PPHB
ENERGY INVESTMENT BANKING

MUSINGS FROM THE OIL PATCH

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Note: *Musings from the Oil Patch reflects an eclectic collection of stories and analyses dealing with issues and developments within the energy industry that I feel have potentially significant implications for executives operating and planning for the future. The newsletter is published every two weeks, but periodically events and travel may alter that schedule. As always, I welcome your comments and observations.* Allen Brooks

Summary:

Changing Forces Behind Energy Demand Creating Conflicts

It seems everyone is questioning whether there is a role for oil and gas in our future energy supply. What is driving energy demand is population growth, which may be slowing appreciably, potentially altering how much energy we will need. Regardless of future hydrocarbon demand, we will need oil and gas for decades.

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Understanding Solar Power Furor Amid Increased Emissions

Is it really possible that solar power can actually create more carbon emissions than if utilities only used natural gas? Yes, but one really needs to understand engine operations and the costs and challenges of operating 100% renewable energy systems. Expensive and technically challenging describe a renewable future.

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Recession; What Recession? On The Road Again To Houston

Driving back to Houston left us sorting our observations into trucks, construction and crowds. We were shocked at how many trucks were on the highways on a fall Saturday and Sunday, as well as the miles of concrete construction barriers we encountered. Crowds made some other experiences more challenging.

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Unknown Yom Kippur War History From A *Musings* Reader

In acknowledging my recognition of Portugal as a supporter of Israel during the Yom Kippur War in 1973, a reader offered his personal experience in flying the military airlift that was related to the Arab Oil Embargo. Enjoy this history lesson, as this airlift helped set the course for U.S. Middle East and oil policies.

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Changing Forces Behind Energy Demand Creating Conflicts

The history of energy demand has been tied closely to global population growth, increased economic activity and improved living standards. These drivers underlie virtually every long-term energy forecast made, and it forces a focus on projections about how the world will meet its growing energy needs.

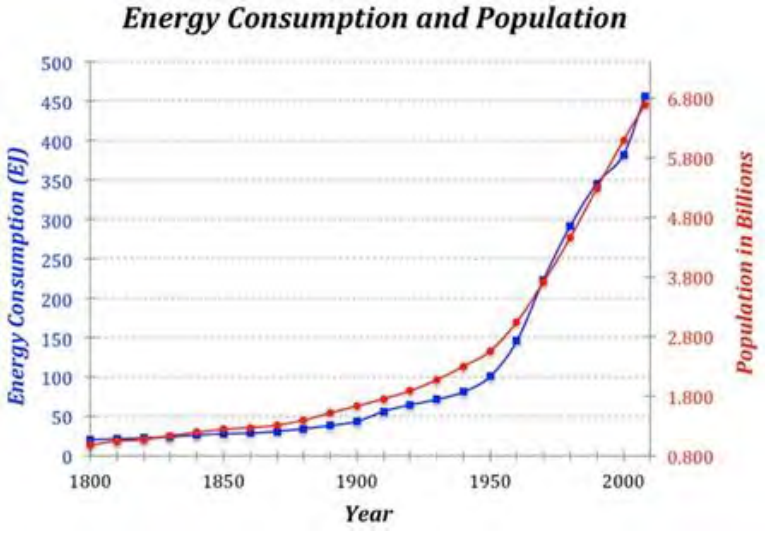
Global population projections show more people in the future, but the rate at which the world's population is growing has slowed

Global population projections show we will have more people in the future, but the rate at which the world's population is growing has slowed in recent years, setting up the possibility we may be entering an era of shrinking population. While total population growth is important, so is its composition. Ageing populations, especially in many of the wealthiest and most developed countries, is now acknowledged as an issue for many societies and economies, with ramifications for future energy demand. The implications may be magnified further if attitudes against the use of fossil fuels for generating energy gain greater traction, thereby depressing the historical energy/population consumption relationship.

Slowing energy use in developed economies with ageing populations is being offset by exploding youthful populations in many developing economies

Slowing energy use in developed economies with ageing populations is being offset by exploding youthful populations in many developing economies. The people in many of those economies have lacked access to power, suggesting that their energy needs will likely be greater than the energy declines experienced by developed economies. As the residents of developing economies eventually gain access to energy, the questions will become: How much energy will they use? And what form will it take? Answering these questions will help forecasters to better project the world's energy needs, and where it will come from.

Exhibit 1. Energy And Population Track Closely Over Time

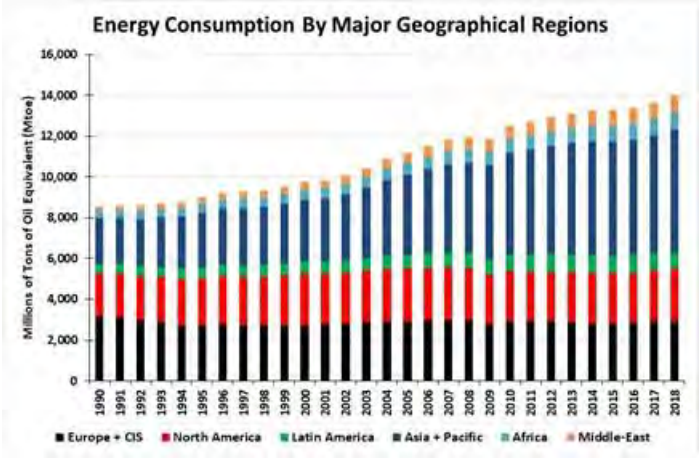


Source: psu.edu

From the late 1800s until 1950, the globe's population grew faster than energy consumption

Exhibit 1 (prior page) shows the historical relationship between global population and world energy consumption growth. It is interesting that from the late 1800s until 1950, the globe's population grew faster than energy consumption, which we believe is explained by improved living standards and medical care that contributed to reduced mortality rates and increased lifespans. Since 1950, the rate of increase in both population and energy consumption have been in lockstep. More recent data shows how energy demand is growing by region, supporting the view that Asia and its population growth is the current driver behind global oil consumption.

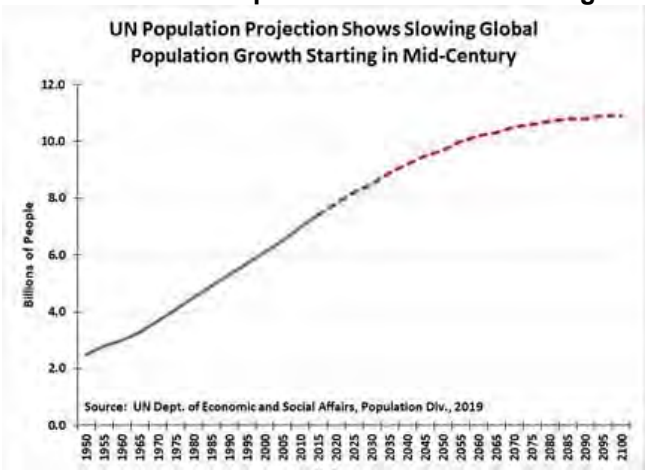
Exhibit 2. Energy Use Is Migrating Around The World



Source: IEA, PPHB

What we see from the UN Population Division's latest forecast is that global population growth is projected to slow as we approach 2050, and eventually plateau during the final quarter of the century.

Exhibit 3. World Population Growth Is Slowing

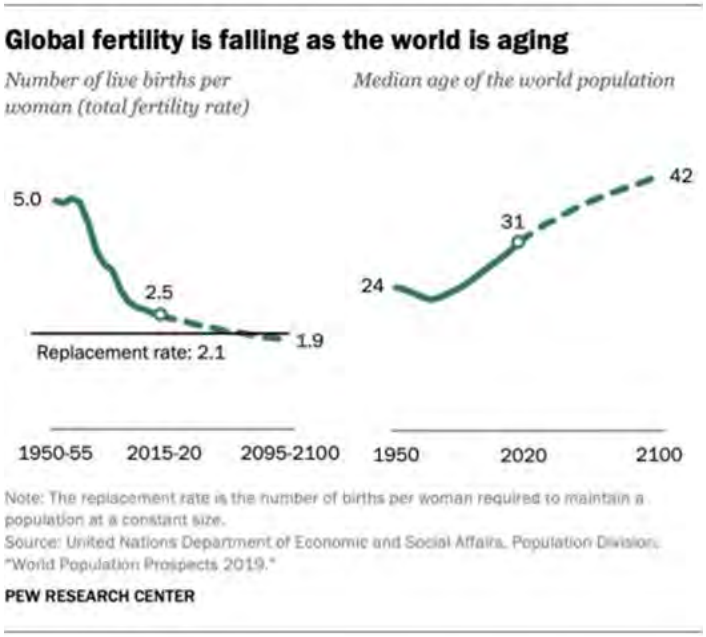


Source: UN, Pew Research, PPHB

The fertility rate has fallen since 1950 and is projected to continue to decline until the end of the century

Slowing population growth is due to a decline in the global fertility rate, or number of births per female. A chart from a recent Pew Research report shows that the fertility rate has fallen since 1950 and is projected to continue to decline until the end of the century. As the chart shows, the fertility rate in 2095-2100 is projected to be only 1.9 live births per woman, below the replacement rate of 2.1. This means the total population will cease growing and eventually contract. It also means the world's population will continue ageing, taking the current median age of nearly 31 years to 42 by 2100.

Exhibit 4. The Driver Of Population Growth Is Falling



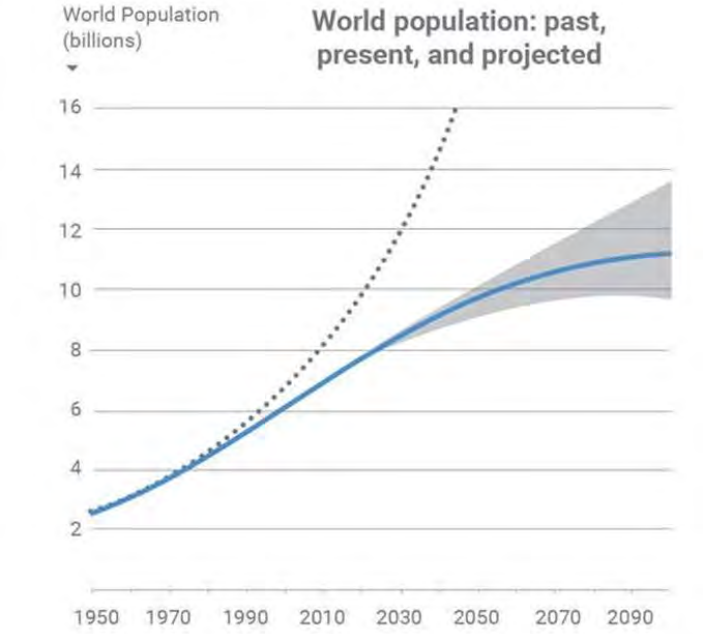
Source: Pew Research

The global population forecast has grown at a linear rate since the 1970s rather than exponentially had fertility rates remained constant

To gain a better appreciation of the significance of the fertility rate decline, one only needs to examine Exhibit 5 on the next page that shows population growth assuming fertility rates had remained as they were in the 1960s. Data shows that Chinese women have been bearing fewer children than American women since the 1990s. As a result, the global population forecast (blue line) has grown at a linear rate since the 1970s rather than exponentially (dotted line) had fertility rates remained constant.

At the time Exhibit 5 was prepared, the UN was projecting a world population of 10 to 13 billion, with a median projection of 11.2 billion, in 2100. The 2019 projection shows the 2100 median population to only grow to 10.9 billion. Further changes to fertility and mortality could reduce population growth, as African women elect to have fewer children in the future.

Exhibit 5. How Population Forecasts Have Changed

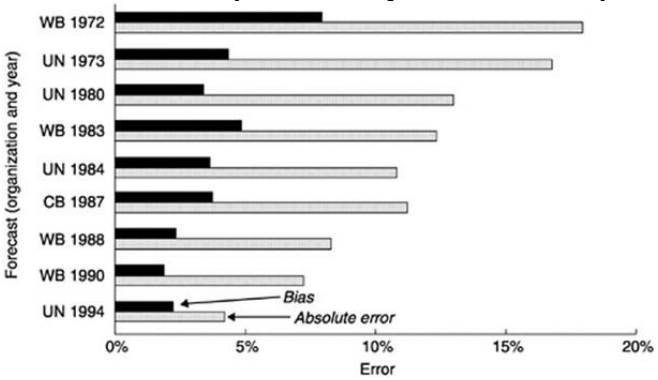


Source: UN Dept of Economic and Social Affairs, Population Division.

The amount of energy needed in 2100 could be much greater, or possibly meaningfully less, depending on the accuracy of the forecast

The population projection forces us to consider that the 30% spread between the high and low estimates for 2100 has significant implications for future energy demand. The amount of energy needed in 2100 could be much greater, or possibly meaningfully less, depending on the accuracy of the forecast. Unfortunately, the history of population forecasts shows them often to be wrong. A series of charts from a 2000 report analyzing the accuracy of United Nations and World Bank population forecasts shows the error amount improving during 1972-1994, but still being significant. The absolute error declined from about 18% in the 1972 World Bank forecast to closer to 4% for the 1994 United Nations forecast.

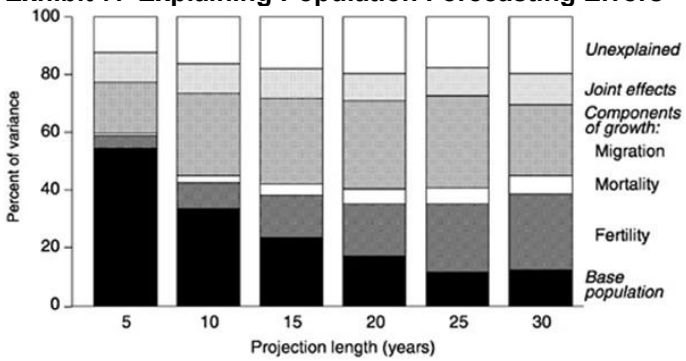
Exhibit 6. How Population Projections Have Improved



Source: Beyond Six Billion

When the researchers examined what influenced the errors, it was interesting that the farther into the future projections went, the greater the error, although that is not surprising. The errors are explained by missed fertility and mortality rate assumptions. There is also a greater "unexplained" factor in the longer forecasts.

Exhibit 7. Explaining Population Forecasting Errors

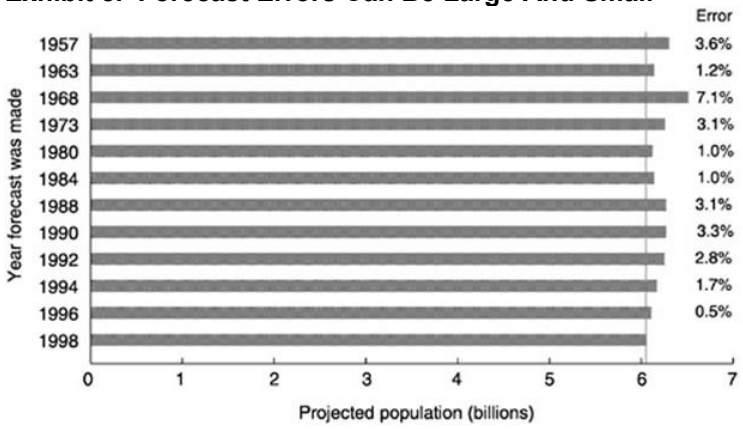


Source: Beyond Six Billion

Overshooting a forecast by 3%, in the case of the latest UN projection of 10.9 billion people in 2100, would equate to more than 400 million additional people than actually would exist

Another accuracy assessment showed the forecasts made every few years between 1957 and 1998, when the global population reached six billion people. Each forecast overshot the actual results. Even the most recently made forecast, barely two years earlier, missed by 0.5%. A forecast made 30 years prior missed by over 7%, and many interim forecasts missed by about 3%. Overshooting a forecast by 3%, in the case of the latest UN projection of 10.9 billion people in 2100, equates to more than 400 million additional people than actually would exist. How much more energy, food, water and CO_2 would be associated with those 400 million additional people?

Exhibit 8. Forecast Errors Can Be Large And Small



Source: Beyond Six Billion

We do not mean to criticize these forecasters. We spent most of our career making forecasts and having most of them turn out wrong.

The lesson to be learned, however, is to appreciate the uncertainties of forecasts. We know people love single-point estimates. They either help or destroy arguments. A plus-or-minus 3% spread around a median population forecast translates into a range of 900 million people around the point estimate, presenting a huge challenge for planners. The challenge is elevated when the forecasts are linked to those of economic activity.

Growing populations propel economic activity

Growing populations propel economic activity. The pace of economic growth is generally faster than for the population due to the productivity enhancements of humans by providing workers with tools and knowledge. The wheel, the locomotive, the airplane, and the computer, to name a few significant inventions, have all contributed to significantly greater economic activity than would have occurred without them. These inventions contributed significantly to long-term economic growth, but their timing and adoption often created short-term economic fluctuations, something that we generally refer to as the business cycle.

With some economies already experiencing contraction, will it be possible to avoid a downturn?

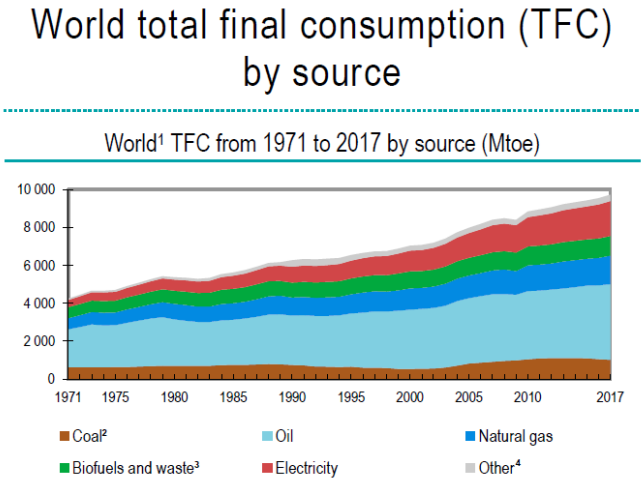
Of great concern now is the future of our current business cycle. We are in the longest economic recovery cycle in U.S. history. Therefore, economists are concerned about the health of the economy. Are we on the brink of a global recession similar to the 2009 downturn, or will any decline that occurs prove to be more modest? What if we do not experience a downturn in the foreseeable future? Can the economy continue to grow at the pace of the past 18 months, or are we destined for slower growth? With some economies already experiencing contraction, will it be possible to avoid a downturn? The pace of future economic activity will determine energy demand growth. Is energy consumption only about economic activity, or are other factors at work that could alter the pace? Expectations are our energy mix – fossil fuels versus renewables – will shift, but how quickly, and by how much?

A quick review of energy consumption history may provide some insight into these issues. Exhibit 9 on the next page shows energy use from 1971 to 2017 by fuel. What is evident is the noticeable consumption drop experienced in 2009 during the Great Recession. The chart also shows the snapback once the recession ended.

If we experience a recession in the next 12-24 months, will it be modest like 1998 or 2001, or more severe such as experienced in 2009 or those of the 1970s?

What we also can see from the chart is the consumption declines following the 1973 oil price spike, as well as after the jump in oil prices in 1979. The aftermath of that latter decline was longer than following the earlier price spike. We can also identify other recessions, such as in 2001 and 1998. Each showed brief periods of energy use declines or energy remaining stable. These latter episodes were not as extensive or deep as the 1973, 1979 and 2009 recessions. If we experience a recession in the next 12-24 months, will it be modest like 1998 or 2001, or more severe such as experienced in 2009 or those of the 1970s? Answering that question will dictate the impact on energy consumption.

Exhibit 9. Energy Consumption Shows Recessionary Impacts



Source: IEA

Renewable energy is afforded a competitive advantage due to political preference

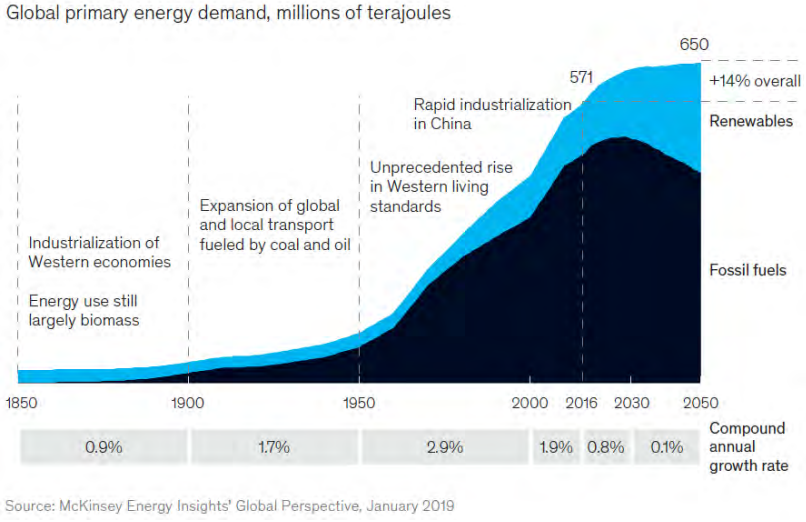
What will be different for energy in the next recession will be the role of renewables. By their nature, wind and solar are intermittent power sources. However, since their fuel is free, the cost of the renewable energy they generate is low, although the total cost is higher due to expensive costs for backup power supplies. Renewable energy is afforded a competitive advantage due to political preference. Renewables will continue producing electricity at the expense of fossil fuels. Therefore, it is likely fossil fuels will bear the brunt of any energy consumption decline due to a recession. Because of the historically slow response of fossil fuel supply changes to demand changes, we could see large increases in oil and gas inventories that depress commodity prices, increasing industry activity volatility and weakening the industry's response.

The unknown in all these forecasts is the speed with which fossil fuel consumption will decline after peaking

This shifting mix of fossil fuels and renewables is demonstrated in a chart from an early 2019 report from consultants McKinsey and Company. The report projects renewables demonstrating significant growth as fossil fuel use peaks in 5-6 years. While fossil fuel's peak timing may be coming sooner than suggested by other forecasts, especially those of major oil companies, even their forecasts acknowledge a peak for fossil fuel consumption within the next 5-10 years. The unknown in all these forecasts is the speed with which fossil fuel consumption will decline after peaking. Will it plateau for a period of time before falling, and will the decline be slow or rapid?

Exhibit 10. How Renewables Will Reshape Energy Use

After a century of rapid growth, energy demand is likely to plateau around 2030, primarily driven by the penetration of renewable energy sources into the energy mix.



Source: McKinsey and Company

Politics is the primary driver behind the adoption of renewables

Politics is the primary driver behind the adoption of renewables. True economic analysis of renewables takes a backseat to political objectives, and there is little the fossil fuel energy industries can do to change that fact. They may be able to slow the pace of renewables adoption, but the handwriting is on the wall. The mob wants "green energy," even though it has little understanding of its shortcomings and economic costs.

The existing global energy infrastructure cannot be switched to renewables overnight

What is important for the fossil fuel industry to appreciate is that, despite the doom and gloom overhanging its future, the existing global energy infrastructure cannot be switched to renewables overnight, or at a minimal cost. It will take decades to make such a switch, assuming it can ever be done, and it will cost trillions of dollars.

The oil industry must bring into production seven million barrels a day of new supply merely to keep total supply stable

For the global oil industry, which is working daily to supply 100 million barrels a day of crude oil, its productive capacity declines approximately 7% per year. To offset this natural decline rate, the oil industry must bring into production seven million barrels a day of new supply merely to keep total supply stable. As Alice in Through the Looking Glass was told by the Red Queen, "Now, here, you see, it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!" All the running the industry can do in today's financial environment will be necessary to sustain oil production, let alone increasing output. Unfortunately, this scenario is likely to last for years, and possibly decades.

Increased regulatory and litigation costs will consume more of oil, gas, coal and nuclear company budgets

While the Green New Deal is receiving increased attention, the realities are that the fossil fuel industry is under relentless attack from environmentalists. Their tactics in this struggle will not only slow the pace for bringing new supplies to market that will be needed despite claims to the contrary, but it will raise the cost of doing business. Increased regulatory and litigation costs will consume more of oil, gas, coal and nuclear company budgets. For environmentalists, anything they can do to raise the cost of more energy-efficient fuels helps their renewables compete. This battle explains why natural gas, the "bridge fuel to the future," has now come under relentless attack. It has the lowest carbon footprint of the traditional fossil fuels, offers 100% efficiency, and is "dirt" cheap, putting significant pricing pressure on wind and solar power that deliver only 40%-65% efficiency, inflating their true cost.

In a growing number of large metropolises around the world, people and bikes are now favored over vehicles

In the battle over public sentiment, the promises of the Green New Deal overlook the reality of what it will require of society. Yes, it envisions societies restructuring economies to be powered entirely by renewable energy, but what will it mandate for lifestyles? It will propel us away from a reliance on horsepower to relying on electric motors and human power. In a growing number of large metropolises around the world, people and bikes are now favored over vehicles. Other tactics are being wielded against fossil fuels that appear to be more subtle, albeit just as effective in retarding their progress. For example, the idea of restricting access to lands where natural resources remain can be effective, although the restriction doesn't appear as a blatant attack against hydrocarbons. If you can't explore for them, how do you know the resources are present, and therefore, how can you say you are being restricted?

Another subtle attack is to shame investors and capital providers into stop making money available for exploration, development and production of hydrocarbons. Again, this does not appear to be blatant, but it may eventually force oil and gas companies to rely entirely on their own cash generating capabilities to provide money for drilling and producing new hydrocarbon resources.

Every time we have confronted supposedly insurmountable odds for our future survival, man's ingenuity proved more powerful than ever thought possible

Observing energy and history from a very high level, we note that fears for the future of the human race have often been elevated to hysteria only to be proven wrong. Plagues have come and gone; global warming and cooling eras have existed, and began and ended without man's intervention; and the ability of the human race to feed the world's population through improvements in farming and plant evolutions elevated billions of people from subsistence existence. Every time we have confronted supposedly insurmountable odds for our future survival, man's ingenuity proved more powerful than ever thought possible. We are now at another one of those crossroads. Suggesting we are heading towards an abyss with no hope of avoiding it is counter to the optimism that has governed human lives. Should we strike up the band on the back deck of the Titanic while we wait to go under the water, or should

we employ our "best and brightest" to unleash their talents for finding solutions? We like the latter idea better, and believe those we are relying on will find solutions.

Understanding Solar Power Furor Amid Increased Emissions

How is it possible that solar power, which is reportedly one of the cleanest renewable fuels, could actually lead to higher CO2 emissions?

Duke Energy's (DUK-NYSE) request for modification to air quality permits to allow adjustments in the operation of combined-cycle natural gas power plants in five counties in North Carolina has generated significant furor among proponents and opponents of solar power. The lead in many media articles highlights that solar power is actually causing more carbon emissions than if only natural gas power plants were used exclusively. How is it possible that solar power, which is reportedly one of the cleanest renewable fuels, could actually lead to higher CO_2 emissions?

The issue is actually true, and supported by Duke Energy's data. The issue, however, has been around for several years and was the subject of debate and study in Los Angeles. It will actually become a more significant issue as renewables gain a greater share of the nation's power supply. So, what's the issue?

When the sun goes down, even after a completely sunny day, electric power needs to be generated by another power source – fossil-fuel power plants or from batteries or pumped storage facilities

Clean renewable energy has one flaw – it is intermittent. That comes from nature's failure to have the sun shine all day, every day, and for the wind to blow non-stop. When the sun goes down, even after a completely sunny day, electric power needs to be generated by another power source – fossil-fuel power plants or from batteries or pumped storage facilities. Electricity supplied from batteries for an entire night is hard to achieve (takes lots of batteries) and is expensive. Additionally, the manufacture of lithium-ion batteries creates significant carbon emissions. Pumped storage is limited by requirements for water supplies and reservoir land. That is why most back-up power supplies come from fossil fuel plants.

Both solar and wind power suffer from intermittency for brief periods of time, especially when clouds obscure the sun and winds stop or blow too hard for turbines. In those instances, back-up power supplies must ramp-up rapidly, which has led to natural gas combined cycle plants being the preferred choice because of their performance. During the ramp ups, gas plants will emit greater amounts of CO_2 than when they are operating at their maximum efficiency. This is where the Duke Energy issue comes into play.

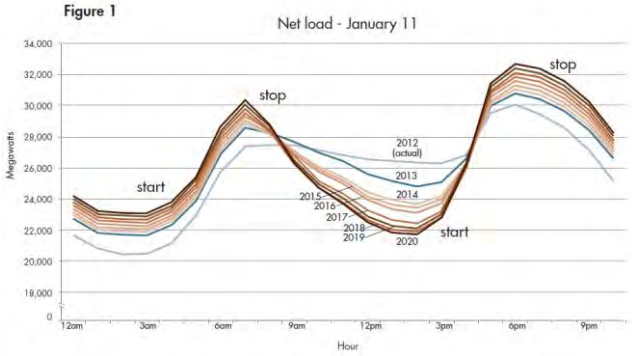
Intermittency requires back-up power, which carries a cost, and as we are finding out, a potential environmental cost

Before turning to the Duke Energy controversy, let's examine the challenge utilities are facing when integrating renewable energy into their operations. This challenge will grow, and it will carry a cost that is only now beginning to be examined. Intermittency requires back-up power, which carries a cost, and as we are finding out, a potential environmental cost. The California Independent System Operator (CAISO) actually published a paper in 2016 on the issue. In that

CAISO declares that adding renewables into the power mix will require utilities to refigure how they will manage their fuel supplies

paper, CAISO published a chart showing its net power load by hour of the day. It created a chart showing how that net power load has changed for January 11 of the years 2012-2020, with the years beyond 2016 representing forecasts. What the data showed was a peak in power demand at 7 am, as households rise and begin preparing for their day ahead. When people go to work and school, the power load declines sharply. It then rises rapidly when people arrive home from work and school and begin preparing dinner, etc. This is a time when air conditioning load increases and electric vehicles are plugged in for charging. As the balance of the evening progresses, the net power load declines as people begin going to bed and turn off their electronic devices and televisions. CAISO declares that adding renewables to the power mix will require utilities to refigure how they will manage their fuel supplies.

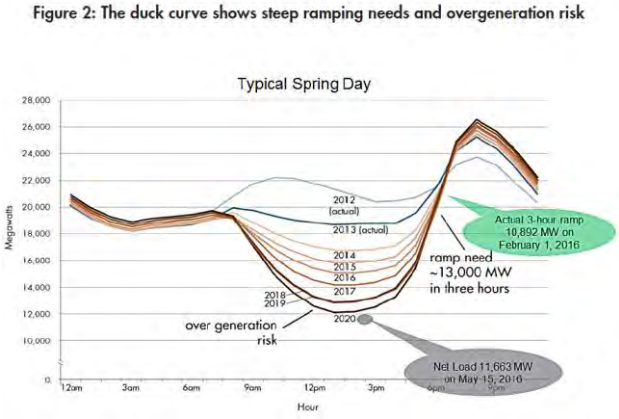
Exhibit 11. Challenge Of Managing Renewables On Grid



Source: CAISO

This report was an early effort at addressing the DUCK curve of power that has become notorious for its implications. A second CAISO chart demonstrated issues utilities face when bringing on backup power, as well as potentially generating too much power.

Exhibit 12. Load Variations Creates Serious Ramp Issues



Source: CAISO

As Exhibit 12 on the prior page shows, on February 1, 2016, CAISO had to manage bringing on nearly 11,000 megawatts (MW) of power supply in a three-hour window. That represented nearly 42% of the peak energy consumed that evening!

For renewable power providers who are receiving subsidies, they care little about negative power prices as long as they do not fall below the subsidy price the generators receive

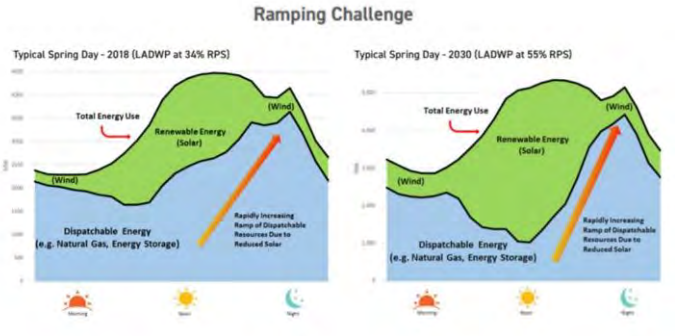
In the same chart, CAISO noted that on May 15, 2016, the net power load dropped to 11,663 MW, below the lowest projected load curve for 2020. At this level of power generation, which notably came between 2 pm and 3 pm, the system was at risk of a serious over-generation condition, meaning it could not take all the power it was paying for, which drives spot power prices into negative territory. That meant power providers would be paying the utility to take its power, or figuring out some way of dumping it into another power market. For renewable power providers who are receiving subsidies, they care little about negative power prices as long as those do not fall below the subsidy price the generators receive.

In Los Angeles, the Department of Water and Power (LADWP) has embraced moving its operations to 100% renewable fuels by 2030, in keeping with the city's and state's mandates for building a totally green economy. The LADWP contracted with a consultant to study the issue. The report concluded that such a shift was possible, but it would require significant changes in how the system would operate. Additionally, there would need to be significant investment in the system, escalating dramatically in the final years of the transition.

It is clear that the magnitude of the ramp up will be much greater in 2030, and in a much shorter time span

The report presented two charts showing the ramping challenge the LADWP system faced as it transitioned from 2018's load to the one projected for 2030. It is clear that the magnitude of the ramp up will be much greater in 2030, and in a much shorter time span. While the numbers were not presented, the magnitude of the ramp up becomes clear when the charts are viewed side by side.

Exhibit 13. LADWP Will Face Similar Power Ramping Issues



Source: Synapse Study

When it came to discussing the cost of operating the system as it neared 100% renewable supply, another chart showed the price. It

should be noted that the annual cost for the system declines in all the prior years until the final two years, in this case 2029 and 2030, at which point the system's annual costs explode.

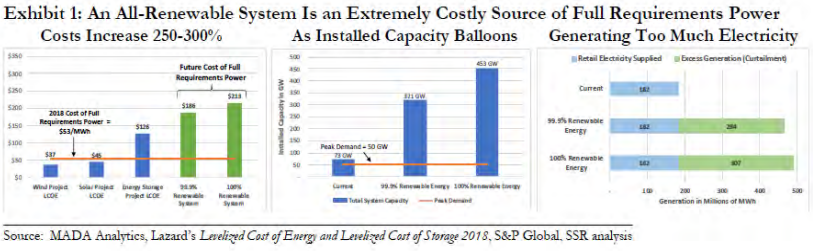
Exhibit 14. System Costs Explode Near 100% Renewables

Source: Synapse Study

Senate Bill 100 puts California on a course towards 100% renewable electricity generation

In an interview following submission of the report to the LADWP, one official remarked that the cost increases in the last two years were only the start of what residents would be facing in future cost increases. That statement is consistent with the results of a study by Sector & Sovereign Research (SSR) estimating the cost of bringing the State of California into compliance with Senate Bill 100. It was passed by the California legislature in August 2018 and signed into law by then-Governor Jerry Brown that September. The bill has set a target of supplying 100% of retail electricity sales in California from zero-carbon resources by 2045. The state's last operating nuclear power plant, Diablo Canyon is scheduled to retire in 2025. Therefore, Senate Bill 100 puts California on a course towards 100% renewable electricity generation.

Exhibit 15. 100% Renewables Creates Many Problems



Source: SSR

The summary of the results of the study brings into focus the cost this move will have on residents of the state. While many people only focus on the electricity ratepayers, it is important to note that apartment renters will find that they either are charged separately for their electricity, or will see their monthly rents increased to offset expected electricity costs. The summary states:

We estimate the levelized cost of electricity from such a system at $213 per [megawatt-hour] MWh; compared with the 2018 average price for full requirements electricity of $53/MWh, this implies an increase of $160/MWh or 300%

"In this research report, we assess the scale and cost of the renewable resources required to transition California to a 100% renewable supply of electricity with a degree of reliability comparable to that of California's power grid today. We estimate the levelized cost of electricity from such a system at $213 per [megawatt-hour] MWh; compared with the 2018 average price for full requirements electricity of $53/MWh, this implies an increase of $160/MWh or 300%. The high cost of 100% renewable energy reflects the intermittency of wind and solar power; to ensure current standards of reliability, we estimate the scale of the renewable generation and battery storage resources required at 450 GW, as against the 75 GW of capacity required by the state today. Such a system would be capable of generating 300 million MWh of electricity in excess generation of the state's needs, with significant implications for the economics of electric vehicles and power prices in neighboring states."

The study does not contemplate the use of natural gas as a backup, rather it assumes the construction of greater renewable generating capacity and associated battery storage. To achieve the California 100% renewable requirement, the authors of the study assessed the existing renewable resources and estimated the least-cost mix of additional renewable energy resources to adequately meet the state's demand for electricity during each hour of the year. That mix requires 15 gigawatts (GW) of wind capacity, 250 GW of solar capacity and 710 gigawatt-hours (GWh) of battery storage capacity, equivalent of 177.5 GW, given the typical four-hour duration of discharge of lithium-ion batteries. Compare these requirements against California's current installed fleet of 9.2 GW of wind, 13.8 GW of solar and 0.2 GWh of installed energy storage. As this study was released in April of this year, we assume the numbers are relatively current.

The 99.9% system would increase the cost of electricity to $186/MWh versus the 100% renewable estimate of $213/MWh

Rather than paying 300% more for electricity than in 2018, the study also considered the practicality of building a 99.9% renewable energy resource system. That would "require 50 GW of wind, 130 GW of solar and 130 GW of battery storage capacity, in addition to 10 GW of existing geothermal and hydroelectric capacity, for a total of some 320 GW of renewable energy and battery capacity. By comparison, California's power demand is met today by some 75 GW of conventional and renewable power generation capacity." The impact on cost is significant. The 99.9% system would increase the cost of electricity to $186/MWh versus the 100% renewable estimate of $213/MWh. The state currently pays $53/MWh for power.

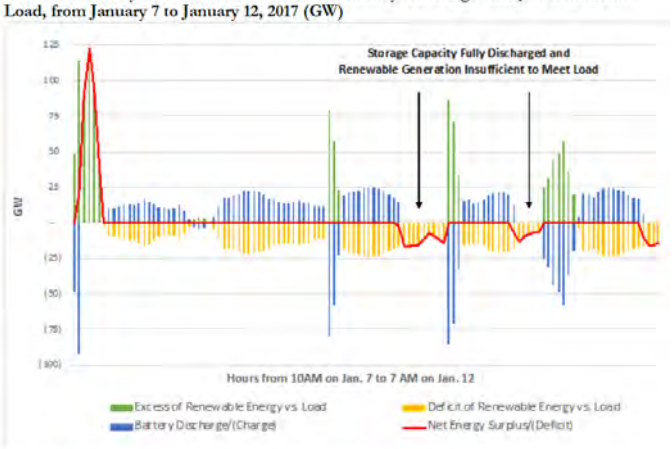
The one issue with the 99.9% system is that it would have left the state without any power for 20 hours in 2017, of which, for 10 hours the shortfall would have been greater than 50% and for four hours it would have been greater than 75%. The shortfalls would have

All the battery storage capacity would have been drained

occurred between January 7 and January 12, 2017. The shortfall was due to cloudy and rainy weather and the shorter winter days for solar generation, plus still winter nights. All the battery storage capacity would have been drained, which adds to the demand when renewable power begins producing again.

Exhibit 16. 100% Renewables Can't Cover Every Hour Of Power

Exhibit 4: Hourly Renewable Generation and Battery Discharge Compared to CAISO Load, from January 7 to January 12, 2017 (GW)



Source: MADA Analytics, Lazard's *Levelized Cost of Energy and Levelized Cost of Storage 2018*, S&P Global, SSR analysis

Source: SSR

The study suggests that rather than build much more renewable generating capacity and larger energy storage capacity, the state should use its gas-fired power systems. Building more wind and solar generating capacity and greater battery storage would cost an additional $125 billion. A 100% renewable power system, if done today, would add $37 billion to residents' electricity bills annually.

The need to ramp up gas generators rapidly, or restart them, increases the CO2 they emit

While the idea of helping Californians save on their electricity bills by not going 100% renewable power involves using gas-fired power plants, the issue of carbon emissions was not considered. This is the issue with the Duke Energy air permit request. The need to ramp up gas generators rapidly, or restart them, increases the CO_2 they emit. Duke Energy is seeking relief from these requirements for certain gas-fired power plants used to back up solar power.

What is making this case so interesting is that it is the first time, according to Steve Gorham, a policy advisor to the Heartland Institute who writes and lectures on energy, climate and pollution, that internal data such as this has been made public. He and others believe this data requires deep scrutiny by regulators and policymakers. Mr. Gorham referenced studies in Colorado and the Netherlands that concluded adding wind power to the electricity grid increased CO_2 emissions. "This issue deserves a re-look, and it needs to be done fast," Dan Kish, distinguished senior fellow at the Institute for Energy Research, said after reviewing Duke's data. These two energy experts, due to their affiliations with conservative

organizations, are being attacked for spreading false stories. In fact, the headline on one news article by Austin Bailey of *Community*, which was published on Daily Kos, "the nation's largest progressive online media and activism hub," blared: "Building A Case That Solar Energy Causes Air Pollution - The Right Wing Noise Machine At Work." Another example of the polarized nation we live in.

"That study relied on computer simulations and hypothetical scenarios, while Duke's numbers are based on recorded data from full-scale operations"

Solar proponents, and those attacking the Duke Energy request, point to a 2013 report by the National Renewable Energy Laboratory (NREL) and other researchers that concluded CO_2 emissions are negligible when wind and solar are added to the electric grid. Nitrogen oxide (NOx) emissions might be reduced slightly more than expected, but sulfur dioxide pollutants could increase. But, as even a number of other media reporters wrote, "That study relied on computer simulations and hypothetical scenarios, while Duke's numbers are based on recorded data from full-scale operations." Is this about the facts or the truth? Is the science settled?

What Duke Energy seeks is relief. Under its current permits in the heavily regulated North Carolina power market, Duke Energy must completely shut down its backup combustion turbines when solar peaks under a full sun, and then restart them when the sun recedes. On cloudy days, the intermittent sun will force the restart and ramp up of gas generators frequently.

In its permit applications, Duke Energy said this change in operating policy would lower emissions and reduce the stress on equipment

Duke Energy wants the Department of Environmental Quality (DEQ) to issue new permits allowing the gas generators to throttle up and down from a "low load" idling operation instead of switching completely off and on as solar waxes and wanes. In its permit applications, Duke Energy said this change in operating policy would lower emissions and reduce the stress on equipment.

When the same gas generators are operated to supplement solar power facilities, daily emissions more than double to 624 pounds a day

In an email exchange between a North Carolina newspaper reporter and Kim Crawford, a spokesperson for Duke Energy, data was provided from a team of Duke Energy subject matter experts confirming that NOx emissions would be lower if there were no solar power on the electric grid. These experts stated that without any solar power in the energy mix, "a typical combined cycle combustion turbine emits NOx at approximately 9-11 pounds per hour (lb/hr), assuming 24 hours of 'normal' operation." Crawford said. That equates to 264 pounds of NOx emissions daily. When the same gas generators are operated to supplement solar power facilities, daily emissions more than double to 624 pounds a day, a number based on a table in Duke Energy's air permit application.

If the DEQ agrees to Duke Energy's alternative operating scenario, a gas generator would emit 381 pounds of NOx daily, approximately 44% more pollution than operating without any solar power on the grid, but lower than the volume of emissions released under the current operating scenario.

Given the current inability to shut off solar power when it's not needed, if Duke Energy does not win air permit modifications allowing gas generators to idle instead of turning completely off, it is left with two viable options for dealing with increasing solar generation. First, it could export excess energy to neighboring regions, but transmission capabilities are limited. Secondly, Duke Energy could dial back its nuclear generation, but this would lead to increased CO_2 emissions. Duke Energy spokesperson Ms. Crawford said that "it's possible that nuclear generation could be impacted by solar; however, we cannot say that definitively at this point." Taking nuclear plants offline to accommodate solar energy would reverse previous reductions in CO_2 emissions and wreck the economics of the grid.

Their reliance on computer models showing no increase in emissions when the actual data refutes that conclusion is the epitome of rejecting scientific data because it doesn't fit the narrative

The Duke Energy CO_2 emissions issue and the response of those proponents of renewables is a reflection of people not understanding engine technology, something basic in the power business. Their reliance on computer models showing no increase in emissions when the actual data refutes that conclusion is the epitome of rejecting scientific data because it doesn't fit the narrative. Moreover, the issue highlights the reality that there is no absolutely clean energy – every form has a negative associated with it. The issue is how great is the negative compared to the benefits of the energy source, and can some of those negatives be mitigated? We will be interested to see what the DEQ rules. Just as we will be interested to see how California addresses the costs it seems willing to inflict on its citizens to meet a goal of 100% renewable electricity generation. We would worry if we were living in California that more residents begin abandoning the state as its cost of living escalates and its quality of life deteriorates, leaving fewer people with the bill.

Recession; What Recession? On The Road Again To Houston

We wonder if it is only Wall Street that is worried about a recession

It is that time of the year. We closed the Rhode Island house, loaded the car and drove back to Houston. Once again, we planned for two nights on the road, but gaining that hour of time as we cross the time line at the Georgia/Alabama border, we decided to extend the second day's drive. Based on what we saw on the road and encountered in restaurants and at our hotel, we wonder if it is only Wall Street that is worried about a recession.

We were shocked at the number of trucks we saw on both sides of the highway on both weekend days

Our trip observations fall into three buckets: trucks, construction, and crowds. What we observed doesn't signal a slowing economy, despite the economic statistics being reported. Our trip spanned a Saturday and Sunday, so we were shocked at the number of trucks we saw on both sides of the highway on both weekend days. At one point, in Pennsylvania, road construction forced eastbound traffic to funnel into one lane. It was late morning on Saturday. We measured the backed-up traffic to be five miles long, but incredibly it was comprised almost equally between trucks and cars.

For the past few years, when the sun went down, trucks went into hiding

Parked trucks were occupying 25%-33% of every rest area and truck stop we saw in the middle of each day, but they were overflowing them at night. Equally surprising was the number of trucks we saw driving each evening. For the past few years, when the sun went down, trucks went into hiding. Not this year! They were everywhere, and often outnumbered cars!

Another observation was the large number of FedEx, UPS, and Amazon Prime trucks we saw. That suggested to us that economic activity is up, especially in support of our new online/home delivery lives. However, we were shocked to see so many trucks rolling down the highway early on a Sunday morning. For the first 1-2 hours that morning that we were on the road in Southwest Virginia and northern Tennessee, trucks outnumbered cars. Wow!

The truck/car mix continued until we reached I-40, which comes across Tennessee from the East Coast near Ashville and then runs south into Knoxville before heading west to Nashville. The traffic congestion was unbelievable for a Sunday morning. It was so great that the average speed slowed and twice we nearly came to a dead stop. Fortunately, when we reached the split that takes I-40 west, most of the traffic went that way, leaving fewer vehicles (including ourselves) heading south to Chattanooga. Secondly, late Sunday night, driving on I-10 in the 9-12 pm window, we were shocked at how heavy the traffic was on the eastbound side. It was probably 2-3 times the volume of traffic we were experiencing heading west. Why all the traffic? We have no idea.

At one time, years ago, we thought how great it would be to own the orange barrel concession

Road construction was another challenge. Many of the roads where we encountered construction years ago are now undergoing new work. Much of this construction was tied to bridge repairs and rebuilding work. It means lots of concrete barriers narrowing the roads to allow for the work to be done safely. There were also several extensive stretches of highways where new roads and widening of existing roads necessitated installing concrete barriers and narrowing existing lane widths. These turned into white-knuckle stretches of road in Pennsylvania, Maryland, West Virginia, Louisiana and Texas. At one time, years ago, we thought how great it would be to own the orange barrel concession. Now we think owning all those concrete barriers may be a better business.

As many readers know, we traditionally stop at McDonald's for lunch and Cracker Barrel for dinner. On Saturday, we stopped for a late lunch at a McDonald's in Clinton, New Jersey. The place was busy, and we were directed to use the new ordering kiosk. As we understand from Wall Street research, this is McDonald's effort to improve efficiency and profit margins, while also providing customers with more food choices and customizing options. The location of the kiosks near the front counter increased congestion, besides creating issues for new users. The restaurant had positioned an employee by the kiosks to help. Once people learn

the procedure, it will likely improve their experience. However, based on two experiences, it was less efficient and confusing, adding to the time needed for lunch.

At the McDonald's we used the kiosk to order, only to find food and drink choices unavailable

Our Sunday McDonald's experience may have been different for another reason. As we headed out of Chattanooga, we needed gas and food, but we noticed a sign saying that there would be event traffic near the Lookout Mountain exits. We were there, but we didn't pay much attention to the signs. Traffic was heavy, but it didn't seem to involve vehicles having a problem exiting the highway. At the McDonald's we used the kiosk to order, only to find food and drink choices unavailable. Being a McDonald's "kiosks ordering pro," we placed our order, picked up our table marker and took a seat. Customers kept arriving, eventually making it impossible for counter staff to find customers. According to the screen above the pick-up counter, our order wasn't even being processed. Eventually, we heard someone starting to call out order numbers. Ours was among them – so much for table delivery. Moreover, the order wasn't correct, plus it left off a drink.

So much for management anticipating they would have more customers and needed more staff given the nearby event

As we were seated at a table next to an ordering kiosk, we wound up helping people unfamiliar with the process. Eventually, the manager came and stuck handwritten lists on each kiosk with items they were out of – including Diet Coke, Sprite, salads, toys, and ice cream. By then, they were without other drink choices, but maybe the staff was just unable to keep up with the lunch traffic. When we commented to the manager about what appeared to be a lack of staff, she said this customer volume had been going on for several days. So much for management anticipating they would have more customers and needed more staff given the nearby event.

Everything was sold out in Roanoke, Blacksburg and Salem, and this was at 5:30 pm!

Neither Cracker Barrel we visited on the trip was packed, although we ate early Saturday night and late Sunday night. What shocked us was the difficulty in finding a hotel room Saturday night. We had stopped for dinner in Woodstock, Virginia, and checked the Hilton app on our cell phone for hotels in the Roanoke area. Everything was sold out in Roanoke, Blacksburg and Salem, and this was at 5:30 pm! We finally found two hotels in Wytheville, Virginia, about 50 miles further south than our preferred choices. They included a Hampton Inn and a Tru by Hilton. Not knowing the second Hilton brand, we opted for the Hampton Inn. When we arrived, staff was turning people away without reservations. The hotel was packed. Football games? Homecoming? Conferences? We never learned why everything in the area was full, but assume it involved weekend sports, especially given the large number of universities in the area.

We looked up the Tru by Hilton brand to learn it is a new, youth-oriented hotel. A small, open room concept matched with a 2,800 square foot open lobby (multi colored) with lots of seating and work stations, along with free Wi Fi and wi-fi-enabled printing from anywhere in the hotel is the design. Not our first choice.

Our "crowds" observation was amplified by our experience the prior week when we attended the National Ocean Industries Association meeting at the Broadmoor in Colorado Springs. We had arranged in advance for the hotel shuttle between the airport and hotel. When we arrived at 12:45 pm, the shuttle was full (16 people). Walk-up passengers without reservations were told they could be accommodated in about an hour, when a second shuttle would begin running. When our shuttle arrived at the front gate, there was a line of cars six deep waiting for admittance. After dropping off passengers, the van made its way to the West entrance where it encountered another line of 6-8 cars waiting to unload passengers and luggage. There was a long line at the check-in counter, and our room wasn't ready for an hour. We commented to Ann Chapman, NOIA's conference coordinator, about our experience. She said there were several very large insurance and medical conferences at the Broadmoor. More interestingly, she said that NOIA could not reserve space for its 2021 Fall Conference at a location it has used many times in the past.

Walk-up passengers without reservations were told they could be accommodated in about an hour, when a second shuttle would begin running

We also learned that the Broadmoor imports labor. In response to our question about how she would deal with the snow that was beginning to fall, our housekeeper told us she didn't like it. We suggested she was living in the wrong place for not liking snow. She then told us she didn't live in Colorado Springs, but rather was from Jamaica. We learned she comes for nine months and then goes home, which is she is scheduled to do on December 1.

She then told us she didn't live in Colorado Springs, but rather was from Jamaica

We were nostalgic when we drove across the new Governor Mario M. Cuomo, Jr. Bridge across the Hudson River on our way home. It replaced the former Governor Malcolm Wilson Tappen Zee Bridge. For us, when we were very young and traveling with our family from Connecticut to West Point, it meant crossing the Hudson River on the Bear Mountain Bridge. Then in 1955, we crossed the newly-opened Tappen Zee Bridge. Days ago, and 64 years later, we crossed the new Mario Cuomo Bridge and observed that there were no remnants of the old Tappen Zee Bridge visible. What a change.

Realizing that one of the great bridges of America is gone because it outlived its time made us sad. It was difficult comprehending having traveled across the Hudson River over three iconic bridges during our lifetime. It may have been symbolic that New England's clouds evaporated into blue sky as we crossed the Hudson River this time.

It may have been symbolic that New England's clouds evaporated into blue sky as we crossed the Hudson River this time

Another thought we had as we completed our trip was how would it have worked if we were driving an electric vehicle. On Sunday, we drove 1125 miles according to the navigation system in our vehicle. We left Virginia at 8:45 am EDT and arrived home in Houston at 1:15 am CDT on Monday morning, an elapsed time of 17:30 hours (15:15 on Sunday, 1:15 on Monday and 1:00 gained from the time change). The trip time included stopping for lunch and dinner, as well as three gasoline fill-ups.

Assuming we started with a full battery charge overnight at the hotel, we would still need five recharges, adding approximately five hours to our trip time, or nearly 30% longer than it took, adjusting for fill-up times at gasoline stations

Had we been in a Tesla Model S, based on range and charging articles we read, you want to keep the battery charge between 10% and 90%, which means the estimated range of 240 miles gives you about 200 miles between charges. An article by *energysage.com* says the Model S needs one hour of charging time at a supercharger connection typically found on Interstate highways. Assuming we started with a full battery charge overnight at the hotel, we would still need five recharges, adding approximately five hours to our trip time, or nearly 30% longer than it took, adjusting for fill-up times at gasoline stations. What we don't know is how difficult it would have been to find supercharging connections, as there were none at the various gasoline stations we stopped at. We have seen some at the service plazas on I-95 in Connecticut, which almost always had cars waiting to charge. It is possible that waiting for access to supercharging connections could add significant additional travel time. Dealing with the range and charging issues is something every electric vehicle person we have talked to has commented on.

"Camp in state parks. Not in the left lane"

The best sign of the trip was in Southwest Virginia. As we approached Bristol, an over-the-highway electric sign board displayed: "Camp in state parks. Not in the left lane."

The key observation we have from our drive home was: Recession? What recession?

Unknown Yom Kippur War History From A *Musings* Reader

In our last *Musings*, we wrote Part 1 of what we anticipate will be a multi-part discussion of the history of the 1980s oilfield downturn and its relevance for people studying the current downturn. We felt it was important to give a brief history of the U.S. and global oil and gas industries from the 1960s as trends during that decade set the stage for the 1970s events that upended the functioning of the industry and drove it on a course that resulted in the dramatic collapse in world oil prices in the 1985-1986 period. From that collapse, we plan to examine the devastation and events that led to the industry's recovery and prosperous years in the early 2000s.

One aspect of our history discussion was telling about the significance of the Yom Kippur War between Egypt and Syria against Israel

One aspect of our history discussion was telling about the significance of the Yom Kippur War between Egypt and Syria against Israel. America rushed to the support of its ally Israel, which was partly in response to the arms shipments Egypt and Syria were receiving from our Cold War enemy Russia. That support upset leaders in the Middle East, and when the U.S. stepped up its support, it even caused the cautious leader of Saudi Arabia, King Faisal, to throw his support behind the members of the Organization of Arab Petroleum Exporting Countries (OAPEC) in embargoing Israel's supporters. Those supporting the Israelis included not only the United States, but also the Netherlands, Rhodesia, South Africa, and Portugal.

We knew that some of our Western European allies were opposed to the U.S. action, but they did work to help ease the 5% oil supply cut to Israel's supporters

Had we been asked prior to doing our research on the Yom Kippur war, and we were analyzing the oil and gas industry at that time, we would not have gotten all the names of the countries supporting Israel right. We knew that some of our Western European allies were opposed to the U.S. action, but they did work to help ease the 5% oil supply cut to Israel's supporters, which escalated by 5% every month the embargo was in place. The embargo led to passage of the Emergency Petroleum Allocation Act, which, among other things, instituted gasoline rationing and oil price controls.

By including Portugal in the list of supporting countries, we triggered an email from Glenn Asher of 4G Energy Services. He told us an amazing story of his involvement in the airlift of U.S. military supplies to Israel that we asked if we could present it to our readers. It goes:

> "I really appreciate your brief history of the Yom Kippur War of 1973. And it was very good to see that you included Portugal in the list of countries that were embargoed by OPEC.
>
> "As one of the pilots who flew the airlift of supplies to Israel during that period, the importance of tiny Portugal to the very life and existence of the state of Israel is not broadly known or appreciated.
>
> "You see, at that time, the two primary airlift aircraft for the USAF were the C-141's (that I flew) and the C-5, at that time the world's largest jet aircraft.
>
> "The C-141 did not have air-to-air refueling capability (it was later "stretched", adding air-to-air refueling capability). The C-5 did have the capability, but not a single pilot was trained to use it in 1973.
>
> "So, in order to fly the massive amount of material needed by Israel in the short time that was required to keep the Arab armies from running over the country, Portugal agreed to let the US stage the airlift out of the Azores Islands.

"We did that, continuously flying the 18-hour round-trip from the Azores to Tel Aviv and back, while other aircraft flew the material from the States to the Azores"

> "We did that, continuously flying the 18-hour round-trip from the Azores to Tel Aviv and back, while other aircraft flew the material from the States to the Azores. We flew 'single ship' to Israel with 15-minute air separation and had to carefully fly through the middle of the Straits of Gibraltar and in the exact geographical middle of the Atlantic. Meanwhile, we would see massive fleets of Russian Bear bombers carrying cargo to Egypt, flying lower than us in formations of 150 aircraft at a time, flying from Odessa, Russia, to Cairo.
>
> "None of our so-called NATO 'allies' in Europe would allow us to fly over their airspace or refuel in their countries

because of the threat of the embargo. And the North African countries of Morocco, Tunisia, Libya, and Egypt had their MIG fighters flying off our wing tips down the entire length of the Mediterranean, just daring us to venture into their airspace and get shot down.

"But in spite of all that, we flew tons of bombs and artillery shells into Israel. And as fast as Sharon's army was running over Arab military sites, we began flying back complete SAM missile sites, Russian tanks, and a lot of other captured Russian equipment.

The airlift lasted just 18 days, and in that time we flew five (5) times the tonnage of the Berlin Airlift, which lasted over a year

"Just a side note – the airlift capability of the jet aircraft was on full display in that airlift, as the airlift lasted just 18 days, and in that time we flew five (5) times the tonnage of the Berlin Airlift, which lasted over a year using C-54 and C-47 piston powered aircraft to haul the cargo."

When we thanked Mr. Asher for his service, and asked for permission to share the email with our readers, we asked if he had additional color to add to the story. He obliged with the following:

"Thanks for the reply, and you are welcome to use that if you ever need to.

"There were some amusing things that happened during that Yom Kippur war.

"As we had hundreds of aircrew members staging out of the Portuguese owned Azores Islands, the officers' club had to stay open 24 hours a day to serve meals.

"We had all been taught at 'officers and gentlemen' that wherever we ate, we were to leave a 15% tip plus '1 dollar for the table' – and we did.

"But it turns out that we were upsetting the economy of the whole island.

"The Portuguese governor made an appearance and appealed to us to never leave more than a 25-cent tip and nothing for the table. Seems the waitstaff in the officers' club were suddenly the richest folks on the island!

With the 30 minutes of ground time that we were allotted in Tel Aviv each trip, the Israelis loaded El Al first class meals for each crewmember for the 9-hour flight back to the Azores

"Also, with the 30 minutes of ground time that we were allotted in Tel Aviv each trip, the Israelis loaded El Al first class meals for each crewmember for the 9-hour flight back to the Azores. But we quickly learned that we had to bring ou[r]t own milk for the coffee because Kosher laws would not let the Israelis put milk on the plane when the meals included meats. It was a small thing compared to what was

> happening in the real war on the ground between Sharon's forces and the Egyptian army, but we managed to tough it out!
>
> "A week after the war, we flew back again – this time with the tail of the plane painted blue to signify the UN, carrying Panamanian National Guardsmen as part of the UN peacekeeping force. No free El Al first class meals this time. They happily charged us $12 a plate for a couple of scrambled eggs, toast, and no bacon!"

We wondered what an El Al (Israel's national airline) first class meal was like in 1973? Mr. Asher responded:

> "They usually were nice steaks – green beans – and mashed potatoes. But no butter for the potatoes or rolls. Lots of soft drinks."

Only with decades of hindsight are we able to understand that this was not as minor an event as often perceived

While the Yom Kippur War was an early event in the modern history of the global oil and gas industry, it helped change the trajectory of the industry, something not fully understood at the time, nor appreciated since, with respect to how significant it would prove to be for the future of energy. Only with decades of hindsight are we able to understand that this was not as minor an event as often perceived. Learning more about America's response to the surprise attack on our long-standing Middle East ally offers a great history lesson. We thank Mr. Asher for writing us and allowing us to share his remembrances with the rest of the *Musings From the Oil Patch* readership.

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