PPHB
ENERGY INVESTMENT BANKING

MUSINGS FROM THE OIL PATCH

July 24, 2018

Allen Brooks
Managing Director

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

Natural Gas: The Forgotten Fuel's Future Needs LNG Exports

If your business is tied to natural gas, you can be excused for believing it's pretty boring

One can be forgiven if he/she believes only crude oil news is important to the energy sector. The volatility of crude oil prices, coupled with the OPEC meeting drama and President Donald J. Trump's twitter campaign against high oil prices, provides opportunities for shocking headlines and non-stop commentary by the media. On the other hand, if your business is tied to natural gas, you can be excused for believing it's pretty boring since no one is talking about gas.

Exhibit 1. Natural Gas Prices Are Flat For Last Year

Source: EIA

The natural gas price chart from the Energy Information Administration (EIA) speaks to our observation about the fuel being

boring. Why? As the chart shows, other than during the blast of Arctic cold weather last winter that caused spot natural gas prices to more than double, prices have been essentially flat for the past year. Relative to crude oil prices, we'd call it boring.

Natural gas is often referred to as the Rodney Dangerfield of energy

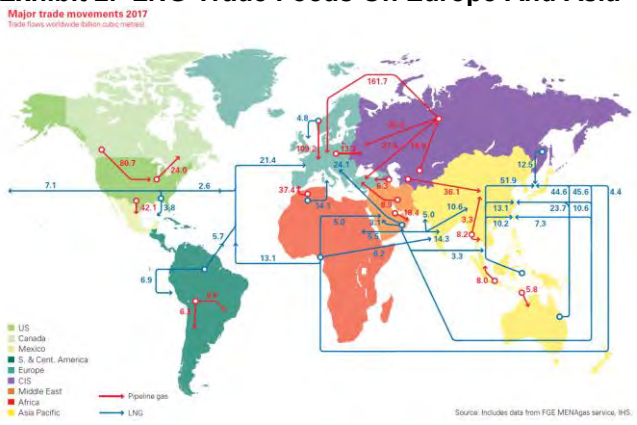
Natural gas is often referred to as the Rodney Dangerfield of energy, identifying the fuel with the American stand-up comedian, actor, producer and screenwriter known for his self-deprecating humor and his catchphrase "I don't get no respect!" He made a career out of skits playing off that phrase, something we are beginning to believe has overtaken the natural gas market. On the other hand, someone might claim that natural gas's profile has been elevated recently, reflecting changes underway in the fuel's global market, which might add some volatility to pricing.

Natural gas took center stage at the recent NATO conference in Belgium, as the construction of the NORD Stream 2 pipeline to haul Russian gas to Germany and Europe became a political flashpoint. Another significant gas development was the announcement of the CME Group Inc. (CME-NYSE) and Cheniere Energy Inc. (LNG-NYSE) having agreed to create a physical delivery futures contract for supplying liquefied natural gas (LNG) that will foster transparency and liquidity for the emerging short-term gas market. Traditionally, LNG projects required 20-year or longer supply/consumption agreements that provided the assurances lenders needed to justify financing the construction of the liquefaction and re-gasification plants and the ships needed to carry the fuel between the sites.

The global gas trade has grown, initially from increased volumes through pipelines and now via LNG

The global gas trade has grown, initially from increased volumes through pipelines, and now via LNG. The global gas market initially focused on Europe and Asia, although in the 1980s the United States was expected to evolve into a major gas importer as domestic supply appeared to peak. The U.S. market deviated from that prediction as decontrolled natural gas prices stimulated a drilling boom with a significant supply increase the outcome. Supply growth

Exhibit 2. LNG Trade Focus On Europe And Asia



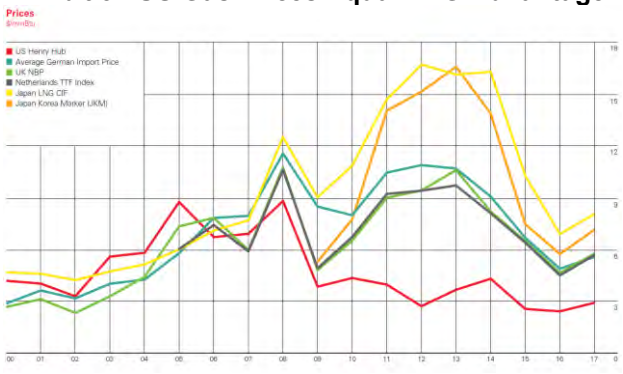
Source: BP

came from the successful use of hydraulic fracturing technology applied to wells drilled horizontally through formations. A number of re-gasification terminals built to handle the planned increase in LNG imports never operated and are being reconfigured into liquefaction facilities to handle the export of surplus domestic gas output.

The United States has now become a meaningful LNG exporter after decades of exporting only small volumes from Alaska to Japan

The United States has now become a meaningful LNG exporter after decades of exporting only small volumes from Alaska to Japan. Companies building export terminals are targeting Europe and Asia, while South America represents an emerging market opportunity. The primary driver of LNG exports is the price disparity between U.S. and international gas prices. That price differential can be seen in the accompanying chart, especially since 2010. Prior to 2010, natural gas prices for all regions were comparable. Post-2010, the differential with U.S. gas prices widened sharply, ranging from $6 to $12 per million British thermal units.

Exhibit 3. US Gas Prices Equal LNG Advantage

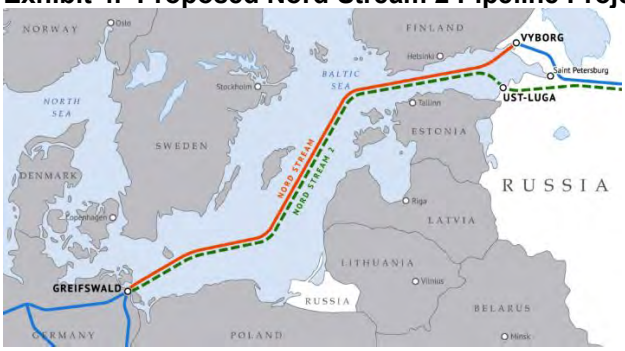


Source: BP

For those involved in the LNG market, the development of a spot market has always been a goal

What the regional price chart shows is why a short-term, or cargo-pricing market has developed. That market allows LNG shipments to be resold, within legal bounds, while they are in transit. In some cases, these ownership changes may reflect cargoes going to different delivery points as well as different customers. This market development allows cargo owners to profit from price movements, especially if they do not need the gas for their own operations. This developing market will be aided by the CME/Cheniere LNG futures contract. In addition, Intercontinental Exchange has begun trading a U.S. LNG futures contract, which will be cash settled against the Platts LNG Gulf Coast Marker (GCM) price assessment and will use Platts-derived U.S. GCM LNG forward curves for daily settlement purposes. For those involved in the LNG market, the development of a spot market has always been a goal. It appears that goal is being reached, and one should expect it to help LNG growth in the future.

Exhibit 4. Proposed Nord Stream 2 Pipeline Project



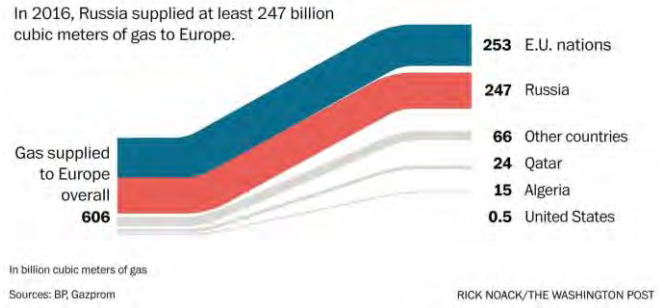
Source: Global Security Review

The recent politicizing of the German-Russia gas supply via the Nord 2 pipeline may disrupt that project's future and open Europe to more LNG imports

A growing LNG market is Europe. The recent politicizing of the German-Russia gas supply via the Nord Stream 2 pipeline may disrupt the project's future and open Europe to more LNG imports, especially from the U.S. The pipeline is Russia's attempt to access European markets while avoiding Ukraine, which already has 13 Russian pipelines crossing it with gas destined for various European countries. Those pipelines carry 142 billion cubic meters per year (bcm/y) of the estimated Russian gas export volume of 257 bcm/y.

While Ukraine earns transit fees from the gas pipelines, they have created significant political tension. Although Russia also delivers some gas to Ukraine, it has used these pipelines as a weapon against the country, and in turn, its European customers.

Exhibit 5. Russian Gas Role In EU Energy



Source: *The Washington Post*

President is pressuring our European allies to forego more Russian gas dependency as a way to hurt Russia that earns 90% of its foreign income from the sale of its oil and gas

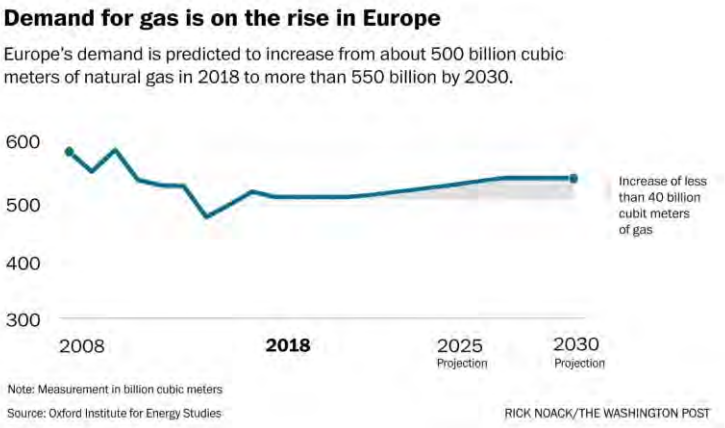
President Trump is pressuring our European allies to forego more Russian gas dependency as a way to hurt Russia that earns 90% of its foreign income from the sale of its oil and gas. President Trump wants to know why the United States is largely funding NATO's budget while its members are sending their money to our adversary. Just as President Ronald Reagan used our military buildup to overwhelm the Russian economy, leading to the breakup of the Soviet Union and the end of the Cold War, President Trump is targeting Russia's energy business as a way to undercut its economy, and its political and military influence globally. The

American oil and gas shale revolutions have enabled the U.S. to re-establish its leading role in the global petroleum industry. This role, backed strongly by Mr. Trump, has the ability to alter the global influence of Russia derived from its natural gas exports to Europe.

Demand could be greater, but the forecaster expects gas supply shortages may delay the pace of decarbonization of the European economy

The Oxford Institute for Energy Studies has forecast Europe's gas demand to grow from about 500 billion cubic meters (bcm) in 2018 to more than 550 bcm in 2030. Demand could be greater, but the forecaster expects gas supply shortages may delay the pace of decarbonization of the European economy. Those shortages may come from the recent decision to restrict output from the Netherlands's Groningen gas field to lessen the risk of earthquakes, and predictions of North Sea petroleum output shrinking. Given these realities, we may be looking at the first battle in a long-term war between Russia and the U.S. to supply more gas to Europe.

Exhibit 6. Europe Gas Demand Growing



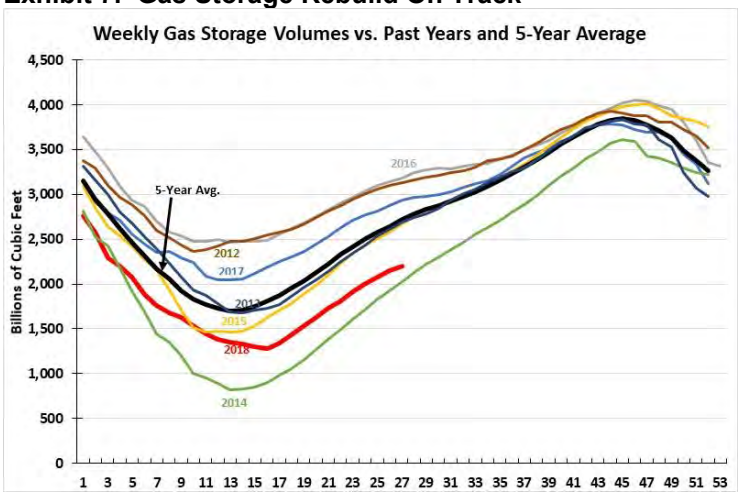
Source: ***The Washington Post***

The key for gas prices is the health of the LNG export market

Will the U.S. have natural gas available to export? Right now, LNG exports are critically supportive of the domestic gas market since gas consumption for generating electricity seems to be plateauing as renewables are making greater inroads into the power sector's fuel mix. As home heating and cooling is subject to weather, and industrial use of natural gas is flat, the key for gas prices is the health of the LNG export market.

We have not revisited the natural gas market outlook since late March. Since then, companies have been rebuilding their gas storage to help meet winter demand, which seems to be progressing normally. To assess how much gas will be injected into storage and its impact on natural gas prices this winter, we have to start by examining the rebuilding of gas storage so far this year.

Exhibit 7. Gas Storage Rebuild On Track



Source: EIA, PPHB

A late cool spring contributed to gas withdrawals continuing until late April

As we started 2018, gas storage was in line with 2014's recent record low volume until warmer weather arrived and weekly gas storage withdrawals fell below those experienced in 2014. However, a late cool spring contributed to gas withdrawals continuing until late April, a much later date than during recent winter drawdowns.

Since the bottom in gas storage, injected volumes have enabled the storage rebuilding to track in parallel with that of 2014, until recently. An interesting analysis is to examine injection season volumes since 2010, which covers the maturing of the shale revolution. As can be seen from the chart showing seasonal gas storage, the industry has started from varying levels of storage and injected substantially different volumes, ultimately achieving a healthy storage level by the start of withdrawal seasons.

The injection rate has ranged between nearly six to over 12 billion cubic feet per day

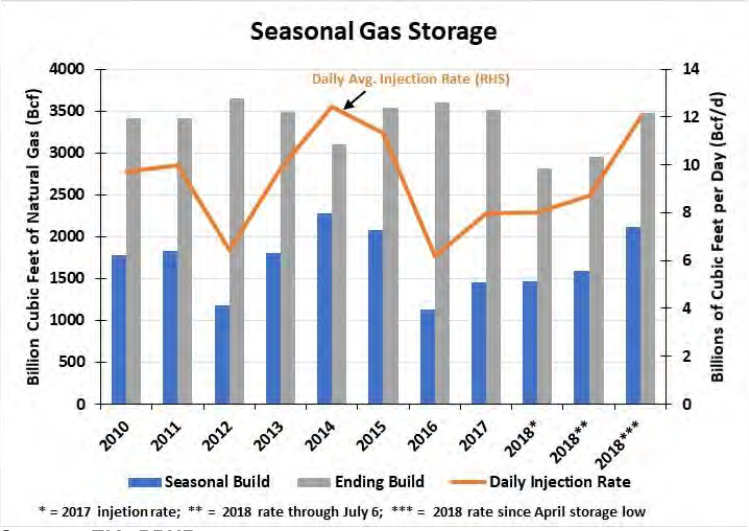
Because industry and market conditions were considerably different each year, what we found interesting was examining the daily average injection volume. As shown in Exhibit 8 (next page), the injection rate has ranged between nearly six to over 12 billion cubic feet per day (Bcf/d). After falling to a low of 6.2 Bcf/d in 2016, which may have been impacted by the storage level when the injection season started. Storage was nearly 2,500 million cubic feet (Mmcf) at the start of the injection season in 2016, about 1,000 Mmcf below 2015's starting point, and nearly 500 Mmcf above 2017's storage level. As a result, daily average injection rates for 2015, 2016 and 2017 were 11.3, 6.2, and 8.0 Bcf/d, respectively.

This injection season commenced with nearly 100 Mmcf less than 2015's low level. Gas withdrawals continued into the injection season for nearly a month. This provided an opportunity for us to model various scenarios for gas injection rates. Each case for 2018 is designated by one, two and three asterisks in the chart. In Case 1, we used the 8.0 Bcf/d injection rate of 2017, which ends the

Could it mean sharply higher gas prices as a result?

season with 2,818 Mmcf, the lowest level since 2010. That would be over 250 Mmcf below 2014's level, the lowest starting point in the past seven years. On average, compared to the rest of the six years, storage would be 400-500 Mmcf below. Does that put American consumers at risk of inadequate storage this winter? Could it mean sharply higher gas prices as a result?

Exhibit 8. Why Gas Prices Reflect Complacency



Source: EIA, PPHB

So far, based on the data through July 6th, according to the EIA, we have had 98 days of injection. Dividing the net change in storage by injection days yields a daily average rate of 8.7 Bcf/d. If that rate continues through the remaining 85 days of the injection season (Case 2), the U.S. will enter winter with slightly more than 100 Mmcf of storage than projected in Case 1.

From the absolute low in storage in late April to now, the injection rate has been 12 Bcf/d

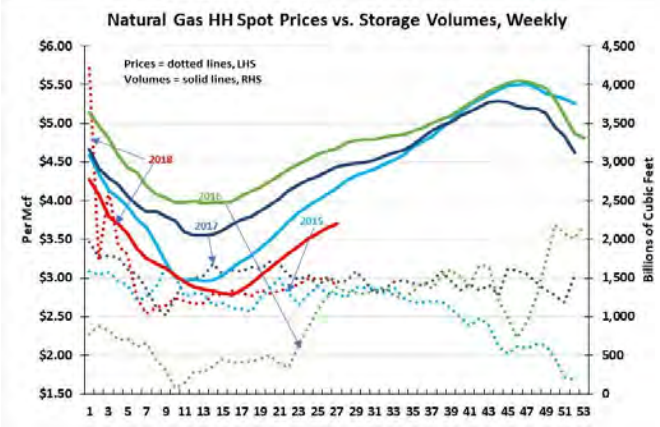
It is instructive to note that from the absolute low in storage in late April to now, the injection rate has been 12 Bcf/d. Applying that rate for the remainder of the injection season (Case 3), we will end this season with 3,472 Bcf of storage. While slightly below the starting storage volumes for the past two years, this amount would be comparable with most years.

From a recent analysis by a Wall Street natural gas analyst based on the behavior of commodity speculators, he deduces they expect 3,488 Bcf of gas in storage by the end of the injection season. This analyst's own model, however, comes to a slightly lower estimate of 3,298 Bcf of storage. We assume the speculators' expectation is based on the same daily injection rate we used in Case 3.

The pace of storage injections and the trend in natural gas spot prices suggest the market is unconcerned about an impending shortage this winter. That comfort comes from the continued growth

in domestic gas output. Exhibit 9 shows how storage volumes are growing, while spot prices are flat, providing an interesting perspective.

Exhibit 9. Storage Rebuilds And Gas Price Trends

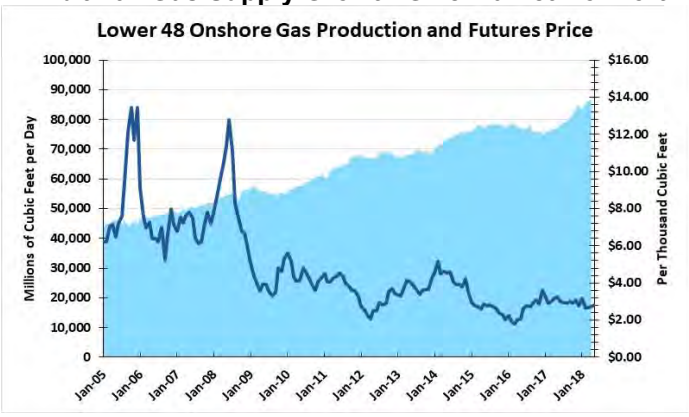


Source: EIA, PPHB

We believe current gas prices reflect abundant confidence that domestic production will enable the industry to meet future gas demand

The dotted red line reflects weekly Henry Hub spot prices. From a high level at the start of 2018 due to the Arctic cold temperatures, prices fell to less than half before climbing back to nearly $3 per thousand cubic feet (Mcf). Currently, gas prices are about 10% below that $3/Mcf threshold, thought to be a critical price point for market sentiment. We believe current gas prices reflect abundant confidence that domestic production will enable the industry to meet future gas demand. Unfortunately, the government's gas production data lags by two months, so we don't have an accurate picture of current output. That said, we have seen onshore production grow steadily since the start of 2017. In fact, onshore gas output between January 2017 and April 2018 has increased by 11,722 Mmcf/d. That is important as during the same time, Gulf of Mexico gas output fell by 877 Mmcf/d.

Exhibit 10. Gas Supply Growth Give Market Comfort



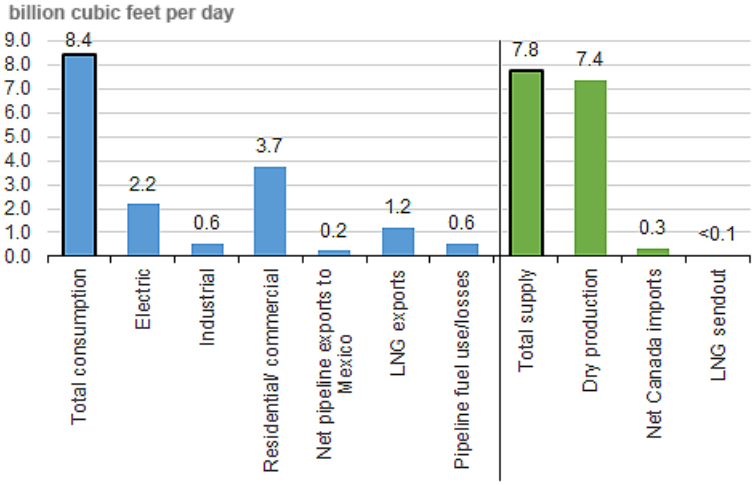
Source: EIA, PPHB

Gas consumption increased by 8.4 Bcf/d, but 44% of that increase was due to higher residential consumption, with 26% from increased electricity generation use

Relying on private data sources and forecasters, EIA presented a chart showing domestic gas market changes between the first halves of 2017 and 2018, through June 26. As seen, gas consumption increased by 8.4 Bcf/d, but 44% of that increase was due to higher residential consumption, with 26% from increased electricity generation use. Both increases were helped by the Arctic temperatures in January 2018. Remember, many people in rural areas of the Midwest and Northeast use electricity for heating.

At the same time, total gas output increased by 7.8 Bcf/d, with 7.4 coming from dry natural gas output. That helps explain why the gas market is complacent about the ability of the industry to meet the storage buildup necessary to be ready for the upcoming winter, along with being positioned to handle increased electricity generation demand and LNG exports.

Exhibit 11. How 2018 Gas Market Is Developing
U.S. natural gas supply and consumption, average change from first half 2017 to first half 2018



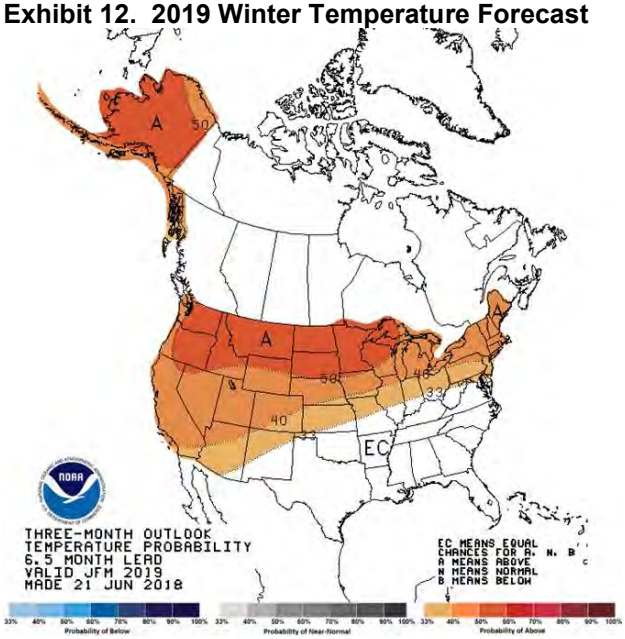
eia Source: OPIS PointLogic Energy, an IHS Company
Note: 2018 data averages are through June 26

Source: EIA

The wildcard for natural gas is what weather we might experience during this winter

The wildcard for natural gas is what weather we might experience during this winter. Few forecasts are available now, so we relied on the long-range forecasts provided by the U.S. National Oceanic and Atmospheric Administration's (NOAA) National Weather Service. It utilizes maps to show how temperatures nationwide may vary from historical norms during three-month spans of time. Maps for each three-month period through the balance of 2018 show only small areas with an equal chance of temperatures matching historical normal winter temperatures.

Exhibit 12. 2019 Winter Temperature Forecast

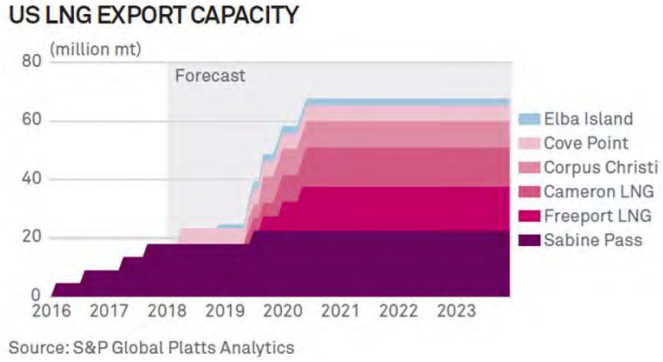


Source: NOAA

The rest of the country is projected to have warmer temperatures, including the Midwest and Northeast regions that influence natural gas demand

Exhibit 12 covers temperature deviations predicted for the first three months of 2019. It shows a major swath of the country with an equal chance for normal winter temperatures. However, the rest of the country is projected to have warmer temperatures, including the Midwest and Northeast regions that influence natural gas demand. Forecasts this far out are notoriously inaccurate. Natural gas prices suggest the market is assuming this forecast is likely, therefore, little reason exists for bidding up gas prices to elicit an increase in gas output to guard against shortages from a colder than normal winter.

Exhibit 13. How US LNG Export Volumes Grow



Source: S&P Platts

For natural gas producers, increased shipments of LNG will be the most important force influencing gas prices during the balance of 2018. With more LNG liquefaction capacity now online, we expect more exports on the horizon. The introduction of the LNG futures

contracts, and the turmoil in Europe about its future gas supply, argue that our low domestic gas prices will further help U.S. gas exports. We will continue monitoring the driving forces in the natural gas market to see if our expectations prove accurate.

Another Decarbonized World View Has Serious Limitations

A week ago, another significant study on how to achieve a decarbonized world, in this case the United Kingdom, was released

A week ago, another significant study on how to achieve a decarbonized world, in this case the United Kingdom, was released, but it contains major problems that are assumed away in what is an attempt to put forward a positive outcome. We are referring to the latest "Future Energy Scenarios" (FES) report presented by National Grid plc (NGG-NYSE), the owner and operator of the electricity and natural gas transmission systems in the United Kingdom and Wales, as well as energy systems in New England.

What is missing from both studies is the cost of the steps, both financially and in lifestyle changes

Feeling pressure from environmentalists over the lack of progress countries are demonstrating toward limiting carbon emissions to hold the planet's average temperature increase to less than 2°C (3.6°F) by 2100, we are getting studies by energy companies on what steps are necessary to achieve this goal. Besides the FES report, we had Royal Dutch Shell's (RDS.A-NYSE) "Sky" report on how to achieve a decarbonized world. What is missing from both studies is the cost of the steps, both financially and in lifestyle changes. There is also a lack of honesty in the studies over the state of carbon removal technology relied upon critically for reducing emissions.

The latest FES, in contrast to prior ones, introduces two new scenarios. As the authors explained, prior scenarios revolved around the axes of prosperity and the level of green ambition. Sensing changes in the energy market, and based on feedback from National Grid stakeholders, it was felt new scenarios were needed.

Exhibit 14. National Grid's Futures Energy Scenarios

Source: National Grid

It was also important to shift the focus to scenarios that considered increased use of decentralized energy

As the cost of renewables have fallen, it was also important to shift the focus to scenarios that considered increased use of decentralized energy. Given the introduction of this shift, it was also thought appropriate to have multiple scenarios for how the UK could meet its 2050 carbon reduction goal.

As the visual of the four energy scenarios shows, they move on axes of "Speed of decarbonization" and "Level of decentralization." The study showed only two scenarios meeting the UK climate change goal of reducing carbon emissions by 80% by 2050. The remaining two scenarios make progress in achieving the UK goal, but fall short.

The key differentiating criteria is whether greater or lesser dependence on centralized energy sources and applications provides the optimal approach

Turning to the two emissions-compliant scenarios, the key differentiating criteria is whether greater or lesser dependence on centralized energy sources and applications provides the optimal approach for achieving the UK climate change target. We have summarized the key points of the two scenarios for reaching the UK goal, which show high degrees of similarity, but with a few key differences.

Exhibit 15. Key Variables Impacting Scenario Outcomes

	Community Renewables	Two Degrees
	(More decentralized)	(Less decentralized)
Power demand:	High use of EVs and heat pumps; Smart technology used to manage peak electricity demand; Appliance efficiency improves	Push to electrify heat and transport; Smart technology used to manage peak electricity; Appliance efficiency improves
Transport:	Extensive use of EVs; Hydrogen to power commercial vehicles; Vehicle sharing a key feature	EVs personal vehicle of choice; Autonomous vehicles; Hydrogen for commercial vehicles; Vehicle sharing and public transportation
Heat:	Homes more thermally efficient; Heat pumps and green gas; More use of district heating	Homes more thermally efficient; Use of gas boilers, hydrogen and heat pumps
Power supply:	Wind and solar with storage dominate; Small scale plants, storage and hydrogen production; CCS needed	Green energy; More large scale storage and interconnectors; Offshore wind , nuclear and CCS
Gas supply:	Gas from North Sea and LNG; CCS; Green gas; Hydrogen from electrolysis	North Sea gas and LNG; Green gas; Steam methane reforming to produce hydrogen

Source: National Grid, PPHB

Given the points in the Community Renewables and Two Degrees scenarios, it was not surprising when we read the comments of Chris Goodall who writes the *Carbon Commentary Newsletter*. Mr. Goodall is described as "a British businessman, author and expert on new energy technologies" by *Wikipedia*. Writing in his newsletter following the release of FES, Mr. Goodall made the following observations about how National Grid's scenarios have changed between 2017 and 2018:

"**National Grid scenario planning.** The UK gas and electricity system operator published its annual scenario update. National Grid is an intelligent watcher of energy trends so it thought it helpful to track the number of times key individual words occurred and compare these figures with 2017. Here are some results, giving the 2017 number first and the 2018 second. 'Vehicle to Grid' 5 to 41, 'Carbon Capture and Use', 0 to 45, 'Decentralized' 0 to 36, 'Hydrogen' 45 to 168 and, most surprisingly of all, 'Community' 4 to 129. Here's how I interpret these changes: National Grid now sees a real possibility of a 100% switch to low carbon energy, powered by small scale community renewables with balancing of energy supply carried out by car batteries (V2G) and by turning surplus power into usable fuels via electrolysis to make hydrogen."

The decarbonized scenarios leave substantial room for failure

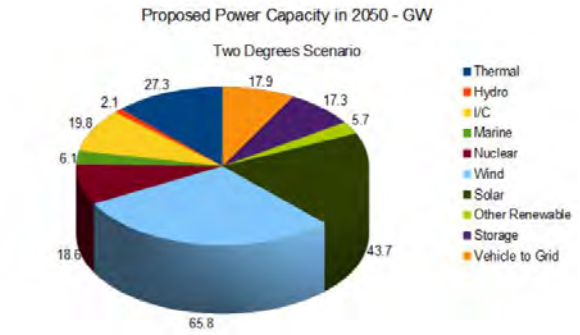
The shift in language to describe the new scenarios is not surprising, as these new technologies reflect the current wave of thinking about how the planet will achieve total decarbonization. The problem is that the decarbonized scenarios leave substantial room for failure due to their dependence on unproven technologies and forcing people to dramatically alter their lifestyles and use of energy. Furthermore, there is no attempt to address the cost of these scenarios.

Fortunately, National Grid provided a list of fixed inputs for its models, such as the price of oil, population size, number of homes, carbon pricing, etc. More important are the 70 working assumptions laid out in a spreadsheet where one can see each item's level of importance within each scenario. The roles of electric vehicles (EV), heat pumps, nuclear power, natural gas, carbon capture and sequestration, as well as interconnectors are extremely important to the success of each scenario, and crucial for those scenarios projected to achieve the UK emissions target.

He focused on the Two Degrees scenario as "probably most realistic (albeit totally unachievable!)"

UK energy blogger Paul Homewood commented on National Grid's FES in a posting shortly after the report was published. He focused on the Two Degrees scenario as "probably most realistic (albeit totally unachievable!)." The chart on the next page shows the significance of wind and solar power sources in the 2050 power capacity composition.

Exhibit 16. 2050 UK Power Capacity Forecast



Source: Paul Homewood

Renewable power grows by 238%, going from 38.2 to 129 GWs by 2050

Potentially more telling is the actual supply capacity change between 2017 and 2050, and the mix between renewables and dispatchable power. The latter is defined as biomass, carbon capture and sequestration (CCS), coal, gas, other thermal, waste and nuclear. In 2017, this power represents 62.9 Gigawatts (GW) versus only 46 GW in 2050, falling from 61% of total energy supply to only 21%. Over the same period, renewable power grows by 238%, going from 38.2 to 129 GWs by 2050.

Exhibit 17. Significant Changes To UK Energy Mix

Fuel Type	2017	Two Degrees
Biomass	3.3	3.7
CCS	0.0	12.1
Coal	12.7	0.0
Gas	34.9	9.5
Hydro	1.8	2.1
Interconnectors	4.0	19.8
Marine	0.0	6.1
Nuclear	9.2	18.6
Onshore wind	11.5	22.3
Offshore wind	6.1	43.4
Other renewables	1.8	5.7
Other thermal	1.5	0.2
Solar	12.4	43.7
Storage	2.9	17.3
Vehicle to Grid	0.0	17.9
Waste	1.3	1.9
Total capacity	103.5	224.3
Amount of capacity that is renewable	*38.2*	*129.0*

Source: Paul Homewood

There is no commentary in the report about how the UK, when its renewable power is in short supply, will be able to import power from Europe who will likely be experiencing a similar power supply shortage

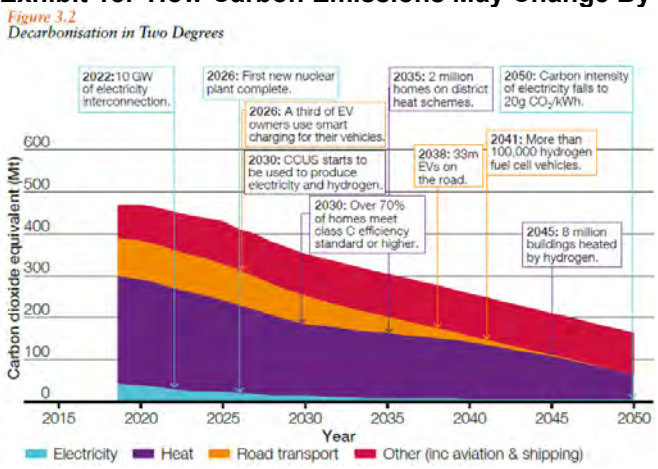
It is important to note that nearly a quarter of the dispatchable power (12.1 GW) in 2050 is to come from CCS, a technology considered questionable in performance, and possibly not scalable, as well as extremely expensive. It is also assumed the UK can import, via interconnectors in 2050, nearly five times (19.8 GW) the power imported now. Presumably this is how surplus renewable power on the continent will be dumped based on the European Union's energy plans. There is no commentary in the report about how the UK, when its renewable power is in short supply, will be able to import power from Europe who will likely be experiencing a similar power supply shortage. The plan further projects a doubling of nuclear power, which will necessitate building six more Hinkley-sized plants. Hinkley is the latest British nuclear plant to be built, which, when

finished in 2025 at an estimated cost of £21 ($27.7) billion, will provide 3,200 Megawatts (MW) of electricity.

It raises the question of how many drivers may allow the grid to take power from their EVs at times of peak demand.

It is also questionable whether there will be 6.1 GW of marine power, which is electricity from tidal movements. A significant project (Swansea Bay) based on this technology was recently killed by the regulators, so one must wonder why that outlook will change. There is also a forecast of 17.3 GW of storage compared to 2.9 GW currently available. This power will be needed to balance power supply and demand between day and night. National Grid doesn't explain how storage will address the inherent intermittency of renewables. Lastly, we see 17.9 GW of power for the grid coming from EVs. While a nice idea, this is unproven technology now, and it raises the question of how many drivers may allow the grid to take power from their EVs at times of peak demand.

Exhibit 18. How Carbon Emissions May Change By 2050



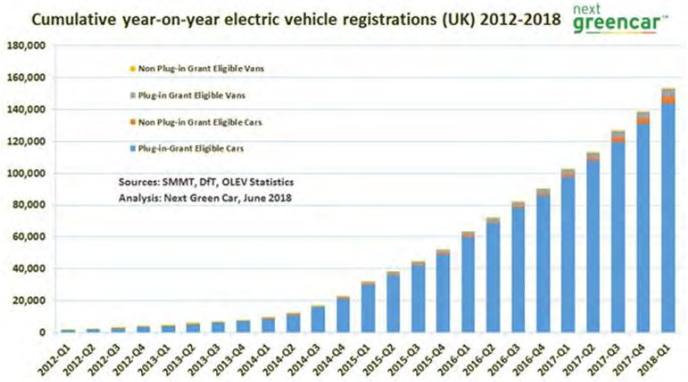
Source: National Grid

Equally important is understanding how many EVs will be on the UK's roads in the future. Through the first half of 2018, EV registrations totaled 29,306, up 31.7% over the same period in 2017. The industry is on its way to posting another record for 2018 EV sales, after having done so in both 2016 and 2017. Registrations so far in 2018 equaled 2.2% of UK new car sales. Cumulatively, as of the end of the first quarter of 2018, there were 155,000 EVs on UK roads.

If National Grid is correct, it foresees upwards of 36 million EVs on UK roads by 2040, double the estimate it made just last year

If National Grid is correct, it foresees upwards of 36 million EVs on UK roads by 2040, double the estimate it made just last year. As shown in the accompanying chart on the next page, National Grid's estimate for the grow of the EV fleet has steadily increased, with the 2018 jump being the most dramatic. Between 2013 and 2015, the company consistently estimated five million EVs on UK roads by 2035. That outlook rose to eight million in its 2016 report, and it added a forecast of 10 million EVs by 2040. In 2017, the forecast

Exhibit 19. How UK EV Registrations Have Grown

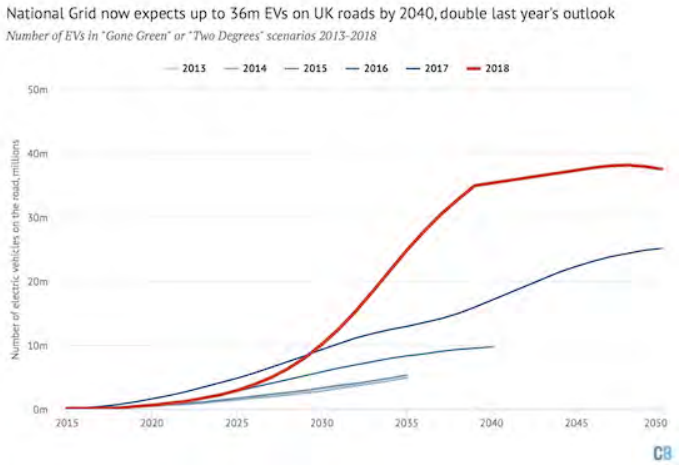


Source: ***Greencar.com***

rose to 13 million in 2035 and 17 million by 2040. Today, we have a forecast for 25 million EVs in 2035 and 36 million by 2040. This represents a tripling compared to its 2016 outlook and a five-fold increase from its 2015 number. National Grid says EVs will become saturated by 2040, meaning that all possible vehicles will be electrified and new EVs will be replacing older ones being retired.

National Grid says EVs will become saturated by 2040

Exhibit 20. How National Grid EV Forecasts Changed



Source: ***Carbon Brief***

The two-thirds increase in the EV forecast from 2017 leads to questions for National Grid about its ability to manage this growth while keeping the grid stable. To address the issue, the company did an extensive review of its EV modeling. That led to a June report stating: "We have been working hard to develop a much more holistic road transport model that takes into account the whole cost of ownership of vehicles. Our new model is much more granular in its detail and consequently it is more robust than previous ones." This year's EV forecast also reflects the UK government's pledge, albeit weak, to ban conventional gasoline and diesel cars by 2040.

This year's EV forecast also reflects the UK government's pledge, albeit weak, to ban conventional gasoline and diesel cars by 2040

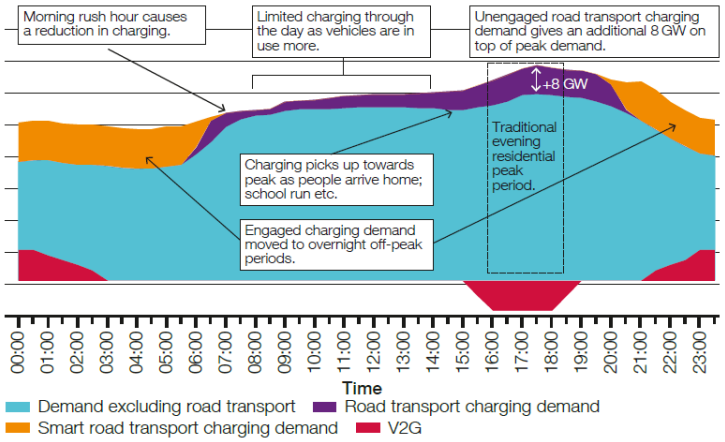
National Grid assumes smarter charging using smart phones and the use of vehicle-to-grid (V2G) reverse power supply will limit the increase in peak electricity demand

To ease fears of power shortages created by the need to charge EVs, National Grid assumes smarter charging using smart-phones and the use of vehicle-to-grid (V2G) reverse power supply will limit the increase in peak electricity demand to between 3-8 GWs in 2030 and 3-13 GWs in 2050. To understand how speculative this scenario is, one only needs to look at the charts in Exhibits 21 and 22 (next page). The former shows the charging demand increment from EVs and the reliance on V2G response to ease the load.

Exhibit 21. More EVs Will Impact Peak Electricity Demand

Figure 4.23

Peak time charging and the effects of engaged consumers and V2G in 2040



Source: National Grid

If V2G assumptions prove wrong, the grid could be challenged within 15 years, or less

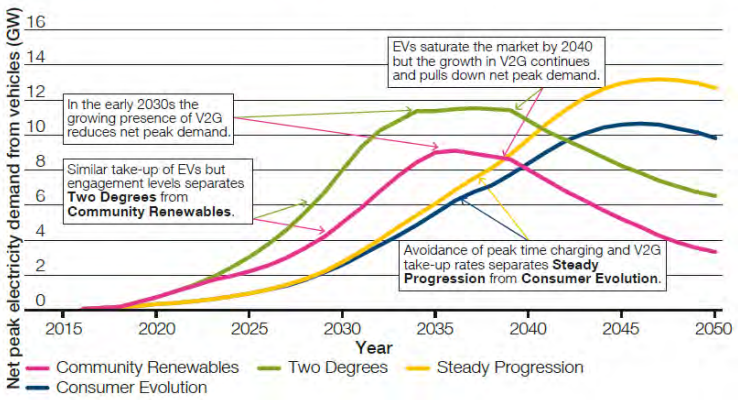
The next chart shows the progression in the peak charging date in the forecast period for each of the four National Grid scenarios. Note that Two Degrees actually has the earliest peak in electricity charging, potentially in the early 2030s. That peak is passed by the Steady Progression scenario, but not for another decade. If V2G assumptions prove wrong, the grid could be challenged within 15 years, or less. The timing will depend on the accuracy of the EV penetration estimate and its timing, as well as the development of new supply sources, in particular for dispatchable electricity, something National Grid doesn't foresee being of importance.

At the present time, heat pumps represent 1% of the UK heating market

Another issue with speculative assumptions is the significant use of heat pumps for reducing carbon emissions. Heat pumps are popular in many European countries, but not in the UK. An article this past spring by *Green Match* of the UK provided an interesting assessment of the market. At the present time, heat pumps represent 1% of the UK heating market. That small market share is due to the high upfront cost of heat pumps, the fact that the high cost of electricity in the UK overwhelms the running cost advantage of heat pumps compared to natural gas, the power supply in the UK is primarily one-phase, which makes it unsuitable for connecting heat pumps because they are considered large loads, and finally the

Exhibit 22. How Peak Demand Is Impacted By EVs

Figure 4.22
Net peak electricity demand from vehicles



Source: National Grid

older housing stock in the UK having a very low thermal inertia. Moreover, homes in the UK are smaller than other European homes and since heat pumps need to be located in living space, due to the lack of basements, this becomes an obstacle to their use.

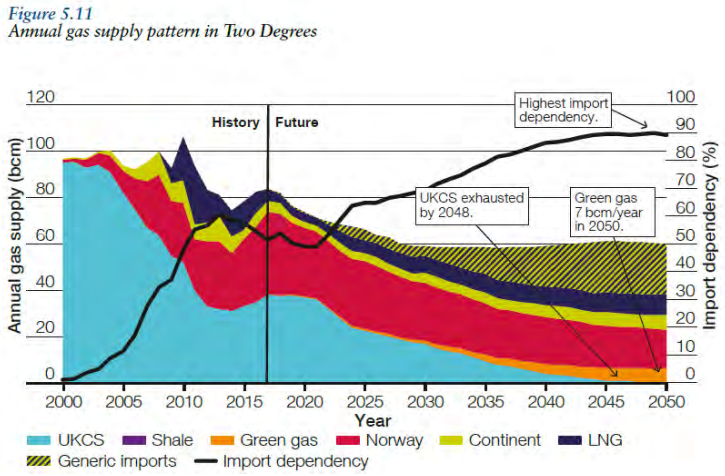
Optimism about heat pumps gaining a larger share of the heating market rests on actions of government and utilities

Optimism about heat pumps gaining a larger share of the heating market rests on actions of government and utilities. The UK government is providing financial incentives to install heat pumps. Improvements in heat pumps will reduce their running costs, likely making them more competitive with gas boilers despite continuing to have a higher upfront cost. Changing building regulations, as new residential buildings move to embrace "Zero Carbon Homes," coupled with the growing support of utilities in providing heat pump installation services, will help drive the market. Even with government and utility support, it is difficult to see how heat pumps are going to claim the market share projected by National Grid.

A residential gas tax

This may help explain one assumption in the report, which deals with a residential gas tax. The level of that tax is designed to incentivize residential consumers to use other heating options. In the Two Degrees scenario, that tax level is assumed to be high.

Exhibit 23. Natural Gas Imports Become Very Important



Source: National Grid

LNG and other "generic imports" will be needed, which seems to be a catchall for "we have no idea where the gas will come from"

When we examine the outlook for natural gas under the Two Degrees scenario, recognizing that UK shale gas incentives are low, but green gas ones are high, we see the emergence of the latter as a supply source beginning about 2025 and then growing, albeit remaining a very small supply contributor. Thus, dependence on Norwegian gas remains strong as UK gas supplies are exhausted. LNG and other "generic imports" will be needed, which seems to be a catchall for "we have no idea where the gas will come from."

Both scenarios rest on the success of unproven technologies, as well as a huge leap of faith about consumer attitudes toward altered lifestyles

As suggested earlier, the Two Degrees scenario, much like Shell's Sky scenario, shows how to achieve a decarbonized future. But, both scenarios rest on the success of unproven technologies, as well as a huge leap of faith about consumer attitudes toward altered lifestyles. Government mandates also play a prominent role in the success of these scenarios.

What makes these studies suspect is the lack of any attempt to address the impact of their cost on consumers. The cost estimates would need to be broad, and would certainly be speculative, but without any indication to the public as to what they may be facing to implement these technologies and plans is a disservice in helping to win public support.

How Important Are Subsidies For Electric Vehicles?

People love low prices

People love low prices. They are often the result of government subsidies, despite the horror heaped on the concept by economists. A recent demonstration of how much people love low prices was the recent riots in Haiti following Prime Minister Jack Guy Lafontant's move to increase fuel prices, a component of an agreement between his government and the International Monetary Fund reached last February. That agreement included raising fuel prices and

aggressively boosting tax collections, while increasing social service and infrastructure spending in one of the poorest Caribbean nations. The agreement was structured to help the government balance the country's budget in return for financial assistance from the IMF

Prime Minister Lafontant raised, by between 38% and 51%, the prices of gasoline, diesel and kerosene. The move set off days of rioting and violence, resulting in several deaths. The U.S. Embassy in Port-au-Prince advised American tourists in Haiti to shelter in place. The U.S. government sent additional troops to Haiti to help protect a hotel where many Americans were seeking safety, as flights were cancelled, and the airport lacked food and security for people trying to leave the country. Prime Minister Lafontant rescinded the price hikes to little avail and was forced to resign before the legislature moved on a vote of no confidence that would have ended his government.

The message learned from this experience with subsidies is that once instituted, they seldom end

Fuel subsidies worldwide count for a substantial amount of government fossil fuel subsidies, which is cited whenever critics target government support for renewable fuels. The message learned from this experience with subsidies is that once instituted, they seldom end. This is especially true when the product or service subsidized is believed to be critical for peoples' everyday lives. Whenever subsidies for renewable fuels such as wind and solar installations were ended, investment in new projects dropped sharply. Virtually every time the renewables tax credits were stopped, Congress revived them, although often with different terms and conditions. The result was new projects were commenced. The same response held for electric vehicle (EV) purchase subsidies, and it hasn't mattered whether they were in the United States or elsewhere.

If focusing only on BEVs, the sales ratio drops to 0.74%

According to the Electric Drive Transportation Association (EDTA), sales of all plug-in electric vehicles (PEV), meaning plug-in hybrid (PHEV) and battery electric vehicles (BEV), in the first half of 2018 increased by 37% over the same 2017 period. In its July report, EDTA noted that 871,394 plug-in vehicles have been sold since 2010. The growth rate and total number of PEVs sold suggests a healthy EV market. Donn Dears of *Power For USA* provided an interesting analysis of the EDTA data. He points out that total EV sales as a percentage of all light-duty vehicle sales in the first half of 2018 was 3.31%. EDTA highlighted that figure on its web site accompanying its July data release. However, Mr. Dears also showed that when traditional non-plug-in hybrid electric vehicles (HEV) are excluded from the PEV total, the sale ratio falls more than in half, to 1.40%. Then, if focusing only on BEVs, the sales ratio drops to 0.74%.

Exhibit 24. EV Sale Success Helped By Ones Counted

US Sales of Electric Vehicles, Including HEVs 2018

Month	Hybrid (HEVs)	PHEVs	Battery (BEVs)	Totals	Total PHEV & BEV
January	22,017	5,800	6,085	33,902	11,885
February	24,900	8,152	8,347	41,399	16,499
March	28,520	10,882	14,880	54,282	25,762
Total 1Q 2018	75,437	24,834	29,312	129,583	54,146
Total 1Q 2017	82,939	19,293	21,410	123,642	40,703
% change YOY	-9%	29%	37%	5%	33%
April	25,019	9,467	9,589	44,075	19,056
May	31,918	11,236	12,741	55,895	23,977
June	31,123	10,280	11,932	53,335	22,212
Total 2Q 2018	88,060	30,983	34,262	153,305	65,245
Total 2Q 2017	94,827	23,786	22,818	141,431	46,604
% change 2Q YOY	-7%	30%	50%	8%	40%
Total YTD 2018	163,497	55,817	63,574	282,888	119,391
Total YTD 2017	177,766	43,079	44,228	265,073	87,307
% Change YTD YOY	-8%	30%	44%	7%	37%
Total sales all light vehicles 2018 YTD				8,558,117	
% BEV YTD to total				0.74%	
% BEV & PHEV YTD to total				1.40%	
% HEV, BEV & PHEV to total 2018 YTD				3.31%	

Source: Electric Drive Transportation Association, Donn Dears

There is little question that EVs are receiving significant media and investor attention today. That attention may be driven by the news surrounding Tesla, Inc. (TSLA-Nasdaq). A few weeks ago, all the focus was on whether Tesla would meet its publicly announced target of producing 5,000 Model 3 EVs in a week before the end of June. The target was met by adding an additional production line housed in a tent, as well as eliminating the "roll and brake" test, traditionally performed at the end of the car assembly process. Tesla responded to media and Wall Street analysts' concerns about the safety of the cars after eliminating the test by pointing out that every car is driven and tested before being delivered to a customer. The point raised by analysts was that the test's elimination afforded the assembly line more time to put more cars together, helping it reach its 5,000-vehicle weekly goal.

A new challenge Tesla is facing is the elimination of the federal tax credit as the company has now sold 200,000 EVs, which triggers the phase out of the subsidy

A new challenge Tesla is facing is the elimination of the federal tax credit as the company has now sold 200,000 EVs, which triggers the phase out of the subsidy. We were unaware of the mechanism for how this federal tax subsidy is phased out, and what appears to be a game Tesla played to delay the phase-out's impact on future sales. Tesla explained how the federal tax credit for eligible vehicles is phased out in the risk section of its most recent 10-K financial report. It wrote:

> "[U]nder current regulations, a $7,500 federal tax credit available in the U.S. for the purchase of qualified electric vehicles with at least 17 kWh of battery capacity, such as our vehicles, will begin to phase out over time with respect to any vehicles delivered in the second calendar quarter

> following the quarter in which we deliver our 200,000th qualifying vehicle in the U.S. We currently expect such 200,000th qualifying delivery to occur at some point during 2018."

That means the phase out will be extended further into the future, which likely will help Tesla sell more vehicles

Tesla was scheduled to cross the 200,000-vehicle sale threshold in June, but the company decided to ship more cars to Canada to push the domestic shipment event into the third quarter. That means the phase out will be extended further into the future, which likely will help Tesla sell more vehicles. It will not be until the second quarter of 2020 before Tesla buyers will not receive any tax subsidy. Will this impact Tesla's sales? It may; and here's how it might impact.

At the present time, Tesla is not building and selling its $35,000 basic, mass-market Model 3, but only more expensive models with greater battery capacity, all-wheel drive, and/or other premium features. As a result, the estimated average sales price of Model 3s being sold is $44,000, which, after the $7,500 federal tax credit, nets to a customer's cost of $36,500. Thus, a Model 3 buyer today gets a superior car for little more than someone who buys a basic Model 3 in the future. Will price-sensitive buyers seek low-priced EVs from other car manufactures?

The latest location to end EV subsidies is the province of Ontario, Canada following the election of Conservative leader Doug Ford

In Europe, tax subsidies have played an important role in promoting EVs. Not only do they receive financial subsidies, but in most countries, they are relieved from paying roadway tolls and urban parking fees, as well as gaining preferential treatment such as access to high occupancy vehicle traffic lanes. Recently, some leading EV countries have cut back on subsidies. The latest location to end EV subsidies is the province of Ontario, Canada, following the election of Conservative leader Doug Ford. He had campaigned on reducing government spending to help resident's pocketbooks. That included ending much of the Liberal government's green energy programs. With EV, hydrogen vehicle and EV charging subsidies leading the list of green energy subsidies, and all funded from a carbon tax in the province, they were at risk of cancellation.

In a statement, the Ontario Ministry of Transport wrote:

> "Ontario cancelled the cap and trade program as part of its commitment to bring gas prices down by 10 cents a liter and help reduce costs for Ontario families and businesses by $1.9 billion dollars per year.
>
> "Given the Electric and Hydrogen Vehicle Incentive Program and the Electric Vehicle Charging Incentive Programs are funded through cap-and-trade proceeds, these programs are cancelled."

While one environmental web site had previously examined the impact on Tesla from Ontario's March 2018 decision to eliminate

The conclusion was that low-priced EVs were hurt by the price increase from the subsidy elimination, but not Tesla's sales

subsidies for EVs costing more than $75,000, it did not contemplate all EV subsidies being eliminated. The Tesla analysis utilized the British Columbia experience when it eliminated its $5,000 per EV subsidy in February 2014 but reinstated it in April 2015. The conclusion was that low-priced EVs were hurt by the price increase from the subsidy elimination, but not Tesla's sales. This signals that buyers of expensive EVs are price in-sensitive, in contrast to low-price EV shoppers.

Prior to the subsidy elimination, one can see how rewarding they were for EV buyers in Ontario. That has been responsible for the rapid growth of EV sales, not only there but in Canada, too.

Exhibit 25. Why Ontario EV Sales Were Records

Plug-in electric vehicle incentives in Canada

Incentives for new light-duty vehicles listed. As of March 24, 2018.

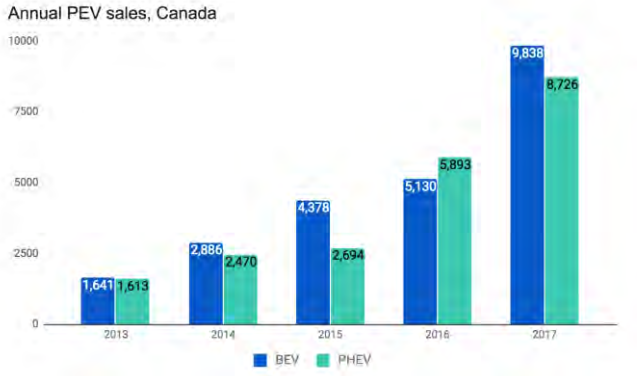
	B.C.	Ontario	Quebec	Rest of Canada
Purchase incentive	$2500 -or- $5000	$5000 - $14,000	$4000 -or- $8000	-
Restrictions (MSRP)	no incentive (>$77,000)	no incentive (>$75,000)	BEVs: $3000 ($75,000-125,000)	-
	-	-	BEVs: none (>$125,000)	-
	-	-	PHEVs: none (>$75,000)	-
Major changes	no incentives Feb 2014-Apr 2015	no price limit up to Mar 2016		
		up to $3,000 (>$75,000) Mar 2016 - Feb 2017		
		up to $14,000 ($75,000-$150,000) Feb 2017 - Mar 2018		
ZEV mandate?	-	-	Y	-
Plug-in electric vehicle market share in 2017	1.36%	0.86%	1.57%	0.15%

© Matthew Klippenstein for GreenCarReports.com

Source: ***GreenCarReports.com***

Sales of PEVs in Canada have grown steadily since 2013. The mix between BEVs and PHEVs shifted year by year, but the overall trend was steadily upward.

Exhibit 26. How Canada's EV Sales Have Grown



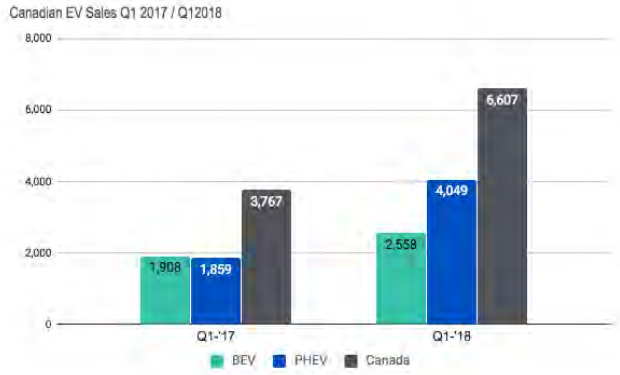
Source: ***FleetCarma.com***

The cancellation of the Ontario tax subsidy will take two months to unwind

The upward EV sales trend continued in the first quarter of 2018, and we expect in the second quarter, too. The cancellation of the Ontario tax subsidy will take two months to unwind, so residents can continue to purchase EVs likely yielding a spike in sales when

results are reported. However, Ontario will disappear as the EV sales leader in Canada, limiting the country's EV fleet growth.

Exhibit 27. Canada First Quarter EV Sales Were Strong



Source: ***FleetCarma.com***

If more tax subsidies disappear, we may find the auto manufacturers gearing up to sell EVs fighting over smaller markets, or actively lobbying governments for mandates and new subsidies

Whether it's Georgia, Denmark, or British Columbia, the record shows that when subsidies for EVs are eliminated, or severely reduced, EV sales suffer. While the cars have many positive performance attributes, their greater upfront cost and the challenges of charging and planning trips with greater restrictions makes them less desirable for many buyers. If more tax subsidies disappear, we may find the auto manufacturers gearing up to sell EVs fighting over smaller markets, or actively lobbying governments for mandates and new subsidies. Georgia, which eliminated its EV tax subsidy and introduced a registration fee that costs more than a conventional car driving 15,000 miles a year, saw new subsidy bills, as well as ones to cut the EV fee, introduced to the legislature earlier this year. According to the web site of the Office of Energy Efficiency & Renewable Energy of the Department of Energy, Georgia has yet to put an EV subsidy back in place. All of these developments raise questions about the pace of EV penetration into the global fleet.

Renewables Growing, But Momentum May Be Slowing

Two events suggest that while renewables continue to grow, the momentum may be slowing for various reasons. Earlier this month, the International Energy Agency (IEA) released its 2018 World Energy Investment report. Two conclusions highlighted from the report are:

> "For the third consecutive year, global energy investment declined, to USD 1.8 trillion (United States dollars) in 2017 – a fall of 2% in real terms.
>
> "There was a pause in the shift of investments towards cleaner sources of energy supply."

The editors went on to point out how high the use of fossil fuels during the winter cold snap was: more than 30% of New England's power generation fuel supply came from oil

About the same time the report was issued, the *Boston Globe* wrote an editorial on July 11th titled "Massachusetts needs to do better on clean energy." It began by citing the prior day's energy supply data for New England's power system: 19% from oil and 7% from coal. The editors went on to point out how high the use of fossil fuels during the winter cold snap was: more than 30% of New England's power generation fuel supply came from oil. This from a region that prides itself on being a national leader in clean energy deployment. In fact, the editorial stated "[c]oal and oil shouldn't play any role generating New England's electricity…"

In addressing the question of what went wrong in "liberal-minded Massachusetts" the editors cited two culprits. First was the effort of some environmentalist activists to block natural gas infrastructure, mainly pipelines. They acknowledged that the activists were fighting the cleanest fossil fuel, and actually forcing utilities to resort to much dirtier fossil fuels to supply power during the cold weather.

They said that the state is at risk of missing its 2020 emissions reduction target because of the search for energy projects that "ticked every conceivable box"

The second culprit cited is the "foot-dragging on the development of new renewable energy sources…" This criticism comes as regulators and utilities have been working through 46 bids to provide long-term clean energy to Massachusetts. While these bids are being assessed on the basis of cost, speed of development, job creation, and emissions mitigation, the decision-making process has been flawed. The *Boston Globe* said project selection "has been beset by a perfect-is-the-enemy-of-the-good mentality that's at odds with the urgency of climate change." They said that the state is at risk of missing its 2020 emissions reduction target because of the search for energy projects that "ticked every conceivable box."

The first project approved was bringing clean hydropower from Canada to Massachusetts via transmission lines through New Hampshire, which that state's utility commission rejected. New Hampshire tourism outweighed Massachusetts' climate change agenda. How un-neighborly!

On May 31, 2019, the Pilgrim nuclear power plant shuts down taking 680 megawatts of carbon-free electricity with it

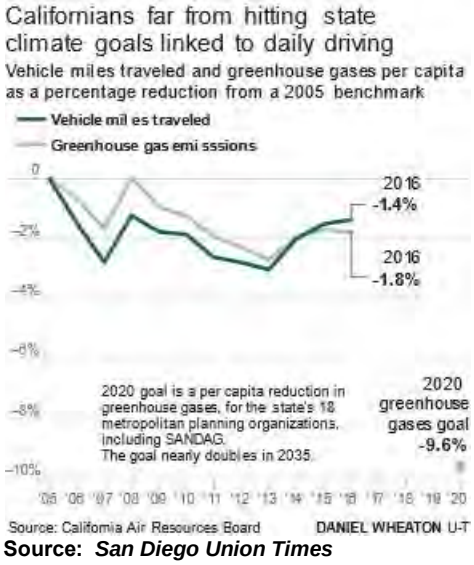
The challenge for Massachusetts and New England is that on May 31, 2019, the Pilgrim nuclear power plant shuts down taking 680 megawatts of carbon-free electricity with it, enough to power more than 600,000 homes. Unfortunately, many of the clean energy projects currently being assessed will not be operating when the shutdown happens, potentially forcing an emergency request to keep Pilgrim operating, or burning even more dirty fossil fuels.

In California, electric vehicles (EV) are being attacked by the push from the state's Air Resources Board, which is tightening it standards for greenhouse-gas emissions from regional transportation sectors. The method for addressing this problem is to restrict vehicle miles traveled (VMT) by residents.

They are fighting for investments that will hurt those people using personal vehicles, and even EV owners, who were not accorded special treatment

The board is planning to release scorecards this fall grading more than a dozen municipal planning organizations on efforts to get people out of their cars and onto public transportation, bikes and sidewalks. Transportation officials argue that the growth of EVs will help reduce emissions even with more VMT. The shock was that environmental groups speaking at a joint public hearing of the Air Resources Board and the California Transportation Commission supported boosting spending for costly transit projects, dissing plans for housing developments far from urban centers, and even discouraging people from driving in toll lanes that charge more during rush-hour traffic. In other words, they are fighting for investments that will hurt those people using personal vehicles, and even EV owners, who were not accorded special treatment.

Exhibit 28. EVs Target Of Air Emissions



Source: ***San Diego Union Times***

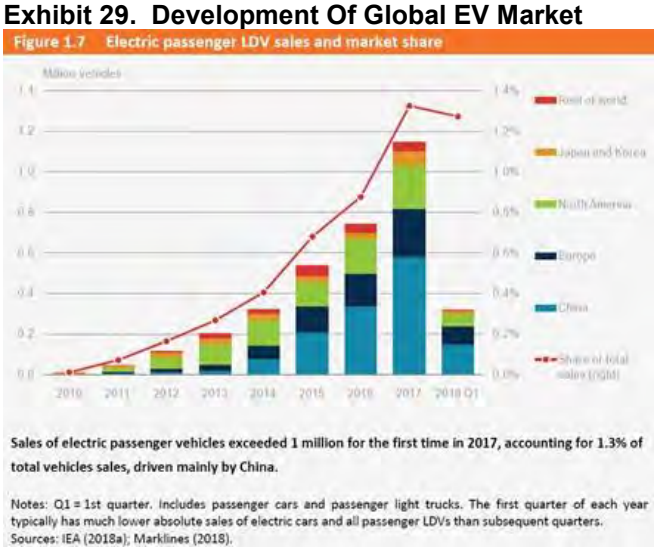
For California to meet its emissions goals – reduce them to 1990 levels by 2020 and 40% below 1990 levels by 2030 – it will need to reduce emissions from the transportation sector, which currently accounts for roughly 40% of the state's carbon footprint, compared to about 16% for electricity. Is California's car culture at risk of being crimped?

According to the agency, the permanent oil demand impact from EV sales is small – a reduction of 30,000 barrels per day compared to the 1.6 million barrels a day increase in global oil demand in 2017

The IEA energy investment report highlights the challenges facing EVs. The 1.1 million EVs sold in 2017 represented 1.3% of all light-duty vehicle sales worldwide. According to the agency, the permanent oil demand impact from EV sales is small – a reduction of 30,000 barrels per day compared to the 1.6 million barrels a day increase in global oil demand in 2017. EVs sold in 2017 represented a total purchase cost of $43 billion. Most of these purchases benefited from some form of government incentive, either local or national. Total government incentives amounted to $10 billion, or 24% of total spending on EVs. The IEA reports that

globally, public budgets for EV incentives have risen by 55% per year over the last four years, signaling how sensitive EV sales have been to subsidies. As Exhibit 29 shows, China has been critical for the development of the global EV industry, and the government has proven generous in support.

Exhibit 29. Development Of Global EV Market



Source: IEA

To meet the IEA's Sustainable Development Scenario, average annual EV sales need to be 33% to 2030

To meet the IEA's Sustainable Development Scenario, average annual EV sales need to be 33% to 2030. If we assume that goal is achieved, with governments funding nearly a quarter of EV spending, one wonders whether the public will tolerate, or can even afford to finance, this magnitude of public spending? Achieving a 33% sales share will need more subsidies, reflecting a potential catch-22 dilemma for the EV business. Given a recent study on the growth of mega cities in the world, one wonders whether more public transit spending is a better way to clean the environment than subsidizing EVs?

Contact PPHB:
1900 St. James Place, Suite 125
Houston, Texas 77056
Main Tel: (713) 621-8100
Main Fax: (713) 621-8166
www.pphb.com

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