ENERGY INVESTMENT BANKING

MUSINGS FROM THE OIL PATCH

September 24, 2019

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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:

What A Week It Was Last Week!

A week ago, last Saturday, Saudi's oil industry was attacked, removing 5 mmbb/d of supply from the market. Oil prices jumped, but fell back in days, not helping oil stock prices. The week brought back 1970 memories.

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Recession, Recession, Recession – Bad News for Oil?

The talk of an impending recession has stock markets nervous, as well as those involved in the energy business. Does a recession guarantee a decline in oil's use, adding a challenge for the industry's profits?

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EV Success Depends on Gasoline And Battery Economics

The key to EVs swamping ICE vehicles depends on lower battery costs. We examine the economics of battery costs as well as overall operating costs. EVs did better than we expected, but other issues play a role, also.

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Gas Leaks Are A Major Problem Haunting A Cleaner World

The attacks on natural gas are growing as its low price impedes renewables progress. Methane leaks in urban areas are a significant problem, but so are SF6 leaks from electrical control units, with worse climate risks.

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What A Week It Was Last Week!

The week was full of events that dredged up memories of the decade that started in the mid-1960s

Apologies to our younger readers who won't identify with TWTWTW. That Was The Week That Was was a comedy television show in the UK in the early 1960s, and arrived in America for a two-year run on the NBC network in 1964 and 1965. The show parodied politicians and political events of the day. Reflecting on the events of last week, TWTWTW was the image that popped into our head. The week was full of events that dredged up memories of the decade that started in the mid-1960s. Oil as a political weapon, automobile worker strikes, worries about interest rates and economic growth, battles over clean air and automobile regulations, and concern over general political discourse matched events and fears that dominated that era. Also, last week wasn't far removed from the 50th anniversary of Woodstock with its cultural alteration.

Optimism about the future was a rare commodity, yet history proved all the fears to be unfounded

Those of us who came of age and started our working careers and families during that time were reminded by last week's events of how chaotic the earlier era was, and how it shaped our views of government, industries, politicians, and importantly, our thoughts about our geopolitical future. The Cold War was coming to a head, and thoughts about how much at risk the planet was from environmental, climate change (although we didn't call it that) and war threats dominated discussions and our thoughts. Optimism about the future was a rare commodity, yet history proved all the fears to be unfounded. Will this period be viewed from a future perch in the same light?

Exhibit 1. Geopolitical Events Impacting Oil Markets

Source: RBC

The Saturday attack on Saudi Arabia's oil production and processing facilities, which removed five million barrels a day of supply from the

There was always the possibility that the strike would prompt a military response from the Saudis and the U.S., which could completely disrupt the world's oil market, with a drastic oil price response

world market, sent oil prices soaring when commodity markets opened for trading Sunday night. Expectations called for a big jump in prices, as commodity traders, who were short crude oil futures contracts, raced to cover their shorts, and in-turn, bid prices up. Other traders would be aggressively buying near-term futures contracts with the expectation that with the loss of this oil supply potentially for months, oil prices would soar to tamp down demand. Of course, there was always the possibility that the strike would prompt a military response from the Saudis and the U.S., which could completely disrupt the world's oil market, with a drastic oil price response.

West Texas Intermediate jumped 12% in Monday morning's opening trade, lifting the price by $6.63 per barrel above the prior Friday close. Throughout the day, the news reported the belief of the Saudis and Americans that the oil attack had originated with Iran and not some rogue Yemeni tribesmen. A fear of long-term oil supply outages due to retaliatory military actions grew, which would further tighten the global oil market and boost prices. WTI eventually reached $63.38, 15.5% higher than Friday, but the lack of any military response to the attack coupled with Saudi Arabian comments its production would be back on stream in weeks not months, took the steam out of the price rise late in the day. The futures price closed at $62.90 a barrel, only a 14.7% increase.

Monday saw E&P and oil service stock prices soar, demonstrating what we had suggested might happen in our recent Musings article. We suggested that the high short interest levels for these stocks could cause an explosion in their prices when investor sentiment shifted. While we didn't know what event might trigger such as shift, the most shorted stocks jumped by 30%-50%, as the energy stocks matched the rise in oil prices.

The oil market and energy stock one-day wonder dissipated on Tuesday, as oil prices fell by over 7%, before ending down 5.7%, as investors accepted Saudi oil officials' declaration that full output would be restored within 2-3 weeks

The oil market and energy stock one-day wonder dissipated on Tuesday, as oil prices fell by over 7%, before ending down 5.7%, as investors accepted Saudi oil officials' declaration that full output would be restored within 2-3 weeks. The oil price slump continued on Wednesday with prices falling 3.8% to the day's low, before climbing back to only drop 2.1% for the day. Oil sentiment shifted on Thursday as traders began to question Saudi Arabia's optimism for how quickly it could restore the damaged facilities and output. What caused the shift were reports Saudi Aramco had begun arranging to import crude oil and refined products for its refineries. Saudi also began telling customers there would be quality adjustments to oil shipments – more heavy, sour oil than low-sulfur, light oil. This adjustment ties in with the Abqaiq processing plant outage.

The Saudi attacks rekindled the debate over how much the U.S. and global oil markets have changed due to shale oil. The oil supply shock has not impacted crude oil prices and energy securities' prices to the degree they have in the past, or would have impacted prices had our domestic supply not grown as much as it has. The U.S. no longer imports significant volumes of crude oil, and specifically large amounts of oil from Saudi Arabia. However, there is a shift underway in the quality-mix of domestic oil production, which has contributed to the U.S. exporting large volumes of light oil that exceeds our refining needs, while we continue importing heavy, sour oil. This will remain a challenge for our domestic oil business until it reconfigures more of the domestic refining industry to use the ultra-light crude oil we are producing now.

If an attack on Saudi Arabia's oil industry can't drive oil prices to $100 a barrel, one wonders what could?

The events of last week and the market responses will shape the thinking of energy company executives as they assess their new business strategies. If an attack on Saudi Arabia's oil industry can't drive oil prices to $100 a barrel, one wonders what could? We doubt last week will cause any business strategy adjustments in the patch. Unfortunately, it also isn't changing investor attitudes toward energy stocks. Living within cash flow and capital discipline in capex spending, along with returning more cash to shareholders, which has made a successful start in altering the industry's DNA will need more time to win over skeptical investors. How long that takes remains unknown. Higher energy share prices will need to await the next industry event that forces a rethinking of the oil market's evolution and its stable performance.

Recession, Recession, Recession – Bad News For Oil?

Maybe President Trump's trade tariffs will cause a recession, but so far, the economic data shows no clear signs of a recession on the horizon

With the 2020 presidential election campaign already underway, Democrats who have opposed President Donald J. Trump since election eve 2016 cheered on the Russian collusion narrative for two and a half years until undone by the Mueller Report. Their focus has shifted to rooting for a recession in 2020 to undo Mr. Trump's economic successes, in hopes that a softer economy will turn voters against him in his re-election effort. What we hear now on cable news is Recession, Recession, Recession, which conveniently rhymes with Russia, Russia, Russia and Collusion, Collusion, Collusion. Will we talk ourselves into a recession? Maybe President Trump's trade tariffs will cause a recession, but so far, the economic data shows no clear signs of a recession on the horizon, albeit much of the data is mixed.

Recessions are bad for people, as the reduced economic activity takes a toll on manufacturing, often costing workers their jobs. When that happens, it impacts workers' incomes and their spending. A victim of recessions is often gasoline consumption, as lower employment reduces commuting driving as well as vacation trips and even just spur-of-the-moment traveling.

Even before we get to a recession, it appears oil consumption growth this year will be much slower than forecasted. In its September Monthly Oil Report, the International Energy Agency

(IEA) kept its estimates for oil demand growth for 2019 and 2020 at 1.1 and 1.3 million barrels per day (mmb/d), respectively. That decision stood out, as the other two leading oil market forecasters – OPEC and the U.S. Energy Information Administration (EIA) – reduced their 2019 forecasts. What may have been lost on market observers is that the IEA's 2019 estimate for demand growth in 2019, made in January, was for a 1.4 mmb/d increase.

What was surprising was seeing that its new 2019 supply estimate reflects a 1.0 mmb/d decline from 2018

In their September oil report, OPEC cut its global demand estimate by 80,000 barrels per day (b/d) to 1.08 mmb/d. People weren't overly moved by this reduction. At the same time, OPEC estimated that the volume of its members' collective output to balance global supply and demand would be 80,000 b/d less than forecast in August. What was surprising was seeing that its new 2019 supply estimate reflects a 1.0 mmb/d decline from 2018. Moreover, the estimate for OPEC oil needed in 2020 is 1.2 mmb/d below this year's new estimate. The reduced calls on OPEC reflect the growing output from non-OPEC sources, in particular, U.S. shale oil.

Another interesting point about OPEC's latest demand estimate is to go back to January 2019 to see how much the organization expected demand to grow. Their estimate was for a 1.3 mmb/d increase. So, after nine months, OPEC has cut its global demand forecast for 2019 by 200,000 b/d.

In addition to OPEC's moves, the EIA cut its most recent demand forecast by 100,000 b/d to only a 900,000 b/d increase

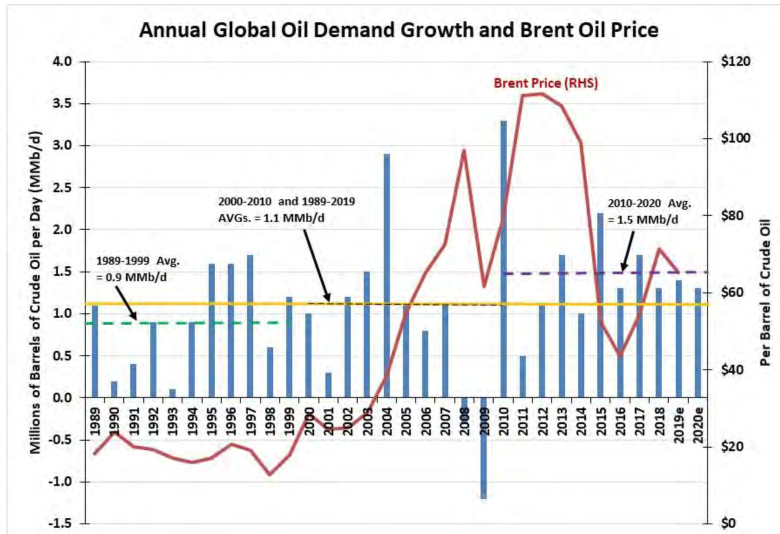
In addition to OPEC's moves, the EIA cut its most recent demand forecast by 100,000 b/d to only a 900,000 b/d increase. Again, if we go back to the January 2019 Short Term Energy Outlook report, 2019 demand was supposed to rise by 1.55 mmb/d. Moreover, its 2020 demand forecast called for a similar increase (+1.52 mmb/d). Now, in conjunction with the 2019 demand reduction, its 2020 estimate is down to only a 1.39 mmb/d increase.

Other oil forecasters who recently cut their 2019 demand forecasts include researcher Wood Mackenzie who reduced its estimate to 700,000 b/d from its prior 850,000-900,000 b/d forecast, an already low number. JBC Energy, an oil and gas research firm that tracks demand data from more than 100 countries, now pegs global oil demand growth at less than 1.0 million bpd for 2019. Australia and New Zealand Banking Group (ANZBY-OTC) economists are also cutting their 2019 oil demand forecast to 1.0 mmb/d from its prior 1.2 mmb/d estimate. All three research firms cited economic headwinds, based on various economic data, for their reductions.

Over the 30-year period 1989-2019, global oil demand grew on average by 1.1 mmb/d

To understand the significance of these recent demand reductions, it is instructive to examine the history of global oil demand growth as reflected in IEA data and forecasts. Over the 30-year period 1989-2019, global oil demand grew on average by 1.1 mmb/d. Growth has been greater and also lower for shorter periods of time. Given the recent reductions in growth for 2019, we are now growing at a slower than normal pace. Will future oil demand growth return to the normal rate, or are we on the brink of a permanent slowing in oil demand growth?

Exhibit 2. Global Oil Demand And Brent Price

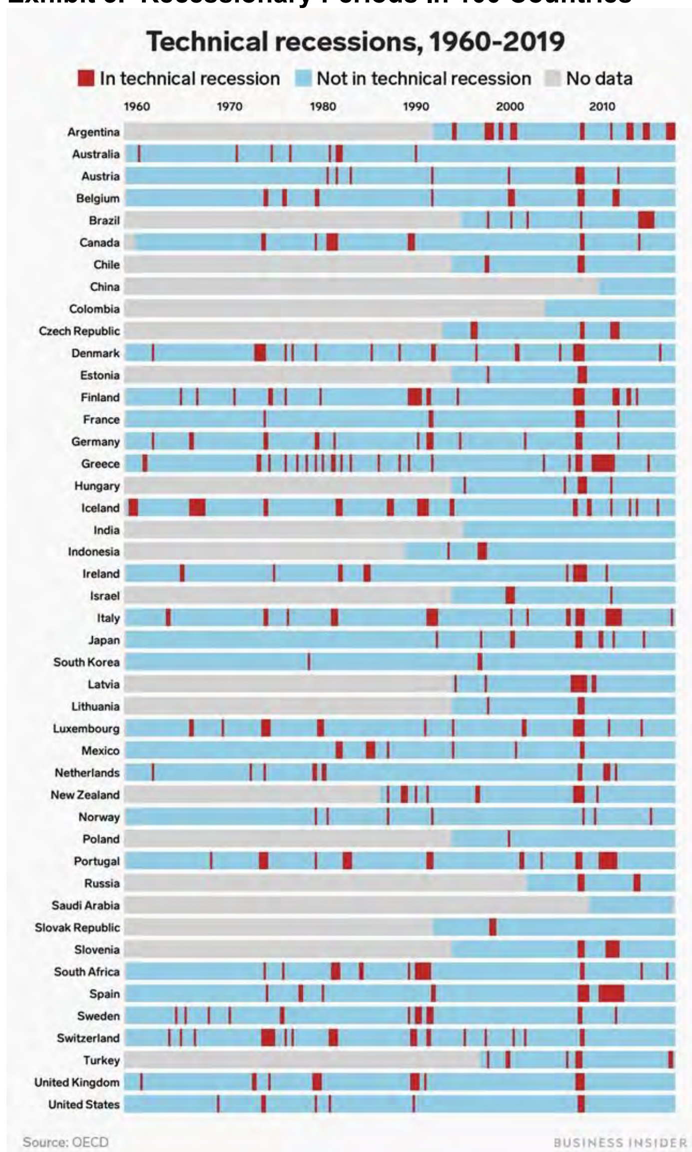


Source: EIA, PPHB

Recessions are interesting animals. Each is different, although they often are caused by similar conditions. While they are responsible for economic pain, it seems that they seldom coincide globally. The 2008 Financial Crisis that was started by the U.S. housing market quickly became a global phenomenon as credit default swaps were traded worldwide and became the toxic security that helped to bring down several Wall Street financial firms, as well as cripple the commercial banking sector. Exhibit 3 shows recession conditions over time for 100 countries. One can scan the chart and see where the red marks line up, providing a perspective on the significance of recessionary conditions. We observed a couple of general alignments – early 1970s, around 1990, and then the global recession in the 2008-2010 period.

While they are responsible for economic pain, it seems that they seldom coincide globally

Exhibit 3. Recessionary Periods In 100 Countries



Source: ***Business Insider***

The history of recession in this nation is extensive, reflecting the large number of financial panics that haunted our past prior to the formation of the Federal Reserve Banking System in 1913

For those of us who call the United States home, *Wikipedia's* discussion of the history of recession in this nation is extensive, reflecting the large number of financial panics that haunted our past prior to the formation of the Federal Reserve Banking System in 1913. The Financial Panic of 1907, caused by speculation on Wall Street, and which required the intervention of J. P. Morgan to organize a banking group to bailout the financial community, caused the creation of an emergency currency and the formation of a commission to seek a permanent solution. The process was unsuccessful. When Woodrow Wilson was elected president in 1912, he engaged Congressman Carter Glass, the head of the

House Committee on Banking and Finance, and the committee's expert, Professor H. Parker Willis, and they produced a bill that was discussed and modified during 1912-13. Late in December 1913, President Wilson signed the Federal Reserve Act, establishing a national banking system that restored stability to financial markets.

Since the Great Depression, the U.S. has experienced a number of recessions

Since the Great Depression, the U.S. has experienced a number of recessions, chronicled by *Wikipedia* in Exhibit 4 (next page). For purposes of assessing the impact of recessions on energy demand, we zeroed in on the six official recessions since 1969.

Exhibit 4. U.S. Recessions Since Great Depression

Name	Period Range	Duration (months)	Time since previous recession (months)	Peak unemploy-ment	GDP decline (peak to trough)
Great Depression	Aug 1929–Mar 1933	3 years 7 months	1 year 9 months	21.3%(1932)[46]–24.9%(1933)[47]	−26.7%
Recession of 1937–1938	May 1937–June 1938	1 year 1 month	4 years 2 months	17.8%[46]–19.0%(1938)[53]	−18.2%
Recession of 1945	Feb 1945–Oct 1945	8 months	6 years 8 months	5.2%[53] (1946)	−12.7%
Recession of 1949	Nov 1948–Oct 1949	11 months	3 years 1 month	7.9% (Oct 1949)	−1.7%
Recession of 1953	July 1953–May 1954	10 months	3 years 9 months	6.1% (Sep 1954)	−2.6%
Recession of 1958	Aug 1957–April 1958	8 months	3 years 3 months	7.5% (July 1958)	−3.7%
Recession of 1960–61	Apr 1960–Feb 1961	10 months	2 years	7.1% (May 1961)	−1.6%
Recession of 1969–70	Dec 1969–Nov 1970	11 months	8 years 10 months	6.1% (Dec 1970)	−0.6%
1973–75 recession	Nov 1973–Mar 1975	1 year 4 months	3 years	9.0% (May 1975)	−3.2%
1980 recession	Jan 1980–July 1980	6 months	4 years 10 months	7.8% (July 1980)	−2.2%
1981–1982 recession	July 1981–Nov 1982	1 year 4 months	1 year	10.8% (Nov 1982)	−2.7%
Early 1990s recession in the United States	July 1990–Mar 1991	8 months	7 years 8 months	7.8% (June 1992)	−1.4%
Early 2000s recession	Mar 2001–Nov 2001	8 months	10 years	6.3% (June 2003)	−0.3%
Great Recession	Dec 2007–June 2009[70][71]	1 year 6 months	6 years 1 month	10.0% (October 2009)[72]	−5.1%[73]

Source: ***Wikipedia***

The six recessionary periods during this time span varied considerably in duration

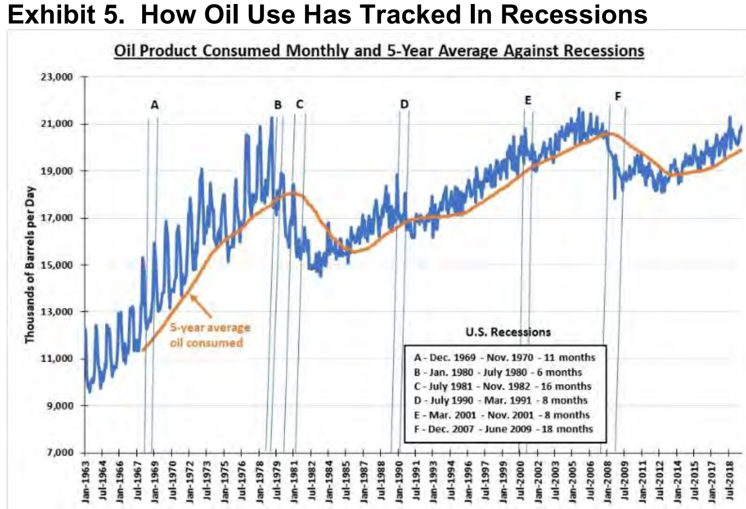
To see how oil demand is impacted by a recession, we plotted total U.S. petroleum consumption monthly between January 1963 and August 2019. The six recessionary periods during this time span varied considerably in duration – from six months (January 1980-July 1980) to 18 months long (December 2007-June 2009). An interesting consideration was information from a recent article in *The New York Times* about "A Cooling Economy, Sure. A Recession? Complicated." It reported:

> "Historically, it has taken six to 21 months from the actual start of a recession to the formal declaration. The committee [National Bureau of Economic Research] announced the start of the recession that started after December 2007 about 11 months later.
>
> "That said, other economic authorities often point out contractions first. Staff at the Federal Reserve, for instance, believed by March 2008 that the economy was moving into recession — a full nine months before the official dating."

It is very difficult to discern any oil demand fall during the 1969-1970 recession, which lasted 11 months

What this suggests is the determination of recessions is a more involved process than merely examining a few data series. We see this when we look at the chart in Exhibit 5. Note that it is very difficult to discern any oil demand fall during the 1969-1970 recession, which lasted 11 months. On the other hand, the two recessions during 1980-1982 occurred in the context of an extended and dramatic oil demand fall caused by the sharp rise in oil prices following the 1979 Iranian Revolution and the loss of its oil supply. In contrast, oil demand fell during 1972-1975 in response to the Arab Oil Embargo and the quadrupling of oil prices. These considerations need to be kept in mind as we think about the possible impact of a recession on future oil demand.

Exhibit 5. How Oil Use Has Tracked In Recessions



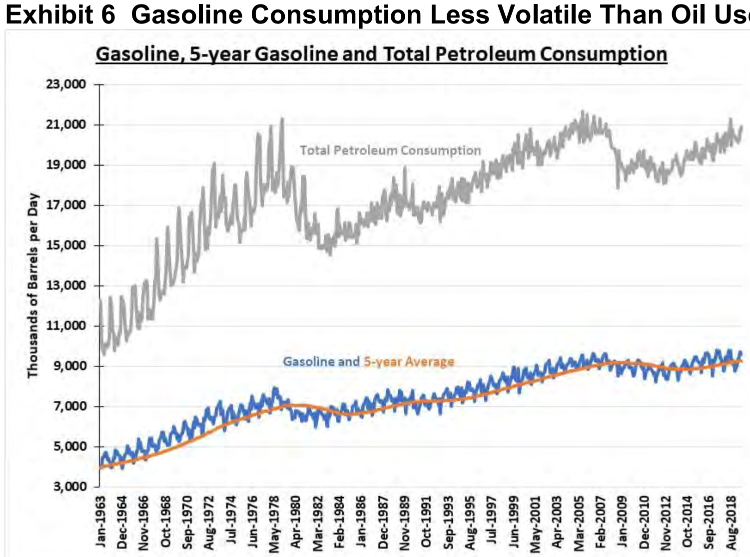
Source: EIA, PPHB

The major global recession of 2007-2009 saw oil demand beginning to fall well in advance of the official start of the recession

Another example of the difficulty in translating recessions into forecasts of oil demand is to note how much longer demand fell during the early 1980s even after the recessions ended. Equally, we see a further oil demand decline, as well as an extended period of flat demand growth following the 1990-1991 recession. The major global recession of 2007-2009 saw oil demand beginning to fall well in advance of the official start of the recession. Oil demand rebounded almost immediately following the recession's official end, in contrast to the pattern of earlier recessions. These pattern differences complicate assessing how the oil market may act during the balance of 2019 and in 2020 given the possibly of recessionary conditions developing.

A favorite measuring rod for oil demand is gasoline consumption. It may reflect changing driving patterns as recessions eliminate jobs and hurt worker incomes. To see whether gasoline consumption, a major share of total oil use, shows a similar pattern to overall oil consumption, we plotted both data series.

Exhibit 6 Gasoline Consumption Less Volatile Than Oil Use



Source: EIA, PPHB

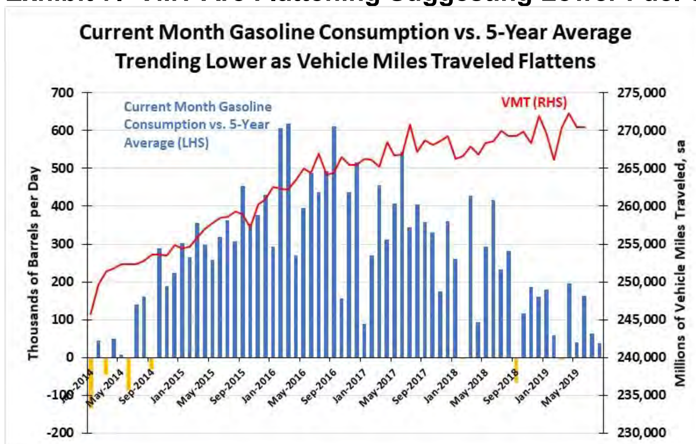
During 1982 to 2007, total petroleum demand changes were more in line with those of gasoline consumption, again reflecting less non-transportation use of oil

What we see is more variation in total petroleum consumption versus gasoline use. In a similar vein, the 1970s showed much greater petroleum demand decline than reflected by gasoline use, which we suspect was due to the rapid shift by consumers, manufacturers and utilities away from using oil for power generation and home heating. During 1982 to 2007, total petroleum demand changes were more in line with those of gasoline consumption, again reflecting less non-transportation use of oil. Oil's fall in use during the 2007-2009 Great Recession was greater than that of gasoline, again reflecting the much more significant impact on manufacturing activity than driving. What might the next recession look like?

The pace of vehicle miles traveled growth has slowed, likely contributing to reduced gasoline consumption

Let's consider what is currently happening with gasoline consumption, the most watched measure of U.S. oil demand. Exhibit 7 shows gasoline consumption growth, measured against its 5-year average, slowing since its peak in early 2016. At the same time, the pace of vehicle miles traveled growth has slowed, likely contributing to reduced gasoline consumption.

Exhibit 7. VMT Are Flattening Suggesting Lower Fuel Use



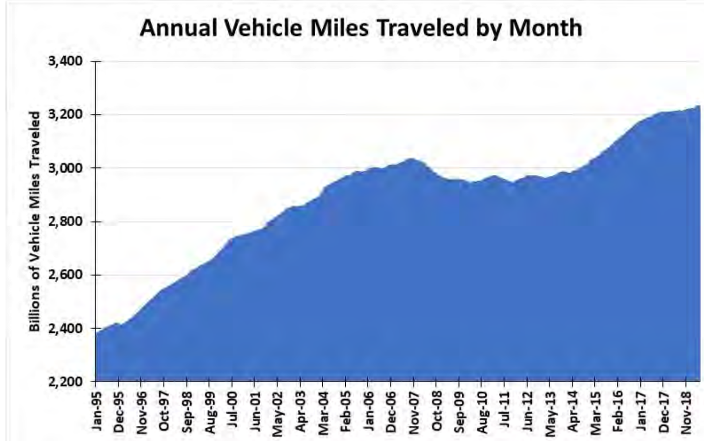
Source: EIA, DoT, PPHB

In hindsight, the tipping point in VMT growth may have been the first signs of the impending Great Recession, which produced significant economic pain and disruption

To better appreciate how VMT have trended over time, we plotted the monthly annual average since 1995 (earliest data available). It shows how miles traveled grew steadily up until early 2007 before growth turned negative. During this time, analysts, including us, spent considerable time analyzing attitudinal shifts, especially among our youth, about driving. We also examined shifts in vehicle use, such as online shopping and working, for example. In hindsight, the tipping point in VMT growth may have been the first signs of the impending Great Recession, which produced significant economic pain and disruption. The extended period of flat VMT following the recession may have resulted from the slow economic recovery.

As the pace of economic activity began to pick up in early 2014, we saw oil prices soar. What is notable now is that VMT have flattened recently. Does this point to an impending recession, or are there other factors influencing travel? Time will tell.

Exhibit 8. Driving Hurt Before, During And After Recession

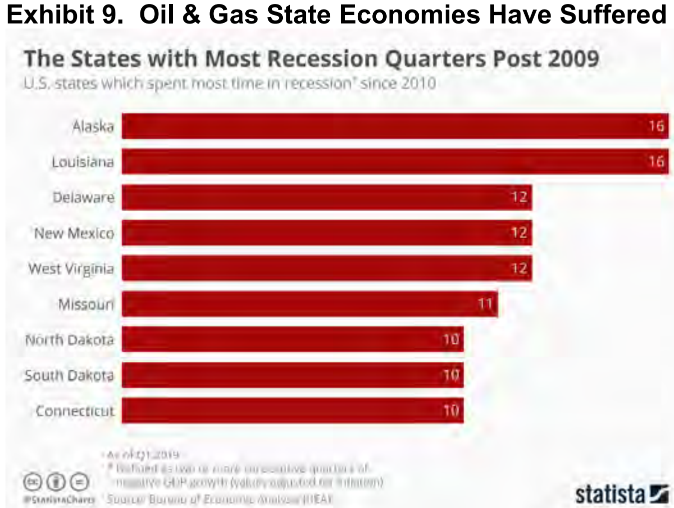


Source: DoT, PPHB

Both states are tied closely to the oil and gas industry, which has been hurt over the past four and a half years, or 18 quarters

Further to the examination of possible impending recessionary signals, we found the chart showing the nine states with the most recession quarters after 2009 quite interesting. The top two states – Alaska and Louisiana – show that they have spent nearly half the time in recessionary conditions. Both states are tied closely to the oil and gas industry, which has been hurt over the past four and a half years, or 18 quarters. The chart doesn't show which quarters the states were in recession, so it is impossible to know whether all the time was when the oil industry was struggling such as immediately after the recession and then since the collapse of oil prices at the end of 2014.

Exhibit 9. Oil & Gas State Economies Have Suffered



Source: ***Statista***

Over half the states experiencing the most time in recession have economies heavily dominated by the oil and gas business. A sixth state, West Virginia, has been hurt by the demise of the coal

Interestingly, Missouri, not a significant oil and gas state, accounts for the largest share of total VMT and showed a slight year-over-year decline

industry, which dominates its economy. To consider whether VMT could be an indicator of recession, we looked at the most recent data for June. We compared each state's annual VMT and looked at it versus June 2018, as well as how significant the state's VMT is of national VMT. Interestingly, Missouri, not a significant oil and gas state, accounts for the largest share of total VMT and showed a slight year-over-year decline. We wonder whether its decline is a reflection of weakness in agricultural activity, as well as potentially due to seasonal flooding.

Exhibit 10. How States With Highest Recessions And Driving

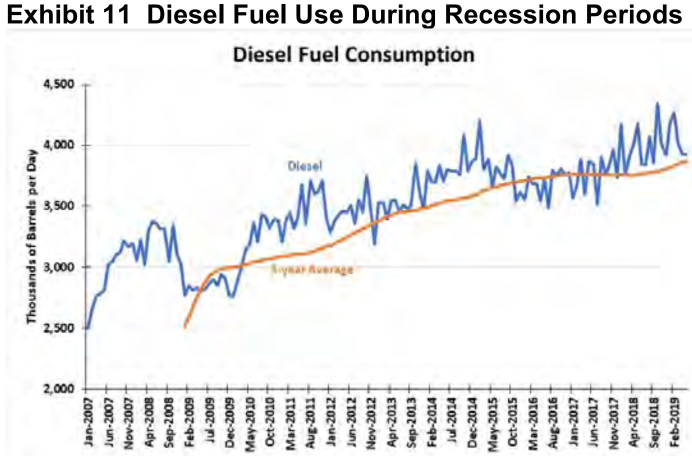
(Billions of VMT)	Jun-19	Y/Y Change	Share of Total
Alaska	141	0.4%	0.2%
Louisiana	1,185	1.6%	2.1%
Delaware	204	0.2%	0.4%
New Mexico	854	2.6%	1.5%
West Virginia	461	-1.7%	0.8%
Missouri	1,701	-0.1%	3.0%
North Dakota	436	1.6%	0.8%
South Dakota	513	0.5%	0.9%
Connecticut	144	-2.3%	0.3%
TOTAL	56,428	0.4%	100.0%

Source: DoT, PPHB

Could that decline have been due to the contraction in oilfield activity in response to the collapse in oil prices?

It is certainly true that oil demand in the U.S. is not growing as rapidly as in the past, but the exact causes are difficult to determine. If we look at low-sulfur distillate fuel, which is what is mandated for our trucking industry, we see the impact of the Great Recession on the shipment of goods. The subsequent economic recovery following the recession restored growth in diesel fuel consumption. It is also interesting to note the decline in consumption that started in late 2014 and continued through 2016. Could that decline have been due to the contraction in oilfield activity in response to the collapse in oil prices? We are sure it had some impact.

Exhibit 11 Diesel Fuel Use During Recession Periods



Source: EIA, PPHB

It is possible oil consumption data will begin to reflect recessionary conditions ahead of other general economic statistics

Recession, recession, recession is what we are likely to continue hearing, especially as it may prove helpful in the upcoming 2020 election. However, economic statistics are spotty in reflecting such a development. That does not mean there aren't indications of economic growth slowing reflected in gasoline and diesel consumption. It is possible oil consumption data will begin to reflect recessionary conditions ahead of other general economic statistics. Stay tuned.

EV Success Depends On Gasoline And Battery Economics

From banning all new oil and gas exploration on public land and ending fossil fuel subsidies to criminalizing any oil company CEO's "wrongdoing," there was no shortage of ways to cripple the energy business

If people only understood that the future of our planet rests on them driving electric vehicles (EV) and eschewing fossil-fuel burning ones, they would push up EV sales faster than forecasters project. Three weeks ago, CNN hosted Democratic presidential hopefuls who touted their pet plans for curbing carbon emissions for seven(!) hours. From banning all new oil and gas exploration on public land and ending fossil fuel subsidies to criminalizing any oil company CEO's "wrongdoing," there was no shortage of ways to cripple the energy business. Senator Elizabeth Warren even proposed entirely decarbonizing the energy, transportation and construction industries. But at the end of the day, as Dr. Ashley Nunes, an academic at the Massachusetts Institute of Technology and Harvard University put it in an op-ed on the *Financial Times* website:

> "But words must be backed up by deeds. Public outrage must be turned into legislative action. When it comes to tackling climate change, don't expect either anytime soon. That's because a climate-conscious public — though admittedly growing — is also its own worst enemy."

Yes. The public likes the idea of a carbon-free world until they are asked to pay for it. Moreover, they are also beginning to realize the lifestyle sacrifices they must make for this carbon-free world to become a reality, and they are not wild about it. Just ask all those Frenchmen wearing yellow vests protesting French President Emmanuel Macron's plan to hike gasoline taxes to pay to curb France's emissions.

While carbon offsetting sounds like a good program, the International Air Transport Association says that only about 2% of online ticket sales opt to participate

Dr. Nunes pointed out that the airline jet-setters, for a small fee, can "offset" their carbon footprint. Flying in coach from New York to Frankfurt will cost only about $10 in offset payments, with the money going into a fund supporting sustainable development projects such as preserving wildlife, planting trees and installing solar panels. While carbon offsetting sounds like a good program, the International Air Transport Association says that only about 2% of online ticket sales opt to participate. According to the European Commission, even programs to nudge people's behavior to increase enthusiasm for carbon offsetting fail to curb emissions in any meaningful way.

The proponents of EVs believe that because carbon doesn't come from tailpipes, EVs are the cleanest vehicles on earth

If all of these programs and attempts to motivate people to offset their carbon footprints are not working, one has to wonder how well, and how quickly, the world will transition to EVs? The proponents of EVs believe that because carbon doesn't come from tailpipes, EVs are the cleanest vehicles on earth. In reality, rafts, canoes and sailboats are the cleanest ones.

EVs have been around as long as internal combustion engine (ICE) vehicles. In fact, they dominated the U.S. vehicle fleet in the early years as they eliminated the difficulty for starting ICE cars. Hand cranks were a problem for women who favored EVs. There was also a lack of roads outside cities, minimizing the range limitation issues for EVs. You just couldn't go very far.

When more people were able to drive, municipalities began constructing new roads to improve travel in their cities, but also to connect them across the nation

When the electric starter arrived, courtesy of Charles Kettering and Henry Leland, the automobile age was opened to women, while also making it safer for all others. When more people were able to drive, municipalities began constructing new roads to improve travel in their cities, but also to connect them across the nation. The idea that a vehicle was limited by the miles it could travel on a single battery charge, let alone that people had to mess with batteries, caused car buyers to favor ICE vehicles.

Now that the pollution caused by fossil fuel-burning ICE vehicles has become a target of environmentalists, the 100-year love-affair with cars and personal transportation is in jeopardy. Will it end? Probably not. There are too many people with too diverse needs for everyone to give up owning and driving personal vehicles, as well as those who merely like the freedom that comes with owning their own car.

Their ideal is a world with personal transportation as a service

EVs have become the environmental favorite for decarbonizing personal transportation, but they still suffer from range anxiety. Battery packs have grown, which seems to be the way to extend an EV's range on a single charge. However, cars tend to sit for 90-95% of the time, so it is not impossible to keep them charged to overcome range anxiety. The problem comes in urban areas where people do not have access to parking garages where battery chargers typically are located. The solution is a public charging network. The future solution envisioned by environmentalists is ride-hailing and car-sharing services eliminating the need to own a personal vehicle. Their ideal is a world with personal transportation as a service. That would allow commercial services to maximize vehicle use by keeping them running as taxis 24-hours a day. Thus, people's transportation needs could be met with a sharply reduced vehicle fleet. If the service is based on EVs, you have effectively decarbonized the personal transportation sector.

The key to bringing this vision to fruition is convincing people to embrace EVs. But, as we pointed out, when EVs are presented as the key pillar for the clean economy movement, people look at all the

If EVs were comparable to ICE vehicles in both purchase and lifetime operating costs, the public might be convinced to buy EVs

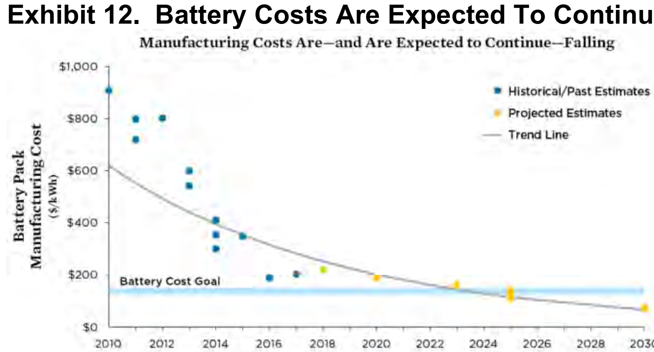
negatives – range anxiety, expensive vehicles, and inconvenient recharging – and assign them greater weight in their buying decisions. If EVs were comparable to ICE vehicles in both purchase and lifetime operating costs, the public might be convinced to buy EVs. Reducing purchase cost, improving range and cutting recharging time are issues EV manufacturers must address to truly win over the public.

Auto manufacturers are making EVs comparable to ICE vehicles, but to equalize purchase prices, they are absorbing losses on every EV built and sold. The willingness to accept loss-leader EVs is driven by the regulations imposed by California. It requires car companies to sell a certain proportion of their vehicles as EVs in order to sell the balance of their output in the state. For auto manufacturers, shunning California's light duty vehicle market of roughly two million units per year, the number one vehicle market in the nation with an 11.7% share in 2018, would not be a smart move. Therefore, they grin and bear the EV losses to capitalize on the profits from the balance of fleet sales.

Auto manufacturers are hard at work lowering EV costs, but they are stymied by battery pack pricing

Auto manufacturers are hard at work lowering EV costs, but they are stymied by battery pack pricing. EV proponents tell us that battery prices are on a downward trend and by 2022-2024, they will be low enough to make EVs price-competitive with comparable ICE cars. Exhibit 12 is a chart of battery manufacturing costs from the Union of Concerned Scientists website showing a cost goal of $125-$150 per kilowatt-hour (kWh).

Exhibit 12. Battery Costs Are Expected To Continue Down



Source: Union of Concerned Scientists

When EVs were introduced in 2010, their battery packs cost an estimated $1,000/kWh

When EVs were introduced in 2010, their battery packs cost an estimated $1,000/kWh. Tesla's (TSLA-Nasdaq) Model 3 battery pack cost is about $190/kWh, and General Motors' (GM-NYSE) 2017 Chevrolet Bolt battery pack is estimated to cost about $205/kWh. That reflects a price drop of more than 70% in 6 years.

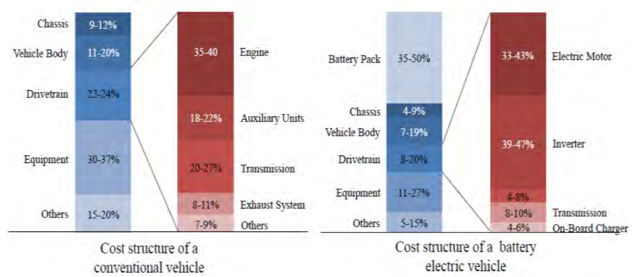
The key to EV-ICE price comparability is battery pack pricing being between $125 and $150/kWh. Optimists believe that pricing can be

In contrast, the drivetrain cost of a BEV ranges between 8% and 20%, which reflects the fewer moving parts in an electric motor versus an ICE engine

reached in 2020, but it is more likely the early 2020s. Some studies suggest that battery pack prices can fall as low as $73/kWh by 2030. What does battery pricing mean to the competitiveness of EVs?

We borrowed a spreadsheet for analyzing battery pricing sensitivity on EV competitiveness from Donn Dears of *Power For USA*. The basis for his analysis is tied to research from the Institute of Automotive Technology in Germany. The research is designed to breakdown the cost of major components for building vehicles – ICE, diesel, hybrid and battery electric vehicles (BEV). The details for ICE vehicles and BEVs are presented in Exhibit 13. It shows that an ICE drivetrain cost, including the engine, transmission and exhaust system, ranges between 22% and 24% of the vehicle's total cost. In contrast, the drivetrain cost of a BEV ranges between 8% and 20%, which reflects the fewer moving parts in an electric motor versus an ICE engine. What the BEV cost breakdown demonstrates is that the battery pack can account for upwards of 50% of the car's cost.

Exhibit 13. Cost Of Components Of Autos And EVs



Source: Institute of Automotive Technology

Applying the highest drivetrain cost estimate, we get the ICE drivetrain costing slightly over $7,000

The analysis is based on GM's Bolt and a comparably-priced ICE vehicle. The Bolt is no longer eligible for a tax credit, which could influence the analysis. Starting with the Manufacturer's Suggested Retail Price (MSRP) for vehicles, we can back out GM's estimated 19.4% profit margin to get to a realistic vehicle cost figure. Applying the highest drivetrain cost estimate, we get the ICE drivetrain costing slightly over $7,000.

Exhibit 14. Deriving ICE Drivetrain Cost

ICE		
$	36,600	MSRP
	80.6%	Cost after GM profit
$	29,500	Cost of vehicle
	24%	Drivetrain cost (highest)
$	7,080	Cost of drivetrain

Source: PPHB

We have elected to use the lowest estimated drivetrain cost for the BEV of 8%. This means the Bolt's drivetrain cost would be slightly below $2,400.

Exhibit 15. Determining Bolt Drivetrain Cost

	BOLT
$ 36,600	MSRP
80.6%	Cost after GM profit
$ 29,500	Cost of vehicle
8%	Drivetrain cost (lowest)
$ 2,360	Cost of electric drivetrain

Source: PPHB

To understand the sensitivity of a BEV's cost to that of its lithium-ion battery, given its significant share of total vehicle cost, we considered battery pack costs of $200, $100 and $80 per kWh. We analyzed a 60-kWh battery, which delivers an estimated 238 miles on a single charge, which compares to an ICE vehicle's 400-mile range on a single fill-up.

As battery pack costs fall, first to $100/kWh, and then to $80/kWh, total power system costs fall.

At a $200/kWh cost, the complete power system for the Bolt is $14,360, slightly more than twice the drivetrain cost for an ICE vehicle. Exhibits 17 and 18 (next page) show that as battery pack costs fall, first to $100/kWh, and then to $80/kWh, total power system costs fall. Cost is cut more than in half with the $80/kWh battery pack cost. This is a powerful incentive for auto manufacturers to push research to reduce battery costs. The research involves both improving the efficiency of existing battery packs, but also seeking new battery chemistries that either boost range at the same cost, or reduces cost while maintaining the range of lithium-ion battery chemistry. Car manufacturers can also hope for reduced raw material costs for batteries, however, given the predicted EV demand growth, it is hard to see significant new mines and rare earth mineral extraction processes lowering costs materially.

Exhibit 16. Cost Of Bolt At $200/kWh

BOLT	
60	kWh
$200	$kWh
$12,000	Cost of battery pack
$2,360	Cost of electric drivetrain
$14,360	Total cost battery plus electric drivetrain

Source: PPHB

Exhibit 17. Cost Of Bolt At $100/kWh

BOLT	
60	kWh
$100	$kWh
$6,000	Cost of battery pack
$2,360	Cost of electric drivetrain
$8,360	Total cost battery plus electric drivetrain

Source: PPHB

Exhibit 18. Cost Of Bolt At $80/kWh

BOLT	
60	kWh
$80	$kWh
$4,800	Cost of battery pack
$2,360	Cost of electric drivetrain
$7,160	Total cost battery plus electric drivetrain

Source: PPHB

While battery costs are the hurdle EVs need to get over, lower annual operating costs can help close the price-competitive gap with ICE vehicles, and even help EVs win the lifetime-cost battle. To assess the competitive status, we first need to estimate the lifetime ownership cost for ICE vehicles.

Total ownership costs, including the initial purchase, range from $49,067 at the lowest gasoline price to $56,400 at the highest gasoline price

With the average age of the American vehicle fleet in excess of 11 years, it becomes a reasonable timeframe for assessing ICE vehicle operating costs. Assuming each vehicle drives 10,000 miles per year, the cumulative mileage over its life is 110,00 miles, which, at 30 miles per gallon, gives us an estimate of the amount of gasoline burned over the vehicle's life. We used three different gasoline prices - $4.50, $3.50 and $2.50 per gallon - to determine lifetime vehicle fuel cost. We also must estimate normal maintenance, such as oil changes, new brakes, tune-ups and coolant flushes. The result is that total ownership costs, including the initial purchase, range from $49,067 at the lowest gasoline price to $56,400 at the highest gasoline price.

Exhibit 19. Total Ownership Cost For An ICE Vehicle

Ownership costs for ICE for 11 Years			
Vehicle cost	$36,600	$36,600	$36,600
Gasoline cost per gallon	$4.50	$3.50	$2.50
Mpg	30	30	30
Operating and Maintenance costs			
Gasoline for 110,000 miles	$16,500	$12,833	$9,167
Oil change cost at $80 every 5,000 miles	$1,760	$1,760	$1,760
Cost for full brake job	$700	$700	$700
Cost to replace spark plugs if required	$270	$270	$270
Coolant flush every 40,000 miles	$570	$570	$570
TOTAL 11 YEAR COST	**$56,400**	**$52,733**	**$49,067**

Source: PPHB

Determining the lifetime ownership cost of an EV also involves making assumptions about operating costs, along with the possibility the battery pack will need to be replaced

Determining the lifetime ownership cost of an EV also involves making assumptions about operating costs, along with the possibility the battery pack will need to be replaced. An internet search for EV battery replacements yields numerous articles suggesting that with proper care batteries will last much longer than assumed. It means they will last more than 100,000 miles (close to the estimated figure used in the analysis) and longer than the 8-10-year warrantees offered by EV manufacturers.

In our analysis, just as in Mr. Dears', a battery replacement occurs once during the 11-year life of an EV. While many people say you won't need to replace the battery, by their nature, its performance begins deteriorating from day one of ownership. Over time, batteries slowly lose their ability to hold the initial maximum charge, eventually reducing the vehicle's driving range and increasing the frequency of recharging. When batteries are replaced, they will be expensive, since they are the most expensive component of the vehicle's initial cost. Research shows that GM charges a 31% premium on the battery cost for a replacement. We applied that markup to our estimate of the battery cost based on the number of kWh in the battery and the estimated price-per-kWh.

EVs need routine maintenance, but not as much as an ICE vehicle. One auto website listed EV maintenance items as: tires, brake fluid, coolant, brake service and battery care. The latter maintenance is a function of how owners treat their battery-charging and where they live. Extreme cold and hot weather will impact the performance of EV batteries.

The electric motors that drive the wheels exerts extreme torque on them, causing tires to wear faster than ICE vehicle tires

We were surprised to see tires as a significant maintenance item. That is because EVs are substantially heavier than a comparable ICE vehicle, but also because the electric motors that drive the wheels exerts extreme torque on them, causing tires to wear faster than ICE vehicle tires. (Everyone talks about the acceleration of EVs, but that comes at a cost to the tires.)

The longer brake life may reduce the number of replacements necessary for an EV

Brake fluid needs to be considered, but due to the regenerative nature of EV brakes, they last longer than ICE vehicle brakes. An EV's brakes produce electricity to recharge the battery when they are applied. The longer brake life may reduce the number of replacements necessary for an EV during its 11-year life.

While many people might wonder about coolant, it is important to understand that rather than cooling a conventional engine, the coolant in an EV is cooling the battery, which otherwise is exposed to potential fire damage from the heat lithium-ion batteries generate. Our research shows that the Tesla Model 3 suggests replacing the coolant every 50,000 miles, while the GM Bolt needs it to be replaced after 150,000 miles. In our analysis, we did not include a coolant flush as it would be required beyond the Bolt's operating life.

Exhibit 20. How EV And ICE Vehicles Stack Up

OEM battery cost at $/kWh	$200	$100	$80
Electricity to recharge battery at 28kWh/100 miles for 110,000 miles @ cents per kWh			
$0.106	$3,274	$3,274	$3,274
$0.137	$4,204	$4,204	$4,204
$0.325	$9,995	$9,995	$9,995
Vehicle cost	$36,600	$36,600	$36,600
Cost for a full brake job	$700	$700	$700
Cost of new battery pack: GM list @1.31% of cost	$15,720	$7,860	$6,288
Total cost with High electricity price	**$63,015**	**$55,155**	**$53,583**
Total cost with Average electricity price	**$57,224**	**$49,364**	**$47,792**
Total cost with Lowest electricity price	**$56,294**	**$48,434**	**$46,862**

Source: PPHB

For EVs, the major expense during its ownership will be the cost of the electricity to charge the battery. In our analysis, we used three electricity costs: the average cost for the 10 lowest-cost states; the average cost for electricity for the lower 48 states; and the average electricity cost for Hawaii, the most expensive state for power. We used June 2019 electricity prices as reported by the Energy Information Administration (EIA).

For all battery costs charged at the highest electricity price, ICE vehicles are less expensive than EVs

The analysis showed that for all battery costs charged at the highest electricity price, ICE vehicles are less expensive than EVs. The other situation where ICE vehicles win is for the $200/kWh battery cost charged at the average cost for lower 48 states' electricity. Those cells are shaded in red in Exhibit 20. All other scenarios show EVs winning the lifetime ownership cost battle with ICE vehicles (shaded in green).

It should be noted that we burdened the ICE vehicle with the highest share of vehicle cost for its drivetrain expense. On the other hand, we assigned the lowest drivetrain expense to EVs. If the EV was

We understand that the analysis is highly dependent on the assumptions that go into the spreadsheet

burdened with the highest drivetrain cost, all cost scenarios show ICE vehicles winning. Mr. Dears' analysis reaches similar results, but he equated ICE vehicles and EVs if their total ownership costs were within plus-or-minus 5% of ICE's cost. While we were surprised by how competitive EVs have become, and will become if and when EV battery costs drop, we understand that the analysis is highly dependent on the assumptions that go into the spreadsheet.

The spreadsheet rated the ICE vehicle to be 2.35% cheaper

In our research, we stumbled on a web site, model3guru.com. It has a tag line stating: "This site is built and maintained by Tesla Model 3 enthusiasts and is not affiliated with Tesla in any way." While discussing aspects of owning and maintaining a Model 3, the site offers a competitive analysis spreadsheet for visitors to use in estimating lifetime ownership cost. We put in our details, including driving history, geographical location, electricity cost and gasoline prices. We accepted their cost estimate for insurance expense. We compared the Model 3 against a BMW320i as our conventional car option. The spreadsheet rated the ICE vehicle to be 2.35% cheaper. Assumptions made the difference.

What surprised us when we reviewed the website's spreadsheet was the annual maintenance cost listed for the Model 3. We won't question it because the site is done by Model 3 owners who presumably know what it costs them to operate their vehicle. Had we included those expenses (assuming we know what they are for) our analysis might have changed.

Personally, while an EV might make sense as a second vehicle, our use pattern makes it questionable

Personally, while an EV might make sense as a second vehicle, our use pattern makes it questionable. We are not going to use it for driving back and forth to Rhode Island, as it would require at least 10 recharges, adding hours of time to our trips. As a second car, it would be charged at home. The problem is we couldn't use it to drive to Ft. Worth to visit family, as that would require an intermediate recharging, stop, adding to our travel time. Lastly, it is not good to leave EVs unused for extended time periods, which creates a problem when leaving Houston for 4-5 months in the summer. For others, our analysis may open up EVs for increased consideration when buying your next car.

Gas Leaks Are A Major Problem Haunting A Cleaner World

A new study of a handful of cities in the Northeast shows that fugitive methane emissions from gas leaks are much greater than thought or estimated by the government

The push for cleaner energy is unearthing under-appreciated challenges. A new study of a handful of cities in the Northeast shows that fugitive methane emissions from gas leaks are much greater than thought or previously estimated by the government. Across the pond in the UK, a new study shows high leakage of the most damaging environmental gas, for which there doesn't appear to be a substitute, from key parts of the growing electric grid. This study may prove more significant than the methane leak study because it points out a risk from the "green economy." It demonstrates that every energy system has issues.

The fugitive emissions study is designed to attack the cleanest fossil fuel, which is challenging renewables and the "green economy"

The fugitive emissions study is designed to attack the cleanest fossil fuel, which is challenging renewables and the "green economy." In the study, aircraft observations of emissions have enabled identifying those coming from natural gas, allowing the authors to identify leaks from ageing pipelines in urban areas. The Plain Language Summary of the paper states:

> "Recent efforts to quantify fugitive methane associated with the oil and gas sector, with a particular focus on production, have resulted in significant revisions upward of emission estimates. In comparison, however, there has been limited focus on urban methane emissions. Given the volume of gas distributed and used in cities, urban losses can impact national-level emissions. In this study we use aircraft observations of methane, carbon dioxide, carbon monoxide, and ethane to determine characteristic correlation slopes, enabling quantification of urban methane emissions and attribution to natural gas. We sample nearly 12% of the U.S. population and 4 of the 10 most populous cities, focusing on older, leak-prone urban centers. Emission estimates are more than twice the total in the U.S. EPA inventory for these regions and are predominantly attributed to fugitive natural gas losses. Current estimates for methane emissions from the natural gas supply chain appear to require revision upward, in part possibly by including end-use emissions, to account for these urban losses."

Once natural gas prices fell back into the $3-$5/Mcf range, the future economics of high-cost renewable energy projects were challenged

As the opening sentence states, this study is only one part of the attack on natural gas, which was once embraced as the "bridge fuel" to our new clean energy world. That embrace lasted only as long as natural gas prices were $8 per thousand cubic feet (Mcf) or above. Once natural gas prices fell back into the $3-$5/Mcf range, the future economics of high-cost renewable energy projects were challenged. As the shale gas revolution expanded and national gas prices fell further, the concern about how to slow the consumer uptake of gas became the focus of scientists, academics and politicians, a powerful triumvirate.

We have recently read an academic paper suggesting that the fugitive emissions from natural gas fracking operations are much greater than previously estimated and are a reason to ban the technology. The paper's conclusion was that "shale-gas production in North America over the past decade may have contributed more than half of all of the increased emissions from fossil fuels globally and approximately one-third of the total increased emissions from all sources globally over the past decade."

Another scientist who examined the scientific data collected by the Greenhouse Gases Observing Satellite (GOSAT) came to a different conclusion. He stated that the data does not support the logical conclusion that if shale gas is the root of the increased emissions, then satellite data should show increased emissions near the centers of gas fracking operations. It doesn't.

The new paper appears to have ignored a footnote from an earlier paper

The new paper appears to have ignored a footnote from an earlier paper, which this new study was supposedly updating. The earlier study's conclusion, based on the satellite data, was that 30% to 60% of the global increase in methane emissions between 2002 and 2014 came from the United States. The footnote was an important qualifier to the paper's conclusion. The footnote stated:

> "The U.S. has seen a 20% increase in oil and gas production [US EIA, 2015] and a ninefold increase in shale gas production from 2002 to 2014 (Figure 1, bottom), but the spatial pattern of the methane increase seen by GOSAT [Greenhouse Gases Observing Satellite] does not clearly point to these sources."

The point of the qualifying footnote was that the satellite data did not show increases in methane emissions where shale gas was being extracted

The point of the qualifying footnote was that the satellite data did not show increases in methane emissions where shale gas was being extracted. That would seem to be an important qualifier for using the satellite data to condemn hydraulically-fractured natural gas. In fact, the absence of the linkage would seem to be a warning about drawing conclusions about higher methane emissions and natural gas fracking activity. Unfortunately, such a conclusion is inconsistent with the desired narrative of scientists opposed to increased natural gas consumption.

What the gas-leak paper did highlight was that the emissions' increase in urban areas came from the ageing gas distribution network. The environmental website *ecoRI* followed up by examining the situation in Rhode Island, since Providence was one of the cities included in the study showing under-estimated methane emissions.

There were four ruptures in a section of pipe in downtown Providence installed in 1870

The *ecoRI* article summed up Rhode Island's challenges. For example, there were four ruptures in a section of pipe in downtown Providence installed in 1870. That pipe section will be replaced in the next fiscal year. The article highlighted the extent to which the local gas utility is involved in addressing this problem.

> "National Grid also didn't comment on the recent gas-leak study. But a spokesman said the company is making progress on its goal of eliminating all leaks within the next 15 years. In the past 10 years, the company has spent $440 million replacing 445 miles of leak-prone pipes across Rhode Island, according to the spokesman. Annual leaks have dropped from a high of 3,660 in 2009 to just under 2,000 in 2018, he said."

This effort is not cheap, as the average National Grid gas customer will pay $20.81 this year for the repairs to and replacement of natural gas pipelines. Given the scale of the replacement effort, there is little hope of the pipe having any value, even from an historical point of view.

The devices are protected by a fire-retardant gas, sulphur hexafluoride (SF6)

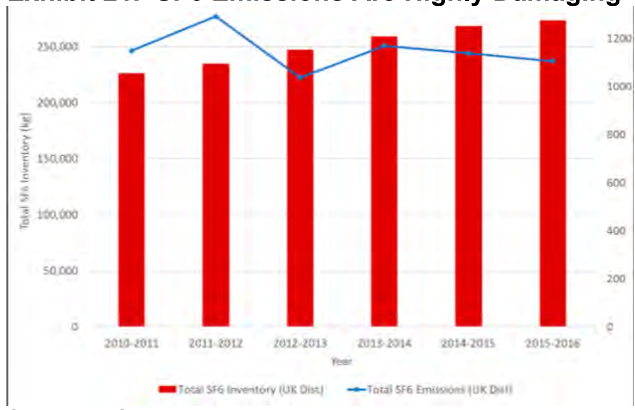
Turning to the problem in the UK, the growth of the electric grid to support its expanding green energy economy involves gas contained in circuit breakers and other electrical system control equipment. The devices are protected by a fire-retardant gas, sulphur hexafluoride (SF6). A summary from the paper highlights the environmental risk of SF6 and the inventory of this gas within the existing power transmission and distribution networks of the UK. The authors wrote:

> "In recent years, it had been concluded that SF6 is an extremely potent global warming gas and can have a significant impact on global warming if released into the environment. Previously, it was determined that SF6 has a global warming potential (GWP) of 22,800 times that of carbon dioxide (CO2) over a 100-year period, as used in EU and UK regulations. However, more recent estimates put the GWP of SF6 at 23,500 times that of CO2. SF6 has an extremely long atmospheric lifetime of 3200 years during which infrared radiation is reflected back towards earth when left in the atmosphere. The use of SF6 has been banned from applications where a suitable alternative can be provided and is classified as a regulated fluorinated greenhouse gas by both the EU and the UK. SF6 is also listed in the United Nation's Kyoto and Paris agreements as a gas deemed to have a high global warming impact and emissions, and, therefore, should be reduced."

There appears to be no alternative, which increases the risk to climate change

The problem is that there appears to be no alternative, which increases the risk to climate change from the increased number of electrical control devices needed as countries add more electrify to their economies. Better seals for the devices are a solution, but that does not eliminate the risk entirely.

Exhibit 21. SF6 Emissions Are Highly Damaging

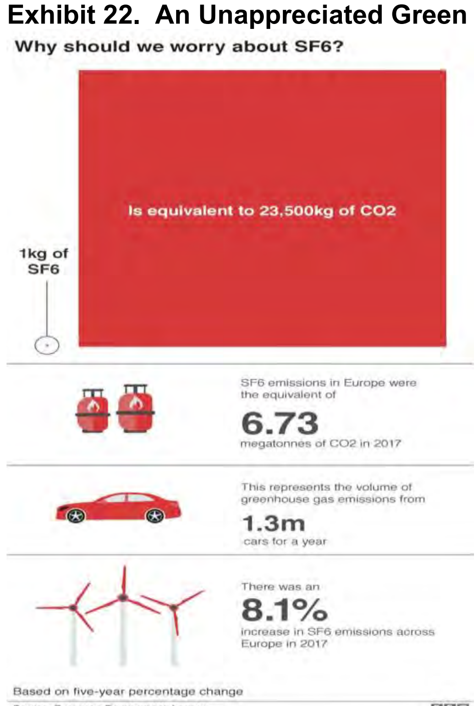


Source: AGU100

Exhibit 21 shows that for the UK, the inventory of SF6 continues to grow, although the amount leaked each year has remained fairly flat. However, as the paper reported, the leakage volume can be significantly impacted by single events. The authors highlighted that in "year 2013–2014, where a rupture disc failure on a newly commissioned circuit breaker led to the release of 113 kg of SF6 in a single event, this contributed to approximately one-third of the SF6 released in that year in that area." The impact of SF6 was summarized in a graphic by *BBC* in a story it published on its website.

In "year 2013–2014, where a rupture disc failure on a newly commissioned circuit breaker led to the release of 113 kg of SF6 in a single event, this contributed to approximately one-third of the SF6 released in that year in that area."

Exhibit 22. An Unappreciated Green Energy Risk



Source: *BBC*

In an effort to reduce methane emissions by eliminating gas pipeline leaks, we have an opportunity to cut greenhouse gas emissions without disrupting the economy

Ageing natural gas infrastructure, combined with invisible risks from carbon emissions that are growing by the push into green energy, are risks that need better understanding. The two papers highlighted here reflect studies in developed economies where green energy is receiving great attention, but they point out the risks. In an effort to reduce methane emissions by eliminating gas pipeline leaks, we have an opportunity to cut greenhouse gas emissions without disrupting the economy. The SF6 issue should represent a new business opportunity, which, frankly, we are surprised has not been addressed yet. These are the opportunities the energy industry should be tacking aggressively, and be helped in those efforts by politicians rather than being criticized and pushed in other directions.

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