Managing Partners:
LEIGH R. GOEHRING
ADAM A. ROZENCWAJG

DÉJÀ VU: A HISTORY & STUDY OF ELECTRIC VEHICLES AND THE OIL MARKET TODAY

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Déjà Vu: A History of the Electric Vehicle

"It's a reality check — per trip a lot more is spent on electric cars than public transport and I don't think anybody intended that to be the case. In the long run, it's just not feasible. 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."

Andreas Halse, environmental spokesman in Oslo for the opposition Labour party

"Norway's Oil Consumption Rises Despite Surging Electric Vehicle Sales"
Forbes, 7/12/07

He is considered one of the great innovators of his day, a crusader for the promise and advantages of electricity. He believes electric vehicles (EVs) should come to dominate the rapidly growing transportation industry. Initially, the EV industry is experiencing strong growth. When it becomes obvious that battery technology is inadequate to accomplish his dream, he creates and produces a

produces a more powerful and longer-lasting battery for the rapidly growing EV market.

In the face of mounting criticism that EVs can never compete with the internal combustion engine (ICE), he pushes ahead relentlessly to meet his goal of displacing gasoline-powered cars from the roads. Even though the large auto manufacturers temporarily abandon the idea of mass-produced EVs, he becomes even more determined.

A decade later, our innovator teams up with the largest auto magnate, a personal friend, to attempt to produce an EV that would be economically competitive while offering the most consumer-friendly driver experience.

The competitive disadvantages and drawbacks of EVs are now well known. However, both men aggressively move ahead with their venture. New battery technology is introduced by our industrious inventor that promises to double the EV's range. The project remains a personal priority of the chief executive officer of the world's largest car manufacturer.

Despite much publicity and fanfare, the new version of their EV is never built.

Even though our famous inventor had indeed pulled off a major breakthrough in battery technology, the additional battery costs, weight, and charging capability still cannot compete with the far-superior economics of internal combustion engine automobiles. Even though the range of the EV has now doubled, "range anxiety" continues to haunt potential EV buyers. Despite plans for aggressive expansion, the network of EV charging stations is not robust and long lines are commonplace. Trips in an EV have to be carefully planned. And finally, no matter what the greatest car manufacturer of the age does, the EVs still cost twice as much to build compared with vehicles powered by gasoline.

With its mounting financial problems making front page news, a reader could easily think we're making a prophesy about the future of Elon Musk's Tesla Motors, but we are describing something that happened over one hundred years ago. Although time and technology have marched relentlessly forward over the last century, the same problems face EV manufacturers today: range and cost. The only thing that has changed are the players.

Thomas Edison originally convinced Henry Ford that all of his cars should be powered by electricity, and Ford seriously considered following his friend Edison's advice. Because of pollution fears, and worries surrounding long-term supplies of petroleum, cars powered by the ICE had not yet come to dominate the passenger car market. 28% of all cars produced in the United States at the time were electric, and in the heavily populated US east coast, approximately one-third of all cars on the road were powered with electricity. Ford recognized the superior economics of the ICE, and the end result was his decision to produce not the EV, but the Model T.

After his initial setbacks with Ford, Edison realized that a rapid advance in battery technology was necessary. In 1904, Edison announced a huge breakthrough: the nickel-iron-alkaline battery, although it would take him another five years to perfect its reliability.

With his battery's 45% increase in energy density, in 1914, Edison convinced Henry Ford to pursue

the idea of the "Ford Electric," an EV with a 100-mile range and retail price of $900 (about twice the price of a Model T at the time). Ford called the car his "personal project," but even with a huge amount of consumer interest (the 1914 archives of the Ford Motor Company are filled with letters from customers, dealers, and suppliers expressing interest and support for the venture), the Ford Electric's range and high cost left it uncompetitive versus the Model T. The "Ford Electric" was never built.

"IN 1912, THE EV LOST ONE OF ITS LAST COMPETITIVE ADVANTAGES: THE ELECTRIC STARTER HAD BEEN INVENTED. CARS WITH INTERNAL COMBUSTION ENGINES NO LONGER HAD TO BE STARTED BY HAND-CRANKING. THE EV LITERALLY DISAPPEARED INTO OBSCURITY FOR THE NEXT FIFTY YEARS."

In 1912, the EV lost one of its last competitive advantages: the electric starter had been invented. Cars with internal combustion engines no longer had to be started by hand-cranking. The EV literally disappeared into obscurity for the next fifty years.

One of the strongest convictions held by investors today is that EVs will come to dominate passenger vehicle sales in the coming decades. We are constantly told that since the attributes of the EV are so compelling (including reducing CO2 output), it will be only fifteen years before they almost completely displace the ICE from the road.

For example, on our last investment trip to Pakistan and India, everyone we met with wanted to discuss EVs and their negative impact on global oil demand. The potential adoption of EVs as a "disruptive technology" has turned thinking in the energy industry upside down. Fifteen years ago, one of the more prominent debates in global oil markets was "peak oil." Many analysts believed world oil supply growth would slow significantly and eventually turn negative over the coming decade. Today however, with the potential domination of the passenger vehicle market by EVs, everyone is asking when, not if, global oil demand will peak and then decline.

All the commentary surrounding EVs and "peak demand" have introduced an incredibly bearish argument into the future outlook for oil. How bearish? Some prominent market commentators have stated that global oil demand will be so weak in the next ten to twenty years that oil could possibly trade to "worthlessness."

"THE ADOPTION OF THE ELECTRIC VEHICLE WOULD BE THE ONLY TIME IN HUMAN HISTORY WHERE WE WOULD ACTUALLY GO BACKWARD IN ADOPTING A NEW TECHNOLOGY WITH SIGNIFICANTLY LOWER ENERGY EFFICIENCY."

But there are problems with the adoption of the EV that we believe are critically important, and which are greatly misunderstood by investors. Although battery technology continues its relentless move forward, the basic problem surrounding the EV has not changed since Thomas Edison and Henry Ford confronted it one hundred years ago. We believe EVs remain uncompetitive versus the internal combustion car. Unless there is a massive breakthrough in storage technology (which is always just around the proverbial corner), the electric car can't compete against the ICE unless oil prices rise significantly. As we will discuss in this letter, the adoption of the electric vehicle would be the only time in human history where we would actually go backward in adopting a new technology with significantly lower energy efficiency.

If oil prices remain at today's levels, governments who wish to significantly increase the penetration of EV sales will have to either massively subsidize their purchase (the route now being taken by rich countries such as Norway) or else discourage the purchase of internal combustion cars (which would represent a massive tax to consumers).

Already, we have numerous examples of generous subsidies put in place to encourage purchases of

EVs (for example in Hong Kong, Denmark, and the State of Georgia here in the US). In each of these examples, either the subsidies were perceived to be "unfair" (since they disproportionately benefitted high-income earners) or else the loss of government revenue became too great and eventually the subsidies were either removed or severely reduced. What happened to EV sales when these subsidies were removed? EV sales in Hong Kong, the State of Georgia, and Demark declined by 100%, 90% and 80% respectively.

The climate-change debate adds a whole new level of complexity when talking about renewable energy and EVs. It's still unclear if the introduction of EVs will reduce a country's level of CO2 emissions. In last quarter's letter, we discussed Germany's massive investment in renewable energy. German electricity rates have doubled, a populist political party has emerged that want the subsidies eliminated, and CO2 output today is higher than it was a decade ago.

Furthermore, as Forbes reported in July 2017, Norway's oil consumption continues to grow despite surging EV sales. Although EV sales are high, it is unclear how much Norwegians are actually driving them. Data seems to indicate that Norwegians continue to use their internal combustion cars for much of their driving needs and are simply keeping their EVs in the garage, except when needed to avoid paying bridge and highway tolls - EVs are exempt. This would explain why Norwegian oil demand continues to grow despite rising EV sales and is another data point highlighting the high cost of EV ownership, even with extensive subsidies.

"TODAY'S INVESTORS BELIEVE THAT EVS WILL QUICKLY ESTABLISH THEMSELVES AS THE PRIMARY MODE OF TRANSPORTATION. AS YOU ALL KNOW, WE TAKE GREAT PRIDE IN OUR RESEARCH HERE AT G&R, AND IT IS TELLING US SOMETHING COMPLETELY DIFFERENT."

Today's investors believe that EVs will quickly establish themselves as the primary mode of transportation. As you all know, we take great pride in our research here at Goehring & Rozencwajg, and it is telling us something completely different. We know that this is an incredibly complicated subject and there are many disagreements on how the data should be analyzed and interpreted. Also, the issue of climate change and how vehicle transportation fits into this problem has created an emotional environment. Please understand that our viewpoint is flexible and open to change. Read the EV section of this letter for an in-depth analysis.

Q1 2018 Natural Resource Market Commentary

Natural resource markets were weak in the first quarter due to continued aggressive talk from the Federal Reserve on the need to raise short term rates, a resulting weak bond market, and the Trump Administration's desire to start (and then escalate) a global trade war. The overall stock market as measured by the S&P 500 fell a little over 1% during the quarter while the various natural resource equity indices fared worse. The S&P North American Natural Resource Stock Index (which has a large weighting of North American energy stocks) returned -6.2% for the quarter. The S&P Global Natural Resource Stock Index (which has more mining and agricultural exposure) fell less, returning -1.4%.

Oil prices continued their advance during the quarter. In response to ongoing record-setting inventory withdrawals, West Texas Intermediate (WTI) prices rose a strong 7.5% and Brent rose 5.1%. The first quarter usually sees large global inventory builds as global demand for gasoline and heating-oil troughs while refinery maintenance peaks. However, US crude and total product inventories actually fell by 40 mm barrels according to the Energy Information Agency (EIA). US inventories drew by

more than 600,000 b/d versus seasonal averages during the fourth quarter, and these draws continued unabated into the first quarter. Although global data for the first quarter is incomplete, global inventories followed the pattern of US inventories for January and February, declining substantially compared with seasonal averages. According to the International Energy Agency (IEA), OECD inventories (a good proxy for global inventories), which normally build by 33 mm barrels during the first two months of the year actually fell by 10 mm barrels. Total inventories drew by almost 700,000 b/d versus ten-year averages.

"THE INVENTORY DRAWDOWN OVER THE LAST TWELVE MONTHS HAS BEEN AMONG THE GREATEST EVER REPORTED BY EITHER THE EIA (FOR US INVENTORIES) OR BY THE IEA (FOR OECD INVENTORIES)."

The inventory drawdown over the last twelve months has been among the greatest ever reported by either the EIA (for US inventories) or by the IEA (for OECD inventories). From the peak reached at the end of February 2017, US core petroleum inventories have drawn down by 170 mm barrels (approximately 400,000 b/d) while total OECD inventories have drawn down by 250 mm barrels. As of today, inventories both in the US and globally have fallen below their five-year averages and are quickly approaching their ten-year averages. This has occurred much faster than most analysts thought possible. Last year the IEA stated that inventory levels would not normalize until 2019, but as we carefully outlined in our past letters, our models told us this would happen much sooner.

Even in the face of an ever-tightening oil market, investors remain firmly committed to their bearish outlook. For example, even though WTI oil prices advanced by 7% during the quarter, the average exploration and production stock fell 5% while the average oil service stock fell 8%. The underperformance of energy stocks over the last eighteen months has been impressive. Between expectations of nearly unlimited shale growth and worries over "peak demand," energy investors have fought the rally in energy prices every step of the way.

Since oil made its cycle-low back in February 2016, prices have advanced almost 160% while the average exploration and production stock has only rallied 65%. The average oil service stock has fared even worse, rallying only 25% during the same period. As you all know, we do not agree with the conventional bearish oil arguments but instead believe the radical underperformance of energy-related equities represents a tremendous buying opportunity for investors.

"WE DO NOT AGREE WITH THE CONVENTIONAL BEARISH OIL ARGUMENTS BUT INSTEAD BELIEVE THE RADICAL UNDERPERFORMANCE OF ENERGY-RELATED EQUITIES REPRESENTS A TREMENDOUS BUYING OPPORTUNITY FOR INVESTORS."

North American natural gas prices were volatile during the quarter, ultimately finishing down. Gas prices started the year at $2.95 per mcf, rallied as high as $3.63 and then proceeded to fall back to $2.73, down 7.5% for the quarter. US natural gas production continues to grow at the fastest pace ever, as the Marcellus, Utica, and associated gas from the Permian basin all strongly contribute to growth. We are now entering the spring "shoulder" season, when demand reaches its yearly low point as heating demand ebbs and before cooling demand rises. We have been neutral on the North American natural gas market for the last several years, as natural gas drilling productivity continues to advance in both the Marcellus, Utica, and the newly emerging SCOOP / Stack play. Because of surging supply, we are maintaining our neutral outlook for North American natural gas.

Base metal markets were weak in the first quarter. Copper fell by 8% while aluminum declined by 11%, and zinc fell by 1%. The only exception was nickel, which benefited from talk of expected EV battery demand growth. During the quarter, nickel rose by 4%. Although copper prices have pulled back nearly 10% from their highs, it remains our favorite metal and we recommend investors maintain current positions in copper equities.

While uranium markets drifted lower during the quarter, nothing has changed regarding our bullish call laid out in our last letter. In fact, after reviewing our models, we now believe we were too conservative in some of our future demand projections. These new demand figures point to a uranium market that will slip into huge structural deficit in the next several years.

Precious metals had a lackluster quarter. In response to a US dollar that continues to weaken despite rising short-term interest rates (a subject that we have discussed at length), gold prices rose slightly, up a little less than 2%. Silver, however, continuing its trendless price action fell 4% during the quarter. Gold stocks, following the trend of most natural resource equities, fell 9% during the quarter, as measured by the HUI Index. In the platinum group metals markets, platinum was up 1% during the quarter. Palladium, which was the best performing precious metal last year, gave up some of its gains, falling 10%.

"WE BELIEVE A HUGE BULL MARKET IN ALL PRECIOUS METALS LIES AHEAD. HOWEVER, BASED ON OUR RESEARCH, WE BELIEVE THAT INVESTORS WILL BE GIVEN A HUGE BUYING OPPORTUNITY IN THE PRECIOUS METALS IN THE NOT-TOO-DISTANT FUTURE."

Although demand for gold in China remains strong, Indian gold demand has been mixed. We have seen some western investment demand for gold (as measured by accumulations in the gold ETFs), but physical silver purchases by the ETFs remain trendless. We continue to recommend some gold exposure today. We believe a huge bull market in all precious metals lies ahead. However, based on our research, we believe that investors will be given a huge buying opportunity in the precious metals in the not-too-distant future.

Bucking the largely negative trend in first quarter commodity markets, agriculture showed pronounced strength. Both corn and soybeans rose by approximately 10%, while wheat prices advanced almost 6%. A number of very important events are taking place in global grain markets today that few investors notice. First, the USDA released its first "Planting Intentions" report for the upcoming 2018 growing season. Although the report is subject to massive revisions, both corn and soybean acres are expected to be below the 2017 planting levels. The final planting estimate for both corn and soybeans were both significantly below analyst's expectations, and grain prices surged when the report was released.

Second, China announced a nationwide plan requiring that gasoline contains a 10% ethanol component by 2020. China has nearly as many cars on the road as the US, so mandating the use of 10% ethanol in gasoline will have a huge impact on global corn markets. Third, global meteorological growing conditions may be turning less favorable in the coming years. From a climatological perspective, we have just finished three near perfect global growing seasons, and the likelihood of this being repeated is quickly receding, as we are now entering a very weak solar sun-spot cycle.

Offsetting these bullish trends, the Trump Administration's trade war rhetoric may have bearish consequences for US grain prices. In a retaliatory move against the imposition of US tariffs on a number of Chinese good, the Chinese government has stated it will impose tariffs on US corn, soybeans, beef, and most recently sorghum.

Although it is hard to predict what the ultimate impact of a trade war will be for agricultural commodities, it is important to note that both corn and soybean prices have managed to rally strongly despite the Chinese tariff announcements (corn even made a new high). We believe we have made a bottom in agricultural commodities, and that prices could move substantially higher. We recommend that investors begin to increase their exposure to the agricultural commodities and related equities.

"WE BELIEVE WE HAVE MADE A BOTTOM IN AGRICULTURAL COMMODITIES, AND THAT PRICES COULD MOVE SUBSTANTIALLY HIGHER. WE RECOMMEND THAT INVESTORS BEGIN TO INCREASE THEIR EXPOSURE TO THE AGRICULTURAL COMMODITIES AND RELATED EQUITIES."

The "Energetics" of EVs

In the introduction, we outlined the challenges both Edison and Ford faced over one hundred years ago in their quest to adopt the electric vehicle. In the end, the electric vehicle could not compete with the energy efficiency of the internal combustion engine (ICE), and in one of the most important events to shape the twentieth century, the passenger car (powered by ICEs) became the dominant mode of transportation. We recently finished reading Vaclav Smil's excellent Energy and Civilization and it made us do some serious thinking about the future of the EV. As outlined in the introductory essay in this letter, consensus investment opinion believes EVs will have great success in displacing the ICE. But what happens if the consensus opinion is wrong? Are the problems that Edison faced 100 years ago the same facing the electric car today?

If it's true that sometime soon the efficiencies of that EV will become equal (if not vastly superior) to the internal combustion vehicle, then consumers will gladly trade in their old cars for the new EVs without hesitation. Adoption would likely be fast and widespread, especially given the concerns and fears over global climate change. However, what if the efficiencies of today EVs are still so far behind the ICE, that even assuming big increases in battery technology, they will never be competitive against the internal combustion engines?

In his book, Smil starts out by stating that there is no difference whatsoever between the study of economics and energy: "Energy is the only currency: one of its many forms must be transformed to get anything done." He goes on to argue that all of human economic development can be recast through the lens of efficient conversion of energy from one form to another (a discipline known as "energetics"). The adoption of major technologies throughout time all resulted in a more efficient conversion of energy than what existed before. For example, early farmers initially avoided horses because the energy generated from the increased harvest was less than the energy required to raise, house and feed the horse. It was not until improved harnesses were introduced that the "energy return on energy invested" (EROEI) swung positive and farming practices changed. Indeed, as Smil carefully points out in his book, there has not been a single example over the course of history when a technology with an inferior EROEI displaced one with a superior EROEI. If the EV were adopted today, it would be a historical "first."

Before we can have a well-informed discussion about electric vehicles, we must therefore consider their "energetics": how do an EV's physical properties compare in terms of energy? In order to answer the "energetics" question, we tried to compute the total energy required to move an automobile one mile using an internal combustion engine compared with an electric vehicle powered by a renewable source. In order for EVs to meet the global demand for less CO2 they must be powered by a "green" source of electricity namely wind, solar, or hydro. We cannot see a case where EVs powered by coal could displace ICEs on a widespread basis.

We must admit, this process is incredibly complicated. There are disagreements even among PhD academics on issues as esoteric as "extended boundaries" and the "energy cost of capital." We have reviewed much of the academic literature on the subject and have tried to incorporate it into our analysis. Certainly, some people will disagree with the assumptions we have made, but we feel the following analysis accurately captures the current state of both internal combustion engines and electric vehicles.

The results are clear: despite all the recent, and significant, advancements in technology, an electric vehicle is simply not as efficient as an internal combustion engine. Unless subsidized, or forced by legislation, the widespread adoption of EVs therefore remains problematic and highly uncertain.

"THE RESULTS ARE CLEAR... AN ELECTRIC VEHICLE IS SIMPLY NOT AS EFFICIENT AS AN INTERNAL COMBUSTION ENGINE. UNLESS SUBSIDIZED, OR FORCED BY LEGISLATION, THE WIDESPREAD ADOPTION OF EVS THEREFORE REMAINS PROBLEMATIC AND HIGHLY UNCERTAIN."

Starting with the internal combustion engine, one gallon of gasoline contains 120 megajoules of energy. The latest generation of fuel-efficient sedans average approximately 35 miles per gallon, which equates to 3.4 megajoules per mile. Approximately 12% of the energy contained in a barrel of oil is lost during the refining process to create gasoline while another 5% is lost in the transportation. Applying these losses to the 3.4 megajoules per mile results in a total gross energy cost at the well-head of 4.1 megajoules per mile.

Next, we must consider the energy return of crude oil drilling. An oil company must expend energy during the exploration, drilling, completion and pumping of a well. In return, they are rewarded with a mixture of energy-rich hydrocarbons. Countless academics have written extensively about the EROEI of the energy industry, and most agree that the EROEI of oil production is approximately 20:1 – in other words, 20 units of energy are generated for every unit expended. Dividing the 4.1 megajoules per mile required in a gasoline powered car by 20 results in approximately 200 kilojoules required per mile traveled.

How does this compare with an electric vehicle? The new Tesla Model 3 contains a 75 kWh lithium-ion battery with a 310 mile range. This works out to 241 watt-hour per mile, or 0.9 megajoules per mile -- 75% less than the internal combustion engine. This figure is so favorable because nearly 80% of the energy released in the combustion of gasoline is lost in the form of heat, exhaust, pumping and friction while an electric motor can transmit nearly 95% of the energy stored in the battery directly to the drive train. Recharging and discharging the latest generation lithium-ion battery results in ~10% energy loss (just touch your phone while it's charging to see how much heat it gives off), while transmission loss along electrical lines consumes an additional 12% of the energy. Therefore, at the source of generation, 1.1 megajoules is required to move one mile compared with four megajoules for the internal combustion engine –a savings of 72%.

However, the inherent efficiency of the EV itself does not tell the whole story. The production of Tesla's 75 kWh lithium-ion battery is incredibly energy-intensive. The raw materials that go into the battery (lithium, cobalt, copper, and nickel, among others) are all energy-intensive to extract and process. Next, the manufacturing of the cell is energy-intensive as well (particularly the "drying" of the anode and cathode slurry). There has been a huge debate surrounding the total energy required to produce lithium-ion batteries, with the highest estimates exceeding the lowest by approximately ten times. Both the extreme high and low values have problems with their methodology. For example, the highest estimates use outdated manufacturing techniques while the lowest estimates leave out the full extraction cost of the raw materials. There is a growing consensus emerging that the total energy cost of battery production is between 900 and 1,800 megajoules per kWh (or between 65 and 134 gj per Tesla Model 3 battery).

A modern lithium-ion battery is expected to last between 400 and 500 full recharge cycles before its capacity begins to degrade in a significant non-linear fashion. Since the Tesla Model 3 can travel 310 miles per full recharge, the total life of the battery works out to approximately 140,000 miles using the mid-point. Dividing 65 to 134 gj per battery by 140,000 miles works out to 0.5 to 1.0 megajoules per mile traveled, bringing the total for the EV up to 1.6 to 2.1 megajoules per mile. Incorporating all the

battery costs, the EV still has a greater than 50% efficiency versus the internal combustion engine.

Lastly, we must consider the EROEI of renewables. There is much academic debate surrounding this point as well. Starting with solar, some academics claim that PV (photovoltaic) solar is actually an energy sink (requiring more energy to manufacture than it generates over a useful life), however most academics now agree that the EROEI for solar is approximately 7:1 (compared to 20:1 for oil production). Please note that this figure does not assume any grid-level battery storage component. Readers of our letters know that solar power is very problematic at the grid-scale because it is intermittent: power levels decrease on cloudy days and at night. If PV solar were used to power a large-scale EV fleet, it would need to have a certain level of grid-level battery storage to help smooth out these variances. Adding the energy cost of the battery to the system takes the EROEI of solar to less than 4:1.

While wind power appears better on the surface, it is very problematic once you dig deeper into the subject. A commonly published EROEI for wind power is 25-30:1, which is much better than PV solar. However, whereas most academics seem to agree on the EROEI of solar, there is a much wider variance when discussing wind. For example, changing methodologies to better account for the full life-cycle of wind costs takes the ERORI from 24 to 12 across many academic papers. Part of the discrepancy in wind comes from the fact that transporting an immense 2 MWe wind turbine is much more energy-intensive than transporting a set of PV solar panels. Moreover, many reports claim a load factor of nearly 50% whereas actual results suggest a level closer to 30-35%. Also, the lifespan of a wind turbine is very much up for debate. While the average assumed life is twenty to twenty-five years, a recent report from the UK states that this figure may be closer to fifteen years, which has a huge impact. Similar to solar, wind power is intermittent and so a large-scale EV fleet backed by wind turbines would also require a grid-level battery system to help smooth out fluctuations. For the purposes of this analysis, we agree with the "input-output" methodology that better captures the full life-cycle cost of wind and had an EROEI of 12:1 as of 2010. We assume this has improved to be ~15:1 without battery storage and 9:1 with battery storage.

Taking the average EROEI of PV solar and wind and assuming the need for grid-level battery storage, the total energy cost to travel one mile is ~305 kilojoules per mile, or ~40-45% greater than the internal combustion engine.

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Proponents of electric vehicles argue that technology is improving so quickly that any study today is by definition already out of date. While it is true that manufacturing processes have become more efficient, looking at the model above it becomes difficult to see how the efficiency of EVs will rival ICEs any time soon. The natural areas to focus on include the energy to manufacture batteries, the recharge cycle life of batteries and the EROEI of renewable power. However, each of these face substantial challenges.

BATTERY MANUFACTURING

As you can see in the analysis above, a large amount of energy is consumed building the battery system to power the electric vehicle and as a result great lengths have been made to improve battery manufacturing efficiency. Analysts talk about the declining cost of lithium-ion batteries and many investors simply assume these trends will continue forever. However, there is reason to think that much of this improvement was one-time in nature.

The energy consumed in battery manufacturing can be put in two categories: energy needed for the raw materials and energy needed for the manufacturing of the battery. Over the last five years, the bulk of the energy savings have come from the manufacturing stage. In particular, the so-called "dry rooms" use a tremendous amount of energy to heat and dry the slurry making up the cathode and anode of the battery cell. Many of these dry rooms were built to handle a large volume of cells and operated at only 25% capacity at their start. Since the same amount of energy was needed to heat the room regardless of throughput, the energy per cell was very high. As these facilities have increased their utilization, the energy necessary to dry one unit has come down considerably. This alone accounts for nearly all of the energy and cost savings in lithium-ion battery production over the last five years. However, most large-scale facilities are now operating near or at their productive capacity and future energy savings will be incremental from here.

The remaining energy required comes from the extraction and processing of cobalt, copper, lithium, and nickel. This makes up approximately 30% of the energy spent to create a battery, and the trends here are very different. Readers of our letters know that we are very bullish on copper based on both demand and supply trends. On the supply side, we are quickly running out of high-grade copper deposits. The new generation of large-scale copper porphyries have a grade of 0.5% compared with an average head-grade of 1.0% a decade ago. It requires 100% more energy to produce one pound of copper from a mine with a head-grade of 0.5% than one with a head-grade of 1.0% (all else equal). Similarly, it will be difficult if not impossible to find high-grade cobalt and nickel deposits to meet future demand. On the lithium side, we do not foresee an imminent shortage considering there are ample undeveloped reserves in both South America and Australia. However, the Australian deposits (which will be the source of much of the world's incremental lithium production), is produced by mining, crushing and floating spodumene ore which, although cheaper per unit, is potentially up to eight times more energy intensive than the current brine-based production.

In other words, the energy and cost savings in battery production have come from the manufacturing side and have largely run their course, while the energy required to produce the raw materials looks set to increase dramatically. While improved battery chemistry will help, this source of energy and cost savings will likely be incremental until so-called lithium 8-1-1 batteries are commercialized (although this presents its own issues).

RECHARGE CYCLE LIFE

Extending the life of batteries would help the equation, but here too there are challenges. Lithium-ion batteries can be very finnicky and require a stable operating environment in order to age properly. If the climate is too hot or too cold, the life of the battery is irreparably damaged. Much of the new proposed battery chemistry is even more sensitive to environmental stresses than the existing batteries and so not ideally suited for use in EVs. Furthermore, quickly recharging and discharging the battery has been shown to impair battery longevity. To that end, "ultra-capacitors" can be used to provide short bursts of power to the drive-train and remove stress from the battery. However, these themselves require energy to produce and to a certain extent are already included in today's EV calculations.

PHOTOVOLTAIC SOLAR

There has been much discussion about the declining cost of PV solar modules over the last seven years. However, a closer analysis reveals that a large contributor to this was the reversal of a price increase in

polysilicon in 2010 due to an industry-wide supply shortage. The shortage proved to be temporary and prices declined by as much as 75% and so in turn has the cost to produce a PV module. We do not mean to imply that manufacturing efficiencies have not improved as well, however we think most people do not appreciate the impact of this one-time supply-chain shock to the cost of PV modules.

On the other hand, there is reason to believe that the energy efficiency of ICEs will continue to improve. Mazda recently announced a new engine technology that is expected to improve efficiency by 20%. Diesel vehicles commonly achieve 20% to 35% greater mileage than gasoline engines while the energy contained in a gallon of diesel is only 10 to 15% higher. Remember, up to 80% of the energy content of a gallon of gasoline is lost in an ICE, leaving ample room for future efficiency gains.

Until EVs are more energy efficient than ICEs, the only way they'll continue to grow is through government incentives or ICE taxes, as we are seeing today. However, as we discussed in the introduction we are already seeing the push-backs of wide-spread incentive programs in many countries around the world .

"ON THE OTHER HAND, THERE IS REASON TO BELIEVE THAT THE ENERGY EFFICIENCY OF ICES WILL CONTINUE TO IMPROVE... REMEMBER, UP TO 80% OF THE ENERGY CONTENT OF A GALLON OF GASOLINE IS LOST IN AN ICE, LEAVING AMPLE ROOM FOR FUTURE EFFICIENCY GAINS."

Before we end, we'll leave you with one prediction: the EV will eventually win out over the ICE based on its energy efficiency, but not in the way most people expect. Once we have depleted our readily available sources of efficient crude, the EROEI of oil production will deteriorate to the point that EVs become more efficient. In fact, if you look at the least efficient marginal sources of crude oil today (Canadian oil sands), the EROEI is close to 5:1. If that was the only remaining source of oil, then it would indeed be more efficient to run an EV fleet. However, were that the only remaining source of global oil, the price would be multiples of where it is today not "worthless" as the EV proponents argue.

Over a century ago, EVs lost their battle against the ICE, as consumers quickly realized the operating and cost efficiency of the latter. Although few have done the work, we believe the EVs energy efficiency still lags the ICE just like it did when both Thomas Edison and Henry Ford tried to make an EV that could compete with the ICE. We believe that EV sales will increase as we progress into the coming decade; however, the costs when combined with investments in renewable sources needed for CO2 reduction are going to be extremely expensive and will have to be borne by governments through subsidies or by consumers through legislation. Given how costly and painful the process could become, we believe we are overestimating the potential penetration of EVs in the global transportation market, and their ultimate impact on global oil consumption.

Closer Oil Market Overview: Global Oil Market Continues to Tighten; $100 is Getting Closer

In January 2017, with global oil inventories at record levels, we predicted inventories would normalize over the next eighteen months. At the time it was a lonely call, and few, if any investors agreed with us (and many called us crazy). However, it turns out our modelling was correct, and today inventories are approaching levels considered normal. Total OECD inventories topped out at 420 million barrels above 10-year averages in July 2016 and as of February (the latest data available from the IEA), they had declined by 75%, and now stand only 100 million barrels above average. Inventories drew relative to long-term averages at a rate of 800,000 barrels per day over the last twelve months, and we expect global inventories will be within 20 million barrels of normal by April/May (in line with our original

estimates made more than one year ago).

Lower-than-expected inventories have forced many analysts and traders to acknowledge what we have been saying for over a year: global oil markets have been, and are today, much tighter than originally predicted. This tightness, along with increased geo-political tensions in the Middle East, has caused oil prices to rally to their highest level since 2014. As we write, Brent is trading for $73.70 per barrel – 42% higher than one year ago and ~150% higher than the lows made in early 2016. Our January 2017 prediction for $100 oil prices (to be reached sometime in 2018) no longer seems as far-fetched as many claimed twelve months ago.

Despite crude oil's price strength, oil-related securities have lagged considerably. While oil prices are ~150% higher than their 2016 lows, oil-related securities have only advanced between 40-60% on average. Because of their underperformance, we believe tremendous investor opportunity exists in energy-related shares.

"LOWER-THAN-EXPECTED INVENTORIES HAVE FORCED MANY ANALYSTS AND TRADERS TO ACKNOWLEDGE WHAT WE HAVE BEEN SAYING FOR OVER A YEAR: GLOBAL OIL MARKETS HAVE BEEN, AND ARE TODAY, MUCH TIGHTER THAN ORIGINALLY PREDICTED. "

Before we discuss the latest oil market data, we would like to review our outlook as published in our last quarterly letter. Starting from a deficit of 650,000 b/d in 2017, we expected global demand to grow by 1.6 mm b/d in 2018. We predicted that the US could grow production by 1.1 mm b/d while the rest of non-OPEC could grow by 400,000 b/d. Were OPEC to maintain its cuts throughout 2018, we argued, the global oil market deficit would increase from 650,000 b/d to 750,000 b/d and inventories would draw to their largest deficit relative to long-term averages ever recorded. Even if OPEC rescinded their production cuts in June, the oil market would likely remain in deficit for most of 2018.

Since we last wrote, several new developments have emerged, and our outlook has become even more bullish. Most importantly, OECD inventory data continues to confirm that the global oil market remains in substantial deficit and that this deficit is accelerating. Over the six months ending January 2018, OECD inventory draws relative to normal have accelerated to 950,000 b/d compared with 580,000 b/d for the six months prior. US core-inventory draws moderated somewhat in February and the beginning of March, but these numbers are particularly variable over short periods. For example, over the last five weeks US core inventories have resumed drawing by a very robust 700,000 b/d relative to long-term averages.

As predicted by our models, global demand estimates for 2018 were revised higher over the last three months by 150,000 b/d. While this is a step in the right direction, we continue to believe that further large-scale upward revisions are still required. Readers of our letters will recall that the IEA will often include a "miscellaneous to balance" line item in their supply and demand tables (what we call the "missing barrels"). This item represents oil that was produced but neither consumed nor added to inventory. Although often referred to as "missing barrels," we do not think this oil is really missing. Rather, "missing barrels" represent a systematic under-estimation of non-OECD oil demand by the IEA that will be eventually revised away in future releases. During the fourth quarter, these "missing barrels" exploded to the upside, averaging nearly 1 mm b/d – one of the highest quarterly readings ever. As in the past, we think the IEA will again be forced to revise demand higher over the course of 2018 to account for this discrepancy (just like they have done in seven of the last eight years). If only 50% of these missing barrels are eventually reclassified as demand then 2018 demand growth may ultimately hit 1.8 m b/d compared with our prior estimate of 1.6 mm b/d.

"INDIA IS TRANSFORMING BEFORE OUR EYES AND YET FEW PEOPLE SEEM TO NOTICE."

In particular, the demand figures coming in for India are incredible. We have written extensively about the coming rise of India over the course of the last year and have just returned from a two-week research trip to both India and Pakistan. It is shocking how few people are commenting on the large-scale developments currently underway in the world's second most populous country. Indian oil demand growth likely exceeded 300,000 b/d year-on-year during the first quarter to reach another all-time high. India is transforming before our eyes and yet few people seem to notice. Indian oil demand is expected to grow by 300,000 b/d this year (and this will likely be revised higher), representing a near 100% acceleration from its 175,000 b/d average over the last decade.

On the supply front, the lack of any material investment in the non-OPEC world outside of the US is beginning to significantly impact production. As you may recall, in our last letter we went into great detail surrounding the lack of conventional discoveries in the non-OPEC world. In particular, we were skeptical that the IEA's estimate for 600,000 b/d of non-OPEC production growth outside of the US was feasible. Instead, we argued that setbacks in Mexico and the North Sea (among other issues) would result in actual production growth coming in closer to 400,000 b/d (and how even that estimate was at risk of disappointing). Since we last wrote, the IEA has revised its estimates for non-OPEC production outside of the US lower by exactly 200,000 b/d split evenly between Mexico and Norway (the two countries we identified in our last letter). We continue to think that a dearth of capital spending in the rest of the non-OPEC world will result in sub-par production over the medium-term with very bullish implications.

Offsetting these bullish developments, the IEA revised its US shale production estimates for 2017 and 2018 higher by 120,000 b/d and a very-large 520,000 b/d respectively. When we last wrote, we said that we were comfortable using the IEA's original 2018 estimates as a "base-case" and warned there was a risk they would be revised lower. In particular, we described discrepancies in the US Department of Energy data that we felt would result in downward revisions to supply.

In retrospect, it now looks like our analysis was incorrect. In a moment we'll go into detail on the US shales, but first we would like to stress this upward revision to US production is largely offset by a combination of downward revisions to non-OPEC production outside the US and higher global demand. Furthermore, given problems in OPEC production (particularly Venezuela), the oil balances today are even tighter than they were three months ago. We have often argued that the world will ultimately need the growth from the US shales to avoid a dangerous structural deficit in global oil markets, and this latest data validates that view.

"IN PAST LETTERS, WE'VE EXPLAINED HOW WE USE "ROAD MAPS" AND "MILE MARKERS" IN OUR FORECASTING PROCESS. FIRST, WE BUILD DETAILED SUPPLY AND DEMAND MODELS. WE LAY OUT A "ROAD MAP" OF OBSERVATIONS WE SHOULD EXPECT TO SEE IF OUR MODELS ARE CORRECT. WE NEXT DEFINE "MILE MARKERS" OR DATA POINTS WE MUST PASS TO CONFIRM WE ARE GOING DOWN THE RIGHT PATH. IF WE DO NOT PASS THESE MILE MARKERS, WE REVISIT OUR ASSUMPTIONS AND CHANGE OUR MODELS AS NEEDED."

In past letters, we've explained how we use "road maps" and "mile markers" in our forecasting process. First, we build detailed supply and demand models. Using these models, we lay out a "road map" of observations we should expect to see if indeed our models are correct. We next define "mile markers" or data points we must pass to confirm we are going down the right path. If we do not pass these mile markers, we revisit our assumptions and change our models as needed. Over the last three months, the Energy Information Agency (EIA – the statistical arm of the Department of Energy) have revised their historical shale production data-series. As a result, we have not passed certain of our "mile markers," and have changed some of our models.

Last quarter we explained how total US production growth slowed materially between February and August 2017. We attributed this slow-down to a lack of remaining high-quality "Tier 1" drilling loca-

tions in the Eagle Ford and Bakken shale basins. We also noted that preliminary EIA data for September and October pointed to a sharp rebound in US production growth, but that we were ultimately skeptical of this new data. Production grew strongly in Texas and New Mexico, but according to the EIA, the growth was not coming from the shales. In other words, production growth was apparently coming from "conventional" sources, reversing a prolonged multi-year trend of declines. With no capital being spent on conventional drilling, it seemed impossible for on-shore conventional production to surge. Our models suggested this data was highly suspect and would ultimately need to be revised lower.

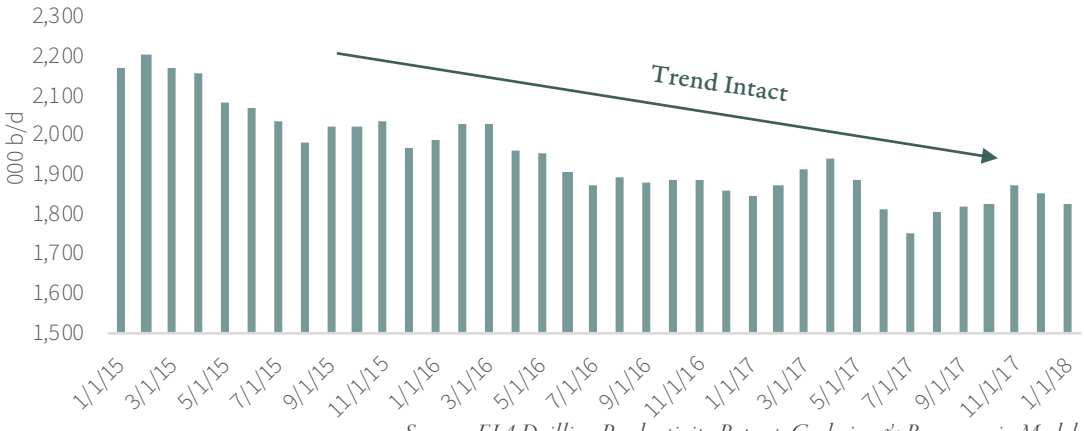
Since we last wrote, the EIA did in fact revise its data but not in the way we had anticipated. Instead of revising total US production lower, they revised Texas and New Mexico shale production higher (and by extension conventional production lower) by 200,000 b/d for October. The revision to shale production was almost entirely from the Permian Basin. While this was not the outcome we had originally predicted, the new data now makes considerably more intuitive sense. After the revision, conventional US production remains in its multi-year down-trend while the Permian basin continues to be the only material source of production growth in the US.

What impact do these revisions have to our "road map" going forward? First, it is now clear conventional US production remains in a prolonged downtrend. As you can see in the following chart, before the data revisions, conventional production had seemingly bucked this multi-year trend and grew by 380,000 b/d in September and October to reach a two-and-a-half year high. After the revisions (see Chart 2), the downtrend now remains intact and conventional production will likely keep declining by 120,000 b/d per year.

CHART 1 US Conventional Production (Pre Revisions)

Source: EIA Drilling Productivity Report, Goehring & Rozencwajg Models

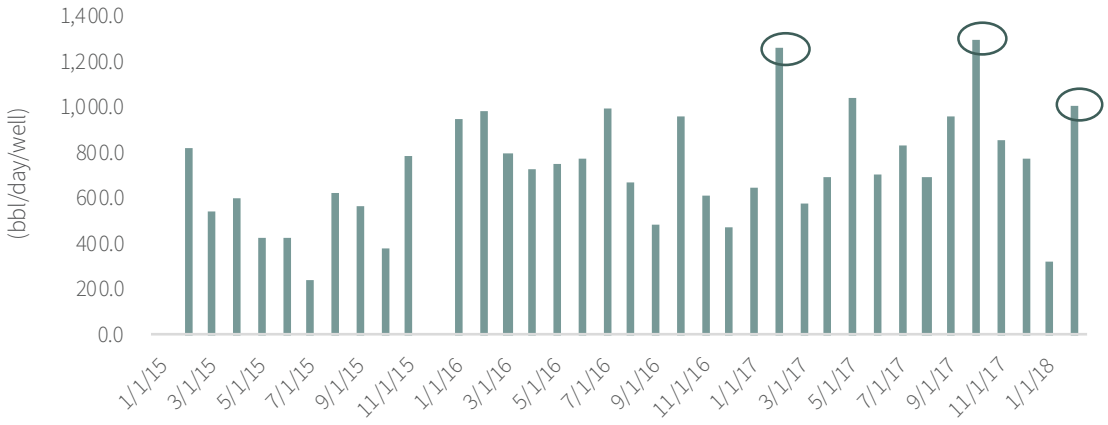
CHART 2 US Conventional Production (Post Revisions)



Source: EIA Drilling Productivity Report, Goehring & Rozencwajg Models

On the other hand, Permian production is now growing faster than before the revisions. Does this strengthen the oil bears' argument that Permian growth will overwhelm the global oil market? Not necessarily. Before the revisions, we modeled that the Permian would grow by 620,000 m b/d year-on-year in 2018. While this level of growth is dramatic, as we have explained it would not be enough to balance the global oil market, let alone shift it into surplus. Our projection was based upon 388 rigs actively drilling in the Permian and an assumed 800 b/d of new production per completed well. The new EIA data suggests that new Permian production per completed well averaged 1,100 b/d in September and October, but it is important to note there is a great deal of monthly variability in these figures. As you can see in the chart below, Permian drilling productivity exceeded 1,000 b/d per well several times over the last twenty-four months only to revert back to the longer-term average and that seems to be what is occurring this time as well. Since October, Permian drilling productivity has indeed gone back to averaging 760 b/d suggesting to us that September and October's readings were the result of normal monthly variation and not the sign of a sustainable shift higher in drilling productivity. In total, we now project that total US production will grow by 1.2 m b/d from the start of the year to the end, or by 1.4 m b/d full-year 2018 over full-year 2017. As we have discussed, this is not enough to balance the market in 2018 nor prevent further steep inventory declines.

CHART 3 Permian New Production per Completed Wall



Source: EIA Drilling Productivity Report, Goehring & Rozencwajg Models

As we have discussed, we believe the declining number of Tier 1 drilling locations in the Bakken and Eagle Ford shales will be the biggest influence on shale production growth going forward. In our third-quarter letter we described a unique way of modeling shale reserves using "Hubbert Linearizations," and this analysis suggests it will be highly unlikely, if not impossible, to replicate the strong growth from those basins in the coming years. Last quarter, we wrote how many top oil executives (notably Mr. Papa from Centennial Development Corporation and Mr. Hamm from Continental Resources), agreed based upon comments from their quarterly conference calls. We also argued that the slowdown in production from February to August was the result of this resource depletion. We have received many calls asking if the uptick in production in September and October has changed our outlook at all. In short, the answer is no.

As we described above, the acceleration in production was largely isolated to the Permian basin, not the Eagle Ford or Bakken where the exhaustion of Tier 1 acreage is of most immediate concern. Moreover, as we described the acceleration in the Permian was within the bounds of normal variation for

that play and indeed has since moderated. However, in keeping with our "road map" and "mile markers", what data do we see today that gives us confidence our models are still pointing us the right direction?

Over the past five years there have been three major trends affecting overall drilling productivity (or how much oil is produced per completed well): longer laterals and larger "frac" jobs have both increased productivity while a shift to lower quality acreage (the third major trend) has reduced productivity. Our hypothesis is that operators drilled longer and larger wells to help offset the shift from Tier 1 to Tier 2 acreage. As drillers reach the limits of both lateral length and frac size, deteriorating acreage quality will quickly come to the fore.

Drilling longer laterals does not increase the total reserves of the field, since there are ultimately fewer (albeit larger) drilling locations available. Therefore, most analysts look at drilling productivity per lateral foot to normalize for length. While drilling productivity per lateral foot has steadily increased in the Bakken and Eagle Ford over the last five years, our models suggest this has occurred as larger frac loadings (primarily sand) have more than offset the move to lower quality acreage. For example, sand loadings in the Bakken and Eagle Ford respectively have increased by 150% and 70% over the last five years. Although it is extremely difficult to determine the exact impact of these larger, more intense completions, most industry experts we spoke to agreed that the 150% and 70% increase in Bakken and Eagle Ford loadings should have resulted in production increased of approximately 70% and 35% respectively on a like-for-like basis. However, the average well has seen initial production per lateral foot increase by only 50% and 17% respectively for the Bakken and Eagle Ford over that same period.

We believe the short-fall could very well be the result of operators moving from Tier 1 drilling locations to less productive Tier 2 locations. Let's assume a Tier 2 well is half as productive as a Tier 1 well (please listen to Mr. Papa on the Centennial Development fourth quarter conference call) and that operators started out drilling mostly Tier 1 wells. In order for a 70-150% increase in loadings to result in only a 17-50% increase in production, operators would have to have gone from drilling mostly Tier 1 wells five-years ago to drilling over ~30% Tier 2 wells today.

While this analysis is only a rough guide and analysts can question our assumptions, it provides a few critical take-aways. First, the shift towards more Tier 2 wells will likely continue as operators appear to have largely depleted their Tier 1 inventory. Secondly, it is unlikely larger loadings will offset this quality degradation going forward. Most operators agree they have hit the limit of increased sand loadings, and that further increases are not economic. If operators go from their current 30% of Tier 2 wells to a 50/50 mix over the next 18-24 months while sand loadings remain the same, the average Bakken and Eagle Ford drilling productivity per lateral foot would decline by 15%. Based upon the current rig counts in both plays, production growth would turn sharply negative for both the Bakken and Eagle Ford.

We admit that this is not meant to be a precise forecast. Instead, we mean to show how the actual drilling productivity from the Bakken and Eagle Ford over the last five years, when adjusted for sand loadings, is consistent with the premise that operators have run out of Tier 1 wells. Since most operators agree that sand loadings in the completion process have hit their maximum, productivity will likely fall from here as underlying resource depletion comes to the fore.

Before we finish today, we'd like to discuss recent developments in the OPEC world. First, the humanitarian crisis in Venezuela continues to impact the national oil industry. Over the last 29 months, production has fallen sharply by 870,000 b/d and these declines are accelerating. Without a material change in that country we cannot see how production will not continue to decline substantially from here. Next, tensions in the Middle East have again raised the issue of an "instability premium" in the oil market – a dynamic not seen for several years. In particular, oil prices have responded to the recent events in Syria. With Saudi Arabia supporting the Syrian rebels, and Iran and Russia supporting the Assad regime, the recent actions by the United States now means that four of the world's top five oil producing countries are involved in a proxy-conflict in the Middle East. Tensions such as these could be put aside in a world of crude surplus, but given global inventories and our outlook for supply and demand, we believe market watchers today are much more concerned with geo-politics than they have been for quite a while.

"OIL MARKETS ARE IN DEFICIT, AND WE BELIEVE PRICES ARE HEADING MUCH HIGHER. INVESTORS SHOULD MAINTAIN THEIR EXPOSURE TO OIL-RELATED INVESTMENTS."

Oil markets are in deficit, and we believe prices are heading much higher. Investors should maintain their exposure to oil-related investments.

Our Visit to India: The Big Changes No One is Talking About

Over the last six months, we have written about India and its commodity demand growth. Since 2000, the world's focus has been primarily on China, as it went through what we call its "S-Curve" tipping point of commodity demand. Once an economy hits a certain level of per-capita real GDP, its commodity intensity per unit of growth begins to accelerate materially. China hit this inflection point twenty years ago, at which point most commodity analysts began to chronically underestimate Chinese demand. Because of India's muted resource demand growth over the last fifteen years, most market watchers have not even attempted to estimate when it might enter its "S-Curve" tipping point. Based upon our research, we believe that time has arrived. For those readers interested in our reasoning and research, please revisit our last two letters where we make this argument. About a year ago, data began confirming what our models had predicted, so we decided to travel to both India and Pakistan at the end of February to learn more. Over nearly two weeks, we met with upwards of thirty companies, consultants and government officials and our outlook today is even more bullish than it was before we left. (Our Pakistan trip alone could fill this letter and we plan to write about it in depth later.)

"OVER NEARLY TWO WEEKS, WE MET WITH UPWARDS OF THIRTY COMPANIES, CONSULTANTS AND GOVERNMENT OFFICIALS AND OUR OUTLOOK TODAY IS EVEN MORE BULLISH THAN IT WAS BEFORE WE LEFT. "

We vividly remember our first arrival in Mumbai back in the fall of 2007. As we landed, the slums surrounding the airport were barely visible through the thick haze and smoke that enveloped the city. The old Mumbai airport was frozen in time. The faded walls were covered in a layer of soot, and we remember the heat in the packed arrivals terminal –the air conditioning was not functioning. Surging crowds pressed in as we jostled our way to the cab stand. The guidebook warned that clouds of malarial- bearing mosquitos inhabited the standing water around the airport, which only added to the third-world experience.

The roads leading into the city were in poor shape and most vehicles were two-wheelers. The taxis were all decades old and most had seen extreme use. Almost all the vehicles on the road, including all the taxis, were Tatas. When the traffic ground to a halt at the few traffic lights, swarms of beggars (including young girls carrying infants and young boys purposely blinded for the job) banged on the windows, asking for money. Some children were selling copies of Rudyard Kipling's "Kim." Millions lived either in vast slums or on the streets. We have been to many third-world countries (including

some of the poorest of West Africa), but even we were taken aback by our first experience in India.

In 2007, India had only just surpassed $900 in real per capita GDP. Over the next four years, we returned three more times and traveled throughout the country. We watched as India took its slow and often frustrating first steps forward. Since our first visit, real per capita GDP has grown by over 7% per year and is now approaching $2,000. The difference between the India we saw in 2007 and 2018 was impressive. For example, the old airports in Mumbai and Delhi have been replaced with ultra-modern ones as part of a nationwide infrastructure program. The new Mumbai airport now handles over forty-five million passengers each year and both airports look like they belong in Singapore or Dubai. The only problem is they are already testing their capacity. Strong economic growth combined with a robust low-cost carrier network has resulted in a sharp increase in Indian air travel. As compared to 2007, the roads are well paved in every city we visited (Mumbai, Delhi, Ahmedabad and Kochin) and the bulk of the traffic was from automobiles which are now all brand-new models, many Japanese and Korean. The two-wheelers that remained were mostly motorcycles instead of scooters. There was much less human and animal traffic. Thankfully, the number of young beggars on the roads is drastically less.

Development of this type is exactly what you expect to see in a country that is going through its "S-Curve" tipping point. Seeing these changes firsthand has left us more convinced than ever that Indian commodity demand will surge over the coming decade.

Last year, the Indian economy was negatively impacted by two controversial programs introduced by Prime Minister Modi that resulted in widespread dislocations. First was the unified federal VAT program (GST) while the second was "demonetization," both of which had large-scale impacts on the economy. In an attempt to reduce tax avoidance schemes, Modi announced on November 8th 2016 that all 500- and 1,000- rupees bank notes (~$10-20 equivalent) would need to be exchanged at a bank within fifty days. This action led to widespread currency shortages for months. While many have argued the effectiveness and need for such policies, they undeniably created numerous economic dislocations in 2017. These dislocations have now worked their way through the economic system and growth appears to be back on track. In fact, since we last wrote, Indian GDP growth for 2017 was revised higher to 7.4% and is expected to persist for several more quarters.

"NO COMMODITY WILL BE MORE IMPACTED BY INDIA'S GROWTH THAN OIL AND JUST-RELEASED GOVERNMENT DATA FOR THE FIRST QUARTER SHOWS ROBUST INDIAN OIL DEMAND GROWTH OF 8.0%."

No commodity will be more impacted by India's growth than oil and just-released government data for the first quarter shows robust Indian oil demand growth of 8.0%. Also, the government announced double-digit automobile sales growth. As we have previously discussed, the IEA, has started to chronically underestimate Indian oil demand, just like they did for China when it first passed through its "S-Curve" tipping point in 2003. Since the IEA first released their projections for 2018 last June, they have revised Indian demand higher by nearly 250,000 b/d (they have also gone back and revised past years by as much as 300,000 b/d). We think more revisions are coming. For example, the IEA is projecting that India's first quarter demand only grew by 7.4% (instead of the 8.0% actually reported). Furthermore, the IEA is expecting full-year Indian demand growth of 6.4% suggesting a dramatic slowdown from here. Were Indian demand growth to stay at the first quarter's 8% for the rest of the year, the IEA would have to revise its estimates higher by another 100,000 b/d on top of the 250,000 b/d revised to date. Given the recent acceleration of Indian GDP, we think continued upward revisions to India's oil consumption are highly probable.

Here's a very interesting development taking place in India that very few (if any) Western analysts

have commented upon. India is in the process of undertaking massive reforms to its natural gas and power sectors that have the potential to dramatically impact their economy (and future economic growth) going forward. India has announced plans to implement a physical natural gas trading hub with transparent pricing and open access. Today, the Indian natural gas market has neither of these features. Instead, natural gas is priced based upon its source (domestic or imported LNG). Furthermore, the state-owned enterprise, GAIL controls both the marketing and transportation of natural gas through its network of pipelines, effectively rendering it a "closed" system. Making matters even more complicated, domestic Indian gas production has declined substantially over the past decade as the great promise of the KG basin suffered from massive technical problems and production shortfalls. As a result, many power plants that depended on an ample supply of low-priced domestic gas now find themselves "underwater" on their power-purchase agreements and are either operating at a loss (by burning expensive LNG) or else not operating at all. Moreover, given the uncertainty around the pricing and availability of domestic volumes, many projects have been either postponed or cancelled outright. Certain industries (such as "city gas") enjoy preferential access to domestic volumes at competitive prices however this only serves to magnify the uncertainty faced by end-users lower down the priority chain.

"A VERY INTERESTING DEVELOPMENT IN INDIA THAT VERY FEW (IF ANY) WESTERN ANALYSTS HAVE COMMENTED UPON: INDIA IS IN THE PROCESS OF UNDERTAKING MASSIVE REFORMS TO ITS NATURAL GAS AND POWER SECTORS THAT HAVE THE POTENTIAL TO DRAMATICALLY IMPACT THEIR ECONOMY (AND FUTURE ECONOMIC GROWTH) GOING FORWARD."

While we were in India, it became clear that PM Modi has made it a priority to reform the current system. These reforms are centered around the adoption of a natural gas trading hub. While many of the details of such a system are yet to be finalized, there are several prerequisites that must be carried out. First, most participants agree that natural gas sales will need to be taxed under the federal "GST" program to allow for feasible pipeline sales across state lines. Next, GAIL, the parastatal natural gas company, will need to be "unbundled" which means separating the marketing business from the pipeline transportation business. In conjunction with this effort, the Indian pipeline network will become "open access" and any party will be able to market their own natural gas and transport it along the Indian infrastructure. Lastly, there is talk of implementing a so-called "unified tariff" where customers would pay a fixed rate to use the pipeline system regardless of distance traveled.

PM Modi hopes to encourage the development of both upstream and downstream gas assets in India. Today, a domestic gas producer receives a low fixed price despite gas shortages (met with LNG) whereas under the new system the producer would receive a market-based price. Furthermore, opening the pipeline system would allow the producer flexibility in marketing his production. Next, it is hoped the new system will provide greater transparency around both volumes and prices both of which should encourage additional natural gas demand among power providers and industrial end users. Lastly, the unified tariff will ultimately act as a transportation subsidy for those users at the extremities of the network (or a tax for those near the center). It is hoped that this will encourage the development of a pipeline network in the eastern parts of the country that today cannot access enough natural gas.

These reforms are all expected to be passed by the end of 2018 and the government has just issued a request for proposals from international consultants with the aim of selecting a finalized plan in three months' time. While the ultimate impact of these reforms will depend on several factors, the end result is that the worlds' second largest country by population is now in the process of deregulating its natural gas and power market. The impacts to India's economic development and growth have the potential to be huge. Lack of investor interest in the monumental reforms only goes to show how little attention is currently being paid to India.

"WHILE THE ULTIMATE IMPACT OF THESE REFORMS WILL DEPEND ON SEVERAL FACTORS, THE END RESULT IS THAT THE WORLDS' SECOND LARGEST COUNTRY BY POPULATION IS NOW IN THE PROCESS OF DEREGULATING ITS NATURAL GAS AND POWER MARKET. THE IMPACTS TO INDIA'S ECONOMIC DEVELOPMENT AND GROWTH HAVE THE POTENTIAL TO BE HUGE. LACK OF INVESTOR INTEREST IN THE MONUMENTAL REFORMS ONLY GOES TO SHOW HOW LITTLE ATTENTION IS CURRENTLY BEING PAID TO INDIA."

Lastly, we'd like to touch on a theme that we wrote about extensively in last quarter's letter: urbanization. The largest driver of the "S-Curve" tipping point is urbanization. When an emerging market urbanizes, its demand for natural resources grows dramatically. As such, we found it very interesting that the largest source of incremental natural gas demand is coming from distribution of gas into urban buildings. The so-called "city gas" segment of demand is growing by 20% and shows no signs of abating. The government has awarded city gas contracts for 75 cities thus far and while we were in India they were in the process of awarding the next 100 concessions. Not only is this an important part of the natural gas story, but it confirms the growing importance of continued urbanization in India. Today only 29% of the country lives in cities (consistent with China in 2003) but this figure is expected to reach 50% over the next fifteen years. The fact that connecting cities to the natural gas grid is a top priority is a sign to us that urbanization is a trend that will accelerate from here. Along with connecting buildings to the gas grid, city gas contracts include plans to provide CNG for the nation's highway system (the so-called "green corridors"). In our last letter we explained how India was underpenetrated in its highway system, and that we expected this would become a priority going forward.

India certainly has many challenges over the next fifteen years and we'll discuss some of these in an upcoming letter. However, after our trip we are more convinced than ever that India will be the dominant driver of commodity markets over the coming decade. Few people anticipated the impact China would have on global resource markets at the beginning of last decade and we think India is in the same position today.

Copper Market: A Tale of Two Roads & the Impact of Renewables

"AS WE HAVE DISCUSSED IN PREVIOUS LETTERS, WE BELIEVE COPPER HAS ENTERED INTO A HUGE BULL MARKET THAT WILL SEE PRICES SOAR IN THE COMING YEARS. OUR STRONG BULLISH VIEWS ARE BASED ON TWO IMPORTANT FACTORS BOTH UNDERAPPRECIATED BY INVESTORS."

Since the start of the year, copper prices have pulled back 8% and investors have begun to question the sustainability of the past eighteen-month advance. Lackluster demand in 2017 from China, combined with a surge in scrap supply, pushed the copper market into a slight surplus last year. Fears of a global trade war and its unknown impact on global copper markets have also given investors a scare. As we have discussed in previous letters, we believe copper has entered into a huge bull market that will see prices soar in the coming years. Our strong bullish views are based on two important factors both underappreciated by investors. First, the adoption of the EV will be extremely painful but we still believe that we will see EV sales approach the numbers put forward by the International Energy Agency (IEA) several years ago. In order for EVs to accomplish their goal of reducing CO2 emissions, we assume (again using IEA data) renewable-sourced power will grow from 5% of world electricity output today to 9% by 2025. Generating electricity from renewable sources is massively copper-intensive (please refer to our 2nd Q 2016 letter where we discuss why). Given the various copper intensities and load factor assumptions, we projected that renewables would add an incremental 400,000 tonnes per year of entirely "new" copper demand that would accelerate as we progressed into the coming decade. Over the last fifteen years, global refined copper demand has increased by approximately 500,000 tonnes per year. Building out renewable power would, in fact, double annual global copper demand growth.

Although these renewable projections seem far out in the future and somewhat abstract, three real-life examples exist today that show how dramatically copper consumption is impacted when countries build out their renewable generating capacity.

Over the last thirteen years, Italy, Germany and Spain have each embarked on huge, long-term, government-sponsored undertakings aimed at significantly increasing the proportion of electricity generated by renewable sources (primarily wind and solar). Each of these three countries have made massive capital investments to take their renewable power mix from mid-single digit levels to between 30-40% of all electricity generated today.

In order to estimate the impact these massive renewable investments have had on copper demand, we decided to compare the historical copper consumption in Germany, Italy, and Spain to a universe of ten similar industrialized countries. All thirteen of these countries have similar per capita GDP, GDP growth rates, and starting levels of copper demand. However, the ten countries in the universe (the United States, Canada, Australia, Japan, South Korea, Belgium, Finland, France, Sweden) have all have made significantly smaller renewable investments over the last fifteen years.

Copper consumption in the ten countries has dropped significantly, even though per capita GDP rose by approximately 50% over last fifteen years. Given that copper consumption intensity begins to significantly decelerate when a country reaches $20,000 of per capita GDP (the ten countries in our survey had 2003 per capita GDP of $25,000 on average), we should have expected copper consumption in these countries to show only minimal amounts of growth even with their economies growing by 50%. In 2003, our ten-country sample consumed 6.2 mm tonnes of copper (approximately 41% of total world consumption). However, given the declining copper consumption intensity in their economic life cycles, and given copper's very high price which definitely encouraged users to seek substitution (copper spent almost six years above $3.00 per pound), copper consumption in all ten counties fell significantly. By 2017, copper consumption fell to 4.3 mm tonnes, or a reduction of 1.9 mm tonnes (30%). On a per capita basis, copper consumption started 2003 at approximately 20 lbs. of copper consumed per person. By 2017, per capita consumption had fallen to 14 lbs.

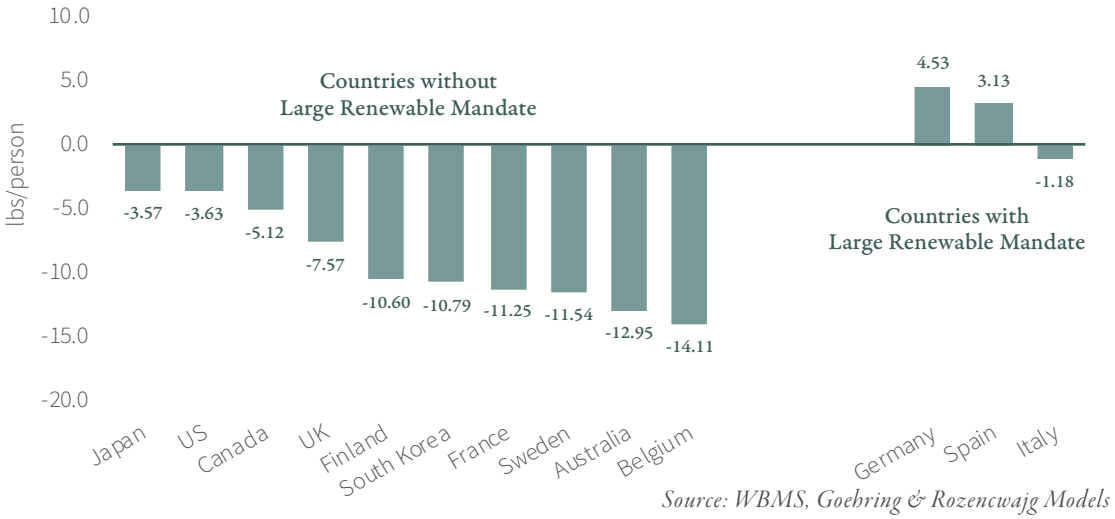
In comparison, the three countries that made massive investments in their renewable electricity base, (Germany, Italy, and Spain), experienced something very different over the same fifteen-year period. For example, Germany's copper consumption increased by 17% (from 1.00 mm tonnes in 2003 to 1.17 mm tonnes in 2017). Spain's copper consumption increased by 23% over the same period. While Italy's copper consumption fell over the period, it did so by only 30,000 tonnes or 5% (much less than the ten-country universe).

Taking these three countries together, the copper consumption over the fifteen-year period increased by 200 tonnes, or about 10%. On a per capita basis, these three countries consumed approximately 23 lbs. of copper per person in 2003 (not too dissimilar from the ten countries in our survey at 20 lbs. per person). However, instead of falling to 15 lbs. per person, like the ten-country survey, per capita consumption actually rose to 25 lbs. per person. The biggest difference between the two groups was the scale of their renewable program.

Using these numbers, we can now make a rough estimate of the potential impact renewables will have on global copper consumption. From 2003 to 2018, the ten countries represented over 40% of total world consumption. During that fifteen-year period their copper consumption fell by 1.8 mm tonnes or 30%. If all ten countries had attempted to replicate the renewable program of Germany, Italy, and Spain, their copper consumption would have grown by 10%, not fallen by 30%. Instead of falling by 1.8 mm tonnes, we should have expected copper consumption in these ten countries to grow by 10%

or 600,000 tonnes. The 2.4 mm-tonne swing in potential demand over a fifteen-year period (1.8 mm actual drop in consumption versus the potential for 600,000 tonnes of demand increase) equates to 160,000 tonnes per year. These ten countries represented 40% of world demand back in 2003 and so we can extrapolate the results to the rest of the world. We estimate that the impact of renewables on a global basis (following this model) would add 400,000 tonnes per year to copper demand.

CHART 4 Change in Per Capita Copper Consumption



Source: WBMS, Goehring & Rozencwajg Models

Although growth in global copper demand was lackluster in 2017, we view that as a lull. Never has the world had as many people entering their "S-Curve" period of strong copper consumption. Very few investors recognize these trends. And please note: all this "S-Curve" related demand comes from traditional sources (i.e., the need to build out the electric grid, etc). However, the impact from renewables investment represents an entirely "new" source of additional demand. This "new" renewable demand will have to be layered on top of the traditional "S-Curve" demand going forward. As the real-life example outlined above clearly demonstrates, you can actually quantify the impact renewable investment is making on copper consumption patterns in Germany, Italy and Spain. Trends in their copper consumption have already significantly diverged from industrialized countries that are investing in renewable at slower rates.

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Regarding supply, the copper analytic community is finally beginning to recognize the severe problems facing future mine supply. Aging mines continue to suffer accelerating depletion problems (a subject we actually began writing about back in 2005), and we have now entered a period where few new large mines will be brought on-line. Copper mine supply grew strongly in 2015 and 2016 as four massive mines in Peru and two new huge mines in Kazakhstan were all brought online simultaneously. Global copper mine supply grew by over 5% in both 2014 and 2015. However, starting in 2017, global copper mine supply growth has turned negative. A 45-day strike at Escondida, the world's largest copper mine, was largely responsible for the decline in mine production last year, however, monthly statistics from the World Bureau of Metals Statistics (WMBS) show that global mine production has again stagnated over the last ten months even as Escondida came back on-line. Our modeling tells us to expect little growth in mine supply until the middle of 2019, when the large Cobre Panama mine will begin to ramp up its production to 190,000 tonnes (contributing approximately 1% to global supply). After Cobre Panama comes online, a three- to four-year gap has emerged before the long-delayed Oyu Tolgoi underground mine in Mongolia comes on line at 260,000 tonnes in 2022 and the

massive Kumoa mine (250,0000 tonnes)in the Democratic Republic of Congo (DRC) is scheduled to commence production in 2023. The Kumoa project, controlled by Ivanhoe mines, has already run into severe royalty and taxation issues with the DRC government, so it will have to be watched closely to see if the timetable for the mine start-up eventually gets pushed out.

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Copper remains our favorite base metal. Few markets combine such robust demand and little in the way of supply growth for the next four to five years. We believe the copper market has slipped into structural deficit and that much higher copper prices will be needed to force this gap closed. We recommend investors to hold all copper related investments

Uranium Markets: The Quiet Before the Storm

Last quarter we described our long historical involvement in uranium markets and how we had turned bullish for the first time in many years. Since we last wrote, neither the uranium price nor the fundamentals have changed materially, but, we have updated both our supply and demand models looking forward and we believe they paint a picture that is even stronger than before. For the first time in nearly a decade, uranium markets are on the verge of slipping into deficit. Originally, we had expected the uranium market to slip into large structural deficit in the middle of next decade, but recent developments to global mine supply and increases in our demand assumptions have pulled this forward by several years.

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From the mid-1990s to the middle of last decade, the world generated approximately 2,600 terawatt hours of electricity from nuclear sources which required 160-180mm lbs of uranium per year. Mine supply averaged 90 mm lbs while so-called secondary supply (primarily from the repressing of old Soviet-era nuclear stockpiles) provided the rest. Starting around 2000, secondary supply growth turned negative, the market recognized the huge gap between demand and global mine supply and uranium prices entered into a bull market. From 2002 to 2007, prices increased sixteen-fold from $9 per pound to $150 per pound.

Uranium prices pulled back following the global financial crisis, but still exceeded $70 per pound as recently as in 2011. Then Fukushima hit. In the aftermath of that event, existing nuclear power generation (and by extension uranium demand) plummeted as forty plants were decommissioned entirely (led by Germany and Japan) while many more began operating at reduced rates. In total, we estimate that reactor shut-downs reduced uranium demand by 11 mm lbs per year while reactors operating at reduced rates lowered demand by 14 mm lbs per year between 2010 and 2016. As the OECD world was decommissioning portions of its nuclear power capacity, the non-OECD world (led by China) was busy starting up new facilities. Between 2010 and 2016, we estimate some forty-four new reactors started up. In total, these reactors dispatched 212 terawatt hours of electricity in 2016 and consumed 14 mm lbs of uranium. The net effect of the shut-downs, curtailments, and new reactors was that by 2016, total uranium demand was nearly back to its pre-Fukushima highs, approaching 175 mm lbs per year.

Unfortunately, at the same time as these countervailing demand dynamics were taking place, global mine supply surged. Cameco brought on its new Cigar Lake project and Kazataprom (the national uranium company of the Kazakhstan government) materially increased its production. We estimate that global uranium mine supply increased by over 30% from 115 mm lbs in 2010 to 160 mm lbs by

2016. Meanwhile, secondary uranium supply continued to average between 35-40 mm lbs per annum which left the global uranium markets oversupplied by 20-25mm lbs per year.

Our original models had predicted that this surplus would be worked through by the middle part of next decade as new reactors in China, India, Pakistan, and Saudi Arabia among others were commissioned at the same time as Japanese reactors were slowly brought back on-line. In total, there are fifty-seven reactors currently under construction and one hundred and sixty reactors in the final stage before production begins. In aggregate, these reactors have a gross capacity of 223 megawatt equivalents and will dispatch as much as 1500 TWh. This will add an incredible 100 mm lbs of uranium demand per year. We model that Japanese reactor restarts could add another 15-20 mm lbs of uranium demand (assuming they reach 65-70% of capacity). Furthermore, there are an additional three hundred and fifty reactors being proposed (half of which are in China) that would generate 400 MWe of gross capacity and would increase demand by nearly 190 mm lbs per year. Even with only those reactors that are being constructed or in the final stages of planning, the global uranium market would go from surplus to a nearly 100 mm lbs deficit by 2030 – the largest deficit ever recorded.

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However, as described in our last letter, there have been recent developments that have greatly accelerated this timeline and tell us the uranium market could slip into deficit as soon as next year. At today's uranium price ($23/lb), we calculate that almost half of all the world's mine supply is operating at cash losses. This is unsustainable and over the last few months we have seen two large scale supply cut-backs. First, Cameco announced it was suspending production at its McArthur River mine beginning in January 2018 (15 mm lbs of uranium production). Next, Kazataprom announced it would cut production by 20% (another 9 mm lbs of uranium production per year) for a period of three years. This with the Cameco cuts amount to nearly 25 mm lbs of total supply curtailments starting this year.

These supply curtailments alone will cut the global uranium surplus nearly entirely. At the same time, we model thirty-six new reactors that have or will come on-line between 2017 and the end of 2019. As these reactors ramp up to full capacity, they will generate 266 terawatt hours of electricity and will consume 18 mm lbs of uranium, pushing the global uranium market into deficit at some point in the next twelve months.

Analysts remain concerned that large global uranium inventories (the result of the Japanese taking deliveries post-Fukushima after they shut their reactors) will keep uranium prices depressed for the foreseeable future. While it is true that inventories today are high, we believe they are more manageable now than they were during the post-Soviet reprocessed weapons programs of the last bear market. Furthermore, we expect that much (if not all) of these stockpiles will go towards the pre-commissioning inventory-build required by all new reactors. If you assume Japan received and stockpiled all of the uranium it would have needed to run its generation capacity at near 100% utilization since Fukushima, we estimate the Japanese stockpiles would have reached ~120-130 mm lbs. Given that a new reactor requires approximately two years' worth of fuel stockpiled before commissioning, the Japanese stockpile would be fully taken up by new reactors with aggregate generating capacity of 1,000 TWh, less than half of the new capacity we expect to come on-line over the next ten years. In other words, we think the Japanese stockpiles will simply be absorbed by the stockpile requirements of new reactors, leaving annual supply to meet annual demand. Given that we expect annual uranium demand to double over the next ten to fifteen years, while mine supply is being shuttered today we do not see how this market can avoid substantial deficits going forward.

"THIS IS THE TYPE OF MARKET WE LOVE TO GET INVOLVED WITH: THE PRICE HAS COLLAPSED BY AS MUCH AS 90%, INVESTOR INTEREST IS MINIMAL, VALUATIONS ARE LOW, AND THE FUNDAMENTALS ARE IN THE PROCESS OF QUIETLY SHIFTING POSITIVE."

We have monitored the uranium market closely over the last several years waiting for the moment when the market would shift back into deficit. With the announcements of production cuts by Cameco and Kazataprom, we believe that moment has been pulled closer by several years and is upon us. This is the type of market we love to get involved with: the price has collapsed by as much as 90%, investor interest is minimal, valuations are low, and the fundamentals are in the process of quietly shifting positive.

Precious Metals : Why We Still Favor Oil over Gold

In last quarter's letter, we put forward a "roadmap" that natural resource investors could use to determine when to increase and decrease their precious metals exposure during the upcoming resource bull market. As we wrote, commodities are about as cheap as they ever get relative to financial markets. In each of the previous cases of radical undervaluation (1929, 1970, and 1999), the resulting massive commodity bull market was accompanied (and often led by) gold. Given gold's radical under-valuation today, (a subject that we discussed at length in our 1st Q 2016 letter), we believe all investors should have precious metals exposure. As we outlined in our last letter, in the next six months to a year, if our "roadmap" is correct, investors will be presented with the investment opportunity of a lifetime to increase their exposure to precious metals.

"AS WE WROTE, COMMODITIES ARE ABOUT AS CHEAP AS THEY EVER GET RELATIVE TO FINANCIAL MARKETS. IN EACH OF THE PREVIOUS CASES OF RADICAL UNDERVALUATION (1929, 1970, AND 1999), THE RESULTING MASSIVE COMMODITY BULL MARKET WAS ACCOMPANIED (AND OFTEN LED BY) GOLD."

What is keeping us from recommending a full weighting in precious metals today? As you might remember from our last letter, we like to study the relationship between the price of gold and the price of oil over time. Over the last one hundred and sixty years, these two commodities have traded with a ratio of between10:1 and 30:1 nearly 90% of the time. When the ratio has fallen to ten or below (when an ounce of gold buys ten barrels of oil), gold is considered cheap and oil is expensive and investors should favor precious metals investments over oil. When the ratio reaches thirty and above (when one ounce of gold buys thirty barrels of oil), gold is considered expensive and oil is cheap: investors should favor oil investments over precious metals (please refer back to our 1st Q 2016 letter, where we discuss the long history of gold-oil ratio going all the way back 1858). In our last letter, we outlined our belief that we were repeating the situation that developed at the start of the last great commodity bull market back in 1999. In a situation not dissimilar to today, commodities in general and gold in particular were extremely undervalued. However, during the OPEC price war that raged at the end of that decade, oil collapsed to $11 per barrel. With gold near $300 per ounce, the gold-oil ratio almost hit thirty, indicating to us that oil was radically undervalued to gold and that oil investments should be favored over gold.

This strategy worked. Over the next two years, oil surged by 200% while gold actually fell 10%. Oil-related equities rose by 50% while gold stocks fell by almost 40%.

As outlined in our last letter, we believe we are closely repeating that 1999-2000 experience today. An OPEC-led price war at the end of 2014 caused oil prices to enter a severe bear market. In a familiar bout of panic selling , oil prices collapsed in February 2016 to $26 per barrel. With gold selling for $1,250 per ounce, the gold-oil ratio hit forty-seven -- the highest level ever recorded in one hundred fifty-eight years of data.

We should point out the previous record high in the gold-oil ratio (39) was reached in the depths of the Great Depression in 1933. Although open to debate, we believe 2016's reading of 47 represented one of the greatest selling climaxes in global oil markets of all time. Given the ratio's extreme levels, we

expected oil to significantly outperform gold since 2016, and it has. Since the beginning of 2016, oil has surged over 150% while gold has advanced less than 25%.

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So far, it looks like we are repeating the 1999 experience. The major difference between today and 1999 surrounds the equities. Because of the intense bearishness surrounding the future of crude, oil-related stocks have advanced only 50% since bottoming in 2016 while gold stocks have advanced almost 85%.

Given the huge outperformance of oil versus gold over the last two years, the gold-oil ratio has contracted significantly and today stands at twenty -- very close to its long-term average of eighteen. Looking back at the gold-oil ratio during the post-World War II period, every time it either approaches or exceeds thirty, it has a tendency to swing back from one extreme to the other. In the period from 1999 to 2000, this is exactly what happened. As oil advanced strongly and gold declined, by the summer of 2000 the gold-oil ratio had fallen below ten, and by the fourth quarter of 2000 the ratio had hit seven (its all-time low).

At that point, gold had become radically undervalued relative to oil and history strongly suggested that investors should aggressively buy gold. In retrospect, favoring gold investments over oil produced substantial excess returns. For example, gold proceeded to advance by over 50% in the next three years, while oil fell over 10%. But it was in the gold stocks where investors made huge returns. For example, the average oil stock lost almost 15% during that time period, while the average gold stock surged by 550%!

At the time, we were aggressively recommending gold stocks. I was profiled in the June 24th 2000 issue of Forbes Magazine , where I stated that gold was one of my favorite investment ideas and could be the best performing asset class of the coming decade. With gold at $280 per ounce, my $2,500 price target seemed ludicrous, but gold in 2011 did hit $1,900 per ounce.

"WE BELIEVE OIL PRICES ARE HEADED MUCH HIGHER, POSSIBLY INTO TRIPLE DIGIT TERRITORY. AT THAT POINT, WE BELIEVE THAT GOLD WILL BECOME UNDERVALUED RELATIVE TO OIL AND WE WILL BE GIVEN A TREMENDOUS OPPORTUNITY TO INCREASE OUR EXPOSURE TO PRECIOUS METALS INVESTMENTS."

Although history can be an unreliable guide, today we believe that we are closely following the 1999 to 2000 experience. First, as we've outlined in these letters, we believe oil prices are headed much higher, possibly into triple digit territory. At that point, we believe that gold will become undervalued relative to oil and we will be given a tremendous opportunity to increase our exposure to precious metals investments.

Gold and silver prices were lackluster in the 1st Q, even with the US dollar continuing its decline. Gold stocks were also weak. The NYSE Gold Bugs Index fell 9%. On the positive side, as evidenced by continued physical premiums, gold consumption in China was strong. India, however, has been lackluster. Regarding Western investors, we are seeing another round of accumulation. After shedding almost 1,100 tonnes of gold over three years from 2013 to 2015, the eighteen physical gold ETFs we follow began to aggressively accumulate gold at the beginning in 2016, eventually adding back over 600 tonnes. By the end of 2016, these ETFs once again began shedding gold, eventually selling almost 35% of what they accumulated in 2016. However, since last summer, we have begun another period of consistent accumulation. In the last nine months, these eighteen ETFs have added 180 tonnes of new gold. We have often said that the upcoming bull market in gold will be driven by western investors' demand (we believe the gold bull market from 2000 to 2011 was driven by eastern demand, primarily India and China). So watching the buying behaviors of these ETFs should be another data point to follow in timing the upcoming bull market. As of now, we are getting positive signals regarding the

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return of western demand. Regarding western investment's silver demand however, signals are still neutral. The nine physical silver ETFs we follow had a big accumulation period last summer, but since then all the accumulated silver has been shed, and no trend has emerged in the 1st Q. Silver usually leads gold in bull markets, so we are carefully watching the buying patterns of these silver ETFs. Combining the lackluster price behavior of silver and related silver stocks and given the trendless activity of buying and selling by the silver ETFs, we believe the gold bull market is still off in the future.

To summarize, a huge bull market in precious metals awaits investors in the not-too-distant future. Look for the gold-oil ratio to fall into the low double digits. In next quarter's letter, we will discuss at length what price targets we should expect in precious metals markets. The numbers we present might shock you, but remember, we were called crazy after we called for gold to hit $2,500 in that Forbes's article back in 2000. In retrospect, that price prediction was not far off the mark.

North American Natural Gas: Supply Surging - Stay on the Sidelines

After a cold start to winter, temperatures moderated in February and March. In total, the winter ended up being exactly normal on a gas-weighted heating-degree day basis. When we last wrote, we explained how analysts were beginning to compare the 2017/2018 winter to the so-called "polar vortex" winter of 2013/2014, however such comparisons were ultimately premature. Total heating-degree-days were a full 12% less than four years ago.

US inventories drew by 1.8 trillion cubic feet during the quarter, ahead of the five-year average of 1.6 tcf but well behind the massive 2.2 tcf taken out of storage during 2013-2104 the polar vortex withdrawal season. Inventories now stand nearly 400 bcf below average for this time of the year – largely unchanged from the start of the year. To put today's inventory situation in perspective, it is less than half the deficit we experienced at the same time in 2014 after the polar vortex winter.

When we last wrote, we explained how surging gas production had us very concerned about North American natural gas fundamentals. While demand remains extremely strong and LNG exports are now a reality, incredible production growth from the Marcellus, Utica, Permian and SCOOP/Stack plays dwarf any and all increases in demand.

"GIVEN THE EXTREMELY DEPRESSED PRICE, HIGH LEVELS OF BEARISHNESS, AND LOW EQUITY VALUATIONS, NATURAL GAS REPRESENTS THE TYPE OF MARKET WE TYPICALLY LOVE. HOWEVER, GIVEN SURGING GAS SUPPLY, WE SIMPLY CANNOT BECOME CONSTRUCTIVE."

Over the last five years, we have made multiple attempts to get bullish on North American natural gas. Given the extremely depressed price, high levels of bearishness, and low equity valuations, natural gas represents the type of market we typically love. However, given surging gas supply, we simply cannot become constructive. To put this supply surge in perspective, consider that the first generation of shale gas wells came on at less than 1 million cubic feet per day and declined by 75% in their first year. Today, the best Tier 1 natural gas wells are coming on at 35-40 million cubic feet per day on a choked basis and are only declining marginally in their first six months. This reflects a near fifty-fold improvement over the last twelve to fifteen years. Moreover, the inventory of Tier 1 drilling locations gets bigger and bigger as we discover new prospective areas (a huge difference from the oil shales). Well results once thought to be impossible are now being reported in no fewer than four plays (Marcellus, Utica, Permian and SCOOP/Stack) and if the recent well results from Ultra Petroleum in the old Pinedale Anticline play are repeatable, there may soon be a fifth new play as well. Ultra's latest wells in

the Pinedale Anticline (an old play we were once involved with more than 25 years ago) are the two largest onshore US wells ever drilled based upon initial production rates.

Not only did US production set a new record in January (the latest data available), but this growth is accelerating. Production growth over the last two months averaged 7 bcf/d year-on-year, a new all-time record. Furthermore, this new production growth record was set using only half the rigs turning in 2014, when the last record was set.

In our next letter, we'll talk about the dynamics in the global LNG market, which we have followed for many years. In particular, several years ago, we predicted that global natural gas would remain much tighter than anyone expected as Chinese LNG demand was set to surge. We are beginning to see evidence that we were correct.

Agriculture: Very Bullish Trends Emerging

"WE BELIEVE A NUMBER OF STRUCTURAL CHANGES HAVE RECENTLY TAKEN PLACE AND THAT INVESTORS SHOULD NOW LOOK TO INCREASE THEIR EXPOSURE TO AGRICULTURAL-RELATED EQUITIES."

Since peaking in summer of 2012, global grain prices have been in a deep and persistent bear market. Peak to trough, corn, soybeans, and wheat prices fell 65%, 51% and 62%, respectively. All made their bear market lows in the summer of 2016. Since then, grain prices have traded sideways as both 2016 and 2017's harvests were among the best on record, causing global grain inventories to surge. We have had very little investment in the global agricultural markets over the last five years as record yields (brought about by a combination of several new genetic traits in both corn and soybeans and excellent global weather conditions) have resulted in surging global inventories. However, we believe a number of structural changes have recently taken place and that investors should now look to increase their exposure to agricultural-related equities.

The most bullish factor emerging in global grain markets is the continued surge in global grain consumption. As we have discussed over the last decade, the number of people living in emerging market economies, who now want to increase their protein consumption, is surging. The commodity most impacted by this protein-related "S-Curve" has been soybeans. In most of the world outside of the United States, soybeans are the feed of choice for both pigs and poultry, two of the most popular protein sources in Asia. Although China's soybean consumption over the last twenty years has exploded (from 25 mm tonnes in 2000 to an estimated 110 mm tonnes today), soybean demand is now surging across the rest of Asia, especially in emerging market economies like Indonesia, Thailand, India, and Vietnam. In the last five years, global soybean consumption has increased by about 15 mm tonnes a year (5% annually). To increase soybean production by 15 mm tonnes, farmers must plant approximately 10 mm additional acres every year. Over the last five years, 50 mm new acres of soybeans have been required to meet surging global demand. About half of these additional 50 mm acres have come from South America and about 30% (or about 15 mm acres) have come from the Unites States. In the US, the additional soybean acres have come at the expense of corn and wheat acres. For example, since 2013, US corn plantings have fallen by 5 mm acres (from 95 to 88 mm acres) while wheat acres have fallen by 10 mm acres (from 56 mm acres to 47 mm acres). Surging global soybean demand is clearly having huge effects on planting trends across all global agricultural markets.

In the case of the US, if yields were to fall back even slightly, reduced corn acreage will ultimately lead to a rapid tightening of global corn markets. The farmer's preference to plant soybeans versus corn is

already being felt globally. Corn production last year was down in the US, Europe, Brazil, and Argentina compared with 2016.

Adding additional fuel to the bullish story is China's stated intention to mandate a new ethanol-gasoline blending policy. Starting in 2020, all gasoline consumed in China must contain 10% ethanol. China's corn production is falling as price supports were eliminated three years ago. Last crop year, the USDA estimated that China's corn production was 216 mm tonnes (down from 225 mm tonnes the previous year). China's corn consumption is estimated to reach approximately 225 tonnes in 2018. Given China's present gasoline consumption and given the corn requirement to produce ethanol, we estimate that an additional 30-35 mm tonnes of corn will be required by the new ethanol rules. Although China holds extremely large corn inventories, (estimates vary between 80 and 140 mm tonnes), you can see this additional grain demand could quickly draw them down.

The release of the USDA 2018 prospective plantings report at the end of March added more bullish underpinnings to global grain markets. Although these numbers have historically been subject to large revisions, US farmers now look to plant significantly less corn and soybeans relative to expectations. Original expectations were for farmers to plant 90 mm acres of corn in 2018, but the USDA estimates came in at only 88 mm acres. In soybeans, farmers now look to plant 89 mm acres versus original estimates of 90 mm acres.

And finally just a comment regarding potential changes in global weather patterns. The global bear market in grains has been exacerbated by outstanding global growing weather conditions. Most agricultural market analysts with long memories say they can never remember such a stretch of near-perfect weather in all grain growing areas of the world. For example, three out of the last four years, crop growing conditions globally have been near perfect.

Although long-term weather patterns are impossible to predict, there are newly emerged weather trends that suggest a repeat of the superb weather period the world experienced over the last four years is becoming more and more unlikely. We have just finished an eleven-year solar cycle that has ended with the sun exhibiting almost no sunspot activity at all. Historically, such troughs in sun cycles that coincide with minimal sunspot activity are usually followed by years of colder and more disruptive agriculture weather patterns.

"AFTER SIX YEARS OF A LONG-DRAWN OUT BEAR MARKET, WE BELIEVE THE FOUNDATION HAS BEEN SET FOR A POTENTIALLY LARGE BULL MARKET IN GRAINS."

With global grain demand so strong, global agricultural markets have come to rely on near-perfect global growing conditions which have resulted in record-breaking crops. If weather trends turn more adverse, any resulting degradation in yields will have a huge impact on global inventories. Any adverse weather conditions in any of the world's growing basins negatively impacting yields could cause global grain inventories to swing from record surpluses to huge deficits in a very short time with huge upward pressure on grain prices.

After six years of a long-drawn out bear market, we believe the foundation has been set for a potentially large bull market in grains.

Investors should increase their exposure to agricultural related equities.