores of carbon. They absorb carbon through the growth of trees and store them in the vegetation or soil. Clearing of these ecosystems would lead to the release of large amounts of carbon into the atmosphere, usually through burning and decomposition of vegetation.

This is the reason feedstock produced on land obtained from cleared forests has a significantly higher carbon intensity than feedstock grown on existing cropland. Biofuels derived from palm oil produced on land converted from forests is 80% more carbon intensive than conventional fuels. An EU study put the carbon intensity of biofuel produced from converted peatland in Indonesia and Malaysia, one of the most carbon-dense ecosystems in the world, at 231 gCO2e/MJ, almost two-and-a-half times higher than that of the average of gasoline and diesel.

Water dependency

Carbon intensity is the favored metric when it comes to regulating the environmental impact of biofuels among top consumers, such as the US, Brazil and the EU. However, governments could potentially broaden the scope of biofuel regulations to include the fuel’s water impact. On an energy unit basis, the water footprint of biofuels is higher than its fossil-based counterparts. Bioethanol has an average water intensity of 3.3 liters/MJ, which is 40 times higher than conventional gasoline. However, water intensity could vary significantly based on where the feedstock is produced. For instance, the production of biodiesel feedstock requires no irrigation in Germany, while an average of six liters of water is required to produce one megajoule of rapeseed biodiesel in Spain. Feedstock produced in regions that are expected to face water shortages is more vulnerable to a decreased yield and increases in the cost of production. For example, McLean County in Illinois and Diamantino municipality in Mato Grosso are some of the biggest soy producing regions in the US and Brazil, respectively. The latter, located in the frontier between the Brazilian Cerrado and the Amazon rainforest, has much lower water stress than the former, meaning the region can maintain enough available water with respect to demand. The water stress is expected to worsen in McLean County due to changes in climate and water demand and could put pressure on future production capacity and prices.

The role of ecosystem restoration and bioenergy has gained a prominent status in recent international climate negotiations. While they certainly have a role to play in the years to come, expect to see the sustainability credentials of biofuels being scrutinized by regulators, scientists and activist groups as these policies are implemented.

It is also important that companies and their investors examine the fuel’s impact with relevant carbon, land, water and other science-based metrics. Because, after all, not all biofuels are created equal.
Brace for turbulence

Aviation will be one of the toughest sectors to decarbonize, as weight, distance and safety concerns limit the alternative fuel options compared with other types of transport.

Recent protests by climate action group Extinction Rebellion and the well-documented Atlantic voyages of Greta Thunberg have put aviation in the spotlight for its environmental impact and the behavior of more affluent sectors of society.

Air travel has become increasingly affordable, competing with other modes of transportation and giving society more choice on where it wants to live, work or go on holiday. More than 100 million people enter the middle class every year, taking their first flights and adding to the growing demand for air travel.

Decarbonizing air transportation is incredibly challenging. The fuel supply chain is strictly governed by Aviation Fuel Quality Control Procedures, ensuring that fuels put in our planes meet high standards to ensure safety. Alternative sources of energy, such as batteries or hydrogen, have great limitations because of weight and safety concerns, let alone the supply chains required. As such, the industry has remained focused and committed to improving aircraft efficiency, meaning demand will remain sticky for jet fuel for at least the next 50 years.

Given this conundrum, the industry has increasingly focused on carbon offsets or new net-zero emission “drop-in” fuels as solutions to reducing the impact of aviation on the planet.

Carbon offsets are relatively cheap, but only pass the problem of aviation emissions to someone else, while NZE fuels are limited in volume and prohibitive in cost. Offsets may help to ease flyers’ consciences, but raising the cost of fuel through increased use of NZE options would provide a greater economic incentive to force consumer choice. In reality, the most effective way to reduce emissions is to eliminate demand – limiting air freight (and demand for perishable goods with high ton-miles) and banning some short-haul flights.

Aviation remains a very effective mode of transportation that supports economic development and growth. As Thunberg’s recent voyage illustrated, alternatives are difficult. Ironically, the carbon savings from her sail from New York to London were effectively offset by crew members taking trans-Atlantic flights to the US so they could help sail the boat back to Europe.

Emissions impact of aviation

While emissions from aviation make up a comparatively small share of total global greenhouse gas emissions, they are also growing faster than any other sector in transportation. S&P Global Platts Analytics estimates aviation emissions currently make up just 3% of global energy carbon dioxide emissions and 11% of emissions from transport. But according to Platts Analytics’ Scenario Planning Service World Energy Demand Model forecasts, they are also expected to rise 2-3% annually through 2040, meaning aviation’s share of total CO2 emissions will double.

Aviation growth will be strongest in the developing world, where the rise of the middle class will lead to increased air travel demand, partly negating other efficiency gains.

This growth in aviation demand is focusing attention on the policies and technologies needed to reduce the sector’s emissions. Unlike most other sectors, aviation CO2 emissions are not directly covered by the United Nations Framework Convention on Climate Change 2015 Paris Agreement, but are instead in the International Civil Aviation Organization’s purview. Following years of negotiations, in 2016, ICAO agreed to adopt the Carbon Offsetting and Reduction Scheme for International Aviation program. CORSIA will require individual aircraft operators to submit carbon offsets to cover the increases in aviation emissions from international flights from 2019-20 levels. Voluntary compliance will begin in 2021, with mandatory participation not coming until 2027.

Neither China nor Russia have confirmed that they will participate in CORSIA’s voluntary stages. The US will participate in the voluntary stage, but has also noted it depends on “a high level of participation by other countries, particularly by countries with significant aviation activity.”

The EU’s cap-and-trade program, the EU Emissions Trading System, started covering aviation emissions from both intra-EU flights and flights to/from the EU in 2012. In response to intense pressure from the US, China, and...
However, this will increasingly focus on assumptions for total crude runs and fuel demand under our current forecasts. Platts Analytics believes that refiners will be able to meet rising jet fuel demand at takeoff and landing, short flights are particularly fuel intense, and have fewer emissions-intensive alternatives. Although UK government estimates suggest that CO2 emissions on a passenger-kilometer basis for a short-haul flight could be two to four times higher than for rail or coach transportation. Advancements in other forms of land-based transportation, such as greater electric vehicle penetration, or even hyperloop technologies, could also encourage cross-modal switching away from aviation.

**Jet fuel supply chain**

Today, jet fuel makes up just under 10% of demand for total refined oil products. Depending on how demand for other products changes over time, this share of refined product demand will rise, putting increased focus on the yield of kerosene from refineries, which is limited at 12-15%. Platts Analytics believes that refiners globally will be able to meet rising jet fuel demand under our current assumptions for total crude runs and demand for road transportation fuels. However, this will increasingly focus on refiners maximizing yield and result in significant regional imbalances and the evolution of new supply chain patterns.

While the complexity of the supply chain and need for rigorous quality testing of petroleum-based jet fuel — Jet A or A-1 — makes changing the base fuel challenging, ICAO is encouraging the increased use of Sustainable Aviation Fuels. SAFs can have a range of feedstocks, including waste oils, fats (tallow), biomass and other production methods such as “power to liquids.” But a key aspect is their ability to be “dropped in” as a replacement fuel with no changes to existing aircraft or fuel-supply systems.

At its first “stocktaking” seminar on SAFs in May, ICAO said its belief was that global SAF production capacity could grow to 1.7 billion gallons/year by 2026, and to 2 billion gallons/year by 2030. Assuming 100% production, SAFs would then amount to about 1-2% of total global jet fuel demand in both years. Assuming they are counted as zero emissions, SAFs could also meet 12% of our expected emissions increase, compared with the 2020 CORSIA baseline by 2025. But with total aviation sector growth set to outpace that of SAF production, it would meet just 7% of the emissions increase compared with 2020 by 2030.

**AirCraft efficiency**

New efficiency measures can also help improve aviation-sector emissions. Fuel consumption represents one of the largest costs for airlines, and so there is an immediate economic incentive to reduce fuel burn. Platts Analytics assumes a 2% annual fleet fuel efficiency increase, in line with ICAO’s existing efficiency target through 2050, based largely on fleet turnover rates. Additional retrofit improvements can also help reduce jet fuel demand — and associated emissions — of the existing aircraft fleet. For example, upturned wing tips (winglets) have become a staple retrofit to reduce aerodynamic drag and cut fuel demand by as much as 6%.

The ensuing generation of aviation efficiency technologies has begun to work its way into design characteristics. More radical shifts in aviation engineering to improve efficiency can be expected over the medium to long term. Aircraft that combine a jet turbine located in the back of the fuselage and a wider, flatter body can potentially reduce fuel burn by between 37% and 50%. Demonstration projects of these models are expected in 2021.

Given concerns over the weight of batteries, it has been more challenging to replace incumbent fossil technologies with electricity in aircraft. Some companies are testing demonstration planes powered by battery electric and hydrogen drivetrains, but it is less likely that alternative-fuel drivetrains will be integrated into large commercial aircraft in the medium term. Operational strategies also show potential for large-efficiency improvements, such as the dynamic optimization of climb and descent trajectories, which operate turbines at the ideal power output for operational requirements.

GrowTh in airline emissions can potentially be addressed by transitioning to alternative modes of transportation. Given the high volume of fuel consumed at takeoff and landing, short flights are particularly fuel intense, and have fewer emissions-intensive alternatives. Although UK government estimates suggest that CO2 emissions on a passenger-kilometer basis for a short-haul flight could be two to four times higher than for rail or coach transportation. Advancements in other forms of land-based transportation, such as greater electric vehicle penetration, or even hyperloop technologies, could also encourage cross-modal switching away from aviation.

**Limits on freight, short flights**

Despite the possibilities of emissions reductions that SAFs, new technologies, and efficiency gains may offer, it is not clear that the policy framework and financial incentives are in place to drive penetration. ICAO has not set an official target for the production or consumption of SAFs. In the US, production of SAFs can generate Renewable Identification Numbers that are used for compliance with federal biofuels mandates, although facilities tend to favor production of higher value road transport biofuels. California’s market-based Low Carbon Fuel Standard, which regulates the carbon intensity of transportation fuels, does not cover the aviation sector, but SAFs can earn credits in the program. Canada is considering a similar program — the proposed Clean Fuels Standard — but has not decided how to cover domestic aviation, nor how to encourage SAF production.

While ICAO has yet to determine what types of offsets will be eligible for use in CORSIA, it is likely to be much less expensive than actual reductions in the sector. Carbon offsets generated under the UN’s Clean Development Mechanism are currently trade below €20 cent/m3 of CO2 (25 cents), having fallen from above €10/m3 earlier this decade. North America-based offsets currently trade at about $15/m3 of CO2.

Nevertheless, the EU experience suggests that even relatively high carbon prices may not send a sufficient-enough price signal to encourage aviation emissions reduction. Aviation emissions covered by the EU ETS have risen 2-8% annually since being subjected to a carbon price. Despite EU carbon prices rising to €25/m3 during 2018, covered emissions nevertheless still rose 4% that year. SAFs currently cost two to three times as much as petroleum-based jet fuel. With petroleum jet fuel currently around $2/gal, Platts Analytics estimates that carbon prices would likely need to reach at least $300/m3 of CO2 to make SAFs cost competitive, absent other mechanisms. That said, SAFs are being supported by bottom-up policy efforts and a willingness to invest by key private-sector stakeholders. A recent example includes a letter of intent signed by KLM and Microsoft that includes a commitment to buying the SAF equivalent to all flights taken by Microsoft employees between the US and the Netherlands on KLM and Delta Airlines.

To reduce the direct impact of aviation, the world needs to reduce demand by: limiting short-haul aviation and providing realistic high-speed train alternatives; curbing air freight; and increasing the cost through mandates for higher use of SAFs, forcing tougher consumer choices and placing the onus on wealthier segments of society to shoulder the burden of responsibility.
**The fight for feedstock**

A shift to cleaner fuels will increase demand for aromatics as an octane enhancer and result in more competition between gasoline and petrochemicals.

For the petrochemical sector, a global shift to cleaner fuels and lower sulfur content will boost demand for aromatics to blend into the gasoline pool.

In the near term, this could provide support for aromatics pricing, serving as a price floor amid existing imbalances in petrochemical fundamentals. Longer term, the shift will result in increased competition for aromatics between the gasoline and chemicals segments and could ultimately lead to a tighter market in North America.

The clearest example of this shift, and its impact on chemicals in North America, can be seen in the US Environmental Protection Agency’s Tier 3 regulations, which aim to limit sulfur content in gasoline to 10 ppm on an annual average basis. Gasoline must contain no more than 80 ppm sulfur/gallon under the rules. While the Tier 3 standards went into effect in 2017, some smaller refineries were allowed to delay compliance until 2020. Bringing all US refineries into compliance will boost demand for aromatics for blending.

Aromatics, such as toluene and mixed xylenes, are highly desirable blendstocks because of their high octane numbers and low Reid Vapor Pressure. They are commonly found in items such as clothing and water bottles. Polyethylene terephthalate, more commonly found in items such as clothing and water bottles.

The push for cleaner fuels ultimately bodes well for aromatics, given that octane demand historically has been seasonal in nature and strongest in the summer months. That said, the impact is difficult to measure as it could be argued regulations, such as Tier 3, will have an equal or greater impact on the upstream reformate market.

Reformate serves as a feedstock for toluene and mixed xylenes, but can also serve as a gasoline blendstock. A general rule of thumb is that toluene and mixed xylenes premiums need to be at least 15 cents to encourage extraction, otherwise refiners will direct the reformate to the blend pool.

Late last year, several North American market participants were heard to be sitting on reformate and building inventory in an attempt to meet Tier 3 compliance standards. This lent support to reformate values, with prices averaging around 225 cents/gal between September and December. At these levels, refiners would be looking for toluene and mixed xylene prices of at least 240 cents/gal or, more likely, 245 cents/gal.

Toluene’s blend value, however, began to gravitate toward reformate values, holding an average premium of just 2.58 cents during the month of November. S&P Global Platts data showed. With blenders bidding at blend value, a disconnect emerged between existing demand and profitable extraction levels. This has curtailed aromatics extraction and could, ultimately, raise prices.

The primary issue the petrochemicals industry is facing at the moment is a disconnect between gasoline and petrochemicals. This will have its own implications for the petrochemical industry.

Increased production of naphtha and other light hydrocarbons would translate into lower feedstock costs for steam crackers.

But the price impact in the US is expected to be muted, given favorable economics from cracking ethane and a limited number of naphtha-based crackers in North America. More likely, that naphtha will be blended into gasoline or exported.

Aromatics markets are expected to remain soft through 2020 because of a supply surplus. This will likely force toluene and mixed xylene prices to gravitate toward blend values, at least until derivative PTA units come online and the global paraxylene market balances out. Further out, the shift to cleaner fuels will lead to stronger demand for aromatics as an octane booster, and result in increased competition between gasoline and petrochemicals.
Beyond IMO 2020

After the marine fuel sulfur cap, an even more protracted battle will emerge over which cleaner fuels can help to reduce the shipping sector’s emissions by 40% by 2030

Some 11 years after the International Maritime Organization first committed to a 0.5% sulfur limit for marine fuels, and three years after it confirmed a 2020 start date, the debut of the cap has finally arrived. A decades-long fight over how best to limit the shipping industry’s greenhouse gas emissions commenced at the same time.

Since the IMO agreed in October 2016 that the 2020 deadline would go ahead, most of the shipping industry has plumped for taking whatever 0.5% sulfur fuel blends the world’s bunker producers and suppliers can come up with, rather than installing emissions-cleaning scrubber equipment or shifting to alternative fuels like LNG.

They now face a raft of potential quality issues in the coming year as the industry discovers which of the new blends can safely be brought into contact with other alternatives without causing engine damage. In general, the wealthiest and most organized shipowners will fare best with the new fuels. Those who are able to pay a premium for fuel with a global compatibility guarantee, and those able to plan their ships’ schedules weeks or months in advance and to arrange the availability of the right fuels accordingly, will largely be able to avoid any problems.

Conversely, shipowners seeking to minimize costs by buying blends with less verification, and ships on the tramp trade with little control over their ports of call, will bear the brunt of the disruption caused as the industry experiments with the various fuel options.

The rise in fuel bills will be pronounced, but likely manageable. At Rotterdam in October and November 2019, delivered 0.5% sulfur bunker fuel prices were 13.5% higher on average than high sulfur fuel oil prices in the same period a year earlier. But the rise isn’t big enough to prove an insurmountable challenge to the industry as a whole, especially with crude prices looking unlikely to jump in the near term. At the end of 2019, 0.5% sulfur fuel prices in Rotterdam were hovering around $500/mt, and shipping companies were used to paying in the $600s/mt for HSFO as recently as 2013.

That said, the need for the bunker industry to access and extend more credit to the shipping industry to cover the increased fuel costs could cause some disruption. This may be enough to drive some consolidation of smaller companies in both industries.

The smaller group of shipowners that installed scrubbers to comply with the sulfur cap — now estimated by S&P Global Platts Analytics at about 2,400 ships out of a global fleet of 80,000 — can expect to see a good return on their investment as they are able to continue buying increasingly cheap fuel oil.

With a wide price spread between HSFO and 0.5% sulfur fuels, it will not take long for shipowners to earn back the scrubber installation cost of a few million dollars per ship. But they will have a limited window to do so: talk of technical problems with some of the cheaper models abound, and more port authorities are likely to consider bans on the use of open-loop models that discharge polluted water back into the sea. In addition, over the longer term, the discount to 0.5% sulfur fuels will narrow as refiners continue to bear down on their HSFO production levels.

The bunker industry expects the worst of the IMO 2020 disruption to be over by the second half of the year. But once that situation has calmed, the industry will then get into what could be quite an aggressive battle over the next decade over which alternative fuel becomes dominant as the shipping industry seeks to wipe out its greenhouse gas emissions.

The IMO has an initial strategy of cutting carbon dioxide emissions per ship by 40% compared with 2008 levels by 2030, and the shipping industry’s total GHG emissions by at least 50% by 2050. That policy is not compatible with oil remaining the shipping industry’s energy source of choice, but no clear replacement has yet emerged.

LNG is currently in pole position among the alternative fuels, with around 150 ships already on the water using it, the oil majors pouring significant funds into developing delivery infrastructure and lobbying in its favor and the current low price make it look attractive.

Fossil fuel-derived LNG alone will not deliver big enough GHG savings to comply with the 2050 target, but bio-LNG — derived from biomass — being blended with it may be viable if supplies become widely available by the end of the 2020s. Methanol could be a cheaper option, as well as being easier for crews to handle, as ships could be retrofitted to use it rather than new vessels being ordered. But to reach the 2050 target, synthetic methanol derived from biomass or hydrogen and carbon dioxide will need to be made available in significant quantities.

Hydrogen and ammonia are widely talked of as possible contenders. Both would largely solve the emissions problem, but would be more difficult to handle and would require more space on board than conventional fuels.

All of these options are expensive, and require large quantities of either renewable power or arable land for biomass to be made available, at a time when other industries going through the energy transition will also be competing for both.

The year 2050 may seem like a distant target, but the cycles of the shipping industry bring it closer. With a life of around 25 years for a commercial ship, zero-GHG models will need to start entering the market by the start of the 2030s.

Over the next 10 years, proponents of each of these alternative fuels will grow increasingly noisy as they argue for their slice of the 300 million mt/year bunker market. Anyone paid to market these alternatives can expect a lucrative decade ahead of them, while the shipping industry can look forward to a long voyage toward increasingly higher fuel bills.
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