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Energy Musings

Insights into the Energy Industry

Allen Brooks, Managing Director

Energy Musings *contains articles and analyses dealing with important issues and developments within the energy industry, including historical perspective, with potentially significant implications for executives planning their companies' future. While published every two weeks, events and travel may alter that schedule. I welcome your comments and observations.* Allen Brooks

June 8, 2021

Inflation Vs. Deflation Debate And Commodity Supercycle

The investment world is wrestling with whether we are going into a new era of inflation, driven by rising commodity prices or remain in our deflationary era. Energy plays a role.

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One Day In May Marks Beginning Of The End For Big Oil

May 26, 2021 has been described as the worst day ever for Big Oil as Shell lost an emissions case in The Netherlands and ExxonMobil gained activist board members.

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Inflation Vs. Deflation Debate And Commodity Supercycle

Wall Street and Main Street are wrestling with rising prices of everyday goods, often driven by increases in the materials needed to produce them. This means growing concern over price trends for raw materials, labor, and transportation costs. Concern is that the "easy money" stimulus policies of the Federal Reserve, as well as central banks around the world, to aid recovery from the pandemic economic shocks, has created inflationary pressure that will drive up the cost of living for people. The most recent economic data supports the view of rising inflation, but the question is whether this recent trend becomes a permanent feature of our economy. If it does, consumers and economic policymakers will be forced to alter their plans and adjust their perspectives on interest rates and acceptable returns on investments. At the same time, people will be figuring out what shifts in consumption will be needed to live within their incomes.

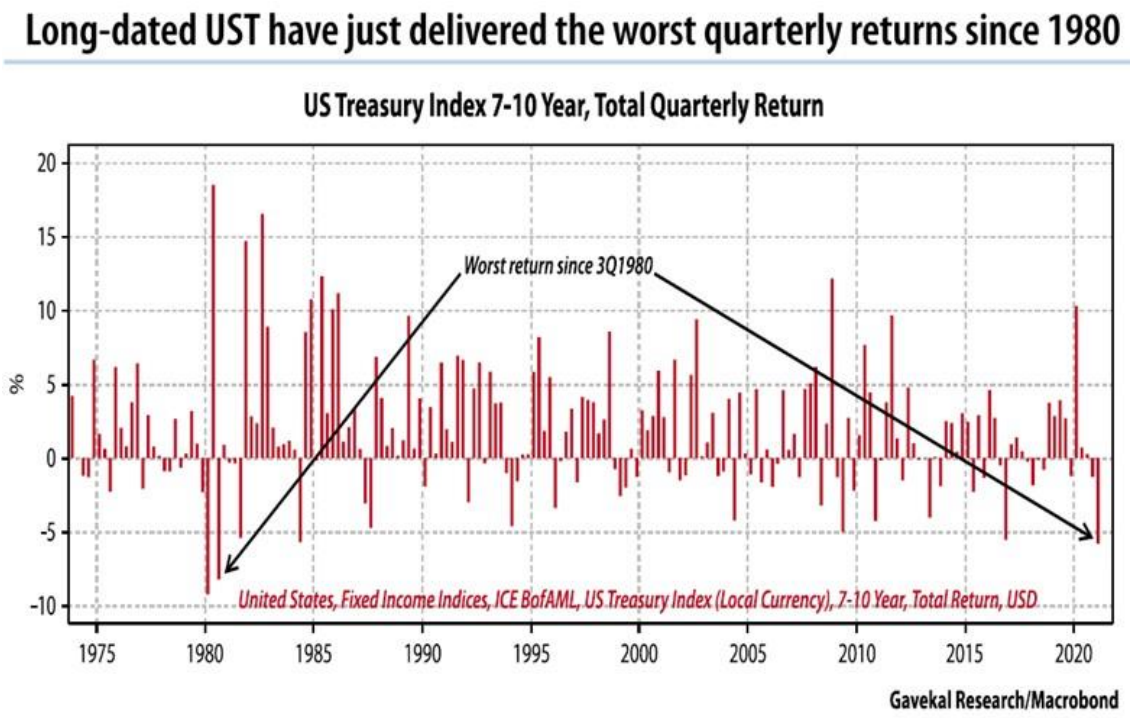
Since last fall, as it became obvious that Covid-19 was beginning to be brought under control and prospects of the arrival of vaccines to fight the virus were on the horizon, investors and policymakers shifted their focus to how and how quickly the economic recovery would come once government lockdowns were lifted. The stock market, always a leading indicator, began lifting the share prices of companies heavily dependent on an economic recovery – the reopening trade. Commodity prices began climbing rapidly, as manufacturing rebounded, and raw materials were in high demand. Rising commodity prices were also driven by logistical challenges in delivering them to manufacturers, as shipping of everything had been hampered by low demand during most of 2020 and the challenges of staffing to handle increased shipping volumes.

We all have memories of empty shelves, as stores were unable to secure products because of outsized demand, production limitations, and transportation issues. The question now is whether these conditions are temporary or reflect a permanent shift in supply and demand patterns. Policymakers' views on this question will impact how they deal with fiscal and monetary policies to accommodate inflationary pressures. Temporary or sustained? The answer will impact our economic future, investments, and the energy market.

Utilizing a series of slides from various investment presentations and research reports, we will explore the cases for and against inflation. It is important to understand that the various slides represent the views of people advocating their position – inflation is likely, or we will experience a continuation of the deflationary environment we are in – and not our opinion.

Louis-Vincent Gave, with global investment strategy firm Gavekal Research, explored the inflation question from the perspective of what may be different this time from the deflationary period of the past 40 years. He pointed out that in a deflationary era, long maturity bonds offer the best hedge. He had a chart covering 1980 to 2021 that showed long-dated Treasury bonds nearly matching the returns from the stock market, with both indices significantly outperforming cash and gold, traditional investments for preserving value. A telling development, possibly signaling a change in the market, is the recent poor performance of 7-10-year Treasury bonds, matching their worst performance in 1980.

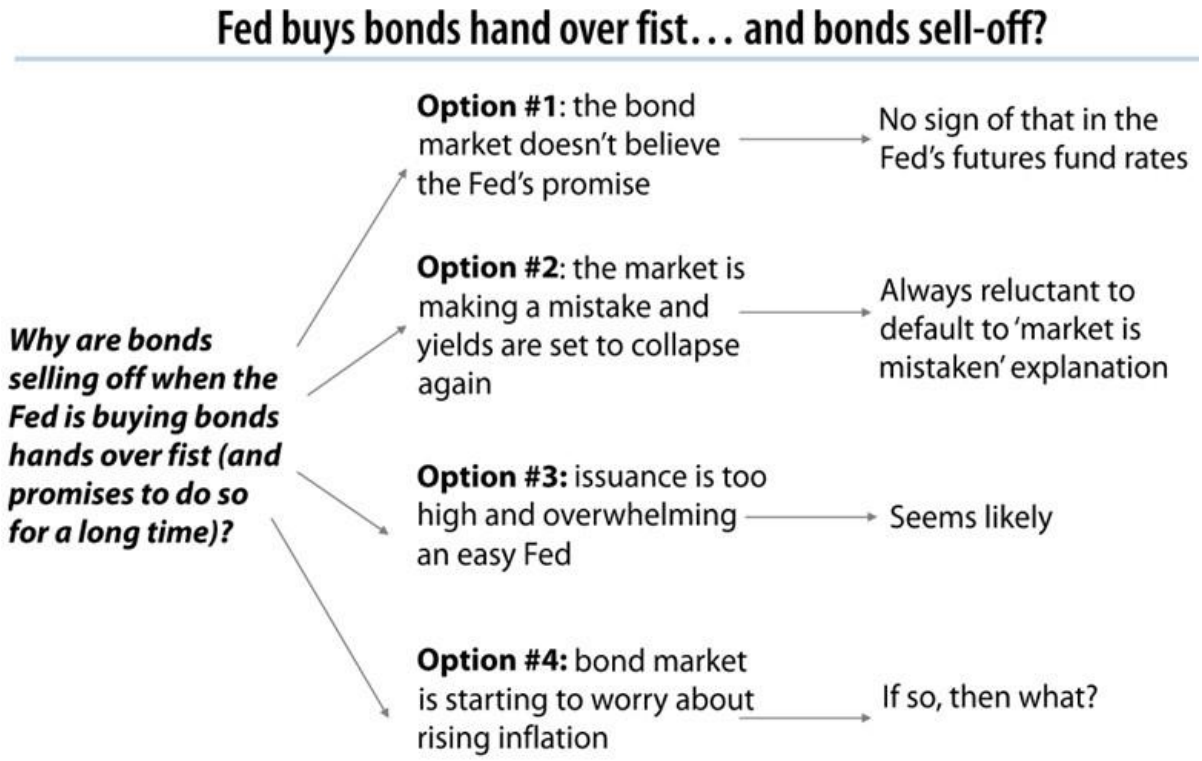
Exhibit 1. Recent Bond Returns Not This Bad Since 1980



Source: Gavekal Research

He also pointed out that during inflationary periods, such as from 1965-1981, bonds are a disaster. During that period, gold and cash outperformed the stock market, in gold's case by fourfold, while cash was marginally better than the S&P 500. Long bonds' performance was 95% below cash returns! Mr. Gave is concerned by the performance of the Treasury bonds given the Federal Reserve buying bonds "hand over fist" while attempting to stimulate the economy. That led him to speculate on what might be going on.

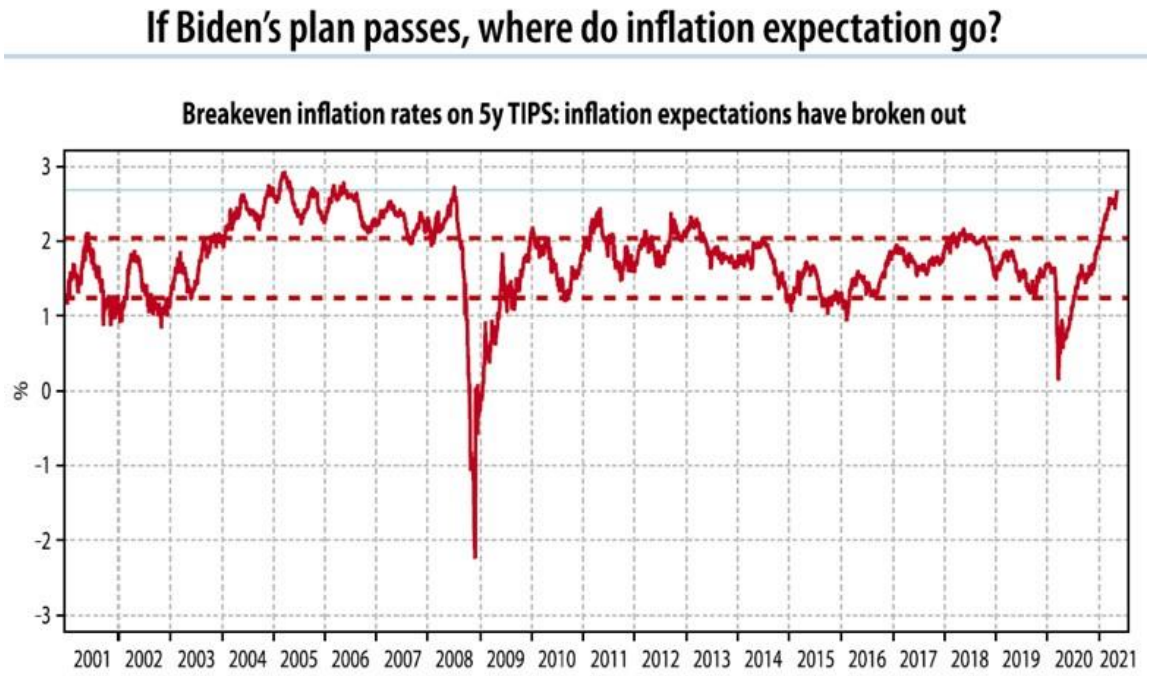
Exhibit 2. Perplexing Reaction Of Bond Prices To Fed Support For Low Interest Rates



Source: Gavekal Research

How can we tell if the bond market is worrying about rising inflation? Not only was the lousy bond performance in 1Q 2021 an indicator, but inflationary expectations are a signal, too.

Exhibit 3. Inflation Expectations On The Rise – Not Good News For Inflation

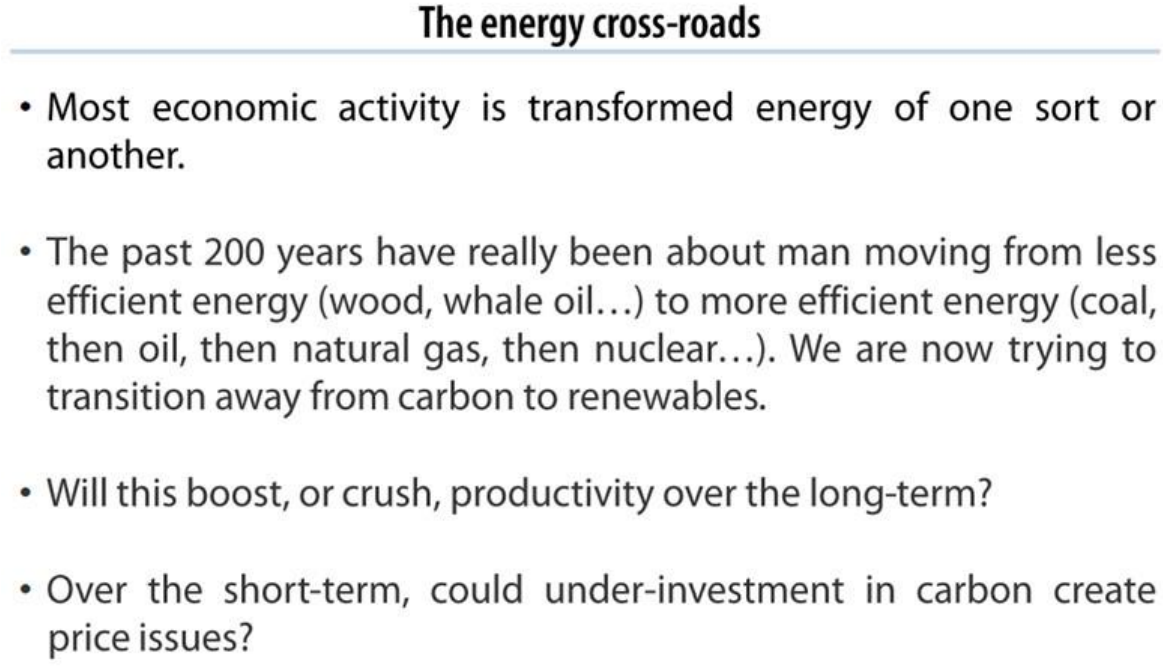


Source: Gavekal Research

We should note that during those periods when inflationary expectations were above 2%, oil prices were exceedingly high. The 2004-2007 period was marked by surging oil demand from China, which caught the oil market by surprise and squeezed global surplus productive capacity lifting oil prices well above $100 per barrel. Note further that the other times when expectations were above 2% – 2010 to 2013 – oil prices surged above $100 again. With inflationary expectations well above 2% now, we should not be surprised that oil prices have climbed from the $20s a barrel in spring 2020 to the high $60s now. Are inflationary expectations a reason to think oil prices might reach Goldman Sachs' target of $80 by year end?

Mr. Gave highlighted the key issues for energy and went on to discuss the current state of the oil market in greater detail. Demand is up, supply is tighter than many people appreciate, and the falling value of the U.S. dollar is helping lift oil prices.

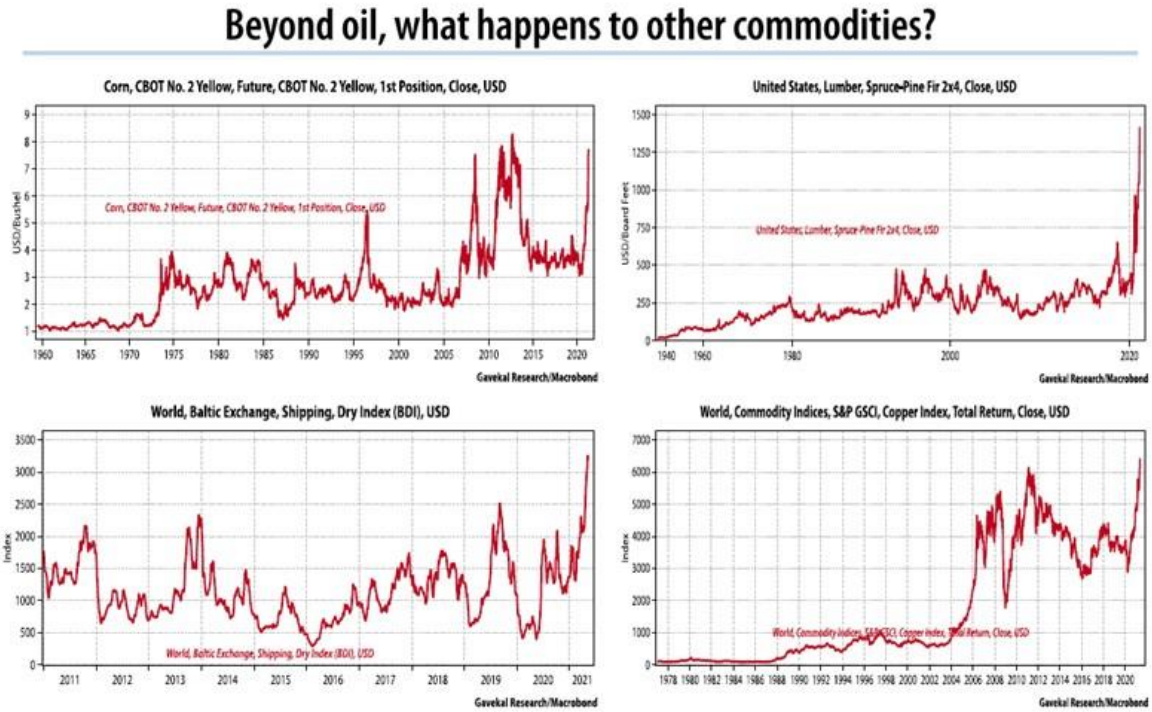
Exhibit 4. Questions For The Oil Market To Consider



Source: Gavekal Research

The final two points on the above slide raise critical issues that will shape the answer to the inflation/deflation question. Currently, there are numerous signs of sharply rising commodity prices, not only compared to more recent periods, but also when considered in their pricing history. The following slide shows the price history for corn, lumber, copper, and shipping. All the commodities, other than corn, are at all-time highs for prices. What this chart does not show is a projection of the next move for these commodities' prices. The Federal Reserve is on record suggesting these are transitory trends reflecting the state of the demand versus capacity issue, as well as the logistical challenges of getting more supply to consumers, who are often reacting to shortages by double ordering, adding to the upward price pressure. Is the Fed's view right? Time will tell, and that becomes the wildcard in forecasting the future for commodity prices.

Exhibit 5. Commodities Other Than Crude Oil Are On The March Higher



Source: Gavekal Research

After exploring the impact of commodity prices on markets such as housing, Mr. Gave focused on the unprecedented amount of stimulus spending and the implications for per capita debt levels. He also highlighted changing conditions within China's economy, in particular the value of its currency. With the renminbi strengthening, it means China will be a less attractive place for manufacturing goods, helping to push up economic activity around the world. China's economy will also shift from a manufacturing, export-oriented one to a consumer demand focused one. After presenting all these issues, as well as discussions of other industries and financial markets, Mr. Gave asked the question: Where will the deflationary pressures come from? His conclusion is that the likely solutions to inflation are distasteful actions by politicians and policymakers. In other words, they are likely not to be implemented, potentially adding to inflationary pressures.

Exhibit 6. Inflation Odds High Because Few Ways to Get Deflation

Source: Gavekal Research

Turning to the deflationary case, economist and bond expert Lacy Hunt of Hoisington Management argues that we are experiencing inflationary pressures currently, but the math and history shows that these lead to deflation in the medium term. Everyone is concerned with the massive stimulus injected into the economy to counter the pandemic hit, and that the corresponding massive growth in debt will cause an explosion in inflation once the velocity of money picks up. In Mr. Hunt's view, this surge in debt will depress economic growth preventing demand from growing, which is necessary to propel inflation. He pointed out that throughout U.S. financial history, every time there was a debt bubble, it was followed by deflation or disinflation. Moreover, the history of these deflationary periods are decades long, and we have barely exceeded a decade between the most recent peaks.

Exhibit 7. U.S. Debt Bubbles Are Followed By Deflation Not Inflation

U.S. Debt Bubble Peaks: 1800-2020

	Year	Peak Level	Years Between Peaks	Inflation Outcome
1.	1838			Deflation
2.	1873	138.3%	35	Deflation
3.	1929-30	183.5%	56	Deflation
4.	2008-09	402.6%	79	Disinflation
5.	2020	407.7%	12	Disinflation
6.	Average	283.0%	46	

Sources: Bureau of Economic Analysis, Federal Reserve, Congressional Budget Office, Census Bureau: Historical Statistics of the United States Colonial Times to 1970. Through 2020.

Source: Lacy Hunt

Mr. Hunt pointed to recent history showing inflation to be a lagging indicator. It does not usually turn higher until well into a recovery. The reason this happens is because rising inflation during a recovery period widens the trade deficit, causes interest rates to rise, and price increases to outpace wage growth, lowering living standards. These forces will act to truncate a recovery. Thus, bottoms for inflation only come after extended time periods following the bottom of the economy during a recession.

Exhibit 8. Inflation Does Not End For Some Time After Recession Bottom

Inflation Troughs After Recessions

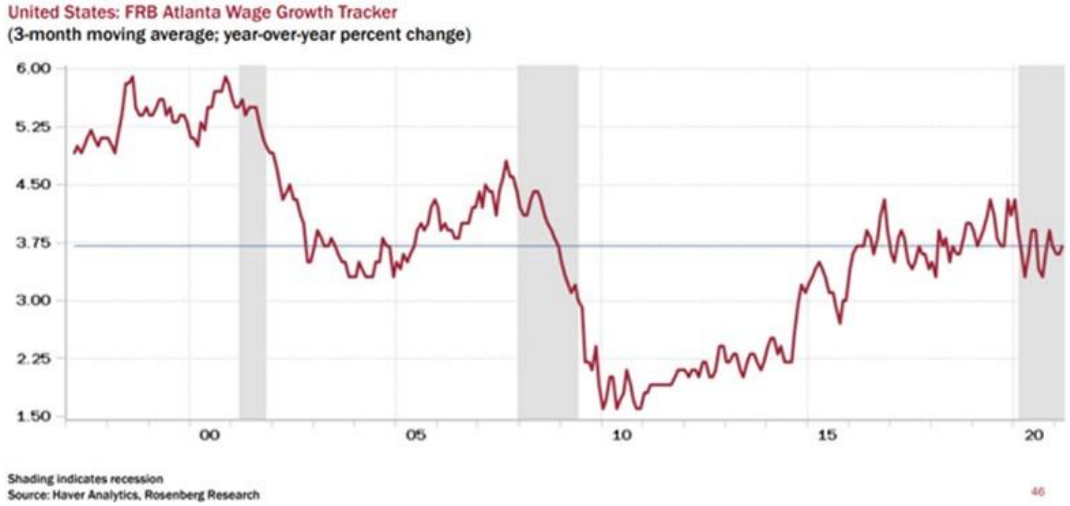
	Last Quarter of Recession	Low Point in Inflation After End of Recession	Lag in Quarters
1.	Q4 1982	Q1 1987	17
2.	Q1 1991	Q2 1998	29
3.	Q4 2001	Q3 2003	7
4.	Q2 2009	Q4 2010	6
5.	Average		14.8

Source: Bureau of Economic Analysis, N.B.E.R. Inflation is represented by the Core PCE price index.

Source: Lacy Hunt

Economist and market strategist Dave Rosenberg makes the point that despite all the anecdotal commentary about rising wages, it has not shown up in the data (at least not yet). He pointed to a chart showing a three-month moving average of year-over-year percentage changes in wages. While the measure had been volatile during the 2020 recession, there is no acceleration in its growth rate.

Exhibit 9. Wage Explosion Stories Have Yet To Impact Economic Statistics



Source: David Rosenberg

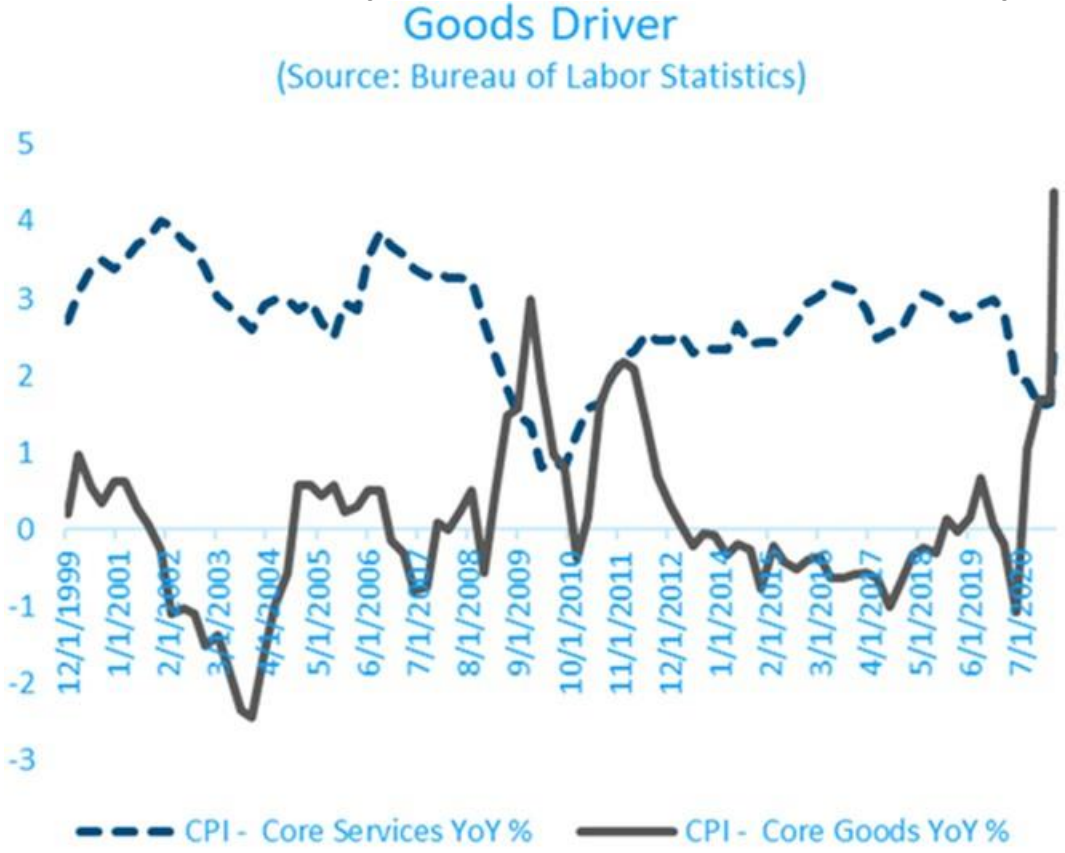
An important reason why wage growth has not exploded is the large number of people not in the labor force but who want a job. Are these people sitting at home collecting supplemental unemployment benefits that give them larger incomes than they would earn if working? As states end these federal supplemental unemployment payments, we will soon learn if job growth accelerates. Last week's ADP jobs report suggesting nearly one million new jobs were created in the past month may be a precursor of the economy entering a period of rapid job growth, falling unemployment rates and rising wages. Counter to that optimistic outlook, the Department of Labor reported only 559,000 jobs created, below the 670,000 expected. However, the labor force shrank slightly, enabling the unemployment rate to fall from 6.1% to 5.8%. Importantly, hours worked and average hourly earnings jumped, especially in the leisure and hospitality sector. The market gave the data a thumbs up and lifted the stock market.

Exhibit 10. So Many Unemployed Workers Suggests Wage Inflation Not A Force Now

Source: David Rosenberg

Mr. Rosenberg's comments about the labor market provided a predicate for Cathie Wood's, from investment management firm Ark Invest, presentation on disruptive technologies impact on the economy and stock market. In her view, the economy is experiencing inflationary pressures due to capacity shortages and logistical challenges that have led to companies doubling, tripling, and even quadrupling orders. She pointed out that the goods component accounts for only one-third of the U.S. economy with the service sector representing two-thirds. It is the goods sector where the inflationary pressures are arising now, boosting various inflation metrics, and driving commodity prices up. However, she foresees that sometime towards the end of 2021 or in 2022, we will experience a surge in inventories due to the overordering. This inventory glut will unleash deflationary pressures.

Exhibit 11. Inflation Currently Is Focused In The Goods Sector Of The Economy

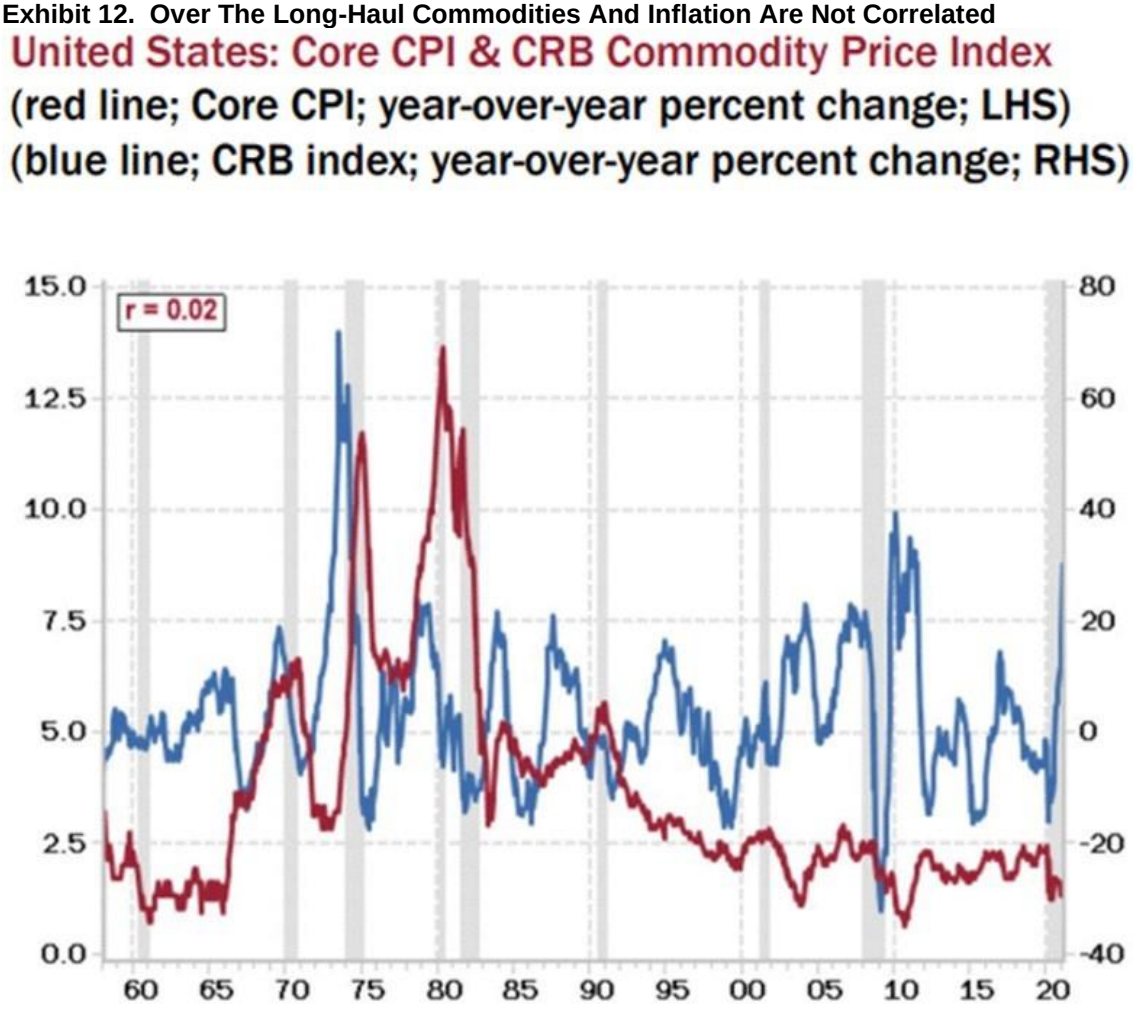


Source: Mauldin Research

Ms. Wood also sees a more sustainable trend driving deflation than the possible inventory recession she predicts. This is from the fallout from disruptive technologies that change the business landscape. Prices for these new technologies will fall, making the products and services more affordable, helping to drive unit volume growth that further lowers their costs. This is good deflation in her view. The corollary is bad deflation, which will impact as much as 50% of the companies in the S&P 500. Since those companies recovered from the tech and telecom busts and the Financial Crisis of 2008-2009, they have managed their businesses in a manner to satisfy short-term-oriented investor demands. They want profits, they want them now. They want dividends, they want them now. In many cases, to meet these demands, companies levered up. Now, with their demand under attack, they will be forced to cut prices to generate the cash to service debt and pay dividends. These trends will sustain deflationary pressures for years.

The final deflationary point was one highlighted by Mr. Rosenberg in a chart showing that inflation (Consumer Price Index, CPI) does not correlate with commodity prices (CRB Commodity Index). The lack of correlation is substantiated by the r = 0.02 calculation. Correlation explains the strength of the relationship between an independent and a dependent variable. R-squared explains to what extent the variance of one variable explains the variance of the second variable. In this case, neither index explains much of the movement of the other. In a way, this relationship appears strange because we have always known that the rise in oil prices during the 1970s was associated with the wave of inflation and high interest rates. However, it is likely that oil's price increase was a driver of inflation and not the inverse. Oil pricing and inflation during the '70s were also impacted by the decision by President Richard Nixon to close the U.S. gold window, preventing holders of dollars exchanging them for gold. This put a lot of downward pressure on the value of the U.S. dollar, which is a positive force for higher oil and commodity prices.

Exhibit 12. Over The Long-Haul Commodities And Inflation Are Not Correlated

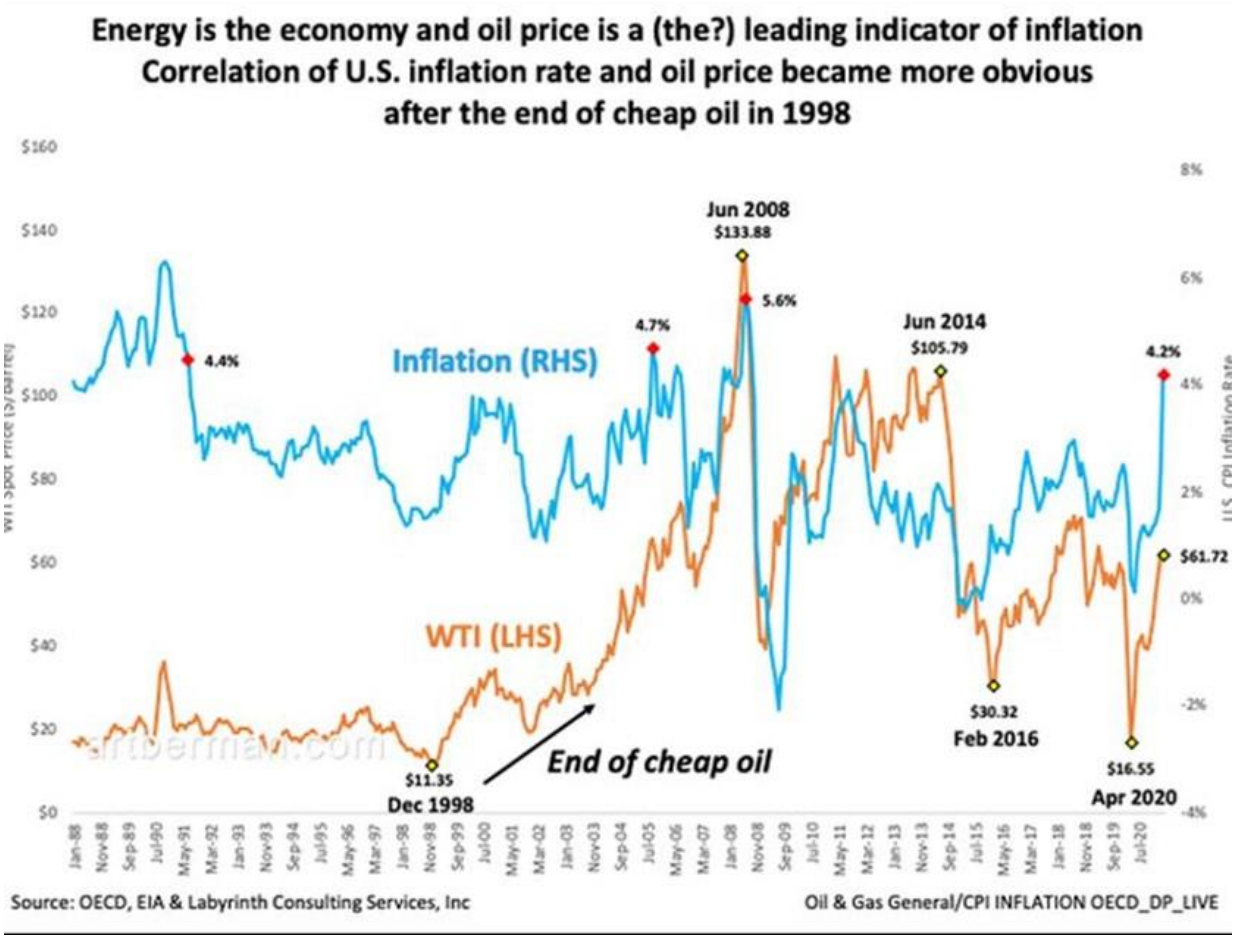


Source: David Rosenberg

A contrasting view is presented in this chart by Art Berman showing how oil prices began rising after the Asian currency crisis and recession of 1998-1999, which he marks as the end of cheap oil. Later, the pattern of oil price movements and the inflation index appear to mirror each other

closely up to now. The current period seems to fit the narrative (above) of the relationship between oil prices and inflation during the 1970s. That decade is essentially the only time in Mr. Rosenberg's chart, which extends from 1957, when the CRB index was created, to now, where the movement of the commodity price index and inflation appear to mirror each other. It is important to understand that crude oil carries a disproportionate (39%) weight in the commodities index.

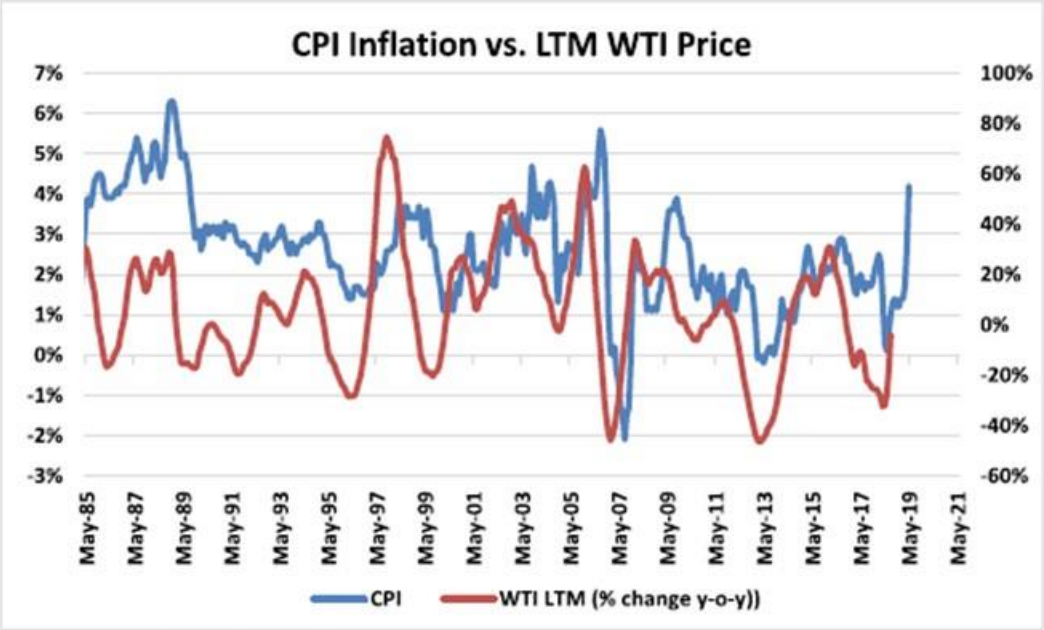
Exhibit 13. How Oil Prices Are Leading Inflation And Inflation Expectations



Source: Art Berman

Another way of looking at the relationship between oil prices and inflation is shown from a research report by Raymond James Research. It plots the year-over-year change in the 12-month moving average of oil prices against inflation. What becomes clear from this chart is that rising oil prices appear to lead inflation. That would be consistent with the view that inflation is a lagging indicator of economic developments. This chart sets up the remainder of our discussion.

Exhibit 14. Change In Oil Prices Shows They Lead Inflation Indices

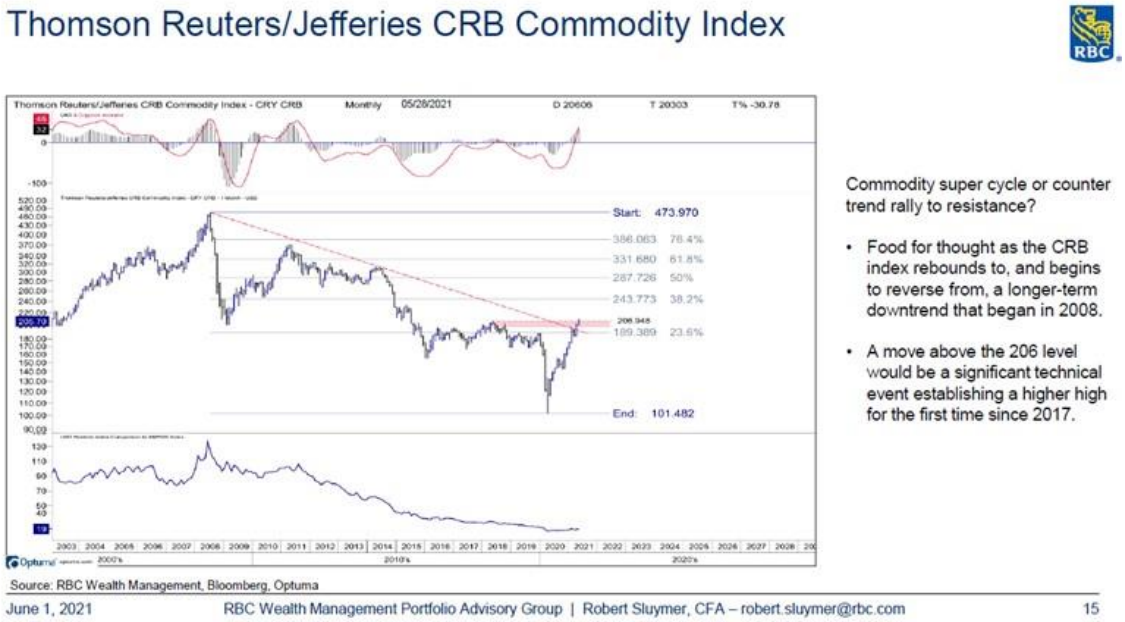


Source: Raymond James Research

As shown above, it appears that oil prices lead inflation. It is also important to note that oil is a large component of most commodity indices because it so important to the health and functioning of economies. Understanding what is happening to oil prices may provide some insight into the future for inflation. Therefore, we will examine a series of charts from the stock market technician at RBC Wealth Management.

The first chart deals with the CRB Commodity index. The adjacent commentary noted that a move in the index above 206 would be significant. Last Friday, the index was at 223. We suspect that this breakout will send the index higher with the next resistance level according to the chart being at 244. We anticipate 206 will become a support point on a pullback. That means, in a market correction, the index might drop back to about 206 and then rally higher. If, however, the index falls below 206, there is a possibility the extended price rise would be dashed. This is how traders map market move odds and how to place their trades.

Exhibit 15. Commodities Are On The Rise With Inflation Implications

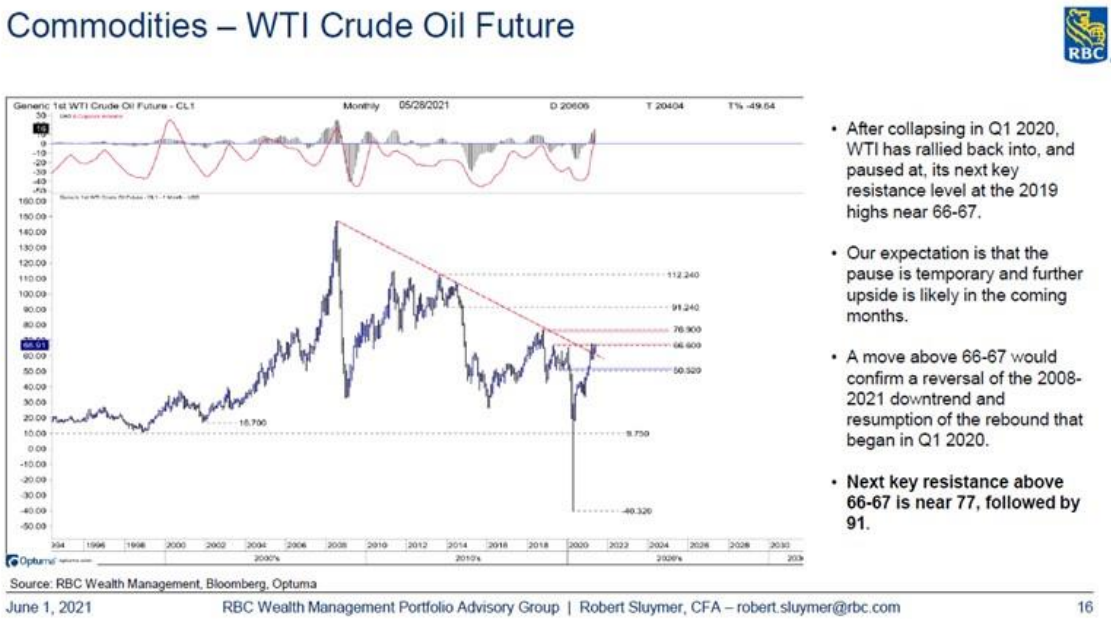


Source: RBC Wealth Management

When we look at the second chart – dealing with crude oil prices – we find a similar pattern as for the CRB Commodity index. The chart showed WTI oil prices breaking above the downward sloping line connecting recent high points for the index since its peak during the boom of 2007. That line reflects the bear market oil has been dealing with since the 2007 peak. Thus, we should take this price rise as a significant event.

As the commentary suggests: "Next key resistance above 66-67 is near 77, followed by 91." That technical analysis would seem to fit with Goldman Sachs' prediction that oil prices may reach $80 a barrel by the end of 2021. The technical analysis would also appear to support those predicting that oil prices may return to the $100 a barrel level in the next several years. That projection assumes global oil demand continues growing after largely recovering to pre-pandemic levels, and that the lack of investment in developing new global oil supplies will lead to a supply/demand imbalance driving prices higher.

Exhibit 16. Oil Looks Poised For A Meaningful Move Higher



Source: RBC Wealth Management

Over the 50-plus years we have been involved in the energy business, we have learned about cycles. The oil industry is always called a "boom-and-bust" business. The cycle starts with a shortage of supply that lifts prices and encourages producers to find and develop more supply. Eventually, the price signal from the tight oil market leads to more supply arriving than needed, depressing oil prices and causing producers to pull back their exploration and production activity. Whenever the supply/demand balance is either extremely tight or we find ourselves drowning in supply, oil prices either explode to the upside, or are crushed to the downside. Are we seeing the beginning of an oil price explosion?

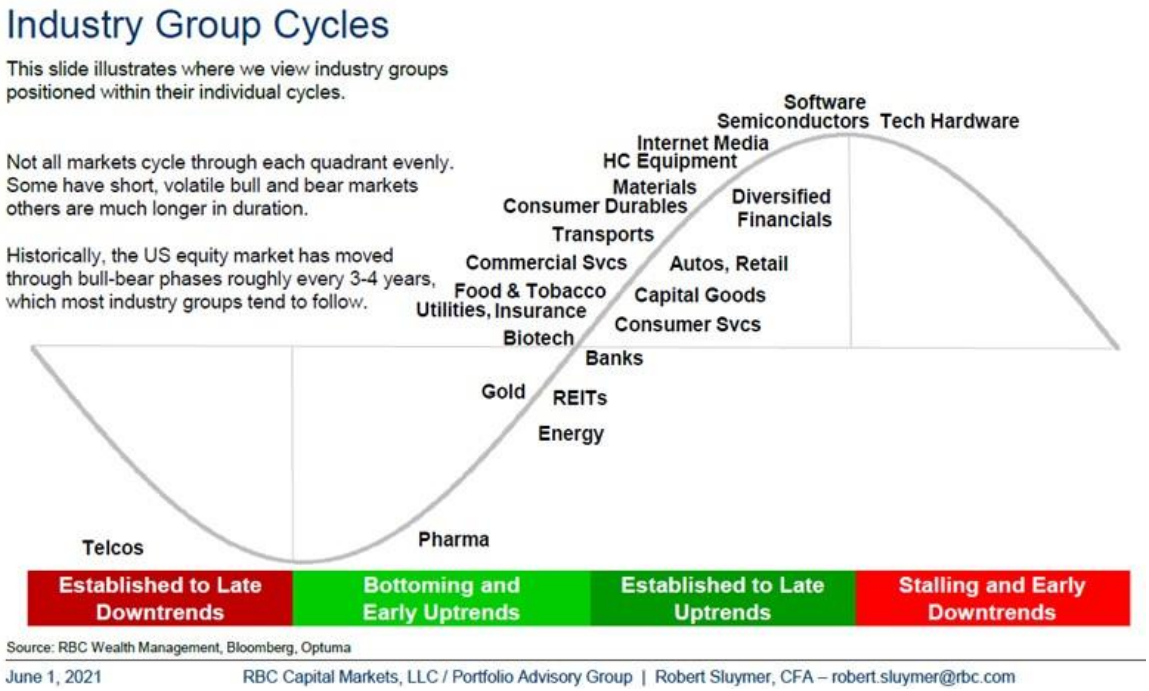
Raymond James presented a unique way of looking at commodity stocks versus the overall stock market in making their argument that we are entering a new "commodity supercycle." The firm has been a strong proponent of the supercycle for oil prices and believes the industry is on the road to $100 per barrel oil prices sooner rather than later due to the lack of investment in new supplies in the face of oil demand growth reaccelerating.

Exhibit 17. Is A Commodity Supercycle About To Start And Lift Oil Prices Higher?

Source: Raymond James Research

The oil industry is virtually like every other industry in having business cycles. Oil's cycle tends to be more dramatic, almost always generating front page news. The stock market also has cycles, and of varying lengths. The major cycle lasts roughly 17 years, with shorter 3-4-year cycles. Our favorite chart shows where technicians put industries within the short-term cycle, such as the following chart. Note that energy is in the "Bottoming and Early Uptrends," while most tech industry sectors are at or past the top of the cycle. For those who watch the stock market, you will be familiar with the recent outperformance of energy and the underperformance of tech stocks. If we examine the YTD performance of S&P sectors through May 27, Energy was up +36.1%, while Information Technology was up +5.6% and Telecommunications had gained +16.3%. The S&P 500 rose 11.8% for that period. Energy was in first place for YTD and 1Q 2021, after falling into last place for the month of April with a +0.7% performance compared to the S&P 500 rising 5.2%.

Exhibit 18. Market Cycle Chart Suggests Move In Energy Is Just Beginning



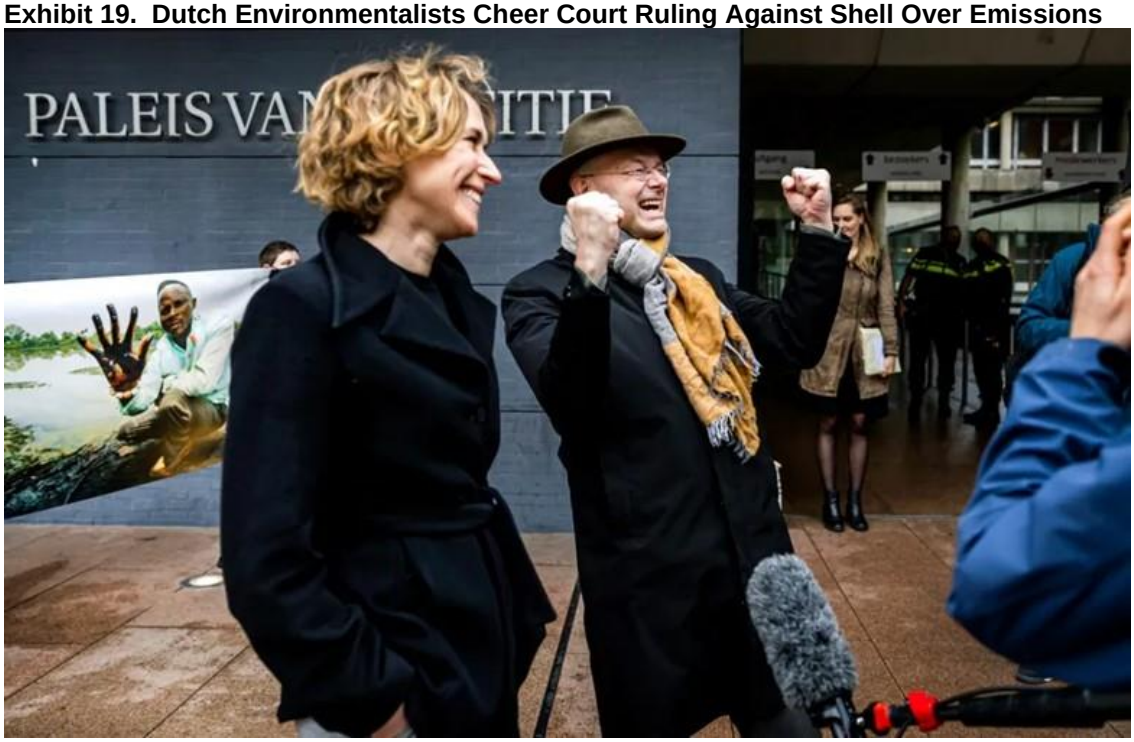
Source: RBC Wealth Management

After reviewing the various arguments about inflation and deflation, as well as the technical analysis of crude oil, commodities, and the overall stock market, we are defaulting to the "wait and see" mode. Is the commodity price rise transitory due to surging demand and pandemic supply and logistic challenges? If so, there will be no shift from a deflationary to an inflationary environment. On the other hand, if the shift is more permanent, there will be plenty of time to invest, as the length of the cycle provides years to earn profits.

One Day In May Marks Beginning Of The End For Big Oil

Sixty years ago, the nation was fascinated with a book and subsequent movie featuring a plot about the discovery and thwarting of a military coup in the United States. The book was titled Seven Days in May. One day this May has created an almost similar fascination with the unfolding of a similar dramatic event – the death of Big Oil.

Exhibit 19. Dutch Environmentalists Cheer Court Ruling Against Shell Over Emissions



Source: ***Reuters***

On May 26, a Dutch court ruled that European-based Royal Dutch Shell must bring its global operations in line with the Paris Agreement goal for limiting the earth's temperature rise to 1.5 degrees Celsius. The company was ordered to reduce both its own and its customers' greenhouse gas emissions by 45% from 2019 levels by 2030. While environmentalists celebrated the decision, Shell has indicated it will appeal the "disappointing" ruling. An issue, however, is that under the law in The Netherlands, the court order is provisionally enforceable, meaning it has immediate effect regardless of whether the court's decision is appealed. One step Shell could take to reduce its emissions and those of its customers, while the appeal process is underway, would be to restrict the amount of fuel sold in The Netherlands. That might not make citizens happy as they would be forced to rely more on bikes and shoe leather for transportation, than cars and trucks.

According to Friends of the Earth Netherlands (Milieudefensie), and its co-plaintiffs Action Aid Netherlands, Both ENDS, Fossil Free Netherlands, Greenpeace Netherlands, Young Friends of The Earth Netherlands, and the Wadden Sea Association (Waddenvereniging), and more than 17,000 Dutch citizens, this was "an enormous step forward for the international climate movement." The key points of the ruling are:

1. Royal Dutch Shell must reduce its emissions by 45% net by the end of 2030.
2. Shell is also responsible for emissions from customers (scope 3) and suppliers.
3. There is a threat of human rights violations to the 'right to life' and 'undisturbed family life'.
4. Shell must comply with the judgment immediately, because Shell's current climate policy is not concrete enough.

The Dutch court ruling was bookended by the voting for directors at the ExxonMobil shareholders' meeting, in which activist hedge fund shareholder Engine No. 1 saw two, and now three, of its four director nominees win election to the board. This contentious vote came after a months-long campaign by the activist to secure the votes of large institutional investors to push change on the company. The overwhelming support of institutional investors was needed, as ExxonMobil's individual shareholding base is large and traditionally votes with management, if they vote at all. With the support (some qualified) of proxy solicitors and several of the largest investment fund organizations that have pledged to challenge the climate change activities of industries and companies, the activists were successful in reshaping the board of the largest and most prominent global oil company.

The activists' criticism has been that ExxonMobil's board lacked directors with energy and climate change experience. The irony of the vote is that one of the company's directors ousted, Wan Zulkifee, had a 30+ year career, culminating as president and group CEO, with Petronas, Malaysia's national oil company and one of the world's largest oil companies. He is now the chairman of Malaysia Airlines, a large consumer of petroleum products. Moreover, he was the first non-American director ever elected to ExxonMobil's board, which added to the board's diversity, but most importantly he comes from Southeast Asia, the most dynamic region for economic activity and petroleum consumption growth. With these credentials, Mr. Zulkifee was not only a highly qualified director, but arguably a more desirable member than the head of a U.S. refiner, one of the activist candidates elected.

The climate change battle between activists and the fossil fuel industry has been underway for decades. Only now are activists gaining leverage against oil, gas, and coal companies. Recent successes by activists – securing President Biden's support for shutting down the Keystone XL pipeline, getting the Administration to suspend oil and gas leasing on federal lands and offshore acreage, suspending active leases in Alaska, and mandating all government policy decisions and actions be evaluated through a climate change lens – signal momentum in this climate battle has shifted to them. That view is supported by the following headlines from recent press releases from environmental groups.

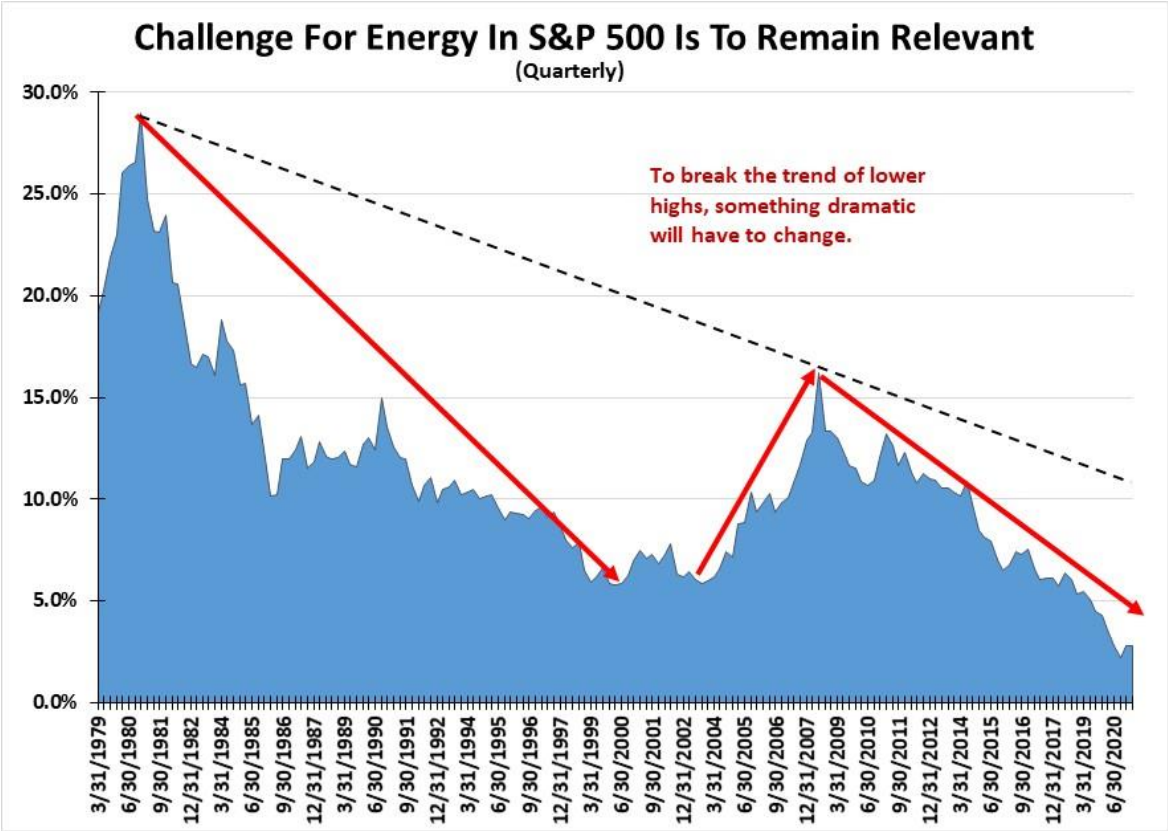
> "The End of Oil Is Near" (Sierra Club)
> "The Decline of Oil Has Already Begun" (Greenpeace)
> "Oil and Gas: An Industry in Decline" (Environmental Working Group)

Much like tides that ebb and flow, momentum often shifts, sometimes in surprising fashion. Few industries ever go totally out of business, even buggy-whip manufacturers. The significance industries play in future economies may shrink drastically, but company strategies can shift to exploit new developments and technologies enabling them to survive and even thrive over time. So, predicting the demise of Big Oil may be premature – possibly by decades! However, as market sentiments shift, support industries are forced to adjust. That seems to be the case with Big Oil – at least based on the view from Wall Street and universities.

One of the easiest measures to see how the fortunes of the oil and gas industry have changed over time is to examine the weighting of the Energy sector within the Standard & Poor's 500 Stock Index. While climbing through the 1970s, the sector weighting peaked in 4Q 1980 at 29.0%, after which it dropped like a rock with the decline in oil prices and the market turmoil that led to the OPEC oil price war in the mid-1980s. The low point was reached in 1Q 1986 at 10.1%, before recovering some and then dropping again. The next low was 1Q 2000 at 5.8%, which was followed by a small increase before falling back to 5.9% in 3Q 2003. From there, with oil prices soaring in response to the extremely strong oil demand from China, the sector weighting rose to 16.2% in 2Q 2008. That seems to have been the last hurrah for the Energy sector as its

weighting has gone straight down to a low in 3Q 2020 of 2.2% before recovering slightly to 2.8% at the end of 1Q 2021.

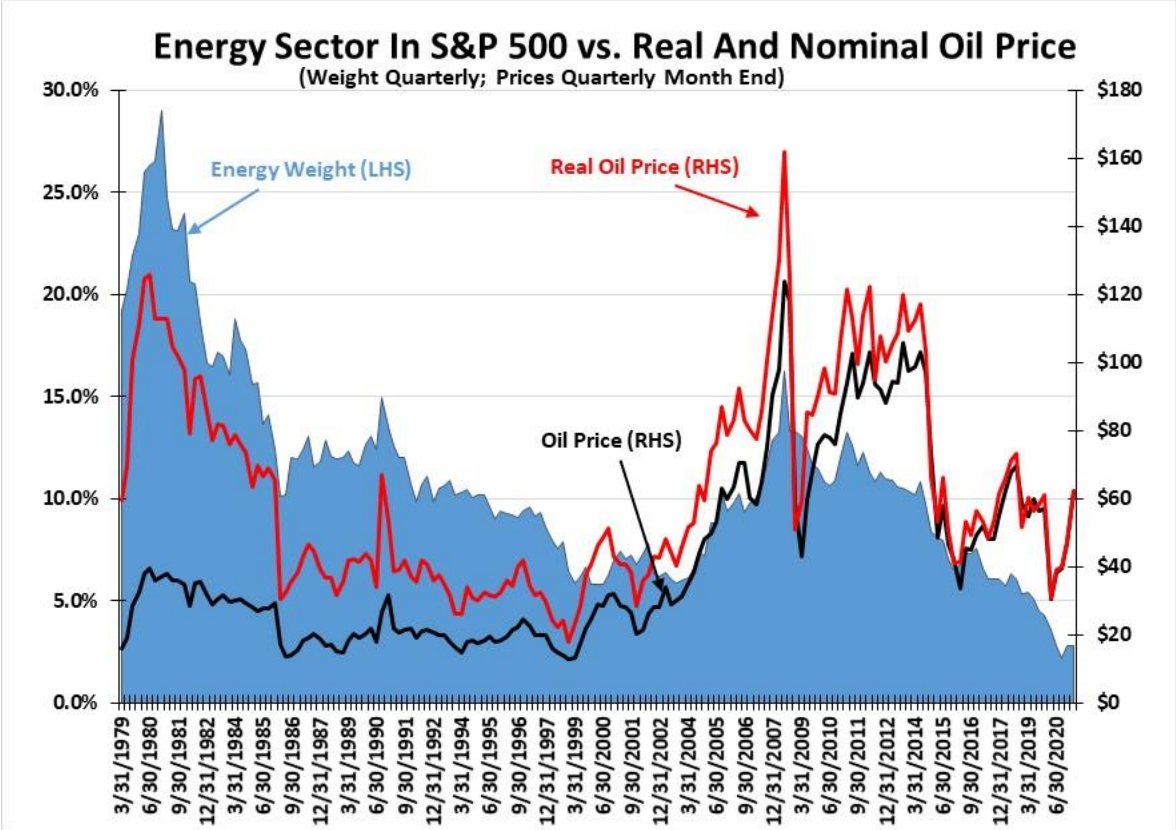
Exhibit 20. History Of Energy's Stock Weighting Reflects Declining Industry Attractiveness



Source: S&P, PPHB

When we plot the Energy sector weighting history against nominal and real oil prices, we find that they correlate well. The correlation was tight until immediately after the last peak in 2008. At that point, oil prices experienced a sharp recovery, returning to the $100+ per barrel range, before being kneecapped by OPEC, primarily Saudi Arabia, in late 2014. While oil prices were rising, the Energy sector weighting fell for eight consecutive quarters to 10.6% before experiencing a brief rebound that took the weighting to its last high of 13.2% in 1Q 2011. Even after oil prices recovered from their collapse in late 2014 and the subsequent pandemic-related collapse in 2020, the Energy sector weighting has struggled to prevent its slide below 3%.

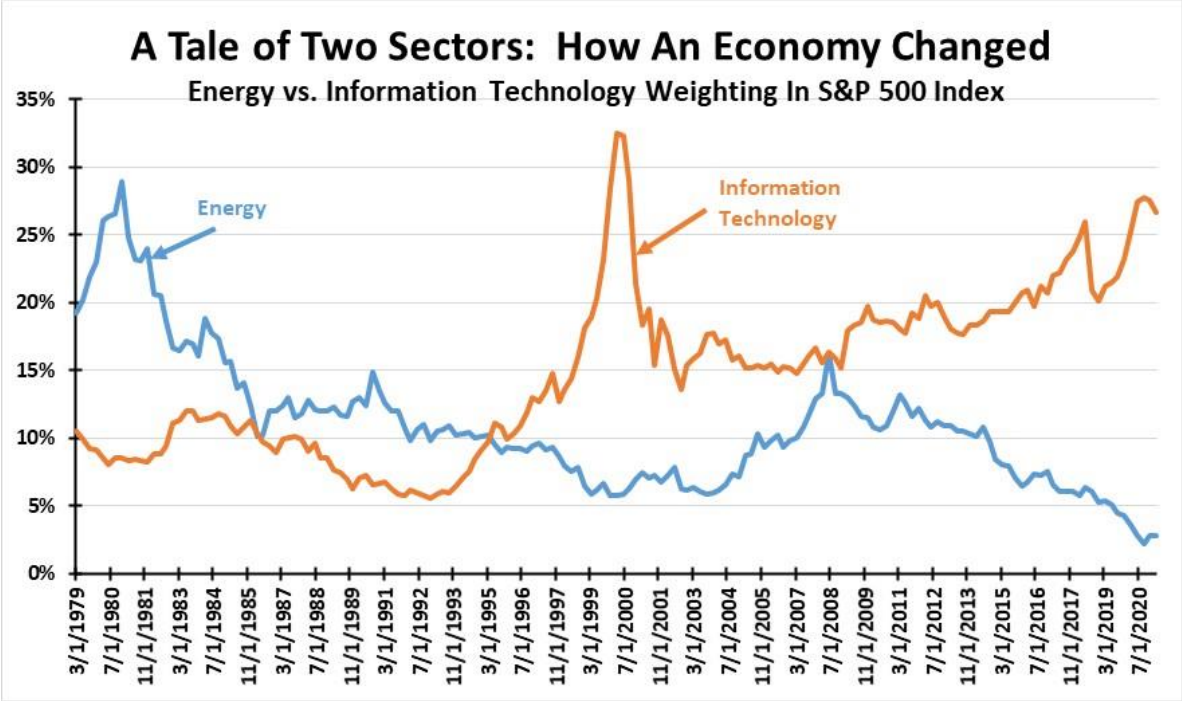
Exhibit 21. Oil Prices And Industry Weighting Closely Aligned Until Recently



Source: S&P, EIA, St Louis Fed, PPHB

If Energy's importance was waning over all these decades, what else was going on in the economy? As we expected, information technology was growing in importance. It was highlighted by the dotcom boom of the late 1990s and early 2000s. We have plotted the two S&P sector weightings showing how technology and energy moved in opposite directions over almost all this time span, but especially since the end of the 1991 recession. The chart shows how powerful the dotcom era was in distorting the overall stock market, as the S&P 500 is supposed to reflect general economic trends.

Exhibit 22. Energy And Technology; A Tale Of Two Different Outlooks



Source: S&P, PPHB

What we have known about energy stocks is that they have been a disappointing investment for the past decade. That has changed in recent months. Once economies stabilized following the shock of the exploding Covid-19 cases during the first half of 2020, prospects for increasing oil demand grew. For the oil market, the epitome of the demand collapse, as governments around the globe locked down their citizens and economies to help prevent the spread of the virus, was the day oil futures contracts fell to a negative $38 per barrel, as traders feared the inability of the industry to deal with the overwhelming glut that was building. The oil market corrected this huge discontinuity in a matter of hours, but the psychological damage was debilitating for the industry. It was forced to shutter activities as quickly as possible, while absorbing the losses of dumping product, closing refineries, and suspending oilfield drilling and production activity.

The end for oil was proclaimed, as forecasters expected it to take years for oil demand to recover, if ever. The forecasting game became one of developing scenarios of extended slow oil demand recoveries, leaving the world awash in stockpiled oil supplies and possessing huge inactive production capacity. Given this outlook, it was not surprising that oil prices remained depressed and energy shares nearly worthless. A flood of bankruptcies, restructurings, and forced mergers and acquisitions were unleashed in the industry. Oil and gas's future was predicted to result in a smaller industry with fewer companies with substantially reduced workforces. Wall Street followed and began reducing its commitments to researching oil and gas and oilfield service stocks, which meant shedding research analysts. Investors began pulling more money from energy shares than they were adding, and some dedicated oil and gas and energy funds moved to broaden their investment mandates or liquidated.

A chart of the performance of the S&P 500 Stock Index industry sectors shows the dismal performance of energy (shown in green) in recent years. The chart shows annual sector

performances from 2003 through 2020. We have also shown the 2021 year-to-date performance through May 27, along with the Q1 2021 and April 2021 performances. Energy was the best performing sector for the first quarter and 2021 YTD. April was not a good month, as Energy was the worst performing sector, although it was positive.

Exhibit 23. Energy: A Disappointing Investment For Past Decade May Be Changing

S & P 500 Sector Performance

2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021 YTD 5/27/21	April 2021	Q1 2021
INFT	ENRS	ENRS	TELS	ENRS	CONS	INFT	REAL	UTIL	FINL	COND	REAL	COND	ENRS	INFT	HLTH	INFT	INFT	ENRS	REAL	ENRS
47.2%	31.5%	31.4%	36.8%	34.4%	-15.4%	61.7%	32.3%	19.9%	28.8%	43.1%	30.2%	10.1%	27.4%	38.8%	6.5%	50.3%	42.2%	36.1%	8.3%	30.8%
MATR	UTIL	UTIL	ENRS	MATR	HLTH	MATR	COND	CONS	COND	HLTH	UTIL	HLTH	TELS	MATR	UTIL	TELS	COND	FINL	FINL	FINL
38.2%	24.3%	16.8%	24.2%	22.5%	-22.8%	48.6%	27.7%	14.0%	23.9%	41.5%	29.0%	6.9%	23.5%	23.8%	4.1%	32.7%	32.1%	28.4%	6.6%	16.0%
COND	TELS	FINL	UTIL	UTIL	UTIL	COND	INDU	HLTH	REAL	INDU	HLTH	CONS	FINL	COND	COND	FINL	TELS	MATR	COND	INDU
37.3%	19.9%	6.5%	21.0%	19.4%	-29.0%	41.3%	26.7%	12.7%	19.7%	40.7%	25.3%	6.6%	22.8%	23.0%	0.8%	32.1%	22.2%	20.3%	6.5%	11.5%
INDU	INDU	HLTH	FINL	INFT	TELS	REAL	MATR	REAL	TELS	FINL	INFT	INFT	INDU	FINL	INFT	S&P	MATR	INDU	TELS	MATR
32.2%	18.0%	6.5%	19.2%	16.3%	-30.5%	27.1%	22.2%	11.4%	18.3%	35.6%	20.1%	5.9%	18.9%	22.2%	-0.3%	31.5%	18.1%	18.4%	6.5%	9.3%
FINL	COND	COND	COND	CONS	COND	S & P	ENRS		HLTH	S & P	CONS	REAL	MATR	HLTH	REAL	INDU	S&P	REAL	MATR	REAL
31.0%	13.2%	6.4%	18.6%	14.2%	-33.5%	26.5%	20.5%	TELS 6.3%	17.9%	32.4%	16.0%	4.7%	16.7%	22.1%	-2.2%	29.4%	16.1%	17.7%	5.4%	9.1%
S&P	MATR	S & P	MATR	INDU	ENRS	INDU	TELS	COND	S & P	INFT	FINL	TELS	UTIL	S & P	S & P	REAL	HLTH	TELS	INFT	TELS
28.7%	13.2%	4.9%	18.6%	12.0%	-34.9%	20.9%	19.0%	6.1%	16.0%	28.4%	15.2%	3.4%	16.3%	21.8%	-4.4%	29.0%	11.4%	16.3%	5.3%	8.8%
UTIL	FINL	MATR	S & P	TELS	S & P	HLTH	S & P	ENRS	INDU	CONS	S & P	S & P	INFT	INDU	CONS	COND	INDU	S&P	UTIL	S&P
26.3%	10.9%	4.4%	15.8%	11.9%	-37.0%	19.7%	15.1%	4.7%	15.4%	26.1%	13.7%	1.4%	13.9%	21.0%	-8.4%	27.9%	9.0%	11.8%	4.3%	5.8%
ENRS	S & P	CONS	CONS	HLTH	INDU	FINL	CONS	INFT	MATR	MATR	INDU	FINL	S & P	CONS	TELS	CONS	CONS	HLTH	S&P	COND
25.6%	10.9%	3.6%	14.4%	7.2%	-39.9%	17.2%	14.1%	2.4%	15.0%	25.6%	9.8%	-1.5%	12.0%	13.5%	-12.5%	27.6%	7.6%	8.2%	5.2	4.7%
HLTH	CONS	INDU	INDU	S & P	REAL	CONS	FINL	S & P	INFT	ENRS	COND	INDU	COND	UTIL	FINL	UTIL	UTIL	COND	HLTH	HLTH
15.1%	8.2%	2.3%	13.3%	5.5%	-42.3%	14.9%	12.1%	2.1%	14.8%	25.1%	9.7%	-2.5%	6.0%	12.1%	-13.0%	26.4%	-2.8%	6.2%	4.0%	3.3%
CONS	INFT	INFT	INFT	COND	INFT	ENRS	INFT	INDU	CONS	UTIL	MATR	UTIL	CONS	REAL	INDU	MATR	FINL	INFT	INDU	UTIL
11.6%	2.6%	1.0%	8.4%	-13.2%	-43.1%	13.8%	10.2%	0.6%	10.8%	13.2%	6.9%	-4.8%	5.4%	10.9%	-13.3%	24.8%	-4.1%	5.6%	3.6%	2.9%
TELS	HLTH	TELS	HLTH	REAL	MATR	UTIL	UTIL	MATR	ENRS	TELS	TELS	MATR	REAL	ENRS	MATR	HLTH	REAL	CONS	CONS	INFT
7.1%	1.7%	-5.6%	7.5%	17.9%	-45.7%	11.9%	5.5%	9.6%	4.6%	11.5%	3.0%	-8.4%	3.4%	-1.0%	-14.7%	20.8%	-5.2%	4.2%	2.0%	2.4%
				FINL	FINL	TELS	HLTH	FINL	UTIL	REAL	ENRS	ENRS	HLTH	TELS	ENRS	ENRS	ENRS	UTIL	ENRS	CONS
				-18.6%	-55.3%	8.9%	2.9%	17.1%	1.3%	1.6%	-7.8%	-21.1%	-2.7%	-1.3%	-18.1%	11.8%	-37.3%	2.8%	0.7%	3.8%

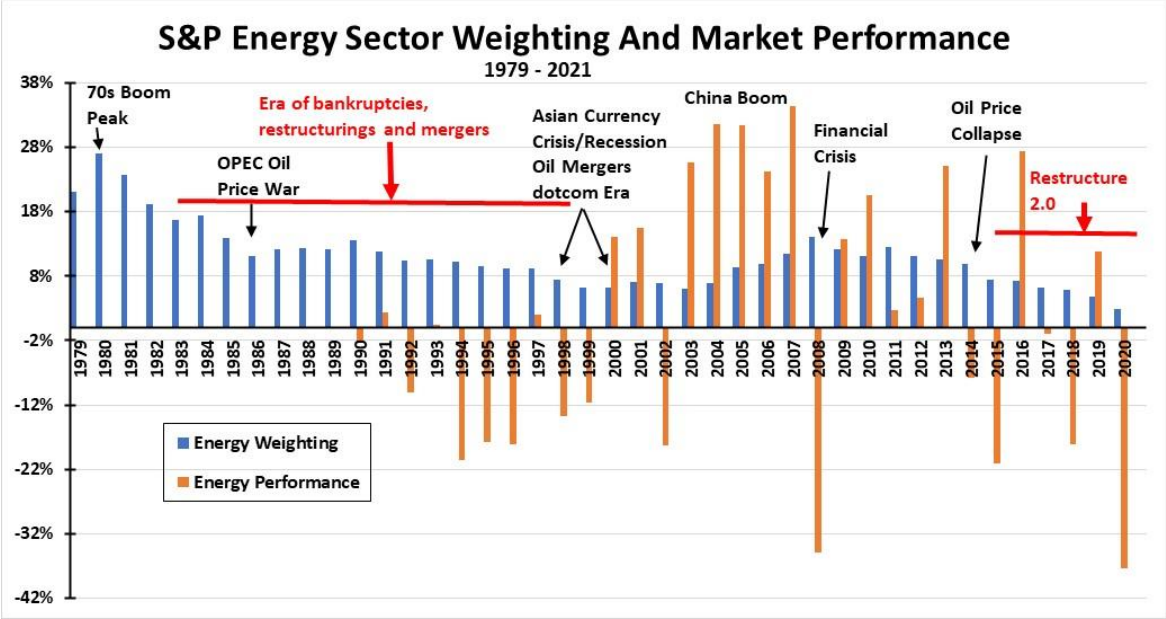
Source: S&P, PPHB

If we examine the 2003 to 2010 period, there were four years – 2004-2007 – when Energy was either the best or second-best performing sector. Prior to 2007, the S&P 500 only had 10 industry sectors. After 2007, it reallocated some technology and communications into a third sector, giving the index 11 sectors now. The difference in Energy's performance in those two periods reflects a widely divergent set of industry conditions. This performance difference led us to calculate Energy sector performance back to 1990.

While a busy chart, we have matched the average annual energy sector weighting from 1979 to 2020 with annual energy sector performance from 1990 to 2020. We have also annotated the time-period with details about the macro industry trends during certain years. What we see is that during the 1990s, Energy experienced losses in seven of the ten years. The three positive years were only marginally positive. That changed in the 2000s when there was a string of five consecutive years with likely the best annual returns of all the years tracked. The annual Energy performance data over 30 years suggests a cyclical industry with periods of dismal performance as well as periods of outstanding gains.

As Energy's weighting was in decline, absent brief recoveries, one must ask if the declines reflected investor recognition of two trends: a shift from a goods-oriented to a services-based economy; and a recognition of a maturing energy industry given the transition from oil and gas to the next major fuel source was underway.

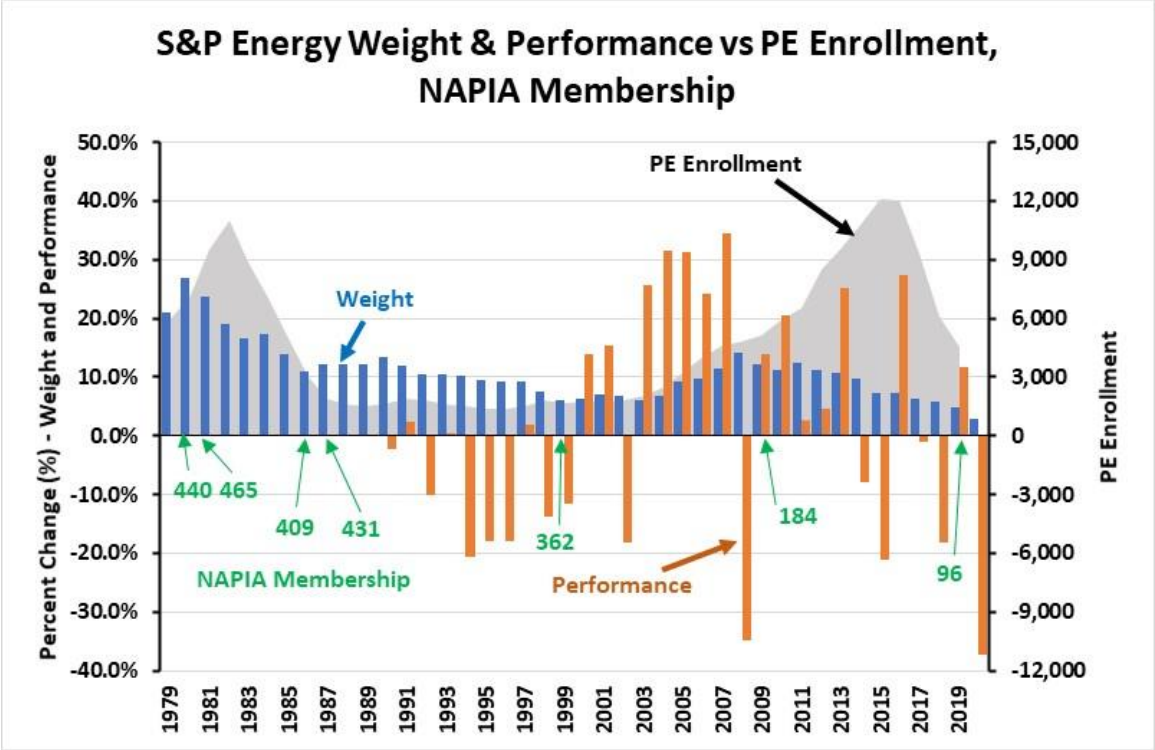
Exhibit 24. Energy Sector Weightings And Performance Not Totally Related



Source: S&P, PPHB

It is interesting to examine the declining trend in Energy's weightings against the sector's performance to assess whether the reactions by investors and the industry was appropriate. The oil and gas industry has gone through prior cycles – some less dramatic than the current one. However, there was one past cycle – the 1980s and 1990s – that was very similar to the current cycle. In that prior downturn, the industry struggled with similar conditions as today and reacted in similar ways - so too did investors, Wall Street, and educational institutions. To gain a perspective on how industry and Wall Street have dealt with the industry's cycles, we have produced the following chart.

Exhibit 25. PE Enrollment And Investor Interest Follow Different Industry Metrics



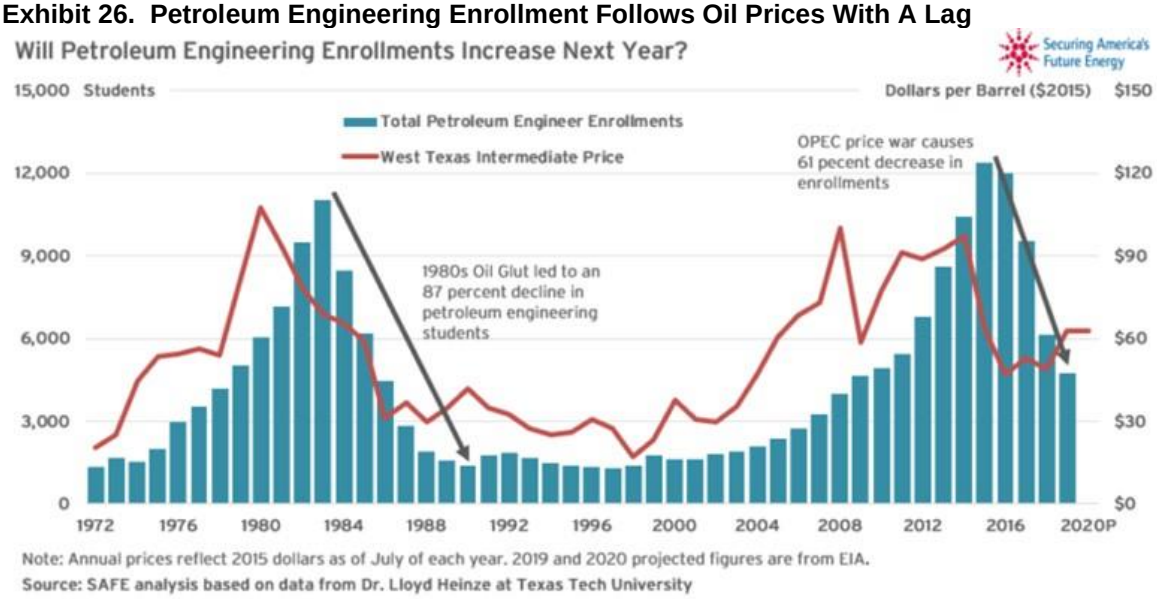
Source: S&P, Texas Tech, NAPIA, PPHB

As in earlier charts, we have plotted the weighting of the Energy sector in the S&P 500 Index as well as the sector's performance since 1990. In this chart we have added two additional measures: petroleum engineering enrollment at U.S. universities; and membership in the National Association of Petroleum Investment Analysts (NAPIA) for selected dates. What is clear is that students seeking to study petroleum engineering are motivated by industry fundamentals and expectations for a continuation of current trends. Following those expectations has proven to be a challenge for the industry when it inevitably goes through one of its cycles.

Another chart using the same petroleum engineering data but going back to 1972 shows just how much the rise in enrollments in the 1970s was mirrored in the 2000s. Moreover, the current enrollment decline is mirroring the pattern following the 1980 peak in oil prices that led to the OPEC oil price war in 1985-86 and inflicted devastation on the global oil industry. Not surprisingly, the growth and contraction in petroleum engineering enrollment follows oil prices with a lag of several years.

Today, the oil industry is not only struggling with the recent fall in oil prices, it also is under a fundamental attack – a permanent decline in oil demand. Currently, oil prices are above $60 per barrel with the possibility they may go higher in the second half of 2021. Assuming the price trajectory unfolds, one would expect a reversal in the enrollment trend by 2022 or 2023. The unanswered question is whether the climate change challenge for the oil industry will hamper an enrollment rebound. If it does, such a scenario will resurrect industry's concern about staffing companies for the next two to three decades as retirements drain current aging technical talent, often referred to as the Great Crew Change.

Exhibit 26. Petroleum Engineering Enrollment Follows Oil Prices With A Lag



Source: *JPT*

Another industry currently struggling with adjusting to the challenging outlook for the energy business is the investment community. On the financing front, climate activists are proving successful in convincing banks, insurance companies, and government-sponsored lending institutions to stop making loans for the development of new fossil fuel projects. Changing the thinking about investing in energy companies is also proving successful. For example, Norway's state pension fund has announced intentions to divest fossil fuel investments. This movement is much like what happened in the 1990s with tobacco and South African investments when investors became concerned about the risk of cancer from smoking cigarettes and the suffering for people of color due to government apartheid policies. The California pension fund, Calpers, is wrestling with divesting from firearms, coal, Iran, Sudan and emerging market equity principles, a program that screens companies from the emerging market portion of its internally managed global equity portfolio that do not meet environmental, social, and governance (ESG) standards. A lookback to the fund's tobacco stock divestment, begun in 2001 and reaffirmed in 2016, showed it lost $3.5 billion in potential returns. For a pension fund that struggles to meet its annual return target, that lost return was costly and has become part of the current divestment discussion.

An analysis of the topics of our articles for the past year showed how ESG issues were becoming a dominant characteristic. Therefore, we renamed our publication a month ago, changing it from "Musings From the Oil Patch" to "Energy Musings" to reflect this shift in focus. Numerous Wall Street investment banks have followed us in recognizing the sea-change underway in investor sentiment toward fossil fuel investments. Several investment banks have merged their respective financing groups responsible for energy, infrastructure, and midstream sectors, sometimes adding in industrials, to create broader groups focused on green energy, climate change, and sustainability investments. These changes are being mirrored by the firms' energy investment research groups.

To gain insight in how dramatic a shift is underway in Wall Street energy research, we turned to the membership data for NAPIA, an organization we have been a member of for decades, including helping organize annual conferences, as well as serving as its president. NAPIA is "a not-for-profit association whose primary objective is the education of its membership in their

knowledge of the petroleum industry." The organization has published a volume with two histories written by participants covering up to 1989 and then 1989-1999. It highlighted that petroleum investment research started in 1914 with an English investment firm publishing an analysis of the value of Cities Service Co. Carl H. Pforzheimer & Co., a market maker in the stocks of the oil companies created by the breakup of the Standard Oil Trust in 1911, was publishing industry market letters starting in 1913.

More formal analyst organizations began to emerge with the formation of the Oil Analyst Group of New York in the early 1950s, emerging from discussions of several oil analysts begun in 1949. In 1973, the idea of forming NAPIA began, which was formalized in 1974. We first joined the organization in 1976 and took full advantage of its educational meetings and industry field trips, as we learned the nuances of the oil and gas industry. NAPIA was national in scope, although other regional oil analyst groups formed in Boston, Chicago, Los Angles, besides New York. Internationally, groups formed in London and Canada.

A complementary group representing the investor relations officers of the petroleum companies had existed under the auspices of the American Petroleum Institute (API) that sponsored an analyst meeting each October for two and a half days. That program ended in 1973, which may have helped prompt the move to form NAPIA, who assumed the educational conference effort. We could go on and on about the conferences, field trips, and educational programs, but it was the personal friendships developed with peers and competitors over the years that we cherish most.

For this analysis, we tracked membership data, with the help of NAPIA's executive director, for the early 1980s, mid-1980s, 1998, 2009 and 2019. As the information on the chart shows, the membership was in the 400s during the 1980s, but declined marginally to the mid-300s by 1998, partly a reflection of the decline in the number of Wall Street investment firms that focused on energy research. NAPIA's membership was cut in half by 2009, and in half again by 2019. An analysis of the membership data offers several interesting points. First, while the number of female petroleum industry analysts has declined along with total membership, as a percentage of the total, it has doubled from the early years and remained steady for the last two decades.

Exhibit 27. Industry Analysis Group Membership Reflects Changing Industry Fortunes

Data from NAPIA Membership Directories							
Year	Members	Male	Female	Buyside	Sellside	Pct. Female	Pct. Sellside
1980-81	440	423	17			4%	
1982-83	465	441	24			5%	
1986	409	384	25			6%	
1987	431	406	25			6%	
1998	362	324	38	206	156	10%	43%
2009	184	166	18	129	55	10%	30%
2019	96	85	11	79	17	11%	18%

Source: NAPIA, PPHB

The representation of sellside analysts (those working for investment banks who provide research for commissions on trades or fees) in the membership has fallen dramatically since 1998. This reflects Wall Street's view of the cost/benefit relationship of providing energy research, and in many cases any investment research. That shift is a function of changes in how research is conducted and how it is compensated. In 2000, Regulation Fair Disclosure (Reg FD) was passed by the Securities and Exchange Commission, which was designed to eliminate selective disclosure of market-moving information by companies to market professionals and certain

shareholders. It required companies to immediately release publicly the information if disclosure accidently occurred, but it encouraged companies to simultaneously disclose information when it was talking to investors. For those wondering, it is this rule that explains why people can easily obtain copies of investment presentations and even attend virtual analyst day meetings today. This rule dramatically altered the nature of Wall Street investment research.

More recently, regulators have forced Wall Street firms to separate their investment research from their investment banking departments. Not only is physical separation a reality, but rules also prevent representatives from both departments even attending meetings together. Additionally, no longer can research analysts benefit from the revenues of their investment banking departments. That was an important component of analysts' compensation in earlier years when the companies they researched used the analyst's firm for stock offerings or mergers and acquisition transactions.

The research trends above, when combined with the collapse in energy share prices in response to the current industry downturn and now the pressure from environmental activists, have made researching energy companies a less attractive undertaking. The decline in the number of energy investment analysts in largely tied to the lack of opportunities, as there are fewer companies to invest in due to smaller market capitalizations and lack of market liquidity. Additionally, since all corporate information must be disclosed publicly, the added value from research is more difficult to evaluate. Now that buyside firms must pay cash for research, often making it less costly for large investment funds to hire their own analysts, further reducing the attraction of energy securities research. Those realities are not likely to change until energy securities have outperformed the stock market for a year or more. At that point, buysiders will begin looking for help in understanding the companies and market trends, resulting in greater value from sellside research.

Combining 4Q 2020 and 1Q 2021, the Energy SPDR ETF is up 76%, well outperforming the overall stock market. Investors have been funneling more money into energy securities, although the flows remain limited by the small number of highly liquid energy company stocks. Continued outperformance and increasing returns of capital to investors will make the sector more attractive for investment. We think that is possible despite the pressure from the environmental movement. Improved financial management by energy companies and increasing returns to investors instead of investing more in oil and gas production growth at the expense of profitability will begin to resonate with investors. Those trends have emerged. Investors will remain skeptical of managements willingness to forgo growth at any cost for disciplined growth until more time has passed. However, those disciplined energy companies will not be ignored forever by Wall Street and investors.

Potential Role For Nuclear In Net Zero Economy Grows

If you have been paying attention to the climate change debate, you likely are aware of the latest International Energy Agency (IEA) report "Net Zero by 2050: A Roadmap for the Global Energy Sector." It is the IEA's plan for an aggressive set of policies, actions, and investments needed for the planet to reach net zero emissions, meaning removing as many emissions as are injected into the atmosphere. This agenda is what will be presented to the 26th United Nations Climate Change Conference of the Parties (COP26) to be held in Glasgow, Scotland in November. This meeting will address the actions necessary for countries to comply with the goals of the Paris Agreement. The goal from that meeting in 2015 was to hold warming of the planet to under 2º Celsius by 2100. Since then, to increase the pressure on politicians to put in place more radical restructuring plans for economies and societies, the warming target was lowered to 1.5º C.

Ramping up the rhetoric from global warming to climate change to climate emergency to climate crisis became necessary as a motivating pressure. How can you not address a crisis?

What is amazing is that there is no science behind the 2º and 1.5º C targets, despite how the numbers are presented. As meteorologist and climate scientist Jeff Berardelli, speaking to a CBS anchor on its Eye on Earth segment recently explained, "Humans chose 1.5. Humans chose 2 degrees." Picked out of thin air because the numbers seemed impressive? This is climate science? It is this type of abuse of climate science that Dr. Steven Koonin illuminated in his book Unsettled: What Climate Science Tells Us, What It Doesn't, And Why It Matters.

Mr. Berardelli explained that hitting these targets, which he said will happen within the next five years, likely during an El Niño year, which is a hot year, but then fall back, represents natural variation on top of climate change. In his view, hitting the temperature target is not "a tipping point and we fall of the cliff," but rather climate events will become cumulative and pile on top of climate change. This is an interesting scenario because Mr. Berardelli acknowledges natural variation in warming is what will take us to the 1.5º C threshold, but natural variation is also what will take us back down.

The IEA report on net zero fleshes out the global plan to electrify the world's economy. This will enable replacing fossil fuel power consumption with electricity generated with renewable energy, primarily solar and wind. These two power sources will be used to produce hydrogen and ammonia as fuels for applications that are not candidates for electrification or battery power. The report also spells out for politicians what policies need to be implemented to affect this transition to net zero.

The core of the strategy in this scenario was laid out in the final paragraph of its summary. The IEA said:

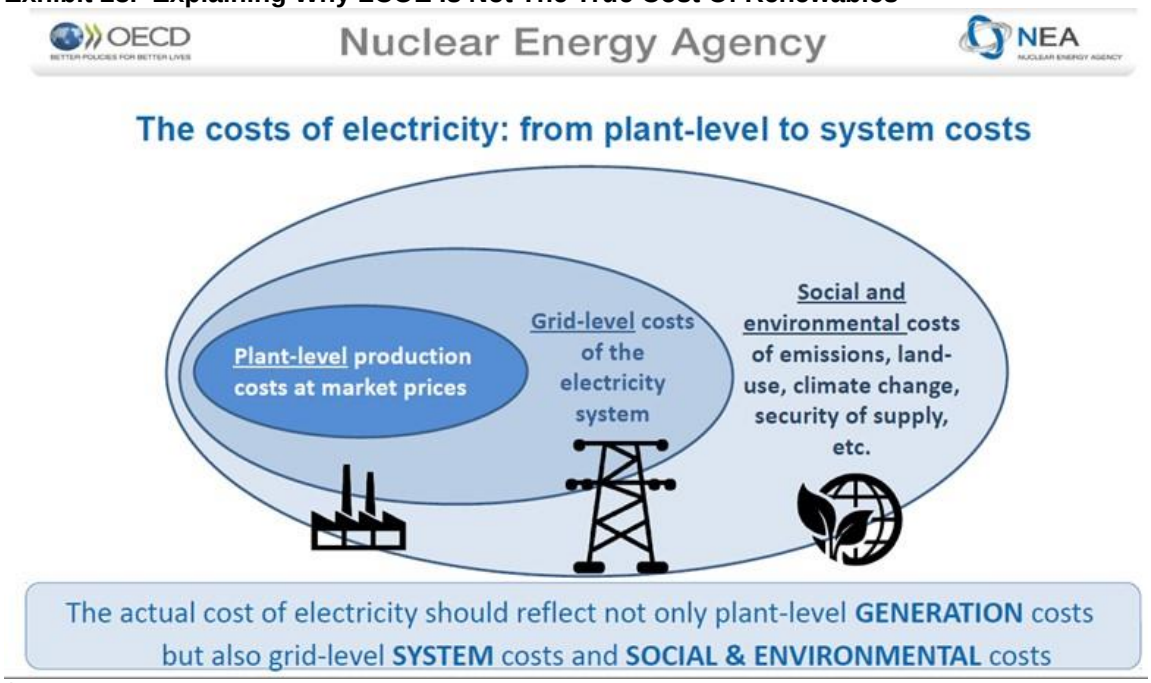
> Ever-cheaper renewable energy technologies give electricity the edge in the race to zero. Our pathway calls for scaling up solar and wind rapidly this decade, reaching annual additions of 630 gigawatts (GW) of solar photovoltaics (PV) and 390 GW of wind by 2030, four-times the record levels set in 2020. For solar PV, this is equivalent to installing the world's current largest solar park roughly every day. **Hydropower and nuclear, the two largest sources of low-carbon electricity today, provide an essential foundation for transitions**. As the electricity sector becomes cleaner, electrification emerges as a crucial economy-wide tool for reducing emissions. Electric vehicles (EVs) go from around 5% of global car sales to more than 60% by 2030. (Emphasis added)

The goals for solar and wind power growth, as well as the percentage of electric vehicle sales, appear unrealistic as the time frame and magnitude of investment and capacity additions is considerably beyond physical realities. The key point was the comment about the fundamental role of hydropower and nuclear (highlighted). Adding more hydropower capacity is challenging because of environmental considerations. As a result, more climate scientists and environmentalists are recognizing the need to embrace nuclear power because it is emissions-free, provides high and constant output, and is low cost. Equally important, which is seldom fully explained, is that in evaluating energy sources, there is an inverse relationship between energy density and the use of resources. Solar power, which is one of the least dense energy fuels being utilized, has a huge impact on land use. The most energy-dense fuel is nuclear, and it needs the least amount of land for a power plant.

In a presentation on the role of nuclear power in decarbonizing the world's economy, the speakers found it necessary to explain what happens to the electricity system as the percentage of renewables climbs. According to conventional arguments by environmentalists, renewable power is continually becoming cheaper. They rely on levelized cost of energy (LCOE) calculations that show solar and wind power becoming cheaper over time. That trend is projected to continue, which is the rationale for why we should be relying on these power sources for our energy system.

LCOE is designed to be used to optimize the selection of the lowest cost fuel in a power plant. The assumption is that the technology of the plant remains constant, only the fuel changes in the calculation. This measurement technique is now routinely used to evaluate the cost of power produced from various technologies. In effect, the calculation measures only the marginal cost of producing power with different fuels. What has confounded many energy analysts is the data showing that the cost of renewable energy is coming down, but those states and localities that rely heavily on renewables for their power are facing higher electricity bills. The explanation was best presented by Diane Cameron, head of the Division of Nuclear Technology Development and Economics of the OECD Nuclear Energy Agency (NEA) in a slide used in the decarbonization webinar.

Exhibit 28. Explaining Why LCOE Is Not The True Cost Of Renewables

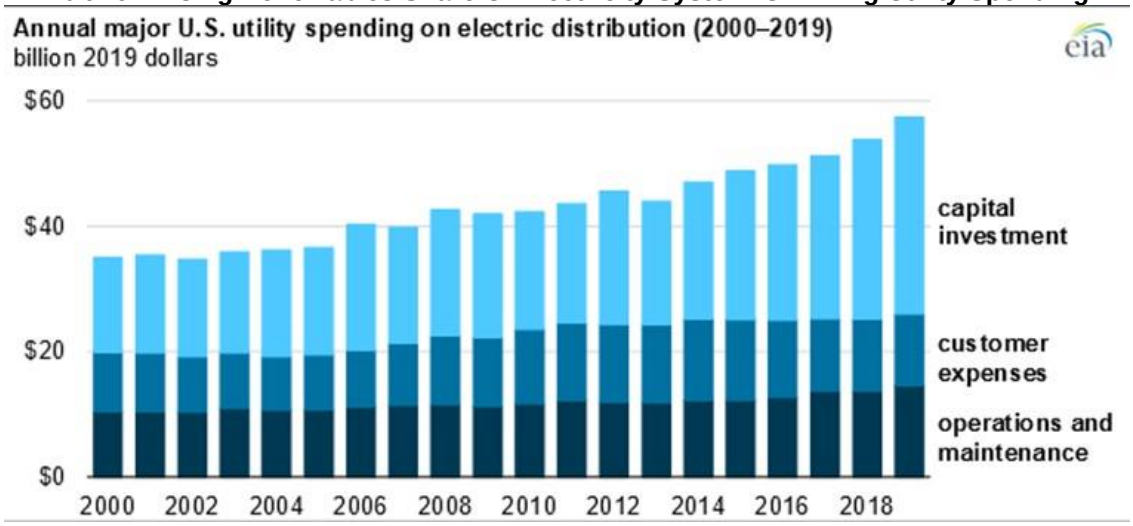


Source: NEA

The LCOE price is represented by the circle on the slide labeled "plant-level production costs." The problem for consumers of electricity is that plant-level costs are only part of the total cost of integrating new power into the grid. This additional cost is labeled "grid-level costs of the electricity system." This larger circle is what is driving consumer electricity bills and is why those states with the highest renewables content in their electricity mix also are among the states with the highest electricity prices. A recent chart from the Energy Information Administration (EIA) shows annual spending by major U.S. utilities on electric distribution from 2000-2019. Total spending has continued to increase, especially after 2005 when we know that the use of

renewable power began climbing rapidly, and the three components of spending are all rising in recent years.

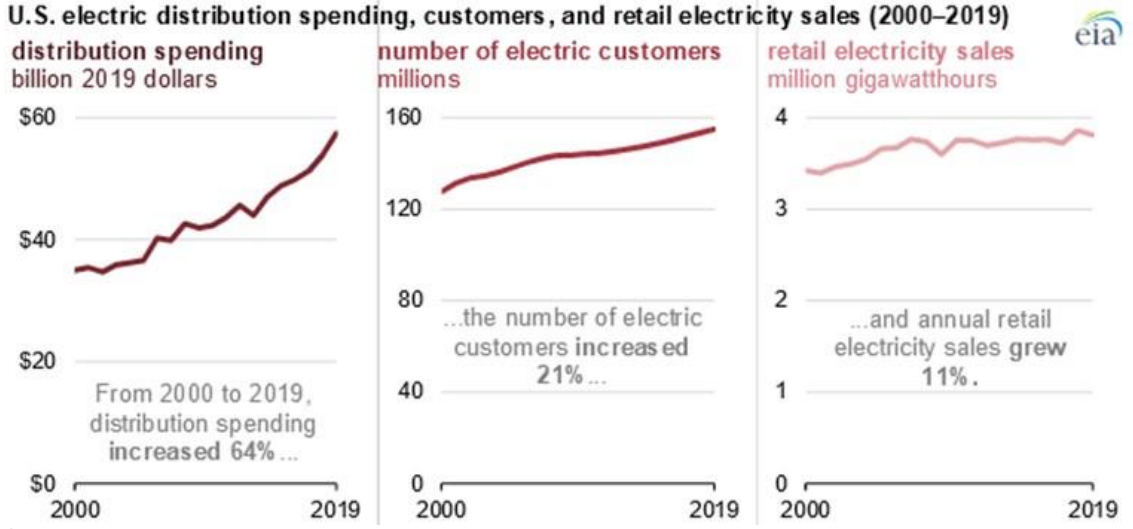
Exhibit 29. Rising Renewables Share Of Electricity System Is Driving Utility Spending



Source: EIA

The EIA data further showed what has happened to electric distribution over the time span. Distribution spending increased 64% over 2000-2019, while the number of customers only increased 21% and annual retail electricity sales grew by only 11%. The message from this data is that consumers are more efficient in their use of electricity, or more after-the-meter electricity supplies are undercutting consumption from the grid, as sales grew 11% although customers increased 21%. With distribution spending increasing threefold over the growth rate for customers, utilities are facing greater demands on their distribution systems to remain stable and capable of delivering electricity as needed, especially as renewables create greater supply challenges.

Exhibit 30. Utility Distribution Spending Is Driven By Customer Growth And Grid Stability

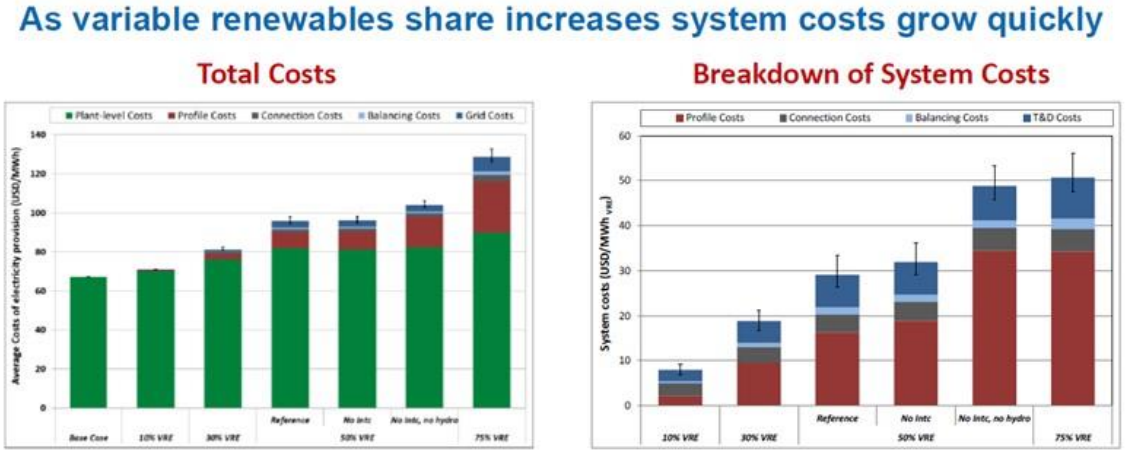


Source: EIA

While grid-level expenses add significantly to the cost of power, especially for renewables that require backup power supplies, the full cost of power may be much greater when all factors that impact the production, transmission, distribution, and consumption are considered. That is why the circle labeled “social and environmental costs” is so large. For renewables, this total cost circle is very large, even though its emissions are lower. That is because land-use is huge for renewables, and constructing the plants is very energy intensive. The chart demonstrates why LCOE is only a part of the cost in selecting the lowest cost electricity fuel and should not be the primary method for evaluating selection. When grid-level costs are included, most renewables are more expensive, which explains rising electricity costs.

To gain an appreciation of the impact of grid expense, the nuclear presentation contained several charts demonstrating how total costs escalate as we move toward 75% of the electricity coming from renewables. What is seen in the chart on the left is how total system costs rise as the percentage of variable energy (renewables) increases to 20%, 30%, 50%, and eventually to 75%. While increases in plant production costs rise, the primary driver of the total cost is the system costs. This is shown in the right-hand chart that breaks down the cost increase into profile (the cost of offsetting the system variability of renewables) and the connection cost (transmission and distribution). The profile cost is the primary impetus of the increase in system cost. This cost includes the expense of providing backup power sources – natural gas and batteries – as well as the cost of overbuilding production facilities. In some studies, there is a need to build 50% to 75% more generating capacity than the power needed to offset the low-capacity output of solar (18%-23%) and wind (30%-47%). These realities (and costs) are never discussed when the low cost of renewable power is being hailed as the savior of the planet, but these high costs are what show up in consumer bills.

Exhibit 31. Renewables Growth Causes Electricity Costs To Rise Rapidly

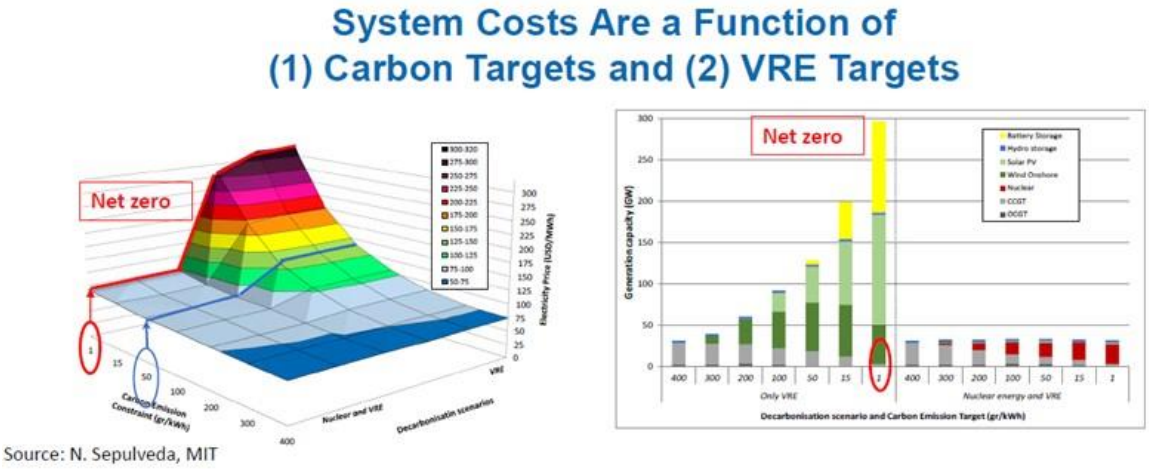


Source: NEA

Ms. Cameron presented two additional slides to illustrate the challenge of getting to net zero emissions. One chart comes from a study by MIT that shows what happens to electricity cost as we move from a no-carbon target to 50% renewables, but importantly to net zero. The way to read this chart is first to understand what the two horizontal axes show. The one going to the left shows the progression of reducing the amount of carbon emissions. The blue line is at 50% and the red line is zero, marking net zero. The axis going to the right reflects the steady increase in renewables, where at the far end, it would be 100%, corresponding to net zero. The vertical axis shows the cost of electricity. At the start of the chart, the cost of electricity is 75. As the percentage of emissions shrinks the cost of electricity rises. At the blue line (50% reduction) the

cost of electricity has gone from 75 to nearly 150. Not bad. However, as we go to net zero, as renewables reach 100%, the cost of electricity soars to 300-320, meaning another doubling of the cost of electricity from the 50% target, or a fourfold increase from the starting point.

Exhibit 32. Getting To Net Zero With Renewables Will Be Extremely Costly



Source: N. Sepulveda, MIT

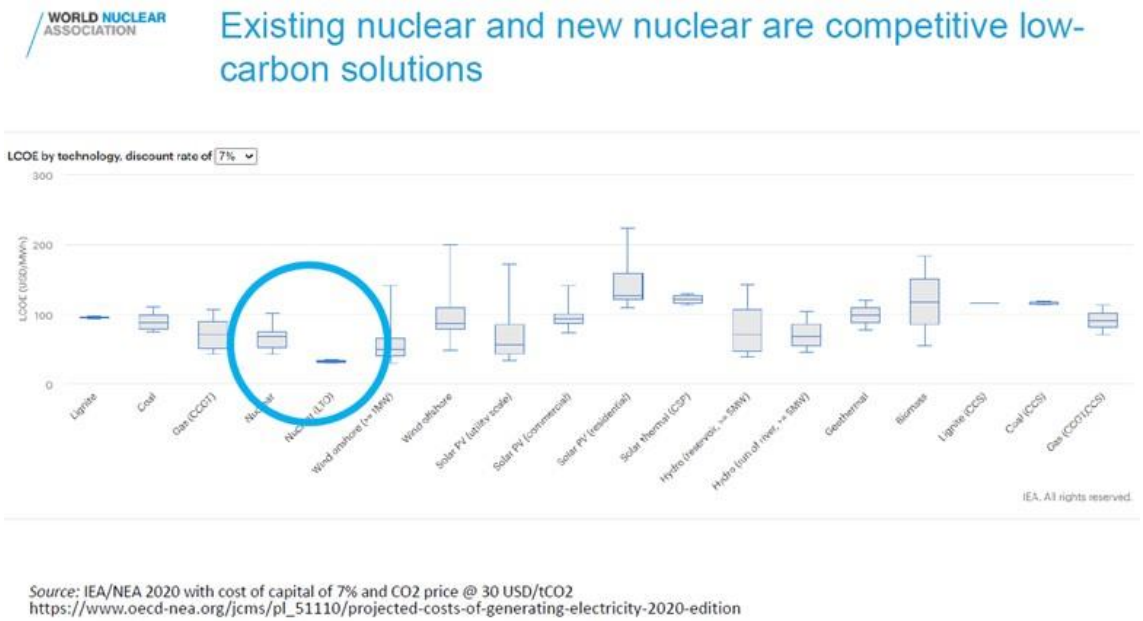
Source: NEA

The chart on the right is how the Province of Saskatchewan plans to move from its present electricity mix to net zero. The left-hand side shows the progression using renewables only. The province relies on coal, natural gas, and hydro. As the renewables share rises – using onshore wind, then solar, and finally batteries – the amount of generating capacity needed soars as emissions approach net-zero.

On the right-hand side, the same progression is shown but using nuclear and renewables. The red wedge represents nuclear power's share, but the important thing is that the amount of generating capacity needed declines slightly due to the greater output and capacity utilization of nuclear plants. Therefore, there is no need to overbuild generating capacity to ensure meeting the power needs of the province. By not having to build six-times the province's existing generating capacity, consumers will be spared huge electricity bills.

The final key point about nuclear is its low LCOE. Based on the results of a joint study by the OECD's NEA and the IEA in 2020, nuclear power is highly competitive with other fuels, and especially offshore wind, solar, biomass, and geothermal, all renewables. Only onshore wind among renewables is competitive with new nuclear. Virtually no other energy source is competitive with nuclear plants with an extended life of 20 years!

Exhibit 33. How Nuclear Power's Cost Compares With Renewables And Other Sources



Source: IEA/NEA 2020 with cost of capital of 7% and CO2 price @ 30 USD/tCO2
https://www.oecd-nea.org/jcms/pl_51110/projected-costs-of-generating-electricity-2020-edition

Source: World Nuclear Association

What is most interesting about nuclear is the experience with small, modular units, something like the units that have powered our navy for decades. These small units could be built in a factory-like setup and installed close to power consumption centers, eliminating the need and cost of new transmission lines, such as are being planned as we build out a renewables-based electricity system. That will help reduce the investment needed in the new electricity system and limit the increase in consumer power bills. The hurdle nuclear needs to overcome is fear of a disaster. However, the history of nuclear power plant accidents shows risks can be mitigated and the cost of plants and the time necessary to build them reduced. This will require a significant public relations effort, and one that should begin immediately. As more serious climate scientists and engineers recognize the role nuclear needs to play in our future power system if climate change goals are to be met, the sooner the PR campaign begins the better.

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