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ENERGY INVESTMENT BANKING

MUSINGS FROM THE OIL PATCH

July 14, 2020

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Note: *Musings from the Oil Patch reflects an eclectic collection of stories and analyses dealing with issues and developments within the energy industry that I feel have potentially significant implications for executives operating and planning for the future. The newsletter is published every two weeks, but periodically events and travel may alter that schedule. As always, I welcome your comments and observations.* Allen Brooks

Summary:

How To Think About Forecasting L-T Oil Consumption

The challenge for energy company managers is planning their long-term future. That depends on future oil demand. Studying the economy's oil intensity and price elasticities suggests less consumption in the future.

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Will Hydrogen Play A Key Role In Our Energy Future?

Environmentalists are targeting hydrogen as the fuel to help in the transition to a carbonless energy world. Hydrogen has been around for centuries, but always too expensive and challenging. What's its status now?

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What Do Facebook And Oil And Gas Have In Common?

Facebook's travails with social justice organizations and an advertiser boycott has dominated the news, but that is only one aspect of increased focus on ESG. These criteria are being used to pressure energy companies.

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How To Think About Forecasting L-T Oil Consumption

Current industry and investor focus on the oil business is attempting to assess how quickly demand will return. That is key to lifting oil prices and restoring producer profitability. Presumably, once producers believe they can drill, complete and produce oil profitably, they will resume work, which is critical to the survival of the oilfield service industry. Understanding the state of demand is why forecasters, analysts and industry executives closely watch mobility data and other measures of economic activity that use oil.

While watching these measures and adjusting current activity, oil companies operate on much longer trends than those for the next 30-90 days

After feeling sanguine about a rapid recovery in activity, as the various states reopened their economies, that faith has been shaken by the recent surge in Covid-19 cases in a number of states forcing their governors to pause or rollback the easing of restrictions. Texas traffic data is reflecting declines after many weeks of rising congestion. While watching these measures and adjusting current activity, oil companies operate on much longer trends than those for the next 30-90 days. In fact, oil companies are really wondering about oil demand in 2021 and beyond, as projecting the supply needed will help them set future production targets and new drilling and completion work.

Oil company capital spending this year has been slashed, and may be subject to further reductions, that provides optimists and pessimists, depending on their respective views on future oil prices, with ammunition for their forecasts. Higher prices will come due to the lack of capital spending now and rebound in demand. Given the steep output declines of shale oil wells, the optimists see supply falling short of demand. The days of $100 a barrel oil cannot be far off under their thinking.

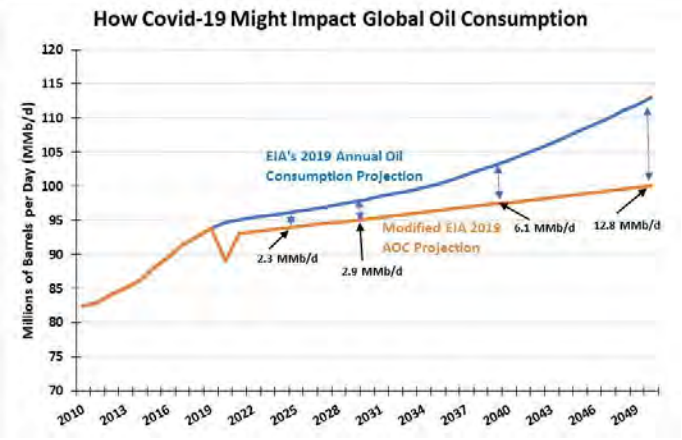
The high oil price scenario could be derailed by a lack of oil demand

The only way this scenario fails to unfold is if there is a surge in supply, likely from the high-grading of new wells, plus the ability to extract more oil per well. On the other hand, the high oil price scenario could be derailed by a lack of oil demand. There are numerous ways the demand rebound might not happen: a second wave of Covid-19 forces lockdowns of state economies; the current economic recession becomes much worse as the closure of businesses, high unemployment and weak income growth restrains consumer spending; commuting traffic fails to return, as workers and companies embrace working at home; schools and universities teach predominantly online; air traffic fails to recover; and global trade falls. While many forecasters weigh these issues in their demand models, most models incorporate only minor lifestyle and work-related changes. Assuming a greater impact pushes the pre-Covid-19 recovery out into 2022, or maybe later, rather than 2021. In fact, Citibank's commodity group sees oil demand as having peaked and never to be seen again.

We see a demand shortfall in 2030 of 2.9 million barrels per day (mmb/d), or 3%

We have previously presented the Energy Information Administration's (EIA) long-term oil consumption forecast, along with modifications we anticipate based on permanent demand shifts due to the pandemic. We see a demand shortfall in 2030 of 2.9 million barrels per day (mmb/d), or 3%. That is the equivalent of losing the output from Kuwait or the United Arab Emirates, not inconsequential.

Exhibit 1. Expect Lower Oil Consumption Through 2050

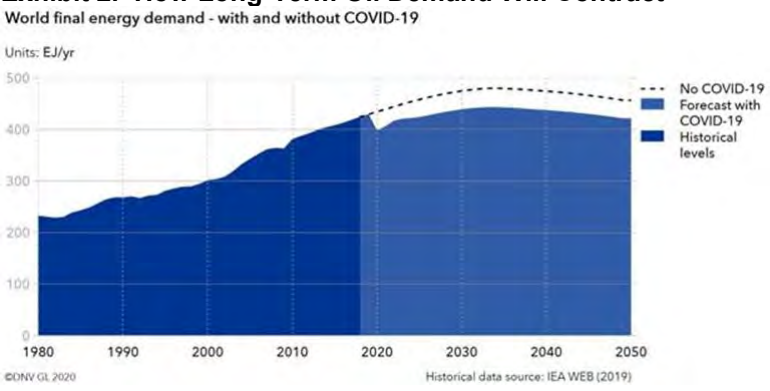


Source: EIA, PPHB

The vast sums of debt added to virtually every major economy due to pandemic response will slow future growth, consistent with historical experience

Here is a recent forecast from the energy classification and consulting firm DNV GL. Their view is consistent with ours, and for similar reasons. We acknowledge the other scenarios calling for little structural change, but these models tend to be more short-term focused with less concern about long-term energy intensity shifts and slowing global economic growth. The vast sums of debt added to virtually every major economy due to pandemic response will slow future growth, consistent with historical experience. In fact, after virtually every significant economic shock, the future growth rate for oil has been lower. That said, we are always willing to change our view based on updated information.

Exhibit 2. How Long-Term Oil Demand Will Contract



Source: DNV GL

DNV GL wrote about the assumptions underlying their latest forecast. Rather than paraphrase them, we elected to report them as written.

"Reducing World GDP in 2050 by 9%, relative to pre-pandemic forecasts"

"Our energy forecast is predicated on IMF's longer outbreak scenario, where World GDP will shrink 6% in 2020. The lingering effects of the pandemic will take the wind out of the sails of the world economy for many years – reducing World GDP in 2050 by 9%, relative to pre-pandemic forecasts. Even with slower growth, however, by mid-century the world economy will still be twice its size today. In contrast, energy demand will not grow. In 2050, it will be about the same as it is today, in spite of a larger population and world economy. This is largely due to significant improvements in energy intensity, but also due to the effects of COVID-19.

"Before the pandemic, we predicted total global energy demand in 2050 at 456 exajoules (EJ), (Global energy demand using the latest historical figures was at 424 EJ in 2018.) Our modelling now shows that the pandemic will reduce energy demand through to 2050 by 8%, resulting in energy demand in 2050 at almost exactly the level it was in 2018.

"Improvements in energy intensity will remain the most important factor in reducing energy demand in the coming decades"

"Improvements in energy intensity will remain the most important factor in reducing energy demand in the coming decades, and the contraction due to COVID-19 comes on top of this. That is as a result of the brakes applied to economic activity generally by the pandemic, as well as some specific sectoral impacts. Lasting changes linked to COVID-19 are mainly behavioral in nature and include the impact of the pandemic on the transport sector, especially aviation, but also on less office work and changed commuting habits, which will result in transport energy use never again reaching 2019 levels. Demand for manufactured goods globally will need almost four years to recover to 2019 levels, and the energy-intensive iron & steel industry, impacted inter alia by lower demand for new office space, may never reach its pre-pandemic heights."

Oil companies need a sense of what consumption levels will be in 2030 and beyond, since they are responsible for developing the supply to meet that demand. Understanding long-term oil consumption helps companies plan their future drilling and completion activity. In that regard, a recent webinar hosted by the United States Association for Energy Economists, featuring Dr. Marie Fagan, the Chief Economist at London Economics International, LLC., provided some interesting insight. Dr. Fagan based her presentation on a paper she prepared in November 2018 for the Columbia University School of International and Public Affairs, Center on Global Energy Policy. The paper, titled "Oil

demand: Up the down staircase," was an econometric study of income and price elasticities of demand for crude oil and key refined products.

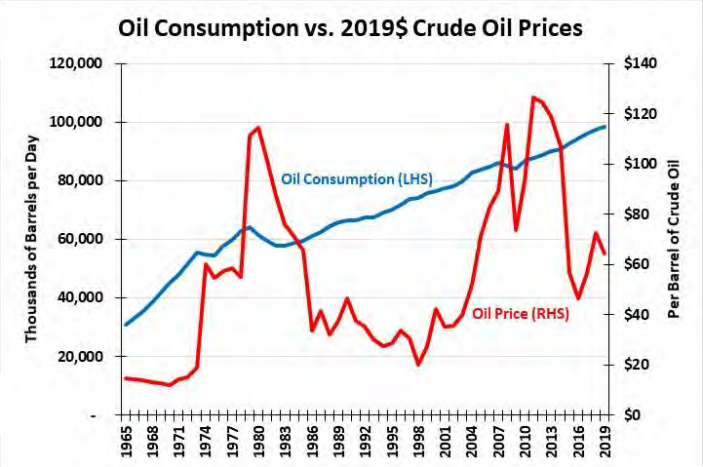
We doubt the elasticities calculated would be materially different if three additional years of data were included

Besides listening to the webinar, we read Dr. Fagan's paper. As the analysis ended in 2016, we have updated it, except for the econometric work, for which we do not have access to Dr. Fagan's model. In considering the paper's conclusions, we doubt the elasticities calculated would be materially different if three additional years of data were included, at least for crude oil. While there is a higher possibility that the elasticities for refined products – gasoline and diesel – might change, we doubt the changes would be material.

We also note that oil consumption declined whenever oil prices, in real terms, rose sharply

When we consider the history of oil consumption for 1965-2019, we foresee a steadily rising trend, albeit with different rates of increase. We also note that oil consumption declined whenever oil prices, in real terms, rose sharply. The most notable times were in the 1970s, at the time of the First Oil Shock, and then again at the time of the Great Recession in 2008-2009. We also see less prominent declines whenever the oil price spiked. Dr. Fagan's paper was designed to examine why these relationships existed and if they changed over time. Detecting any relationship changes could help in forecasting future oil consumption.

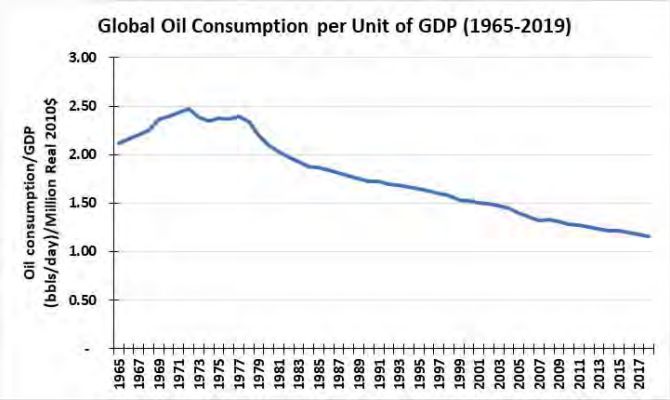
Exhibit 3. Price Shocks Translate Into Demand Shocks



Source: BP, PPHB

The start of the analysis of crude oil and refined product demand involves understanding oil intensity in the economy. That measure is developed by calculating the amount of oil used to produce a million dollars of economic activity in real terms. We updated Dr. Fagan's analysis and calculated oil intensity since 1965. We used the World Bank's global gross domestic product (GDP) estimates in 2010 dollars as well as BP plc's estimates of world oil consumption. The resulting chart shows a long-term declining trend in oil intensity, which has significant implications for oil's future use.

Exhibit 4. Since 1980s Oil Intensity Has Been Declining



Source: World Bank, BP, PPHB

Oil intensity rose from 1965 to 1972, and then declined due to the 1973 oil price shock

Oil intensity rose from 1965 to 1972, and then declined due to the 1973 oil price shock. As the economy adjusted to higher oil prices, oil intensity rose marginally until the next oil shock associated with the Iranian Revolution. Since then, oil intensity has declined, albeit at differing paces over 1979-2019. As a result of this analysis, Dr. Fagan reached her first two conclusions. Those were:

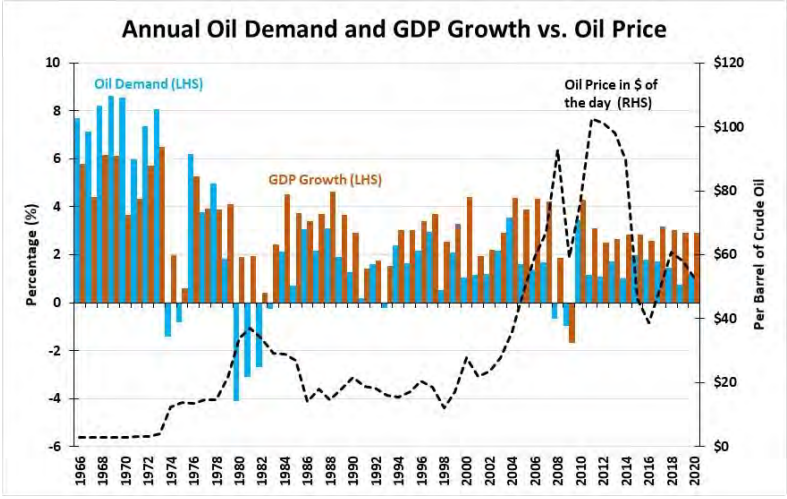
> "The decades-long upward movement in crude oil demand has been undermined by a 'descending staircase' of declining oil-intensity of economic activity."
>
> "This finding implies that we should expect oil demand growth to continue to lag behind economic growth as key developing countries' population and economic growth rates slow and they transition away from an oil intensive economy to a service economy, and the world experiences periodic oil price spikes due to geopolitical events that destroy oil demand, which is not fully restored when prices recede."

In a world in which global economic growth is moderating, it is unlikely world oil consumption will grow rapidly. The long-term history of oil use versus GDP growth shows annual rates of increase slowing dramatically since the end of the 1960s and early 1970s. At that time, oil and GDP were growing at 6%-8% rates. In recent years, growth has been more in the 1%-3% range. The question we have is whether these low growth rates will slow further, or begin rising?

There are numerous reasons to expect slower growth, primarily due to aging demographics in developed economies, and now also being experienced in China

There are numerous reasons to expect slower growth, primarily due to aging demographics in developed economies, and now also being experienced in China. Population predictions show India's surpassing China in a few decades, but in the interim, China's population is aging. At the same time, the global birth rate is falling, to the point it risks dropping below the replacement rate. In addition to demographics, productivity is slowing, which hampers economic

Exhibit 5. Era Of Slower Growth Means Less Oil Demand



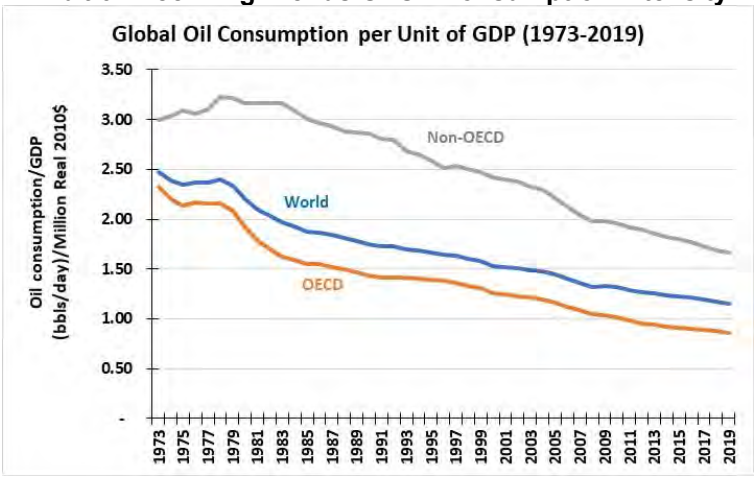
Source: IMF, EIA, PPHB

growth. Add to that the potential for a reversal in globalization, lowering trade volumes. Huge government debts, besides growing corporate and personal debt, makes it harder for economic growth to be stimulated by future government stimulus.

OECD economies have been steadily reducing their oil intensity since 1973, in contrast with Non-OECD economies

We see the significance of the slowing growth rate of economies when we examine the history since 1973 of oil intensity of the developed economies (OECD) versus developing economies (Non-OECD). OECD economies have been steadily reducing their oil intensity since 1973, in contrast with Non-OECD economies where oil intensity rose from 1973 to 1979, then stayed level through 1984, before starting to decline.

Exhibit 6. Declining Trends Of Oil Consumption Intensity



Source: World Bank, BP, PPHB

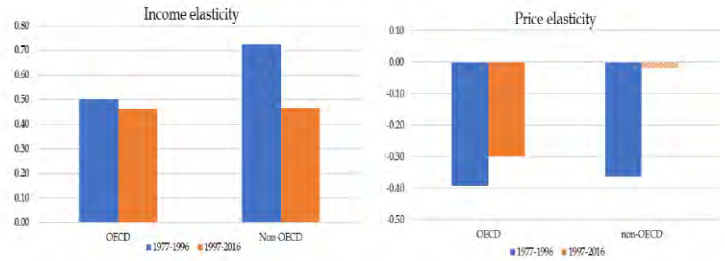
The OECD rate was 0.86, whereas the Non-OECD rate was nearly double it at 1.66

In 2019, the world's oil intensity was 1.16. The OECD rate was 0.86, whereas the Non-OECD rate was nearly double at 1.66. If these declining trends continue, they doom the prospects of oil demand growth ramping up significantly.

After analyzing oil intensity, Dr. Fagan used her econometric model to assess the income and price elasticities of crude oil and refined products. She had created populations of OECD and Non-OECD countries to conduct her analysis. A key aspect of the analysis was to divide the history into two eras: 1977-1996 and 1997-2016.

Exhibit 7. Changing Oil Income And Price Elasticities

Figure 5. Estimated long-term crude oil income and price elasticities



Note: The econometric models used to generate these results were dynamic, symmetric, fixed-effects models using panel data with total oil demand and total GDP.
Shaded bars indicate not significant at 95%
Vertical axes are different scales

Source: Dr. Fagan

For OECD economies, the long-term income elasticity of demand was 0.50 in 1977-1996, meaning a 1% change in GDP corresponded to a 0.50% change in oil demand in the same direction

The econometric analysis showed that income elasticities of crude oil demand were higher in the 1977-1996 period than the 1997-2016 period for both OECD and Non-OECD economies. For OECD economies, the long-term income elasticity of demand was 0.50 in 1977-1996, meaning a 1% change in GDP corresponded to a 0.50% change in oil demand in the same direction. But for the second period, 1997-2016, the income elasticity declined, but only to 0.46. The income elasticity for Non-OECD countries was much higher in the early period at 0.72, but it fell in the later period to 0.47, not much different than the elasticity of OECD countries. This means the relationship between economic activity and oil consumption did not break down completely, but it did weaken.

The price elasticities provide another interesting perspective about future oil growth. For the 1977-1996 period, price elasticity was similar for both OECD and Non-OECD economies. In 1997-2016, both groups of economies saw lower price elasticity measures. The Non-OECD countries actually had a tiny and not statistically significant price elasticity for this later period.

Dr. Fagan believes the decline in long-term price elasticity may reflect the response to an oil price spike driven by supply shocks versus price hikes due to fast-growing demand. The first period

"The price volatility in the earlier period was seen as a crisis—the 'energy crisis,' and may have led consumers to expect a long period of high prices, or of physical shortages of oil"

included the oil price shocks of the 1970s, while the latter period included the rapid growth of the China-driven oil boom in the early 2000s. As Dr. Fagan wrote, "The price volatility in the earlier period was seen as a crisis—the 'energy crisis,' and may have led consumers to expect a long period of high prices, or of physical shortages of oil. Also, opportunities to substitute other fuels for oil may have been more abundant in the 1970s and 1980s, as oil was more widely used for heating and electric power generation in many locations. Both these conditions would lead to higher (absolute) price elasticities of demand."

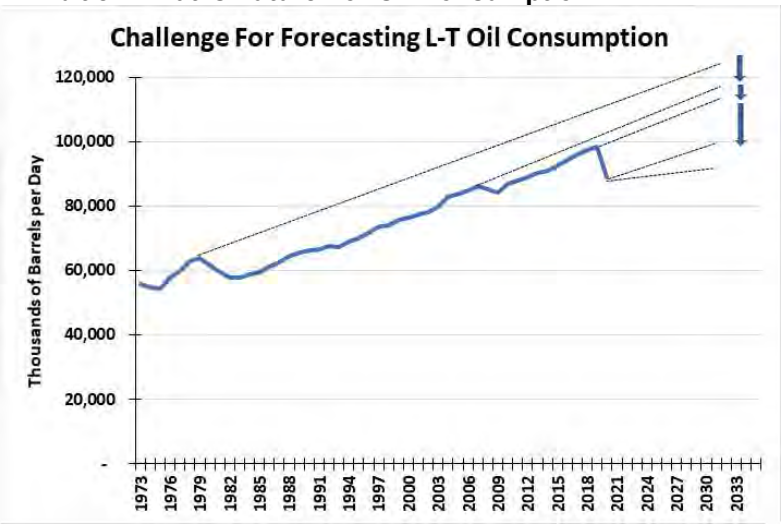
In her view, the oil price increases of 2001-2008 did not create fear of oil shortages, and did not create a global recession. Additionally, there may have been fewer opportunities for efficiency gains and fuel-switching. Both conditions might explain why the more recent period experienced lower absolute price elasticities of oil demand.

The fact that the income elasticity of Non-OECD countries is nearly half of what it was in the earlier years suggests that even as these countries grow, their need for oil will not be as great as it was before

The elasticity relationships have important implications for predicting future oil consumption. As we showed earlier, the oil intensity of Non-OECD countries is much higher than the oil intensity of OECD countries. Therefore, the fact that the income elasticity of Non-OECD countries is nearly half of what it was in the earlier years suggests that even as these countries grow, their need for oil will not be as great as it was before. How should forecasters look at possible scenarios for future oil consumption?

If we focus on how the relationship existed in the 1970s, we see oil consumption exceeding 120 million barrels per day (mmb/d) by 2030. On the other hand, if we look at how oil consumption was growing prior to the Great Recession of 2009, oil consumption reaches close to 119 mmb/d in 2030. Will oil consumption only grow

Exhibit 8. What Is Future For Oil Consumption?



Source: BP, PPHB

in line with the recent history prior to the 2020 downturn? If so, then we are looking at 2030 oil consumption close to 115 mmb/d. However, the shocks the global oil markets have experienced this year due to Covid-19 and the Russia-Saudi Arabia oil war, raise the question of whether we are going to resume growth from a much lower base and at a lower rate. We have presented several possible trajectories that keep oil consumption below 100 mmb/d in 2030.

This is indicative of a view of a lower oil consumption growth rate

We should consider the moves by Royal Dutch Shell and BP plc to write down the value of some of their oil and gas assets in response to lowering their long-term oil price forecast to $55 per barrel, down from their prior $70 forecasts. This is indicative of a view of a lower oil consumption growth rate. Those moves, likely to be replicated by other oil companies, signal that fewer reserves will be developed because they will not be necessary. The industry is beginning to embrace the "lower for longer" mantra that emerged in 2015.

The industry is just beginning to come to grips with this outlook

The trend of global oil intensity, and especially the convergence of the Non-OECD and OECD measures, is an indicator for lower future oil consumption. This is reinforced by the lower income and price elasticities. The industry is just beginning to come to grips with this outlook. The restructuring of companies – streamlining operations, selling marginal producing assets, as well as reconfiguring, selling and closing refining plants signals management expectations of a different world for their businesses.

Will Hydrogen Play A Key Role In Our Energy Future?

Some of the proposed projects are hopeful of proving up methods and technologies that can become a foundation for significant expansion of the fuel's use

If you haven't been paying attention to the debate over our energy future, you have missed the growing focus on hydrogen's role in getting to a low- or zero-carbon emissions world. From Europe to the Middle East to North America, there are numerous tests of how to generate less-costly hydrogen and how the fuel could be used to reduce carbon emissions. Some of the proposed projects are hopeful of proving up methods and technologies that can become a foundation for significant expansion of the fuel's use. We are likely years away from knowing the projects' outcomes, but they all assume they will work and prove financially successful.

This is not the first time hydrogen has been touted as a possible solution for our energy challenges

This is not the first time hydrogen has been touted as a possible solution for our energy challenges. Its use in earlier times was for powering our transportation. In the 1970s, oil price shocks, petroleum shortages, concern over air pollution and acid rain, all combined to drive interest in clean and domestic hydrogen. Work was done on producing hydrogen from coal or nuclear electricity. The challenges proved too great, and oil prices crashed in the early 1980s, ruining the effort.

The 1990s were marked by concern about climate change. That drove studies of producing hydrogen while employing carbon

capture and sequestration (CCS) and renewables, with the fuel again targeting the transportation sector. Another period of low oil prices caused interest in hydrogen to wane. This cycle was revisited in the early 2000s when climate change, high oil prices, and peak oil concerns drove interest in the fuel. Again, the focus was on how hydrogen could reduce transportation sector emissions. Once again, the drop in oil prices reduced interest in hydrogen.

Another period of low oil prices caused interest in hydrogen to wane

The fuel has a long history. Electrolysis and primitive fuel cells attracted scientists in the 1800s. Hydrogen was an initial fuel for internal combustion engine cars some 150 years ago. It also fueled the balloons and airships of the 1800s and 1900s, and we cannot forget that hydrogen powered the rockets that took American astronauts to the moon in the 1960s. General Motors built its first vehicle powered by hydrogen in 1966. Instead of revolutionizing the auto industry, the GM Electrovan landed in a museum. Fifty years later, the world is still waiting for hydrogen to live up to its promise as a clean energy technology.

Instead of revolutionizing the auto industry, the GM Electrovan landed in a museum

The industry joke is that hydrogen is the fuel of the future – and it always will be. Given its association with technology revolutions, it may be too soon to write off its potential to power a new energy revolution. The ability of hydrogen to make an impact on all forms of energy use, not merely transportation, is part of why the interest in the fuel is growing. The fact that hydrogen can be created from a wider range of fuels is another factor influencing the interest. Making it a cost-effective alternative fuel, however, requires overcoming a number of technological challenges.

Interestingly, some of the projects proposed or starting in Europe are based on renewable energy facilities where power costs are low or the power output is wasted during part of the day because it peaks when demand is low. Often, the oversupplied power is paid fees to not produce, which becomes a possible avoided-cost that would help offset the expense of hydrogen. Another region where increased research is being conducted on the economics of hydrogen use is the Middle East, where huge natural gas supplies exist, as well as potentially large solar renewable power. This is why hydrogen fuel is being studied intently.

Some of the projects proposed or starting in Europe are based on renewable energy facilities where power costs are low or the power output is wasted

After reading the various studies about hydrogen and its future published by the International Energy Agency (IEA), various European think tanks, and Wall Street research, we see how critical assumptions about hydrogen's future costs, especially compared to fossil fuel costs, as well as the adoption of decarbonization targets by governments will be to its success. While many of the studies are aspirational in their discussion of the future potential for hydrocarbon, we question whether this fuel will prove to be much more than another niche energy source. What we do know is that hydrogen is being counted on for some of the long-term decarbonization plans for utilities in the United States. As regulators

and politicians are buying into these plans, we wonder whether they have an appreciation for the technical and economic costs associated with hydrogen, or are merely taking the attitude that the fallouts will not happen on their watch?

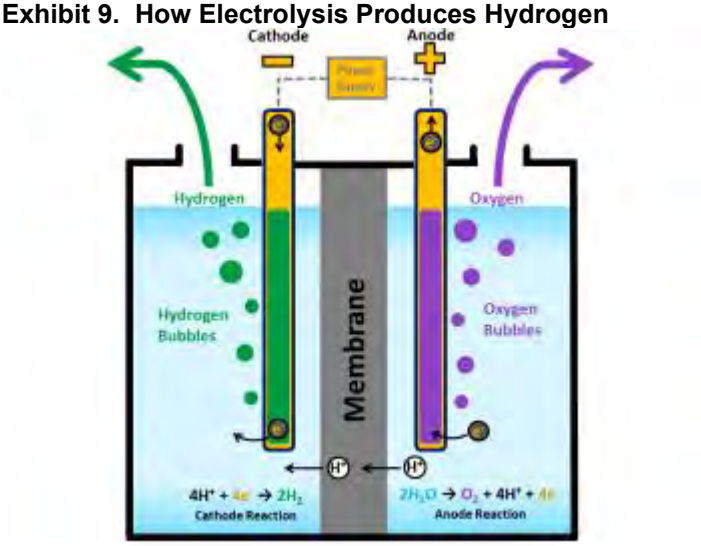
The ability of this industry to solve significant technological challenges throughout its history is well-known, so maybe it can solve the current challenges facing hydrogen

Many smart people we know are focusing on hydrogen and its potential role in the energy supply of the future. These analysts understand the technical and economic challenges, but they are also optimists about the future based on their long experiences with the oil and gas industry. The ability of this industry to solve significant technological challenges throughout its history is well-known, so maybe it can solve the current challenges facing hydrogen.

There are basically two ways to produce hydrogen – steam reforming and electrolysis. The following are explanations of each process taken from the U.S. Department of Energy's Office of Energy Efficiency & Renewable Energy's web site:

> "STEAM-METHANE REFORMING
> "Most hydrogen produced today in the United States is made via steam-methane reforming, a mature production process in which high-temperature steam (700°C–1,000°C) is used to produce hydrogen from a methane source, such as natural gas. In steam-methane reforming, methane reacts with steam under 3–25 bar pressure (1 bar = 14.5 psi) in the presence of a catalyst to produce hydrogen, carbon monoxide, and a relatively small amount of carbon dioxide. Steam reforming is endothermic—that is, heat must be supplied to the process for the reaction to proceed.
>
> "Subsequently, in what is called the "water-gas shift reaction," the carbon monoxide and steam are reacted using a catalyst to produce carbon dioxide and more hydrogen. In a final process step called "pressure-swing adsorption," carbon dioxide and other impurities are removed from the gas stream, leaving essentially pure hydrogen. Steam reforming can also be used to produce hydrogen from other fuels, such as ethanol, propane, or even gasoline."
>
> "ELECTROLYSIS
> "Electrolysis is a promising option for hydrogen production from renewable resources. Electrolysis is the process of using electricity to split water into hydrogen and oxygen. This reaction takes place in a unit called an electrolyzer. Electrolyzers can range in size from small, appliance-size equipment that is well-suited for small-scale distributed hydrogen production to large-scale, central production facilities that could be tied directly to renewable or other non-greenhouse-gas-emitting forms of electricity production."

Exhibit 9. How Electrolysis Produces Hydrogen



Source: U.S. DoE

The cost of producing hydrogen through electrolysis is three-times the cost if produced from steam reforming, or nine-times the cost of natural gas

Like every other fuel, hydrogen has its pluses and its minuses. Cost is a major negative presently. In producing hydrogen by steam reforming, carbon dioxide is a byproduct. Although some of the CO_2 can be reprocessed, there will always be some remainder. In a low-carbon world, maybe these emissions can be tolerated and offset in other ways, but if hydrogen produced in this way is to become emissions-free, carbon capture will need to play a role. That means the hydrogen produced is three-times the wholesale price of natural gas. The cost of producing hydrogen through electrolysis is three-times the cost if produced from steam reforming, or nine-times the cost of natural gas.

Part of the reason for the higher cost is the physical details of hydrogen versus other fuels. In last year's IEA report on hydrogen, it provided a table detailing these comparisons. Energy density is a major challenge. In liquid form, hydrogen has only one-third the energy density of natural gas.

Exhibit 10. Hydrogen's Qualities And Comparisons

Table 2. Physical properties of hydrogen

Property	Hydrogen	Comparison
Density (gaseous)	0.089 kg/m^3 (0°C, 1 bar)	1/10 of natural gas
Density (liquid)	70.79 kg/m^3 (-253°C, 1 bar)	1/6 of natural gas
Boiling point	-252.76°C (1 bar)	90°C below LNG
Energy per unit of mass (LHV)	120.1 MJ/kg	3x that of gasoline
Energy density (ambient cond., LHV)	0.01 MJ/L	1/3 of natural gas
Specific energy (liquefied, LHV)	8.5 MJ/L	1/3 of LNG
Flame velocity	346 cm/s	8x methane
Ignition range	4–77% in air by volume	6x wider than methane
Autoignition temperature	585°C	220°C for gasoline
Ignition energy	0.02 MJ	1/10 of methane

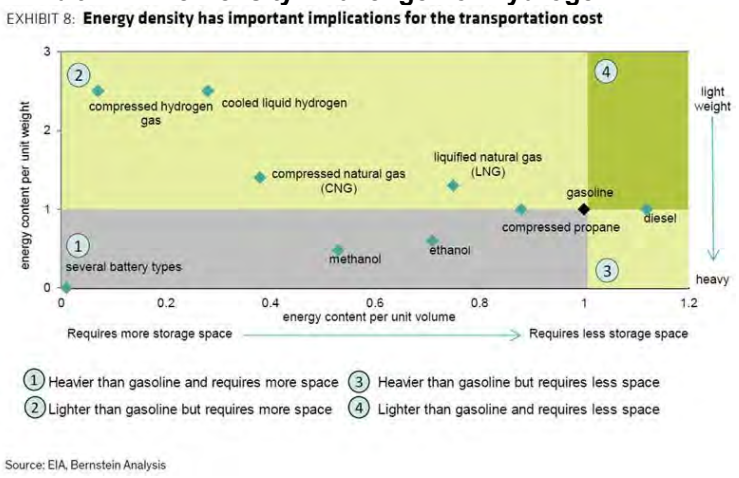
Notes: cm/s = centimetre per second; kg/m^3 = kilograms per cubic metre; LHV = lower heating value; MJ = megajoule; MJ/kg = megajoules per kilogram; MJ/L = megajoules per litre.

Source: IEA

While hydrogen is much lighter than gasoline, that advantage is offset by the greater space requirement and low energy content

The issue of energy density is important when considering fuel sources for the long-term. Bernstein, using EIA data, constructed a chart showing how various fuels rank against measures of weight and space requirements compared against gasoline. Both compressed and liquid hydrogen requires more space because their energy content per unit volume is extremely low. While hydrogen is much lighter than gasoline, that advantage is offset by the greater space requirement and low energy content. For transportation uses, this makes hydrogen a questionable option.

Exhibit 11. The Density Challenge For Hydrogen

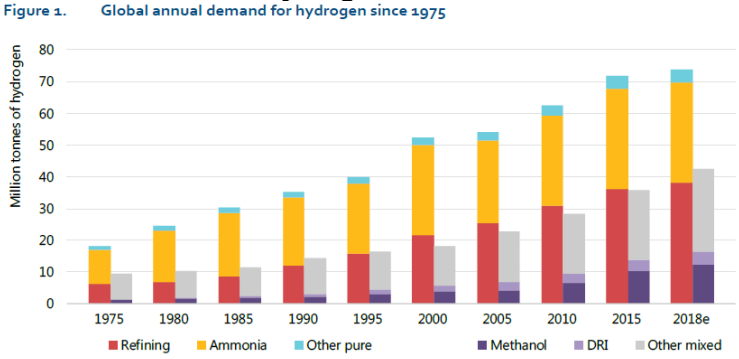


Source: Bernstein

Despite hydrogen being costly, its use has grown by more than threefold since 1975

Despite hydrogen being costly, its use has grown by more than threefold since 1975, primarily as an input for the oil refining and ammonia businesses. The IEA, in its 2019 report, showed the history of hydrogen production since 1975. In 2018 (latest data available), roughly 70 million tons of pure hydrogen were used, split

Exhibit 12. How The Hydrogen Market Has Grown



Source: IEA

almost equally between refining and ammonia. In terms of energy, this is the equivalent of 330 million tons of oil (Mtoe), more than the total primary energy use of Germany. Unfortunately, according to the IEA, producing this volume of hydrogen contributed to about 830 million tons of CO2, equal to the combined total CO2 emissions of Indonesia and the United Kingdom.

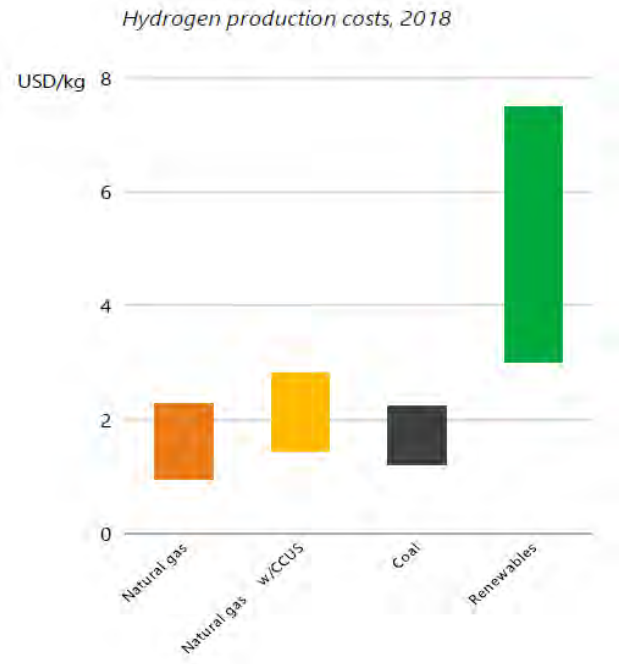
The greatest challenge for hydrogen is its cost

The greatest challenge for hydrogen is its cost. It is compounded by the lack of infrastructure to store and distribute hydrogen. In the case of fuel-cell powered cars, the lack of a network of filling stations turns that future into the proverbial "chicken and egg" debate. That is an impediment unless one is going to operate the vehicle within a limited distance, and return the vehicle to a location where it can be refilled much like home-charging stations for electric vehicles.

Natural gas is the cheapest fuel source for making hydrogen by a wide margin

Jose M. Burmudez, an Energy Technology Analyst in the Hydrogen and Alternative Fuels division of the IEA, speaking on an International Association of Energy Economists (IAEE) webinar, presented a chart documenting that natural gas is the cheapest fuel source for making hydrogen by a wide margin. In fact, all fossil fuels are cheaper fuel sources for hydrogen than renewables, even if CCS technology is employed.

Exhibit 13. Hydrogen Is An Expensive Alternative

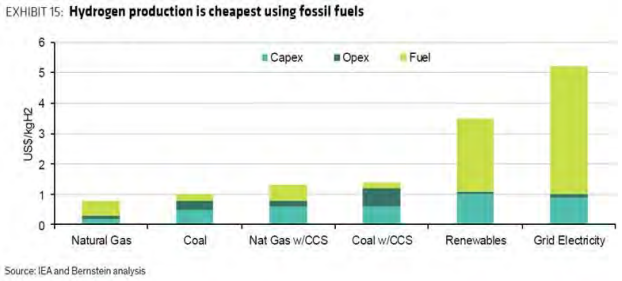


Source: IEA

Using IEA cost data, Wall Street broker Bernstein created a chart showing how expensive renewable-generated hydrogen is versus natural gas and coal. In fact, as the chart shows, the capital cost of

renewable hydrogen production exceeds all the cost of natural gas and coal, and almost exceeds the total cost of those fuels using CCS technology, not a cheap undertaking. Can this cost structure change? That is obviously the unanswered question, and the one the test projects are being designed to answer.

Exhibit 14. Fossil Fuels Produce Cheapest Hydrogen



Source: Bernstein

It should be noted where the hydrogen cost is the highest – Europe and China

While we understand the cost challenge, it is interesting to see the difference in hydrogen's cost by region of the world. The IEA produced a chart showing the cost using natural gas with or without CCS for the United States, Europe, Russia, China and the Middle East. It should be noted where the hydrogen cost is the highest – Europe and China. Europe is experimenting with projects designed to produce hydrogen with renewable energy that is essentially free, but highly interruptible. The hydrogen will be used for energy storage, rather than relying on batteries for power backup.

Exhibit 15. U.S. And Middle East Are Least Costly

Source: IEA

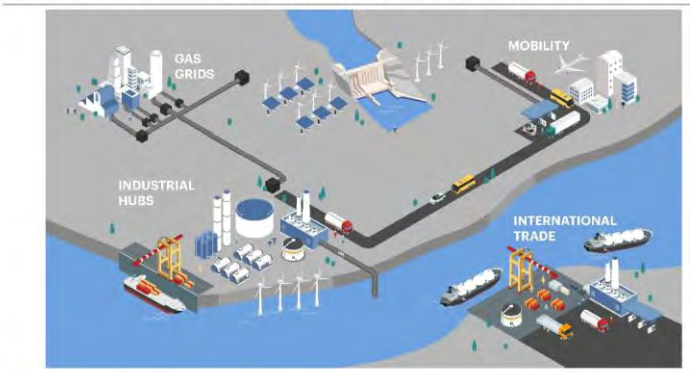
The push to solve this problem is driven by the realization that hydrogen can power not only cars, but also trucks and ships

Solving the cost problem is critical for hydrogen's success. The push to solve this problem is driven by the realization that hydrogen can power not only cars, but also trucks and ships, as well as being a raw material for refineries, chemical plants and steel mills, all of which have few alternatives to today's polluting fuels. The IEA has pointed out that these sectors tend to cluster at major industrial ports, offering opportunities to build combined infrastructure.

Critical, as the IEA's analysis shows, is that more than 200 projects underway still rely heavily on direct government funding, making them highly dependent on continued support.

Exhibit 16. Integrated Hydrogen Plants Lower Costs

Four key opportunities for scaling up hydrogen to 2030



Source: IEA

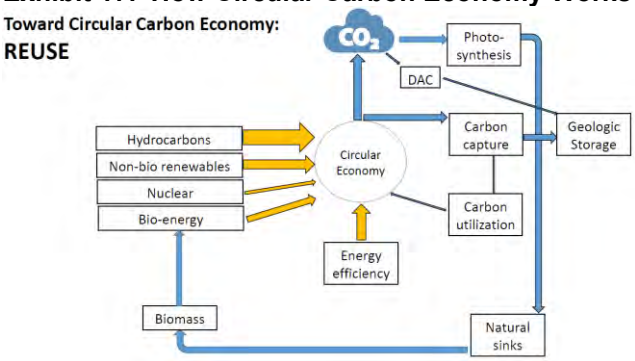
Saudi Arabia is promoting a hard look at the economics of hydrogen

What is also interesting is that with cheap natural gas in the U.S. and the Middle East, the cost of producing hydrogen is lower than elsewhere. That may explain why Saudi Arabia is promoting a hard look at the economics of hydrogen. That research is being undertaken by researchers at the King Abdullah Petroleum Studies and Research Center (KAPSARC) in Riyadh, headed by Adam Sieminski, formerly the head of the United States Energy Information Administration (EIA). He recently moderated a discussion sponsored by the IAEE on the role of hydrogen in the circular carbon economy. Besides presentations by Dr. Burmudez of the IEA, Eric Williams, a Research Fellow at KAPSARC, and Fareed Alasaly, a Senior Advisor to His Royal Highness the Saudi Minister of Energy, and the Chairman of the G20 Energy Sustainability Working Group under the Saudi G20 Presidency 2020, spoke. Mr. Williams is currently overseeing the writing and publication of a series of reports on the Circular Carbon Economy to be delivered to the G20, the leading economies of the world, later this year. Numerous global energy agencies and think-tanks are preparing the reports.

CCE builds on the Reduce, Reuse and Recycle aspects of the circular economy, but it adds Remove as an aspect

This examination is a part of the discussion about developing the circular carbon economy, which can lead to a low-carbon economy that meets the climate change initiatives of the Paris Agreement. The circular economy focuses on material flows rather than energy and emissions. The circular carbon economy (CCE) builds on those principles, but the priority is managing energy and climate flows to reach a carbon balance or net zero, in order to achieve climate goals. CCE builds on the Reduce, Reuse and Recycle aspects of the circular economy, but it adds Remove as an aspect. The four Rs are elements of the energy and carbon management system. More input from one R means less is needed from another R.

Exhibit 17. How Circular Carbon Economy Works

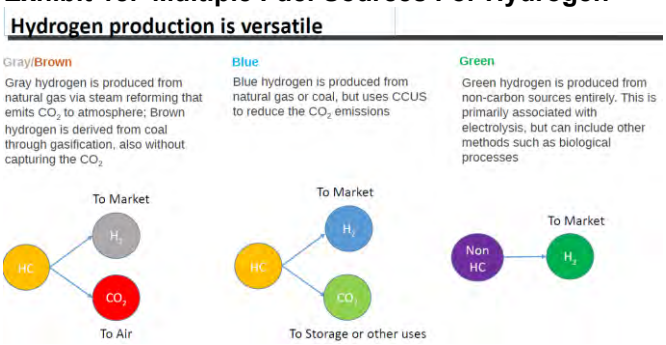


Source: KAPSARC

Widescale deployment of hydrogen needs government policies, as the business case of hydrogen is limited without a price being assigned with carbon

Hydrogen can become an important input to the CCE because of its diverse applications and potential to eliminate carbon emissions. The fact that hydrogen can be produced from hydrocarbons or renewables means its production can be tailored to local resources and needs. However, widescale deployment of hydrogen needs government policies, as the business case of hydrogen is limited without a price being assigned with carbon.

Exhibit 18. Multiple Fuel Sources For Hydrogen



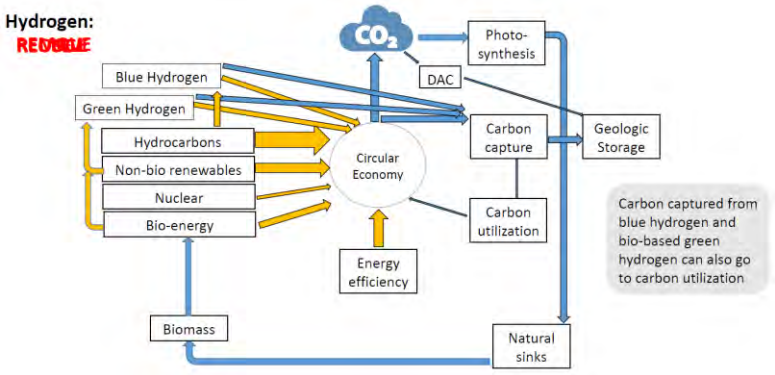
Source: KAPSARC

This is how the contribution from Blue and Green hydrogen can impact the CCC to achieve the environmental goals of the Paris Agreement (see Exhibit 19, next page). The versatility of fuels to produce hydrogen is another attraction for its use.

That means the only way hydrogen could become an important energy source is with government intervention in the energy market and assigning a price to carbon, or subsidizing the hydrogen fuel

The conclusion that comes from our examination of hydrogen is that without some major technological breakthrough that reduces the cost of producing it substantially, the economic hurdle will not be overcome. That means the only way hydrogen could become an important energy source is with government intervention in the energy market and assigning a price to carbon, or subsidizing the hydrogen fuel. At this point in time, as governments around the world struggle to reopen their economies and repair the financial damage done to their citizens and businesses by the response to the pandemic, it is difficult to see them embracing carbon prices,

Exhibit 19. How Hydrogen Could Impact CCE



Source: KAPSARC

The long-term future of the oil market will be impacted by the success of governments instituting carbon prices

which raises energy costs for their people and companies. This is why the strong push, especially in Europe, for tying net-zero carbon emission policies in government stimulus efforts to rebuild their economies following Covid-19. We suggest energy executives, analysts and investors worry more about the debates over the economic rebuilding efforts than the short-term moves in oil prices, demand and supply. The long-term future of the oil market will be impacted by the success of governments instituting carbon prices.

What Do Facebook And Oil And Gas Have In Common?

"[Facebook] showed up to the meeting expecting an 'A' for attendance."

Last Tuesday, there was a high-profile meeting involving senior executives of social media giant Facebook and representatives of several non-profit social justice organizations. According to media reports and based on comments from the social justice attendees, the meeting did not go particularly well. As Rashad Robinson, the president of Color of Change, put it, "The meeting we just left was a disappointment. [Facebook] showed up to the meeting expecting an 'A' for attendance."

Terence Kawaja, chief executive of LUMA Partners, an advisory company specializing in digital media and marketing mergers and acquisitions, said he worried that Facebook founder, CEO and major shareholder Mark Zuckerberg's stance was already clear. Mr. Kawaja said that Facebook "ought to reorient their attitude towards this. It seems to be one of obstinance."

At issue for Facebook is its role in policing racist and other inflammatory postings on its platform, especially in the 'woke' environment engulfing the nation. Facebook spokesman Andy Stone said the company has established new policies banning voting and census suppression and removed more than 200 white supremacist organizations from its platform. He characterized the meeting as "an opportunity for us to hear from the campaign

organizers and reaffirm our commitment to combating hate on our platform. They want Facebook to be free of hate speech and so do we."

The groups' list of demands is to put civil rights leaders in the company's corporate suite

According to Jonathan Greenblatt, chief executive of the Anti-Defamation League, on the groups' list of demands is to put civil rights leaders in the company's corporate suite, rather than simply leave important issues to diversity-focused human resources executives. The group also wants victims of hate to be able to connect with a live employee at Facebook.

Facebook has pointed to research that found that it took down 90% of hate speech before it was reported, evidence that it has made major strides in its moderation efforts. That didn't impress Mr. Greenblatt, an attendee at the meeting, who was quoted telling a reporter, "Ford Motor Company doesn't get to say 90 percent of our seat belts work."

Facebook has been targeted by social justice reformers and politicians to address 'hate speech,' and now the pressure is being brought by advertisers. The advertisers are being pressured by the social justice organizations and motivated customers and employees to abandon advertising on the social media platform in order to pressure Facebook to make more radical changes to its speech-policing policies.

Economic pressure is always a plank in social justice reform platforms

Economic pressure is always a plank in social justice reform platforms. It is believed by these agents of change that economic pressure is the most effective leverage the public has against commercial enterprises to win concessions. Right now, not only have a number of social justice organizations organized boycotts of Facebook, but they are motivating their members and the public generally to apply pressure on companies to suspend their advertising. The pressure is ramping up to inflict financial pain on Facebook. The movement is hopeful that the pressure will force Facebook's executives to embrace the social justice organizations' demands.

The last time we remember the social justice weapon being used against oil and gas companies was in the 1980s when the issue was divestment of operations in South Africa over its apartheid policies

Why is Facebook's predicament of significance for the oil and gas industry? Facebook is being targeted under an increased focus on ESG (environmental, social and governance) criteria that is becoming a greater focus of investors. Investors are just as likely to be exploited on issues by activists – in the case of energy companies, it is environmentalists. The last time we remember the social justice weapon being used against oil and gas companies was in the 1980s when the issue was divestment of operations in South Africa over its apartheid policies.

Today, ESG is being used to target all capital flows to the oil and gas industry. While ESG standards initially targeted commercial

bank lending to energy companies, the effort has expanded to include all global financial institutions such as the World Bank and the International Monetary Fund.

"To prosper over time, every company must not only deliver financial performance, but also show how it makes a positive contribution to society"

The most high-profile embrace of ESG criteria for allocating investment capital has come from Larry Fink, the CEO of BlackRock, the world's largest fund manager with over $7 trillion in assets under management. In his 2018 annual investment letter, he wrote: "To prosper over time, every company must not only deliver financial performance, but also show how it makes a positive contribution to society." Mr. Fink has been leading the charge to expand the corporation's obligation to protect and promote the interests of shareholders. Expanding that obligation was endorsed by the Business Roundtable last year, when it released its revised "Statement on the Purpose of a Corporation." The statement, signed by 181 corporate CEOs, including many of the nation's largest corporations, expanded the obligations of corporations to include all stakeholders – customers, employees, suppliers, and communities, as well as shareholders.

One should not underestimate the power of ESG in the investment world. In a November 2018 *Business Insider* article reporting on *The New York Times* DealBook Conference, Mr. Fink was quoted as having told the audience, "I do believe that the demand for ESG is going to transform all investing. Now, that may be one or five years away from now, but it's not that far away." The future appears now.

Mr. Fink has openly talked about the potential ESG offers his firm to grow its assets under management. BlackRock is one of the leaders in sponsoring exchange-traded funds (ETF). An ETF is an investment fund traded on stock exchanges, much like stocks. An ETF holds assets such as stocks, commodities, or bonds and generally operates with an arbitrage mechanism designed to keep the ETF trading close to its net asset value, although deviations can occasionally occur. ETFs have become a significant asset class on Wall Street, allowing investors to target their investments via packages of stocks with specific characteristics to achieve the investment goal. ETFs eliminate the need to purchase a portfolio of individual stocks to create that vehicle. Additionally, ETFs are traded so the owner can buy or sell immediately, rather than waiting for a mutual fund's end-of-day valuation to buy or sell.

As part of BlackRock's strategy, it plans to double the number of sustainability-focused ETFs if offers to 150

As part of BlackRock's strategy, it plans to double the number of sustainability-focused ETFs if offers to 150. A reason for its plan is recognition of the potential for ESG ETFs. At the present time, ESG funds account for only $20.9 billion in ETF assets under management, or about 0.4% of the roughly $4.5 trillion the ETF industry controls. BlackRock also will eliminate from actively-managed portfolios investments in companies that derive 25% or more of their revenue from thermal coal. Lastly, it aims to increase sustainable assets 10-fold from $90 billion today to $1 trillion within

the next 10 years. The latter goal is in keeping with Mr. Fink's comments about how much ESG investing will grow in the future, largely driven by the desire of younger investors for socially acceptable investments.

Only 17% of millennials and 7% of Gen Xers actually have money invested in ESG funds

A 2019 survey by Allianz Life Insurance Company found that 66% of millennial and nearly half of Gen X respondents said they were interested in at least having some money in ESG investments. However, only 17% of millennials and 7% of Gen Xers actually have money invested in ESG funds, according to the survey.

Another reason why BlackRock is targeting ESG funds is that they are moneymakers, in an industry where fees are being slashed due to competitive pressures. While ESG investing is growing, the expense ratios for ESG funds are falling. ESG funds, because they are a more recent phenomenon, as well as being popular, will lag the fees charged for basic total market funds. A column late last year in *Forbes* magazine shows the impact of the higher expense fees of ESG funds. At Vanguard, the fee for the Vanguard Total Stock Market Index Fund is 0.14%. That contrasts with the Vanguard Global ESG Select Stock Fund fee of 0.55%. Although that fee is still a significant savings compared to typical actively-managed fund expense ratios, the 0.41 percentage point spread between the two Vanguard funds is large, especially when considered over long investment time horizons.

That $6,400 difference is significant to final total returns because the annual fee difference compounds over the life of the investment

For example, $10,000 invested in a fund for 30 years with a 0.14% fee would cost you over $2,300 in fees, assuming a 6% average annual return. The fees paid with a 0.55% expense ratio would come in at over $8,700. That $6,400 difference is significant to final total returns because the annual fee difference compounds over the life of the investment, as well as with every extra dollar you invest. That extra $6,400 in fees adds to the profits of the asset manager, boosting his bottom line.

There are three financial markets that are subject to ESG pressure, enabling pressure to be directly applied to companies. The three markets are: equities, bonds and commercial loans. When it comes to fossil fuels, global institutions such as the International Monetary Fund and the World Bank, as well as various regional national banks are very active in financing energy projects. These institutions are subject to ESG pressure from their owners – governments from around the world – as well as activists. Getting them to stop financing new coal power plants is an important goal of many environmental organizations.

When it comes to commercial banks, of the top ten global commercial banks, they have between 8%-14% of their total credit exposure to all publicly-listed energy companies. A more important measure of activity comes from a study by banker UBS, which showed that between January 2014 and September 2017, 60% of

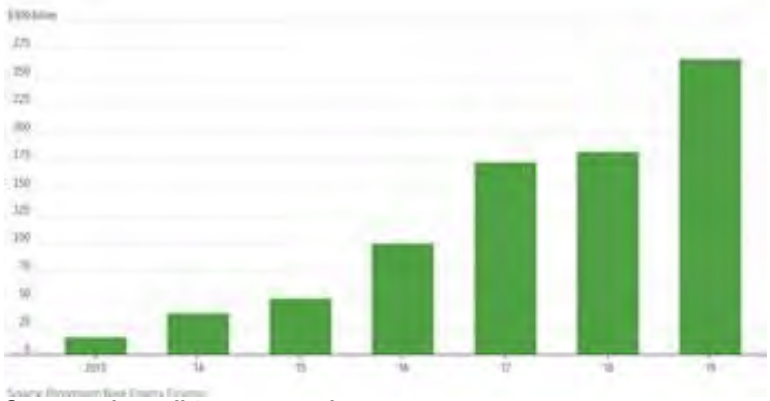
the financing for the world's biggest 120 coal-fired power plant developers came from Chinese banks. The next biggest source of funding came from Japanese banks (8%) and Indian ones (7%).

In the bond market, the hottest segment is green bonds, primarily in the municipal debt sector. A study published earlier this year of U.S. municipal issues of green bonds produced interesting results. The only effective difference between a green bond and a non-green bond is the use of proceeds. The former must be invested in "environmentally friendly projects," such as sustainable water management and energy production.

The conclusion of the study was that this relationship was "precisely equal to zero"

The purpose of the study was to examine whether "greenium" exists, or the premium green assets trade for compared to otherwise identical non-green securities. The conclusion of the study was that this relationship was "precisely equal to zero." The study's authors observed that the spread between green and non-green bonds was approximately 0.45 basis points, a trivial difference. In fact, in approximately 85% of matched cases studied, the differential yield was exactly zero.

Exhibit 20. Green Bond Issuance Has Grown

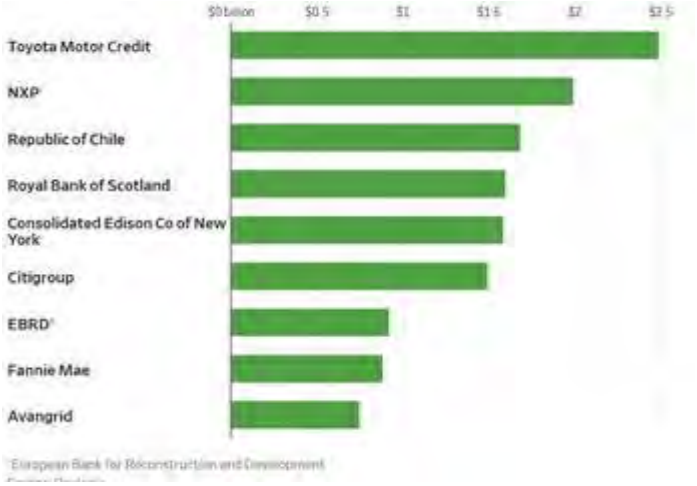


Source: ***The Wall Street Journal***

The study concluded that municipalities actually increase their borrowing costs by issuing green bonds

What the study did find was that borrowing costs were on average approximately 10% higher for green bonds versus almost identical non-green bonds. That premium reflected the greater difficulty in marketing green bonds, which enables investment bankers to charge borrowers more for the effort. The authors also examined the pricing effects of third-party certifications on the pricing of green bonds. This would ensure green bond buyers that the bonds were legitimate and not subject to "greenwashing," where there are questionable environmental benefits. The study found no evidence that certification leads to incremental yield benefits for municipalities selling green bonds. As a result, the study concluded that municipalities actually increase their borrowing costs by issuing green bonds. Is this a cost that municipalities, and their taxpayers, wish to bear for virtue signaling?

Exhibit 21. Companies Issuing Green Bonds

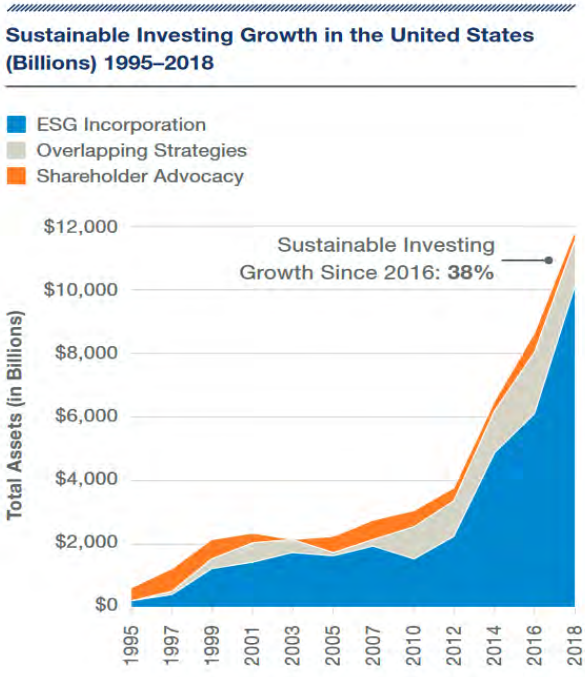


Source: ***The Wall Street Journal***

ESG investing has grown in popularity over the past five years

In the equity arena, ESG investing has grown in popularity over the past five years. At the start of 2019, estimates were that $12 trillion in assets under management in the U.S., according to the Forum for Sustainable and Responsible Investment, and $23 trillion worldwide, according to the Global Sustainable Investment Alliance, is managed based on ESG criteria. Both totals represent about 25% of the respective market totals.

Exhibit 22. ESG Investing's Impact Is Growing



Source: ***FT.com***

What is boosting ESG is the "realization that extreme weather events pose threats to businesses seeking investment"

The climate change movement has had a significant impact on ESG investing. In fact, it was the number one reason cited in a recent article by *The Economist*. As they put it, what is boosting ESG is the "realization that extreme weather events pose threats to businesses seeking investment." That concern is further amplified by the fact that governments are taking steps to limit greenhouse gas emissions, and large, long-term investors, such as national pension funds, are demanding managements pay attention to climate risks. The last reason for more attention being paid to ESG investing is the higher profits from those funds at a time when investment manager margins are under pressure, as we pointed out above.

ESG investing has had a mixed performance, although more recent studies by *Bloomberg* and *Thomson Financial* show this approach outperforming comparable funds composed of companies not ranking particularly high on ESG criteria. One has to wonder how much the recent outperformance of ESG investing has been driven by self-selection. If investors want to crowd into a limited ESG investing space, the flood of money may be responsible for the outperformance.

The greatest challenge for ESG investing is the lack of company disclosures of metrics allowing measurement and comparison of their performance

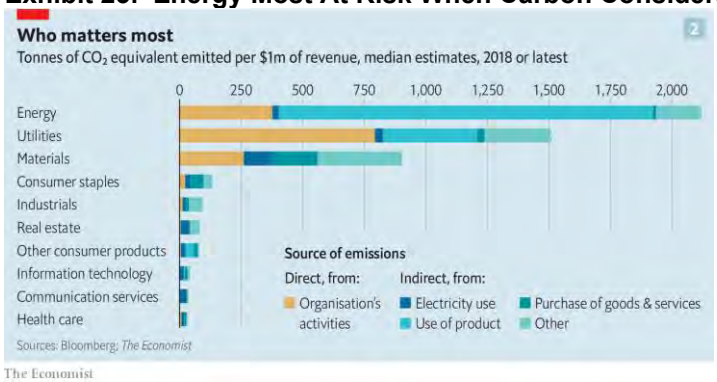
The greatest challenge for ESG investing is the lack of company disclosures of metrics allowing measurement and comparison of their performance. *The Economist* article focused on the "E" aspect of ESG. Carbon emissions disclosure is rising. Based on the magazine's examination of over 5,000 publicly listed companies, it found in America, the disclosures for companies in the Standard & Poor's 500 index increased from 53% in 2014 to 67% in 2019. In Europe, the increase was from 40% to 79% in the Euro Stoxx 600, and from 13% to 46% in the Nikkei 225 in Japan.

While carbon disclosure is increasing, many investors question how much and how well this risk is being incorporated into strategic planning and operational practices

While carbon disclosure is increasing, many investors question how much and how well this risk is being incorporated into strategic planning and operational practices. Answering those questions has not been done well by the energy industry, especially given its exposure risk that was highlighted in two charts accompanying *The Economist* article. The challenge was summed up by Mr. Fink when he stated: "Climate change is different. Even if only a fraction of the projected impacts is realized, this is a much more structural, long-term crisis. Companies, investors, and governments must prepare for a significant reallocation of capital." That will be a challenge.

The first chart (next page) showed the tons of CO_2 equivalent emissions per $1 million of revenue by aspect of the business for every investment sector of the Standard & Poor's 500 index. Energy stands out as most at risk, with the largest component of its carbon emissions due to the use of its products by customers.

Exhibit 23. Energy Most At Risk When Carbon Considered

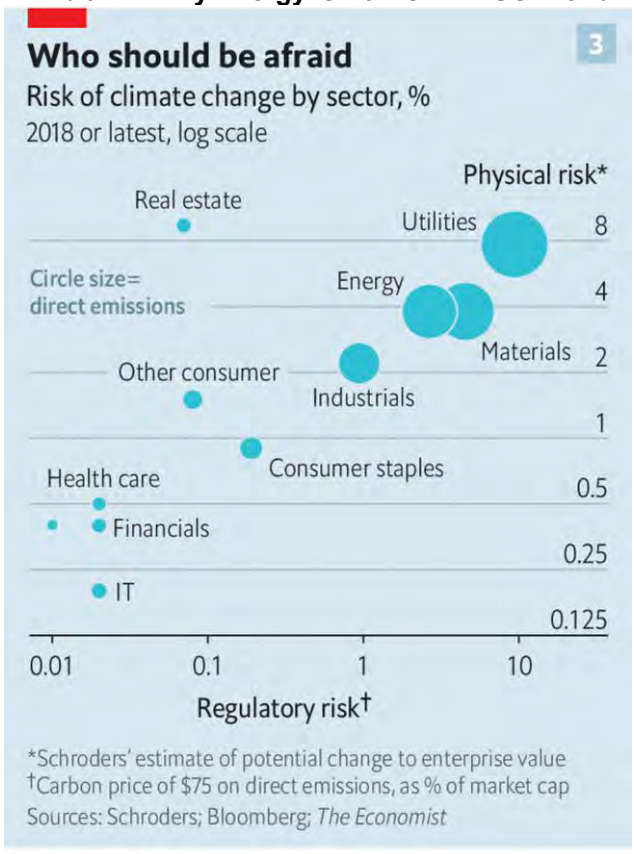


Source: ***The Economist***

The imposition of a $75 carbon tax is the vehicle used to assess the regulatory risk

The second chart reflects an assessment of the risk of climate change by market sector based on physical risk versus regulatory risk. The imposition of a $75 carbon tax is the vehicle used to assess the regulatory risk, although that could be magnified if government clean energy mandates are considered.

Exhibit 24. Why Energy Is At Risk In ESG World



Source: ***The Economist***

Today, the "S" of ESG is receiving the greatest attention among investors, as the fabric of the nation, and even the world, is seemingly being pulled apart over racism and the attacks on freedom of speech and thought. These tensions have been elevated as citizens react to the often draconian and imprecisely levied restrictions by government leaders on peoples' work and personal freedoms. When you are in the middle of a storm, it is hard to imagine blue skies ever returning. Survival and focusing on the moment guide our actions and emotions.

Oil and gas will supply over 50% of our energy needs, even with demand shrinking

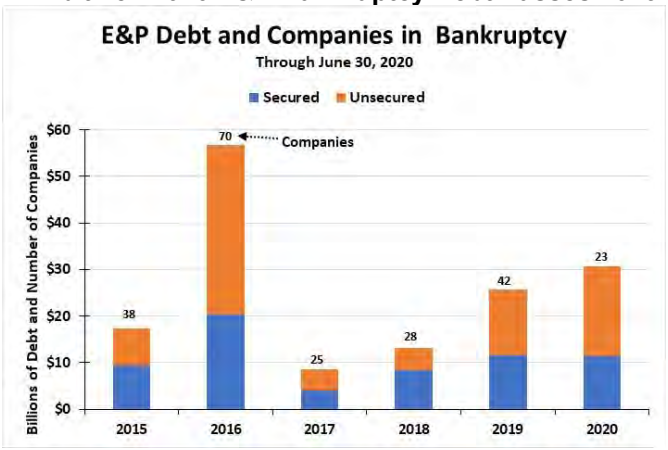
In virtually every economic model, including the most reactionary for limiting climate change damage, energy continues to play a major role. Oil and gas will supply over 50% of our energy needs, even with demand shrinking. Securing the future supply necessary to fulfill these projections will require trillions of dollars. Raising that investment will be challenging in an era of intense ESG focus, and the struggle of energy company managements to demonstrate they can manage their businesses, while meeting the needs of civilization, generating returns for their investors, yet not destroying the world.

Oil & Gas And Oilfield Service Company Bankruptcies Climb

As expected, the number of companies and the amount of debt involved in the bankruptcies increased over the filings in 1Q 2020

Lawyers at Haynes and Boone released their updated E&P and Oilfield Service company bankruptcy totals through the second quarter of 2020. As expected, the number of companies and the amount of debt involved in the bankruptcies increased over the filings in 1Q 2020. We have updated our charts showing the annual number of companies and debt, broken down between secured and unsecured debt. The year-to-date totals for 2020 are for half a year. Due to the anticipated surge in bankruptcy filings, Haynes and Boone announced earlier that it plans to update its reports monthly rather than quarterly.

Exhibit 25. 2020 E&P Bankruptcy Debt Passes 2019

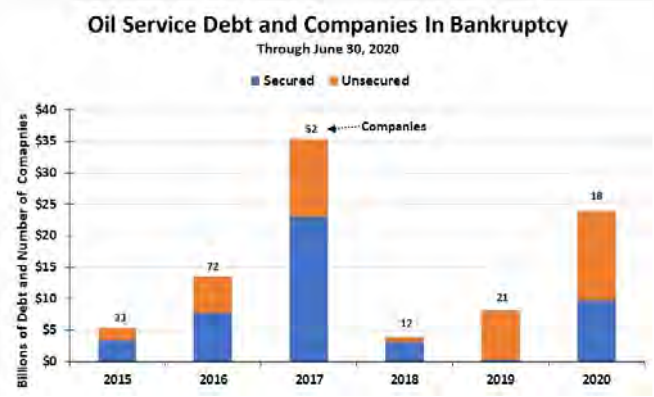


Source: Haynes and Boone, PPHB

In the E&P sector, while the number of companies so far this year is slightly more than half the number for all of 2019, the total debt involved has exceeded last year

In the E&P sector, while the number of companies filing so far this year is slightly more than half the number for all of 2019, the total debt involved has exceeded last year. The primary reason for this increase was the Chesapeake Energy Corporation. filing with $9.2 billion of debt, adding to Ultra Petroleum's $5.6 billion and Unit Corporation's $4.8 billion. For the month of June, five companies filed bankruptcy representing $13.4 billion of total debt, compared to the 13 companies and $15.7 billion that filed during April and May.

Exhibit 26. Debt Of OFS Bankruptcies Gaining On Peak



Source: Haynes and Boone, PPHB

As oilfield activity remains low, the probability is that the number and dollars involved in oilfield service company bankruptcies will grow during the second half of this year

While only 18 companies filed bankruptcy in the oilfield service industry so far this year, the $24.9 billion of debt involved is rapidly gaining on the total 2017 debt, the most recent peak year. June had nearly as many bankruptcies as April and May combined (5 vs. 6). However, only $425 million of debt was involved in the June filings compared to $12.6 billion for the April and May bankruptcies. As oilfield activity remains low, the probability is that the number and dollars involved in oilfield service company bankruptcies will grow during the second half of this year. This is the unfortunate aspect of the oil downturn, as companies are forced to restructure costing the jobs of employees.

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