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## MUSINGS FROM THE OIL PATCH

June 20, 2017

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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

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### Rig Count Gains – From 22 Weeks Straight To Infinitely?

**These increases have continued for 22 weeks, the longest consecutive streak of weekly rig count gains since 1987**

Last Friday, Baker Hughes (BHI-NYSE) reported its weekly U.S. drilling rig count data showing a six-rig increase from the prior week, as well as a six-rig increase in the number of drilling rigs seeking crude oil. These increases have continued for 22 weeks, the longest consecutive streak of weekly rig count gains since 1987. WTI ended last week at \$44.74 a barrel, up 28 cents on the day, but down for the fourth consecutive week. Over that span, WTI has fallen by 11%, from \$50.33 a barrel. At the same time, the overall rig count increased by 2.8%, but the oil rig count rose 3.5%.

**oil inventories in the 35 countries that make up the OECD increased by 18.6 million barrels in April**

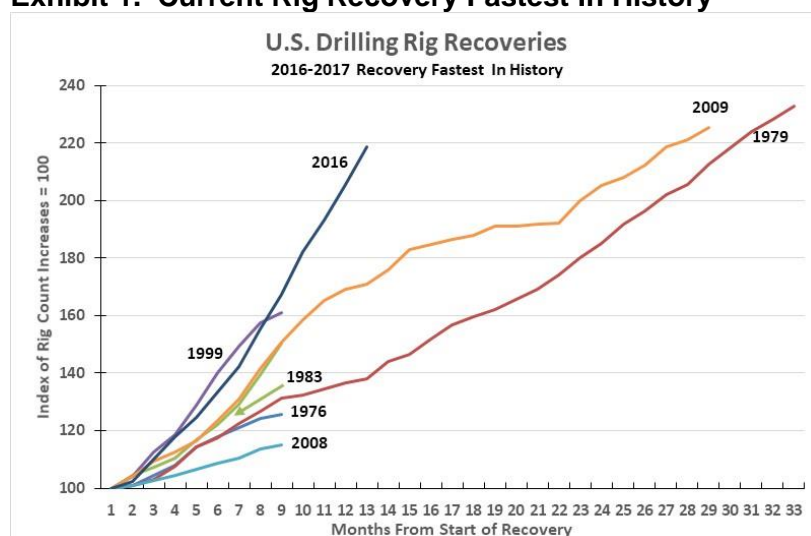
One would have thought that the pessimism for oil prices overtaking the crude oil market following OPEC and its non-OPEC supporters' agreement to extend their production cuts for another nine months, would have caused explorers to pull back their drilling activity. Libya and Nigeria, both OPEC countries excluded from the production cut quota, have increased their output that, along with non-OPEC producers, has minimized the decline in global oil inventories, from the OPEC production cut. In fact, oil inventories in the 35 countries that make up the Organization for Economic Cooperation and Development (OECD) increased by 18.6 million barrels in April. OPEC points out that OECD oil inventories have fallen during the first four months of 2017, but only by 88 million barrels. At that pace, it will take OPEC and its partners until March 2018 to reduce global oil stocks by another 250 million barrels, or back to the average inventory level of the last five years, the organization's goal.

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**The IEA is projecting that U.S. oil output will grow by almost 5% on average this year, and by nearly 8% in 2018**

At the same time, U.S. oil output continues growing in response to the increase in the number of working drilling rigs. As a result, the International Energy Agency (IEA) is projecting that U.S. oil output will grow by almost 5% on average this year, and by nearly 8% in 2018, overwhelming projected demand growth and re-establishing the glut environment. This forecast is creating concern about the success of OPEC's strategy of cutting its output. The pessimistic view of crude oil prices rests on the belief that the slow pace in reducing oil inventories will create an environment where cheating on production cuts occurs, making it impossible for demand growth alone to drive oil prices higher. The optimists, including OPEC, believe that its strategy is working, it will merely need more time – hence the nine-month extension rather than a six-month one.

### Exhibit 1. Current Rig Recovery Fastest In History



Source: Baker Hughes, PPHB

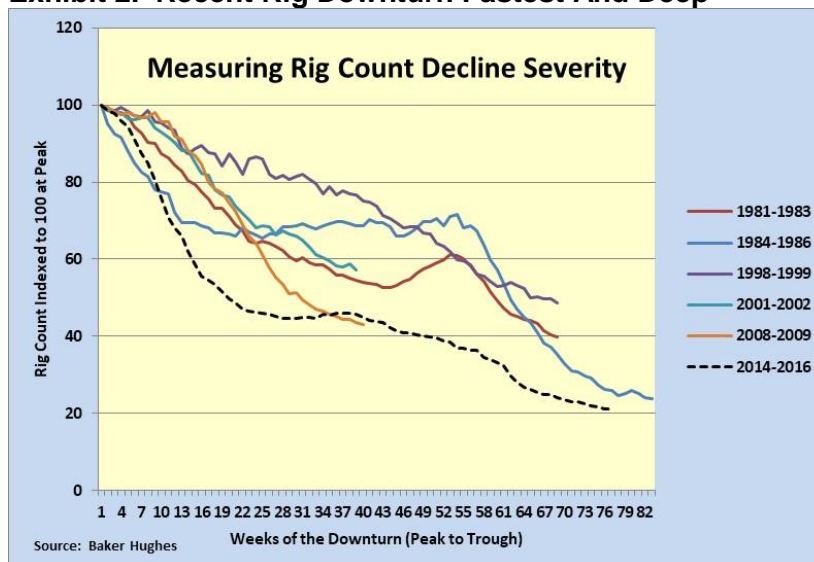
**Although the recovery has been the fastest, it has yet to reach the levels of the recoveries of 1979 and 2009**

What we know is that the lift in oil prices sparked a drilling rig recovery in 2016, which has continued into 2017, and has become the fastest industry recovery in history. Although the recovery has been the fastest, it has yet to reach the levels of the recoveries of 1979 and 2009. The current weakening of crude oil prices is likely to cut short this rig recovery below the levels reached in those earlier recoveries, unless something else is at work in the oil patch.

Many people are interested in seeing how the current industry downturn and recovery compares to previous ones. To begin to answer this question, we dug into our archives for several

charts of rig declines to go along with the chart in Exhibit 1 that shows the performance of various drilling recoveries.

**Exhibit 2. Recent Rig Downturn Fastest And Deep**



Source: Baker Hughes, PPHB

**In the 1981-1983 rig decline the industry lost more working rigs than were operating at the start of the 2014-2016 decline**

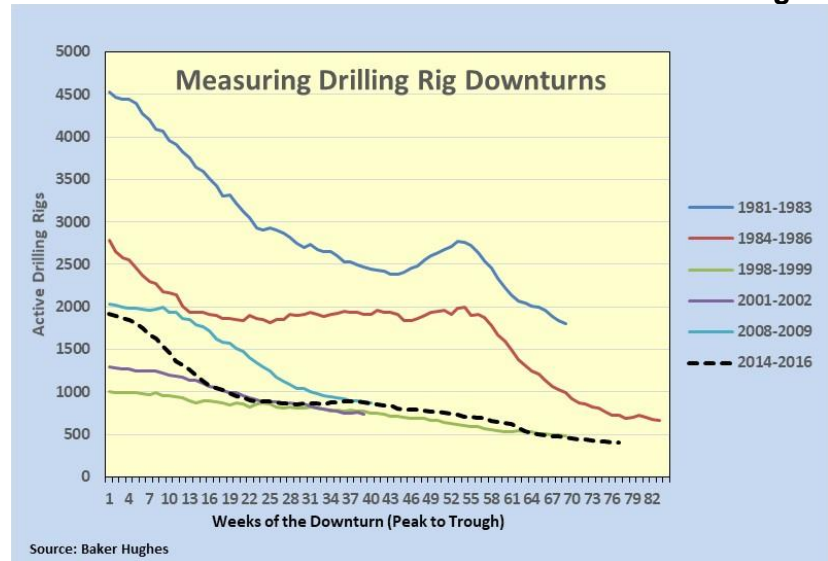
The indexed 2014-2016 rig decline was the sharpest drop ever and was nearly as long as the decline of 1984-1986. What is possibly more interesting, however, is to examine the magnitude of the various rig declines. As shown in Exhibit 3, in the 1981-1983 rig decline the industry lost more working rigs than were operating at the start of the 2014-2016 decline. The same was true for the 1984-1986 decline. This reflects the impact of drilling rig capability and efficiency due to the introduction of new drilling technology, and now, new well completion technology.

**One wonders if the current rig recovery will continue with crude oil prices residing in the mid-\$40s a barrel**

One wonders if the current rig recovery will continue with crude oil prices residing in the mid-\$40s a barrel due to the improved breakeven prices of shale wells? If that is the case, then OPEC/non-OPEC's efforts to cut production, reduce the oil supply glut and boost oil prices into the \$60s a barrel range will help U.S. shale producers more than OPEC expects. It would certainly suggest that rather than an impending flattening or decline in drilling activity, the rig count could continue to go higher as profitability increases with higher oil prices, helping to make more shale areas economic. If Saudi Arabia works to lift oil prices into the \$60s to help support its initial public offering of Saudi Aramco in early 2018, we could

see the U.S. rig count rise almost continuously, further transforming the U.S. oil industry into a global market force.

**Exhibit 3. Past Downturns Have Lost Thousands Of Rigs**



Source: Baker Hughes, PPHB

**A stronger drilling rig recovery may reflect a significant change underway in America’s oil industry**

A stronger drilling rig recovery may reflect a significant change underway in America’s oil industry. It certainly supports the IEA’s view of solid oil production growth during the next 18 months, and maybe for even longer. We may be witnessing the rebirth of America’s oil industry dominance on the world stage, but don’t fully appreciate the event.

**Tibet Trip Is Eye-opener For Economy, Energy And Religion**

**The country’s religion is Buddhist, which was brought there from India by an early king at the start of the 11th Century**

We have just returned from nine days touring the nation of Tibet, which is considered an autonomous region of China. The attraction for the trip was to learn more about the country, its people, its religion, its topography and its future under Chinese rule. As many readers may know, the country’s religion is Buddhist, which was brought there from India by an early king at the start of the 11<sup>th</sup> Century. Prior to Buddhism arriving, the country worshiped traditional symbols, such as the sky, land and water. The king became interested in Buddhism and sent scholars to India to learn about it and return to Tibet with the necessary religious texts and symbols.

Tibet is a relatively isolated country high on a plateau leading into the Himalayas Mountains. Of course, it is one of the

**The uneven stairs and rock stepping stone walks at all the monasteries and the royal palace had us walking with our head down much of the time to avoid a misstep**

attractions of Tibet – going to the border with Nepal and seeing Mt. Everest and its four sister mountains, all soaring over 8,000 meters (26,240 feet) high.

The trip's challenge is the possibility of altitude sickness, although medicine can help offset its effects. However, even with the medicine, one can suffer lightheadedness and headaches from the lack of oxygen in the extremely thin atmosphere. Fortunately, it did not impact us, and we moved around pretty quickly, although not as fast as our local guide. The uneven stairs and rock stepping stone walks at all the monasteries and the royal palace had us walking with our head down much of the time to avoid a misstep, which actually helped in dealing with the lack of oxygen since we couldn't walk too fast if we wanted to be safe.

#### **Exhibit 4. Potala Palace – Leader's Home Since 1600s**



Source: Allen Brooks

**One issue with that explanation was that most of these villagers were subsistence farmers or sheep herders**

In our roughly 800-kilometer (500-mile) drive from the capital of Tibet, Lhasa, the largest city in the country, to the Base Camp at Mt. Everest, we passed through many small villages, as well as the second largest city, Shigatse. We observed extensive new housing and commercial building construction in a number of locations. When we queried our guide, we learned the construction was being undertaken to provide local residents with more modern and better housing and social facilities, such as schools, government offices and commercial stores. Additionally, most of the new construction would enable the locals to live closer to the main highway, rather than in their current villages and towns that were at a distance from the road. This would reduce the time needed to get from their homes to the road. One issue with that explanation was that most of these villagers were subsistence farmers or sheep herders. They essentially produced all their



food, but purchased everything else. The government plan is to move these people from their single-story family homes into multi-story apartment units.

#### Exhibit 5. Mt. Everest From Yak Tent Camp 4 km Away



Source: Allen Brooks

**The local government is composed of local Tibetan people and a Chinese official at the top with the “power of the stamp.”**

**At the same time, the Chinese identified another Lama who they assigned the succession selection role**

After further investigation, we learned it was the local government, rather than either the national or regional governments, undertaking the construction. We understand the local government is composed of local Tibetan people and a Chinese official at the top with the “power of the stamp.” This suggests the construction is being done to help grow Tibet’s economy and is likely financed with government debt – the classic problem confronting China’s economy. We remember learning about China’s new cities with modern high-rise apartment units, but no residents. We saw some eerie like similarities on the outskirts of Lhasa.

This new construction, especially given its control by Chinese officials, is part of the plan to further subdue the role of local Tibetan leaders. It may also be tied to China’s efforts to eventually control the country’s Buddhist religion. The current head of Tibet’s government and religion, the Dali Lama, lives in exile in India, where he went first in the 1950s when the Chinese military moved into Tibet and established operations. Several years ago, the most important official below the Dali Lama died, the person responsible for finding the successor to the spiritual leader following his death. The Dali Lama established a group of five high-ranking religious leaders to seek this leaders’ replacement. At the same time, the Chinese identified another Lama who they assigned the succession selection role. That Lama now lives in Beijing. So

**The current Dali Lama is considering changing the succession process in order to identify his successor soon, giving the country continuity after his death**

Tibet's religion has two factions in place that will battle over succession to the Dali Lama, who is 86.

One of the key tenets of the Buddhist religion is reincarnation. Thus, the process for identifying the next Dali Lama requires finding a baby born at the exact time of the death of the Dali Lama. It takes several years for candidates to mature to where the religious leaders can determine, through a series of tests, whether a particular baby is to become the next Dali Lama. Obviously, the baby needs to be educated and trained, a process that requires years, leaving the government and religious leadership in the hands of trusted senior leaders. Given the current factions, and especially one supported by the Chinese, the current Dali Lama is considering changing the succession process in order to identify his successor soon, giving the country continuity after his death, rather than a void that would provide an opening for further Chinese takeover of the country.

**The Dali Lama's autobiography describes the Chinese liberation as a "takeover"**

While we were traveling in the country, we read about an official delegation from Tibet that had gone to Japan to establish closer relations. According to an article in the *China Daily*, a statement was made by the Chinese officials with the Tibetan group about the economic progress that had been made in the last 50 years since Tibet was "liberated" by China. The Dali Lama's autobiography describes the Chinese liberation as a "takeover."

**These imported Chinese workers enjoy their employment and are deciding to stay as they can develop a career**

Many of the subjects taught in Tibetan schools are done in Mandarin, while only a few specialty classes are taught in the Tibetan language. As a result, many locals prefer to home-school their children. We also learned that the new construction required the importation of Chinese laborers due to a shortage of local labor. These imported Chinese workers enjoy their employment and are deciding to stay as they can develop a career. At the same time, many Tibetans desire to migrate to India to rejoin the Dali Lama and the religious leaders who escaped there during the Chinese takeover.

**The wide spread use of traffic cameras to clock the speed of vehicles**

Other observations from our trip include the wide spread use of traffic cameras to clock the speed of vehicles. There are measured intervals where driving the speed limit will cover the distance in a specified time. If a vehicle gets there too soon (drives too fast) it is subject to a fine. This can be devastating for commercial tour operators, so routine rest stops are made to allow time to pass so the tour bus/van doesn't incur a fine.

**We understand that the penalty for illegal border crossings into Tibet is jail time**

Seeing cars stopped on the highway immediately in front of traffic cameras is common, as they await for the final few seconds of time to pass before driving on.

For those concerned about enforcement of America's borders, they only need to experience the monitoring of people's movements within Tibet to see how the rest of the world views border security. As you drive toward the Nepal border, each time you pass from one region into another, there is a Chinese military checkpoint where all people in the vehicle must show identification, and for tourists, their alien papers authorizing their presence in Tibet. We understand that the penalty for illegal border crossings into Tibet is jail time.

**We did see rare earth mining operations on the drive**

Tibet is an interesting country with a long and colorful history. It is a country in transition as China exercises greater control. Its economy is subsistence agriculture with some industry. We did see rare earth mining operations on the drive. Tourism is an important industry. Solar power is growing, with new utility-size facilities along with some to power industrial plants. But, Tibet is a poor country dependent on farming.

**China's control over Tibet will increase, especially following the death of the 14th Dali Lama**

China's control over Tibet will increase, especially following the death of the 14<sup>th</sup> Dali Lama. Rather than an official handover of the country as occurred in Hong Kong, this takeover will be much less obvious. Whether peoples' lives will be better or not in the future remains to be seen, but the country will lose some of its charm.

## **Norway Wrestles With The Cost Of Electric Vehicle Subsidies**

**One of the issues at play in the election campaign is the cost to the country of its generous EV subsidy program**

Norway is approaching its next election on September 11, 2017, when the 169 members of the legislative body, the Storting, will be chosen for new four-year terms. One of the issues at play in the election campaign is the cost to the country of its generous electric vehicle (EV) subsidy program, which has been a central tenet of the government's efforts to shift its transportation sector from fossil fuels to electricity.

**The national goal is to shift its car sales to 100% electric by 2025**

At the present time, Norway is the world leader in electric cars. About 35% of new cars sold in the country come with a plug. The national goal is to shift its car sales to 100% electric by 2025. Citizens are beginning to question the cost of this effort. After watching what happened in Denmark, the previous leader in promoting clean vehicles, the EV industry is worried about its demise if subsidies are reduced or



**EV sales in the first quarter of 2017 dropped by 60% versus unit sales in the same period of 2016**

eliminated. Until the end of 2015, electric cars were exempt from Denmark's high taxes on new cars, which could reach as much as 180% of the sales price. Beginning on January 1, 2016, new EVs were assessed a 20% tax on their sales price. Not surprisingly, in December 2015, EV sales soared. The first month of 2016 brought a different EV sales' landscape as only 68 vehicles were sold compared to the 1,588 sold the prior month when the zero tax rate existed. Through the first seven months of 2016, 1,332 EVs were sold in Denmark, down 80% from the number sold the prior year. Adding to the competitive automobile landscape was a reduction in taxes on conventional cars, making them less expensive when compared to EVs. On January 1, 2017, the sales tax rate for EVs doubled to 40%, and is scheduled to expire entirely by 2020. As a result, EV sales in the first quarter of 2017 dropped by 60% versus unit sales in the same period of 2016.

**After the incentive was eliminated effective July 1, 2015, car dealers couldn't give EVs away**

What happened in Denmark was similar to the experience in Georgia, where the state's legislature voted to end its nation-high EV incentive program of \$5,000 per vehicle, and to add a tax to EVs to account for road wear and tear. After the incentive was eliminated effective July 1, 2015, car dealers couldn't give EVs away. Sales of Nissan Leaf EVs plunged from more than 1,000 a month to just 66 in August 2015. So what might happen in Norway if the EV subsidies are changed?

**"What we have proven in Norway is that if you give enough subsidies and impose enough restrictions on fossil fuel vehicles, people will buy electric"**

The extensive nature of the EV subsidies in Norway is surprising, but they are acknowledged to have been the driver behind EV growth in the country. The cost of these subsidies is becoming contentious as cited by quotes from politicians in Norway as reported by the *Financial Times*. The paper prepared an extensive article on the subsidy issue versus the dream of shifting Norway's car fleet away from fossil fuels. As Andreas Halse, the environmental spokesman in Oslo for the opposition Labour Party, said, "What we have proven in Norway is that if you give enough subsidies and impose enough restrictions on fossil fuel vehicles, people will buy electric." He went on to say, "If we want to continue to be an example for the rest of the world, we need to show how this can be commercial. We need to get there because we can't rely on public finances forever."

The article interviewed a government employee who drives the 200 kilometers between Oslo and Lillehammer two to three times a week. He drives a Tesla Model S, but he pays

**72% of EV buyers are choosing them for economic reasons and just 26% for environmental reasons**

no tolls on the highway, saving Nkr810 (\$96) every week. He also can charge his car at one of the 20 Tesla superchargers along the way for free. In addition, he gets free parking and his car's purchase was tax free, essentially cutting its purchase price in half.

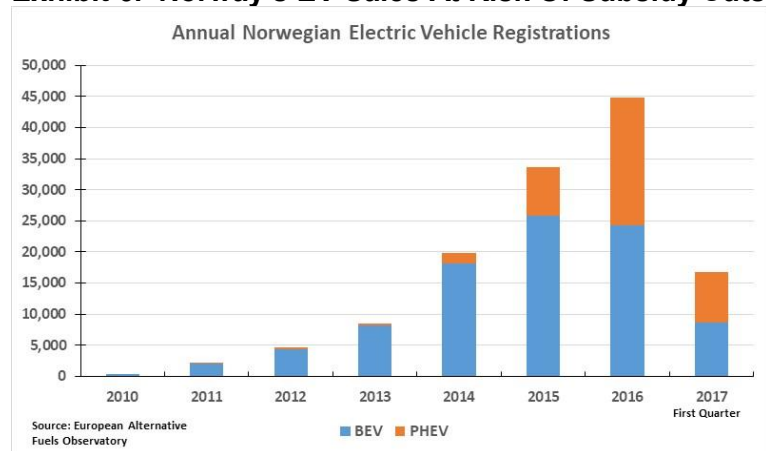
According to a recent study conducted by the Norwegian Electric Vehicle Association (NEVA), 72% of EV buyers are choosing them for economic reasons and just 26% for environmental reasons. Another NEVA survey of 12,000 EV owners showed that it was not just the big subsidies that influenced their purchase decisions, but also because they didn't have to pay highway tolls. The island of Finnøy, near Stavanger, has the highest concentration of EVs in the country because of the Nkr150 (\$17.75) one-way toll charge in the tunnel connecting it to the mainland. If you are commuting to work through the tunnel, this means a weekly savings of Nkr1500 (\$177.50).

The impact of the free tolls is significant. According to Mr. Halse, Oslo loses about Nkr300 million to Nkr350 million (\$35.5-41.4 million) a year from the free tolls for EVs. Additionally, about Nkr800 million (\$94.7 million) of toll revenues goes to subsidizing public transportation per year. He questions whether it makes sense for the local government to spend half as much on EVs that represent 5% of daily commuting trips into Oslo as it does for public transport that accounts for almost 50% of commuter trips.

**A total of 91,688 new battery EVs and 38,920 new plug-in hybrid EVs were registered, representing about 5.2% of the currently estimated total number of passenger cars in the country**

Relying on new electric car registration data from the European Alternative Fuels Observatory (EAFO) for 2010 through the first quarter of 2017, we have made an estimate of what these subsidies are costing the Norwegian government. Over the time period studied, which encompasses the period of the government's EV subsidy largesse, a total of 91,688 new battery EVs and 38,920 new plug-in hybrid EVs were registered, representing about 5.2% of the currently estimated total number of passenger cars in the country.

A 2013 study by Reuters estimated that the purchase price (VAT) subsidy for an EV was equal to about \$11,000 per vehicle, which they estimated was equivalent to about \$1,400 per year per car. The study also cited about \$1,400 per year per car in savings from the absence of toll expenses, a \$5,000 per year benefit from free parking and about \$400 per year in other savings. Based on these estimates, EV owners are

**Exhibit 6. Norway's EV Sales At Risk Of Subsidy Cuts**

Source: EFAO, PPHB

benefitting by about \$8,200 per year in savings from government subsidies. A Norwegian Green Car group challenged the assumptions in the *Reuters* study suggesting they grossly overstated the cost of the subsidies. That was not a surprising position, given the group's focus. The group puts the annual EV subsidy at only \$3,336 per vehicle.

**Over the period of 2010 through the first quarter of 2017, the high end of the cumulative subsidy cost is estimated at \$1.07 billion, with a low estimate of \$435.7 million**

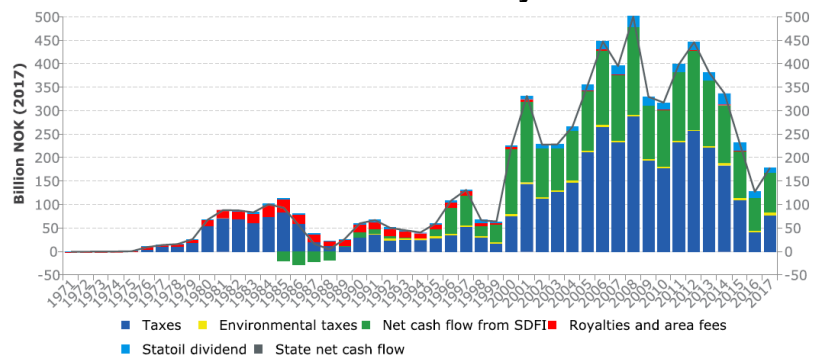
Using the EAFO new electric car registration data, we have been able to estimate within a range, what the cost to the Norwegian economy has been from the EV subsidies. If we assume that the *Reuters* annual cost estimate is too high, it is equally as likely that the Green Car group's estimate is too low. But using each of their annual cost estimates, we arrive at a range within which the likely subsidy cost lies. Over the period of 2010 through the first quarter of 2017, the high end of the cumulative subsidy cost is estimated at \$1.07 billion, with a low estimate of \$435.7 million.

In local currency, the cumulative subsidy cost estimate range is from the high end of Nkr9.05 billion to the low end of Nkr3.68 billion. Averaged over seven and a quarter years, the annual subsidy cost range is Nkr1.25 billion to Nkr508 million. That is a small amount, even if at the high end of the range, compared to an estimated Nkr175 billion in government revenue.

**The scale and fairness of the EV subsidy scheme will be an issue in the upcoming Norwegian election**

It is clear that the scale and fairness of the EV subsidy scheme will be an issue in the upcoming Norwegian election campaign. Norway is fortunate that it gets 98% of its electricity from hydroelectric power. That is both a good thing, but also

**Exhibit 7. Low Oil Prices Hurt Norway’s Revenues**



Source: Ministry of Finance, Statistics Norway

**“We can’t close a coal plant unlike many countries. So, transport is pretty much the answer”**

a problem for the government in reducing the country’s carbon dioxide emissions. In 2016, Norway emitted 53.4 million tons of greenhouse gases, up from 51.7 million tons in 1990. The country’s prime minister has stated that emissions will reach the 1990 level by 2020, but that is well above the target established eight years ago when Norway said it would reduce greenhouse gas emissions 30% below the 1990 level. As Christina Bu, secretary-general of Norway’s Electric Vehicle Association put it, “We can’t close a coal plant unlike many countries. So, transport is pretty much the answer.”

**“per trip a lot more is spent on electric cars than on public transport and I don’t think anybody intended that to be the case”**

That sentiment explains why EVs and their subsidies are being targeted in the upcoming election campaign. From Mr. Halse’s opposition viewpoint, (he does own a Leaf) “It’s a reality check – per trip a lot more is spent on electric cars than on public transport and I don’t think anybody intended that to be the case. We need to find a way for it to pay for itself, not just for us but because it’s important for the development of electric cars all over the world. You can’t expect Germany, France or Italy to hand out subsidies on this basis.”

**“Crossing the gap from early movers to early mass market is hardest”**

The counter to Mr. Halse’s view is that of Ms. Bu who suggested, “I have been worried about pulling the plug too early on incentives. We need to have higher sales before we think about removing them [subsidies].” On the other hand, Ms. Bu pointed out that “Crossing the gap from early movers to early mass market is hardest. It’s too early to remove the incentives.”

It appears from all the EV data we have examined worldwide that no country has crossed that gap from early movers/EV advocates to mass market appeal. Is it all about battery costs, range anxiety and subsidies? It seems that until there are

**Norwegians may find out whether subsidies can be reduced or eliminated without killing EV sales**

significant breakthroughs in the first two issues, subsidies cannot be abandoned. Norwegians may find out whether subsidies can be reduced or eliminated without killing EV sales, but the country continues to face an emissions reduction challenge necessitating more EVs. Norway will be pressed by the environmentalists desirous of seeing that the Paris Accord has a bite to its enforcement, but the finances of Norwegians may trump that effort.

## Issue of Driver Acceptance of Electric Cars Remains Unclear

It has been taken as a given that the world's transportation system will transition from fossil fuels to electricity. That assumption underlies all the forecasts of the imminent demise of the crude oil industry, and can be considered a hidden tenet of New York State Attorney General Eric Schneiderman's case against ExxonMobil (XOM-NYSE) for deception of shareholders over the value of the company's energy reserves because it had covered up the potential negative impact on their value from climate change.

**There is little doubt that electric vehicle (EV) sales are increasing, and that they will continue to increase given the support and blessing of governments around the world**

There is little doubt that electric vehicle (EV) sales are increasing, and that they will continue to increase given the support and blessing of governments around the world. The biggest impetus to EV growth globally is the push from China for more of them as part of the government's solution to the country's air pollution crisis in its major cities. But, as an article in a recent issue of *China Daily* entitled "Electric car sales dip due to customers' doubts" points out, Chinese EV buyers are having second thoughts about the value and usefulness of their purchases. The lead paragraph of the story put a positive spin on the EV issue.

**In its survey of 1,002 Chinese respondents, 60% are considering buying an EV for their next car**

The newspaper's article began: "Among the world's major auto markets, China takes pole position in demand for electric vehicles and is leading in absolute terms for related infrastructure, despite deliveries tumbling in the first quarter." So why are deliveries falling? Research into attitudes of Chinese car buyers toward EVs is quite positive reported German consultancy Roland Berger. In its survey of 1,002 Chinese respondents, 60% are considering buying an EV for their next car. That percentage compares with a global average of 37% of car buyers, based on a survey of purchasing intentions in China, France, Germany, India, Japan, the Netherlands, Singapore, South Korea, the United Kingdom and the United States.



**They pointed out that without the government subsidy, an ordinary EV would be just as costly as a luxury vehicle**

Statistics show that China's sales of EVs, including both full EVs and plug-in hybrid electric vehicles (PHEV), reached 507,000 units in 2016, up more than twice the number sold in 2014. This is a staggering number considering that automotive research services peg the total number of EVs on the road at the end of 2016 at barely two million.

Expectations among automotive executives and industry analysts was for a flattening, but still healthy sales volume in 2017. However, first quarter 2017 statistics show that China registered only 90,402 EVs between January and April, down 0.2% from 2016's number. Analysts are saying that China's EV market is highly dependent on government policies and subsidies. That was supported by Nielsen, a market research company, who said that among potential EV buyers, the highest motivating factor is the free license plates the government hands out, followed by the state subsidies. They pointed out that without the government subsidy, an ordinary EV would be just as costly as a luxury vehicle.

**The EV buyer said that he uses the EV occasionally, but it is only for the benefit of the electric car's license plate**

According to Yale Zhang, general manager of *Automotive Foresight* (Shanghai), "Buyers are basically paying for a power battery, as the battery in an electric car is so expensive that it makes up about half of the production cost." The problem this creates is the rapid deterioration in the used car value of EVs as their batteries wear out. Mr. Zhang stated, "The electric car value diminishes much more speedily than a gasoline car after years of use, since the battery will be exhausted." A Beijing EV buyer "told *China Daily* that he bought a 3-year old JAS iEV5 for less than 50,000 yuan (\$7,350) last year, but the previous owner had paid about 90,000 yuan (\$13,235) after enjoying government subsidies." The EV buyer said that he uses the EV occasionally, but it is only for the benefit of the electric car's license plate. He said he had foreseen the problem Beijing was having with car registrations and how the environmentally-friendly EVs were prioritized. This year, 51,000 new car license plates were issued for Beijing, but the quota was used up by April. New car buyers will have to wait for next year's quota to be allocated, which won't happen until February 2018. The EV buyer said the previous owner viewed the EV as a "white elephant" and moved on to a gasoline-powered car.

The newspaper article also reported on stories from various EV owners in Beijing about problems they experienced with the cars. A female EV buyer of a new BAIC E160EV returned

**“Despite being fully recharged, on every attempt it would stop in the middle as the battery output was not as strong as that of a gasoline car”**

**The point of the article was to highlight the growing dissatisfaction among EV car owners due to the vehicles’ lack of power and performance when their owners most need it**

**The car’s owner’s experiment was to see what happened if he completely depleted the vehicle’s battery charge**

**With 5% of the charge remaining, the Ioniq seriously reduced its power output**

the car and received a full refund after she found the car’s performance inadequate for use. “She drove the electric car to the parking lot under her apartment, but had no way to get it back onto street level.”

She told the *China Daily* reporter, “The tilted ramp has such a sharp angle that the electric car was unable to drive up to the end. The only solution was to call the tow truck.” She went on to say, “Despite being fully recharged, on every attempt it would stop in the middle as the battery output was not as strong as that of a gasoline car.”

Another problem cited by EV owners was their performance during the harsh Beijing winter of 2015. There is a long ramp on the fourth ring road in the city that became a hazard for EV drivers. A Beijing EV owner described how one night during that winter with his car showing a 30% charge, his Denza 400 failed to climb the ramp, leaving him stranded half way up. His resolution was to call a tow truck. He told the reporter he spent hundreds of yuan on towing services during that harsh winter. The point of the article was to highlight the growing dissatisfaction among EV car owners due to the vehicles’ lack of power and performance when their owners most need it, something all the interviewees cited as a reason why they reverted to internal combustion engine (ICE) cars. This is not to say that all EV buyers and owners will suffer the same problems, but it is an issue that challenges the universal assumption of EVs rapidly replacing ICE vehicles.

In this vein, we were intrigued to read an article about an experiment the new owner of a Hyundai Ioniq EV conducted. The car is rated by the Environmental Protection Agency (EPA) for 124-mile range utilizing a 28 kilowatt-hour battery pack to power an 88 kilowatt (118 horsepower) electric motor. This Ioniq owner had been averaging 137 miles on a single charge, suggesting he was not losing his battery power as quickly as the EPA projected. The car’s owner’s experiment was to see what happened if he completely depleted the vehicle’s battery charge.

What he found was that with 5% of the charge remaining, the Ioniq seriously reduced its power output. The car did this to conserve as many electrons as possible. For the driver, the turtle light on the dash came on to remind him just how the travel pace of the car was performing.

**The car was moving at only 10 miles per hour!**

At 3% of the charge remaining, there was an audible warning to the driver, along with visual warnings on the car's main interactive display and on its gauge cluster. But with only 1% of the charge remaining, the car really slowed down and the turtle light began flashing. The car was moving at only 10 miles per hour! The aim of the vehicle's performance at this low battery charge was to attempt to extract the maximum from every electron remaining in the battery while urging the driver to quickly find a charging station.

**At a typical 50-kilowatt, fast-charging station, getting the car back to an 80% battery charge capacity would take about an hour**

At a typical 50-kilowatt, fast-charging station, getting the car back to an 80% battery charge capacity would take about an hour. At a 100-kilowatt charging unit, such as Tesla offers, the charging time would be reduced by half, although this charging capacity exceeds that of any operating CCW fast-charging sites in the U.S. For this performance, an Ioniq buyer will be looking at a cost for a hybrid model that starts at \$23,035, while the EV model prices out at \$30,335.

**At the end of the day, the role of government subsidies may influence the EV market much more drastically than anyone anticipates, but that will set up further challenges down the road**

The issues raised by the *China Daily* article and the battery exhaustion performance test of the Hyundai Ioniq suggest there remain numerous technological improvements needing to be commercialized, as well as to bring down EV costs on a sustained basis, and not just through the gimmickry of government subsidies, before they become mainstream. How the cost curves develop is questionable because it requires forecasting technological improvements – a sometimes precarious undertaking. Yes, technological improvements might occur quicker than anyone anticipates, but it is equally possible they will take much longer to be implemented, keeping vehicle purchase prices high. At the end of the day, the role of government subsidies may influence the EV market much more drastically than anyone anticipates, but that will set up further challenges down the road.

## Understanding The Issues for Electric Vehicle Batteries

**Auto manufacturers need government subsidies to help offset high battery costs, making EVs more price-competitive with their ICE counterparts**

The greatest drawback for the public's acceptance of electric vehicles (EV) is "range anxiety" – running out of battery charge before reaching a charging station. A secondary concern is the high cost of the battery packs in EVs, which is what makes the cars so expensive. Auto manufacturers need government subsidies to help offset high battery costs, making EVs more price-competitive with their internal combustion engine (ICE) counterparts.

**In May, GM sold 1,566 Bolts, bringing its five-month total for 2017 to 5,950 units**

The first moderately priced EV with long-range capacity is the Chevy Bolt, introduced by General Motors (GM-NYSE) last December. That month, GM sold 579 vehicles in California and Oregon, the only two states where Bolts were sold. Since the start of 2017, GM has rolled out sales in other states. It now anticipates selling Bolts in every state by the end of August, four months ahead of its original schedule. The accelerated rollout is likely in response to anger among dealers and EV enthusiasts in states without access to the car. In May, GM sold 1,566 Bolts, bringing its five-month total for 2017 to 5,950 units.

#### **Exhibit 8. The 2017 Chevy Bolt Electric Car**



Source: General Motors

**While this marketing plan sounds solid, it actually reflects the reality that EVs remain a niche product**

According to details provided to auto writers, following the August nationwide rollout, GM plans a “highly targeted” national advertising campaign for the Bolt with a strong presence in online sites and very specific media where Chevy’s buyer data shows electric car fans, advocates and likely shoppers are concentrated. While this marketing plan sounds solid, it actually reflects the reality that EVs remain a niche product, otherwise, GM would be widening its marketing campaign to general media and internet sites.

In response to a question by *Green Car Reports*, we learned that the battery pack for the Chevy Bolt is not cheap, although the performance of most GM EV batteries has not been a major issue so far. Depending on the state where a Bolt is purchased, GM warrants the battery’s performance for either eight years/100,000 miles, or 10 years/150,000 miles. That

**Based on the original sales price and the government's subsidy, the used car buyer paid about 32% of the EV's unsubsidized sales price**

**The test showed that at an average temperature of 14oF, the Leaf had a travel distance of 50 miles, while at an average of 71oF, the range increased to 91 miles**

would seem to be sufficient time for the Bolt's owner to enjoy its value, but since the cost of battery packs represents a significant percentage of the initial EV purchase price, the older the battery or the more mileage on the vehicle, the greater the erosion in the car's trade-in value.

This result was pointed out in an article about EVs in Beijing from the perspective of buyers and owners. One EV owner reported he purchased a three-year old car for ¥50,000 (\$7,352) from a seller who had paid ¥90,000 (\$13,235) net of the Chinese subsidy in 2014. Based on the history of Chinese electric vehicle subsidies, the sales price was reduced by ¥67,000 (\$9,800). Based on the original sales price and the government's subsidy, the used car buyer paid about 32% of the EV's unsubsidized sales price.

The cost of the Bolt's battery pack is much greater than for most EVs, primarily because it is larger, enabling it to go further on a charge. The Environmental Protection Agency (EPA) credits the Bolt with a range of 238 miles. The Bolt has a 60 kilowatt-hour battery pack, compared to a Nissan Leaf's 24 kilowatt-hour battery pack and an EPA rating of 75 miles. Of course, the range of all EVs is a function of ambient temperatures as they impact the power output of the battery. A test conducted on a Leaf by the Idaho National Laboratory showed that at cold temperatures the mileage performance of the EV was significantly reduced. The test showed that at an average temperature of 14°F, the Leaf had a travel distance of 50 miles, while at an average of 71°F, the range increased to 91 miles.

#### **Exhibit 9. Design Of Bolt Battery Pack**



Source: General Motors



**The Bolt's replacement battery costs \$15,734 compared to the \$5,500 cost of a Leaf replacement battery pack**

Because of the greater range of the Bolt given its larger battery pack, it is not surprising that it costs much more than the smaller battery pack in a Leaf. The Bolt's replacement battery costs \$15,734 compared to the \$5,500 cost of a Leaf replacement battery pack. A 2017 Nissan Leaf S model has a suggested retail price of \$30,680, but this new model possesses a 30 kilowatt-hour battery pack, larger than the earlier 24 kilowatt-hour version, and a correspondingly greater range of 107 miles per charge. The Leaf's battery pack represents 18% of its suggested sales price. In contrast, the larger Bolt battery pack with its substantially greater range represents 42% of the unsubsidized \$37,500 sales price, or 52% of the subsidized price. The key to success for EVs will be to bring the cost of these larger battery packs, with their greater range, down so overall vehicle costs can be reduced, which would mean government subsidies could be reduced or eliminated.

**Exhibit 10. Location Of Bolt Battery Pack**



Source: General Motors

**A consideration in his dealer selection was the availability of high-speed charging stations on his route home**

A recent article highlighted the issues EV car owners face when trying to take long-distance trips. *Green Car Reports* carried an interview with a man desperate to own a new Bolt before it would be available in his part of the country. The man lived in St. Louis and Bolts were not scheduled to be sold there before December. Thus, he started looking for dealers in either the East or West who would sell him a new Bolt in the spring. A consideration in his dealer selection was the availability of high-speed charging stations on his route home. He wanted to only use Level 3 charging stations, which provide 160 miles of range per hour of charging, in order to

**He found that there was not a single DC fast charging station in Kentucky**

minimize the number of stops in comparison to relying on Level 2 charging stations that only provide 25 miles per hour of charging.

What he found was that there were insufficient Level 3 charging stations to get him from the West to St. Louis in the time he had available for the drive. Therefore, he focused on the East and negotiated a purchase with a dealer in Richmond, Virginia. He drove his 2007 Honda Acura RDX to the Richmond dealer and began his drive home in his new Bolt. The dealer selection was keyed to the fact Interstate-64 went between Richmond and St. Louis. However, when he started mapping out his route, he discovered there weren't enough fast-charging sites along the route. In fact, he found that there was not a single DC fast charging station in Kentucky. Given his schedule, he was forced to consider alternative routes.

**A vehicle's actual range depends on the driver's approach, road conditions and ambient temperatures**

A southern route through Tennessee would have worked until he reached Illinois, where he faced having to make at least one Level 2 charge that provided little distance for a long stop. A northern route might have worked, but it turned an 814-mile trip into a 1,003-mile trip. All the route choices required making judgements about how far the Bolt could go on a single charge. Despite all the information offered online, the owner would only know how far his Bolt could travel once he started driving. A vehicle's actual range depends on the driver's approach, road conditions and ambient temperatures.

**Although that was a slow charge, by spending the night at the hotel, he was fully charged the next morning**

The Bolt owner found he could schedule his charging stops with other activities such as eating or sleeping. His first charging stop was in Harrisonburg, Virginia, after 129 miles, at a 5 Guys Burgers and Fries. The second stop was 114 miles further on in Hagerstown, Maryland, at the Hagerstown Valley Mall, where he hung out and had dinner.

His final stop on the first day was at a Holiday Inn Express in Bentleyville, Pennsylvania, after another 169 miles, where there was a 240-volt Level 2 charger. Although that was a slow charge, by spending the night at the hotel, he was fully charged the next morning.

One thing the Bolt owner learned was how to overcome "range anxiety." He ventured information about his experience coming out of the Appalachian Mountains. Part of the route included a 9% downhill grade for three miles. By

**His observation was that the Bolt won't get you 200 miles of range by driving at 70 to 75 mph, and going 80 mph is out of the question**

**Without a very extensive and dense charging station network, when we get a large number of EVs on the road, unless they all charge at home overnight, there could be really extended waits to access charging stations**

coasting downhill, when possible, and using the "Regen" feature on the Bolt EV, the vehicle gained 50 miles of range. That's great in areas where there are hills or mountains, but it won't help in the Great Plains region of the country.

The Bolt trip also highlighted issues for overcoming range anxiety by controlling driving speed and the use of climate control. According to the Bolt owner, when driving between Columbus, Ohio and Indianapolis, Indiana, he set his cruise control at 60 miles per hour (mph) and turned the climate control off every once in a while, maximizing miles per charge. His observation was that the Bolt won't get you 200 miles of range by driving at 70 to 75 mph, and going 80 mph is out of the question. He commented, "We set the cruise at 60 mph, and still had a little range anxiety. Imagine driving three and a half hours at 60 mph. We thought many times we were going to be run over by 18-wheelers, but it worked. So, yes, you can drive a Chevy Bolt the advertised 238 miles on a charge, if you can drive 60 mph."

The key conclusion of the Bolt owner is that you can drive half way across the United States, but you need to do some research and planning, and also be prepared for extended stops. This is akin to the issue of fighting the charging time versus the fill-up time at the gasoline service station. Without a very extensive and dense charging station network, when we get a large number of EVs on the road, unless they all charge at home overnight, there could be really extended waits to access charging stations. This challenge, coupled with the continuing high cost for EV battery packs for vehicles that can overcome buyer "range anxiety" fears are merely assumed away in the optimistic EV forecasts. This is a reason to be cautious about assuming how quickly EVs will erode the demand for oil used in the transportation sector.

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