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

Energy Transitions: Issues, Questions And Some Answers

The last *Musings* began with an article titled "Understanding The Energy Transition In Transportation." It's not as if we haven't written extensively about electric vehicles (EV) versus internal combustion vehicles (ICE), because we have. But that is only one aspect of the broader subject of energy transitions.

The subject of energy transitions is important, but confusing

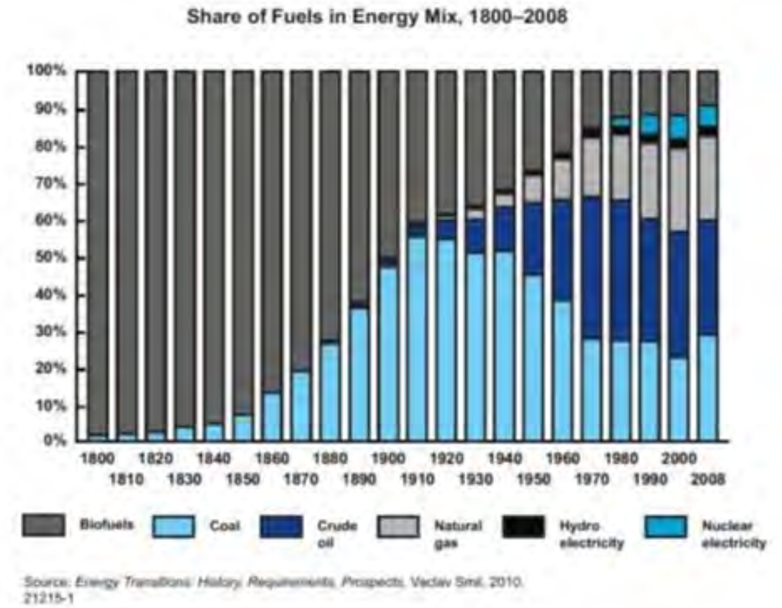
The subject of energy transitions is important, but confusing, so we decided to devote this entire *Musings* to the topic. Our goal is to frame the issues and their significance. To do that we have to delve into what the issues mean, along with discussing proposed solutions and their impact on our economy and society. Hopefully, we can provide answers and bring insights to the debate. As a disclaimer, we understand that *Musings* is a newsletter and not a book – so we need to stay at a high level of discussion. That may disappoint some readers, but the magnitude of the topic means we can't dig deeply into each sub-issue. We will identify subjects for deeper analyses. In that effort, we welcome readers' questions and direction.

"…the term energy transition is used most often to describe the change in the composition (structure) of primary energy supply, the gradual shift from a specified pattern of energy provision to a new state of an energy system"

If energy transitions are always underway, what is the current debate all about? First, we need to understand what an energy transition is. To do this we turn to the recognized dean of energy transition studies for a definition. Vaclav Smil, Distinguished Professor Emeritus at the University of Manitoba, writing in 2010 in his book Energy Transitions: History, Requirements, Prospects, defined the subject thusly: "…the term *energy transition* is used most often to describe the *change in the composition (structure) of primary energy supply*, the gradual shift from a specified pattern of energy provision to a new state of an energy system." (Emphasis in the original.)

To set the stage, let's revisit the world's energy sources for the past 200-plus years.

Exhibit 1. From Wood To Coal To Oil, Gas And More



Source: Vaclav Smil

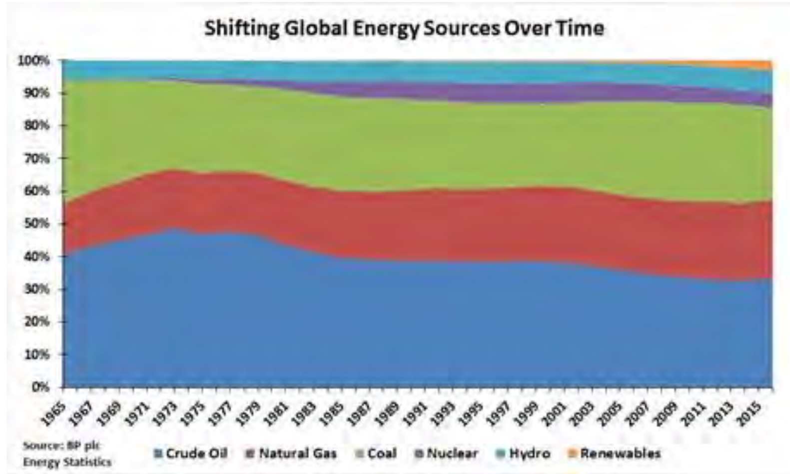
It took 100 years for wood to fall to half the world's energy supply

The energy transition history in Exhibit 1 is based on Dr. Smil's data. In 1800, about 98% of the world's energy came from burning biomass, i.e., wood. The remainder came from coal. It took 100 years for wood to fall to half the world's energy supply. Coal's share grew along with a small contribution from hydro power. It was only after 1900 that oil became a noticeable component of energy supply, but from that point forward, its share grew rapidly. After the 1970s, oil's share began to ebb, given the emergence of natural gas, and the rise of nuclear power, first begun in the 1970s. When the chart ends in 2008, renewables had yet to become a measurable energy source. That has changed dramatically in recent years.

Natural gas has seen its market share expand over time, especially in recent years in response to the move to reduce the use of dirty fuels such as coal

Looking at more recent data, we see how oil's market share peaked in the early 1970s and has been in a steady decline ever since, despite total consumption growing over this time period. Natural gas has seen its market share expand over time, especially in recent years in response to the move to reduce the use of dirty fuels such as coal. Coal's share, while down from its peak in 1965, experienced several demand revivals during the interim, and may be experiencing another one now. Nuclear power emerged as a measurable fuel source in the 1970s, rising to a peak about 2000, before beginning a slow decline as aging plants retired faster than new ones came on stream. Hydro power's market share remained steady over the entire period, but dams are considered an ecological problem, limiting the fuel's growth in the future. The most

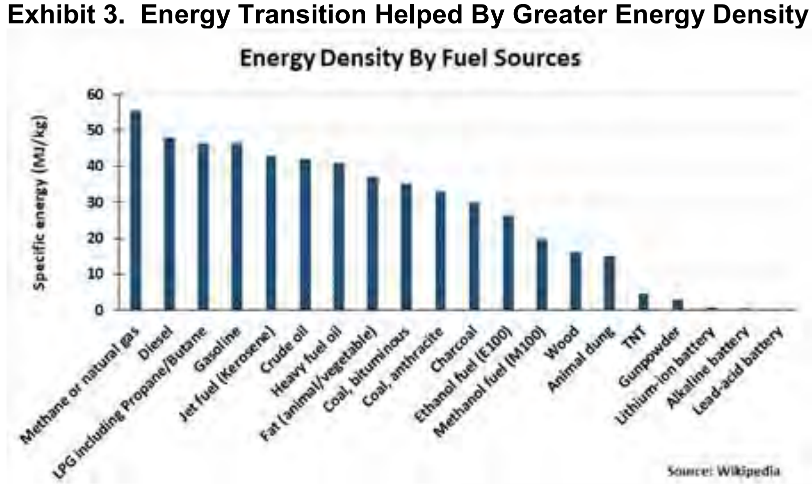
Exhibit 2. The Rise Of Natural Gas And Renewables



Source: BP, PPHB

interesting development in the fuels market has been the emergence of renewables – wind, solar, and biomass - from obscurity in the 1980s and 1990s to a measurable, and now the most rapidly growing, fuel source.

Exhibit 3. Energy Transition Helped By Greater Energy Density



Source: *Wikipedia*

We have moved from fuels with less energy density to those with greater density

Another aspect of the energy transition is how we have moved from fuels with less energy density to those with greater density. This means we have needed less land to generate the same or greater energy. That trend has enabled society to progress from manpower to animal power to mechanical power that enabled the industrial revolution, which created the world's modern standard of living.

The current fuel mix demonstrates one of the several energy transitions underway. The first, underway for over 200 years, is moving from depending on a single fuel source to having a wide array of fuel choices. The diversity of our fuel choices has been growing in response to concern over environmental damage caused by increased carbon emissions from burning fossil fuels, our primary energy supply. This concern underlies the decarbonization push, but whether we can achieve a totally decarbonized economy is questionable, but that goal occupies the center of the energy transition debate.

It is the return of America to the big leagues of global oil producers, which is causing the Organization of Petroleum Exporting Countries to fracture

Beyond decarbonization lies a second energy transition. It is the return of America to the big leagues of global oil producers, which is causing the Organization of Petroleum Exporting Countries to fracture. The shale revolution – both in natural gas and crude oil – has contributed to a near doubling of U.S. crude oil output since 2009, and steady growth in natural gas production. Barely a decade ago, our future foresaw the U.S. on a road to total dependence on imported oil and natural gas supplies, but now we are disrupting the global oil and gas markets with our rapidly growing exports.

The short-cycle shale business, coupled with the opening of world markets to U.S. oil and gas exports, is stimulating business strategies of U.S. upstream-focused oil enterprises

At that time, the bleak outlook for our domestic oil supply some years ago was largely responsible for the coal industry revival. Although questions over the long-term sustainability of America's oil and gas production revival exist, the intermediate term outlook suggests a bright future. The short-cycle shale business, coupled with the opening of world markets to U.S. oil and gas exports, is stimulating business strategies of U.S. upstream-focused oil enterprises. This development signals that the discipline among OPEC producers to sustain their production cut in order to shrink global inventories in order to boost oil prices may be sowing the seeds for the organization's break-up.

A world swimming in crude oil signals lower prices

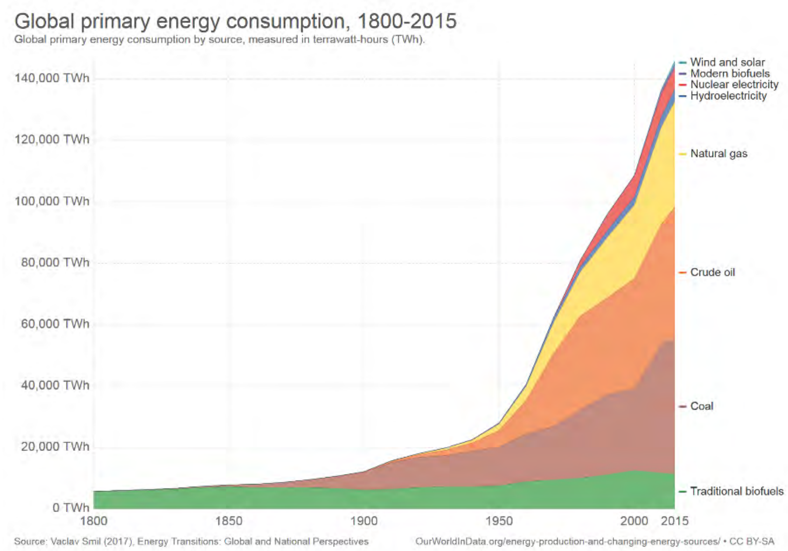
The existence of two significant energy transitions simultaneously, partially explains why seeing a path to the future is so difficult. If OPEC breaks up, or is transformed into another set of oil production alliances, it will be due to more oil coming on the market, rather than less. A world swimming in crude oil signals lower prices, which works against the economic case for more expensive clean fuels. Yes, we understand many environmentalists expect clean fuels to be cheaper than fossil fuels, but to-date, clean fuels are merely chasing fossil fuels down the cost curve.

To understand the global energy fuels transition currently underway, we offer Exhibit 4 (next page). It shows the growth in global energy consumption by fuel type, as measured in terawatt-hours (TWh), since 1800. There are two take-a-ways. First is the explosive growth in energy consumed since the end of World War II. That should not be a surprise, as it is linked to global population growth, which is shown in Exhibit 5 (page 6). The world population reached its first billion people in 1804, but then needed 113 more years to reach two billion. Thirty-three years later (1960), the world had three billion people, and then proceeded to add an additional billion people on average every 12-13 years thereafter. Today, the United Nations estimates we have slightly over seven billion people on the planet, with the potential of reaching eight billion in about seven years. What population growth has meant, and means going forward, is more energy will be needed. How much more is the key issue.

We doubt that many people appreciate how much of the world's population still depends on wood and dung for energy

The chart's second take-a-way is the growth in traditional biofuels – which is a euphemism for wood. We doubt that many people appreciate how much of the world's population still depends on wood and dung for energy, the earliest power sources utilized by man. In its earliest use, wood fires provided warmth and light, but more importantly, enabled the cooking of meat, adding protein to early human's diet. All three of these attributes helped improve the lives of early humans, enabling them to survive and evolve into a more adaptive species.

Exhibit 4. Energy Use By Fuel Throughout History



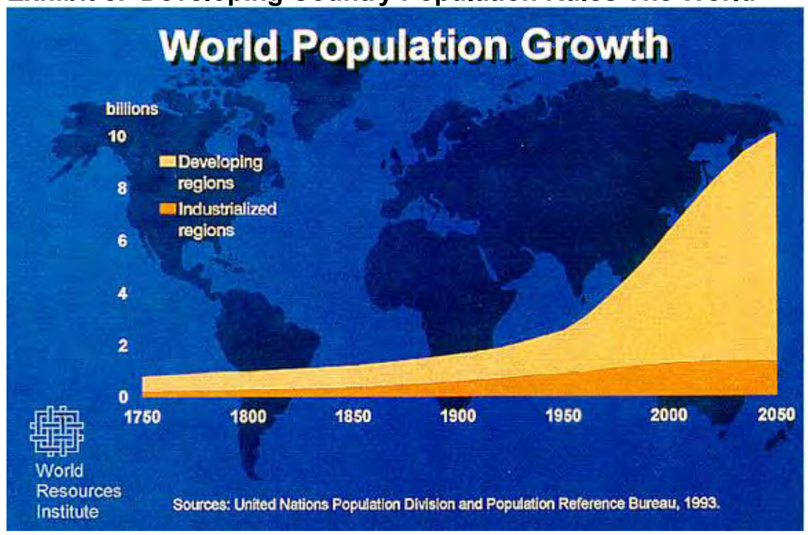
Source: Vaclav Smil

An opportunity to meaningfully reduce future energy use through efficiency gains, altered lifestyles, fuel switching and variable pricing

Increased energy consumption is driven by population growth, which today is largely in the developing countries of the world. The highly developed economies – the members of the Organization for Economic Co-operation and Development – are facing rapidly aging populations, or are experiencing population declines. Since OECD economies are among the wealthiest in the world, their citizens have accumulated the conveniences of modern life, meaning their energy intensity is high, offering an opportunity to meaningfully reduce future energy use through efficiency gains, altered lifestyles, fuel switching and variable pricing.

Those choices do not exist for most of the developing world, where more than one billion people still lack access to electricity, which is the critical energy necessary for economic and social improvement. At a high level, the growth of the developing world's population

Exhibit 5. Developing Country Population Rules The World



Source: United Nations

means that total energy needs will continue growing. Can that growth be moderated, or is it possible to generate the power from cleaner energy sources? Progress in those endeavors will have a much greater impact on the outlook for the fossil fuel industry than many are considering.

Can more energy for developing economies be provided without driving overall energy costs higher?

Equally important in the energy transition picture is understanding how much energy demand in developed economies might decline in the future, and how a demand reduction might be accomplished? Additionally, will using less energy in those economies provide room for developing economies' energy needs to be accommodated? That would mean environmental goals could be achieved with less pain. Likewise, can more energy for developing economies be provided without driving overall energy costs higher?

85% of the world's population has access to power, up from 73% in 1990

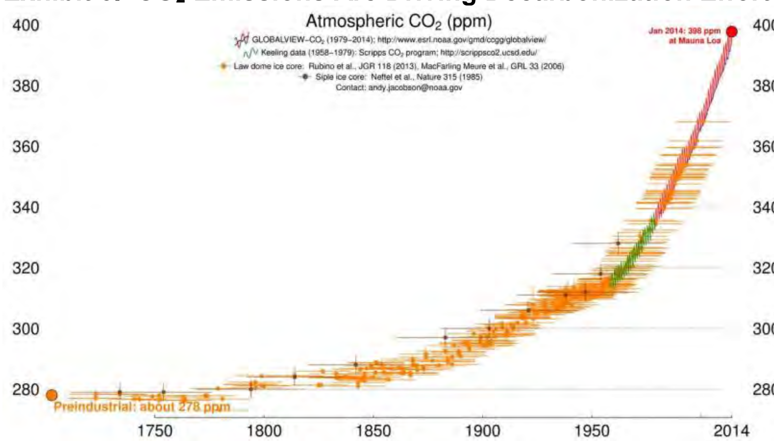
With respect to electricity, the latest estimate (2014) says that 85% of the world's population has access to power, up from 73% in 1990. What does electricity do for these people? It extends their day, providing increased educational opportunities. Electricity enables refrigeration that revolutionizes the working day, as the hours devoted to securing food every day are no longer required, freeing up time for additional work to boost a family's income and its standard of living. Refrigeration also enables the preservation of medicines and vaccines that saves and improves lives, leading to longer, healthier lives, reduced infant mortality leading to lower birthrates, and reduced poverty. As living standards rise and incomes grow, will these newly empowered people desire more energy-dependent devices?

At the present time, most people lacking access to electricity are relying on wood and dung for energy – two of the lowest rated fuels

More fuel must be burned to generate equivalent energy compared to more dense fuels

by energy density measurements, as well as fuels that create high pollution. The lower energy density means more human effort must be devoted to gathering the fuel, and more fuel must be burned to generate equivalent energy compared to more dense fuels. More low-density fuel also means higher pollution, and in turn, less healthy living conditions. All of these characteristics and qualities are detrimental to human existence.

Exhibit 6. CO_2 Emissions Are Driving Decarbonization Effort



Source: CIRES

Other environmentalists point to the historical variability in the composition of the earth's atmosphere and the lack of correlation between CO2 levels and changes in global temperatures

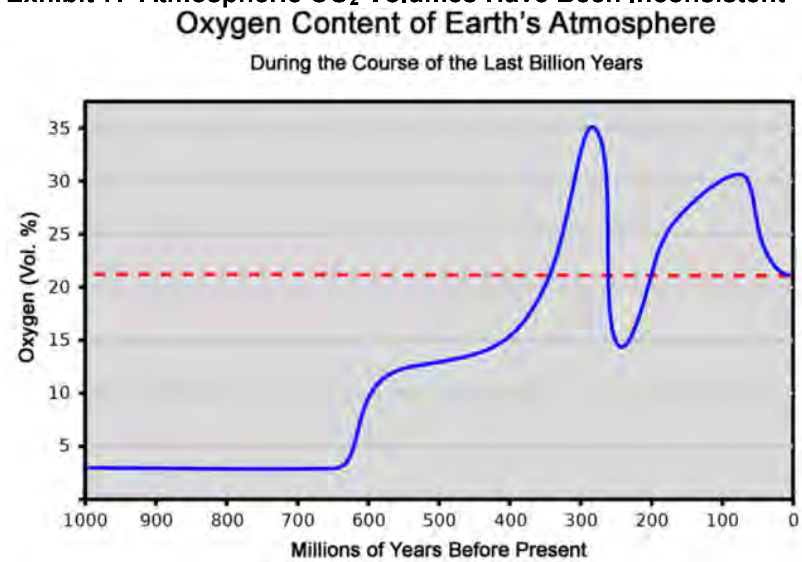
It is the rise in atmospheric carbon dioxide over the past 50 years that has some environmentalists predicted a dire future for the planet if the growth isn't stopped, or slowed. They believe it would be better if it was reversed. Those concerned environmentalists believe the CO_2 increase is almost entirely due to man-made causes – the burning of fossil fuels – and they ignore any contribution from natural causes. On the other hand, other environmentalists point to the historical variability in the composition of the earth's atmosphere and the lack of correlation between CO_2 levels and changes in global temperatures. That view is in Exhibits 7 and 8 (page 8).

Actions are codified into law and will take a long time to unwind

We are not here to debate these opposing positions, but rather to recognize that the climate change debate is a driving force behind the energy de-carbonization movement begun in the late 1990s with the UN's Kyoto Protocol. Rather than concerning ourselves with the climate change debate, we take the position that "the climate change horse has left the barn." That means, right or wrong, that the push for a cleaner atmosphere will continue to dominate the pace and extent of the energy transition underway. While the emphasis continues to come from environmentalists, it now has the backing of governments, meaning that actions are codified into law and will take a long time to unwind.

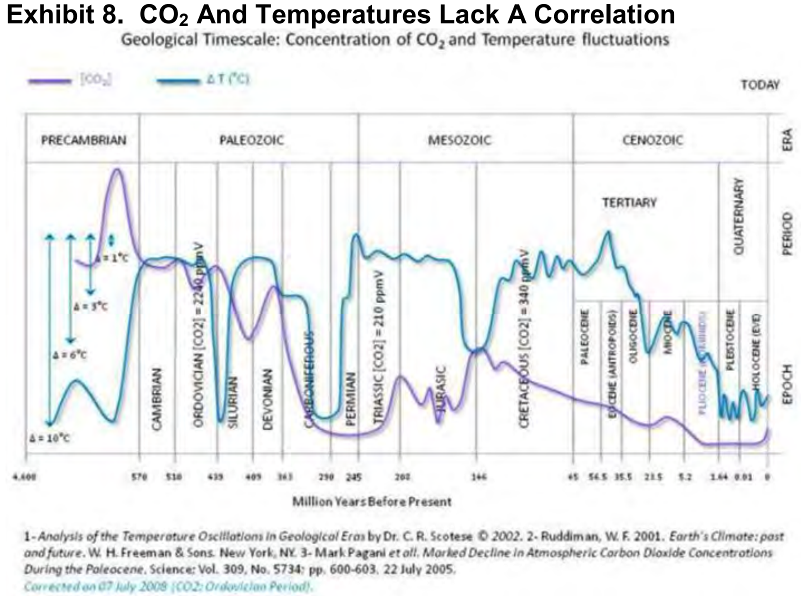
Government environmental actions previously adopted are having a positive impact on energy consumption and carbon emissions. We see it in the transportation sector where the CAFÉ standards have

Exhibit 7. Atmospheric CO_2 Volumes Have Been Inconsistent



Source: Vincent Gray

Exhibit 8. CO_2 And Temperatures Lack A Correlation



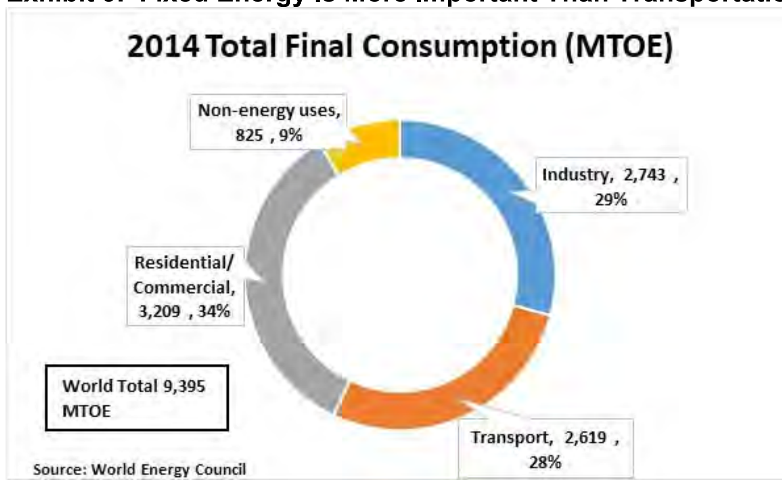
Source: Vincent Gray

Better lightbulbs have cut electricity consumption by 2.7% between 2010 and 2016

improved the fuel efficiency of new vehicles. Fuel efficiency of new cars has improved from 20.1 miles per gallon at year-end 2007 to 25.0 miles per gallon at the end of 2016. It is also manifested itself in the electricity sector where better lightbulbs have cut electricity consumption by 2.7% between 2010 and 2016. Rules implemented in 2012 mandated a 25% higher efficiency for most typical household lightbulbs.

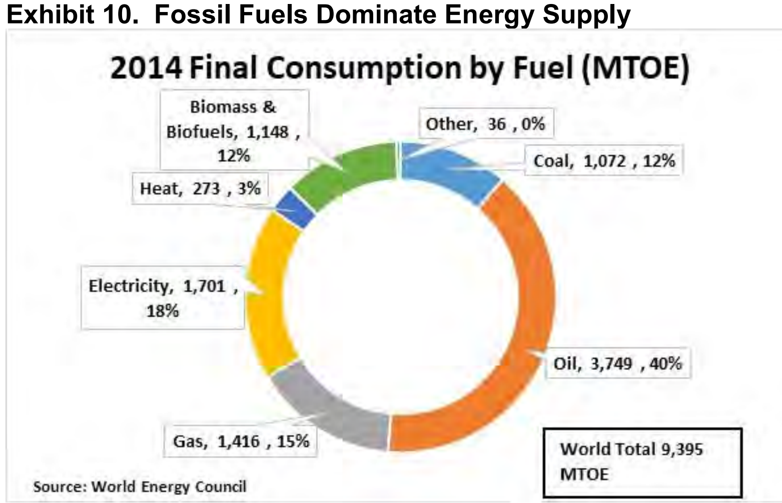
To set the stage for the rest of the articles, we present Exhibits 9 and 10. These charts show the world's energy use in 2014 by economic sector as well as by fuel. Acknowledging that energy consumption has increased since 2014, the charts still provide a fair assessment of the energy transition challenge.

Exhibit 9. Fixed Energy Is More Important Than Transportation



Source: World Energy Council

Exhibit 10. Fossil Fuels Dominate Energy Supply



Source: World Energy Council

Is it possible these steps will cause damage to the global economy and impede society's efforts to lift the living standards of the world's population?

Questions addressed in the following articles consider whether the steps being taken at the behest of environmentalists and governments to create a cleaner environment make economic sense. Is it possible these steps will cause damage to the global economy and impede society's efforts to lift the living standards of the world's population, or especially that portion living in poverty? What are the hurdles clean fuels must overcome to displace the current fuel mix? In the transportation arena, the issues are energy density and vehicle range versus subsidies and carbon emissions.

In the fixed power sector, the key issue is the intermittency of renewables, the favored clean energy alternative to dirty fossil fuels. Can that problem be overcome with battery storage, or some other form of energy storage, at a reasonable economic cost? All of these are addressable issues, the question is how long it takes to find solutions, and what the financial costs are.

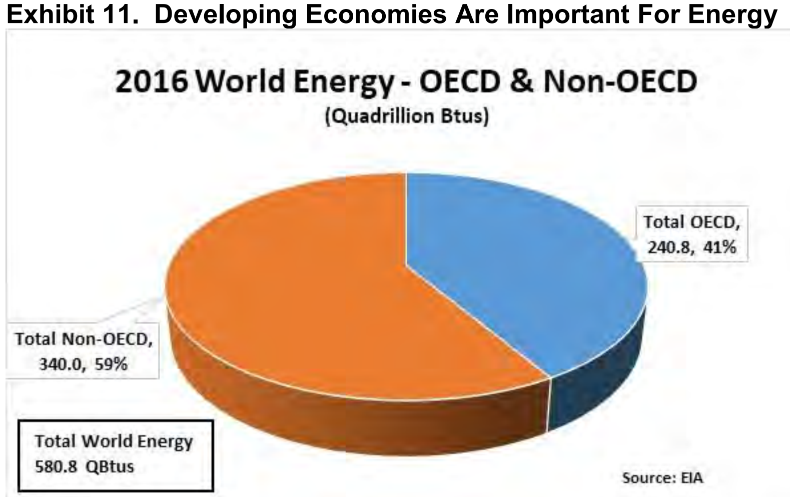
Therefore, the transition's pace can be faster and prove less costly than forecasters project

Dr. Smil has presented an analysis showing that energy transitions require upwards of 50 years or more to occur, because new infrastructure was always needed. A contrasting view is offered by environmental author Chris Goodall, who believes clean energy will not require a massive new infrastructure, therefore the transition's pace can be faster and prove less costly than forecasters project.

What goes on in the developing world with regards to clean energy will have a greater impact on the fossil fuel industry's future than actions in OECD countries

To appreciate the economic situation, Exhibit 11 shows the world's energy consumption in 2016 split between the OECD countries and the non-OECD countries. The latter group of countries now accounts for nearly 60% of global energy consumption. Given the population growth projection in Exhibit 5 (page 6), the future share of global energy claimed by non-OECD countries will grow, and materially. This may mean that what goes on in the developing world with regards to clean energy will have a greater impact on the fossil fuel industry's future than actions in OECD countries.

Exhibit 11. Developing Economies Are Important For Energy



Source: World Energy Council

There are two major energy battlegrounds – crude oil, which is primarily a transportation fuel, and electricity, which provides power from fixed sources

While we will explore the two major energy transitions, keep in mind that there are two major energy battlegrounds – crude oil, which is primarily a transportation fuel, and electricity, which provides power from fixed sources. These two battlegrounds – transportation and electricity – have unique issues prompting many suggestions for how each can be decarbonized, as well as reducing their energy consumption. It is also important to understand that while addressing one energy battleground, we may create issues for the other; think about electric vehicles in the transportation sector and

Since energy is tightly interwoven in the fabric of our modern economy and society, changing it will likely not be done easily or rapidly

how they will create the need for battery charging points and increased electricity use, especially time of day demands. Since energy is tightly interwoven in the fabric of our modern economy and society, changing it will likely not be done easily or rapidly. That is partly due to unintended consequences from changes that are not fully appreciated. Our effort will hopefully identify some of the hurdles needing to be overcome.

Transitioning Energy For The Transportation Sector

By the 1830s, some cities installed rails in the streets enabling horse-drawn trolleys to move faster than regular horse-drawn omnibuses

In the 1820s, trolley service began in major cities, starting with omnibus lines where horses pulled wagons on usually unpaved city streets, but routes were altered by just following the streets. Since most cities were fairly compact, people continued to walk rather than ride the omnibuses. By the 1830s, some cities installed rails in the streets enabling horse-drawn trolleys to move faster than regular horse-drawn omnibuses. These horse-drawn trolleys remained the primary mass transit in many cities, but horse-drawn carriages and taxis helped meet the transportation needs of many people. This development came despite the existence of steam engines.

Even as the industries driving the Industrial Age built more railroad, canals, ferries and ports, they utilized more animals to help gather and distribute workers and goods

The worth of the horse was explained by Robert Thurston, a U.S. steam engine expert, in 1894, when he said that horses are not only "self-feeding, self-controlling, self-maintaining and self-reproducing, but that are far more economical in the energy they are able to develop from a given weight of fuel material, than any other existing form of motor." As a result, even as the industries driving the Industrial Age built more railroad, canals, ferries and ports, they utilized more animals to help gather and distribute workers and goods. Their success in helping power the early stage of the Industrial Age resulted in the working North American horse population growing from four million in 1840 to more than 24 million by the end of the century.

A major issue was horse waste and the associated health hazards

In 1872, the Great Epizootic sickened horses in Toronto and many northeastern cities. The results of the epidemic highlighted the dependence of cities and farms on horsepower for their energy. This recognition came at the same time many eastern cities were undergoing social challenges from the flood of European immigrants. A major issue was horse waste and the associated health hazards. An urban workhorse left 20-50 pounds of manure and a gallon of urine per day on a city's streets. Walkers in cities confronted these obstacles when crossing streets, as well as the rodents and flies the waste attracted, let alone the impact of carcasses of horses that died while working.

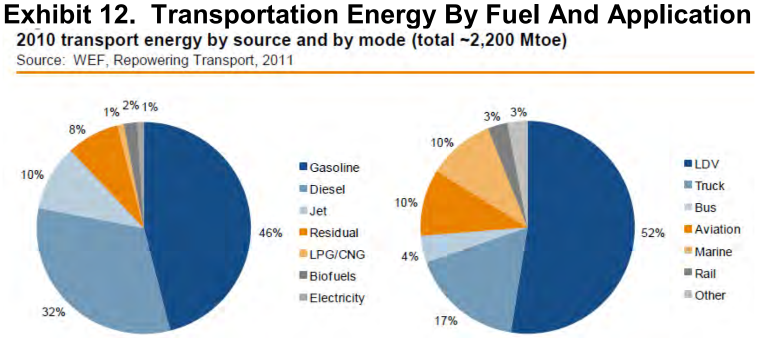
These environmental issues developed as the "horseless carriage" evolved as a new mode of travel. The transition away from horse-drawn vehicles in urban locations and on farms required nearly 50 years to complete. There were three primary developments that

The perfection of the internal combustion engine vehicle facilitated the free movement of individuals and goods

facilitated the shift. First, steam-engines replaced horses for long-distance haulage. Then coal-fired electricity eliminated the need for horses for urban public transit. And, lastly, the perfection of the internal combustion engine (ICE) vehicle facilitated the free movement of individuals and goods. That last development has powered global economic growth since the early 1900s, and facilitated the evolution of transit and the movement of goods.

Exhibit 12 shows the 2010 distribution of global energy fuels by type and vehicle. It shows that gasoline had the largest transportation market fuel, at 46%, with diesel fuel next at 32%. Together they accounted for nearly 80% of the transportation fuels market.

Exhibit 12. Transportation Energy By Fuel And Application



Source: World Energy Council

The smog issue remains a major challenge for many of the world's largest cities that are primarily located in developing economies

Vehicle distribution, when matched against fuel distribution, shows how transportation has become such a significant source of carbon emissions. With light-duty vehicles and trucks accounting for 69% of energy consumption, their pollution is the target of environmentalists. In developed economies, cleaner gasoline and diesel fuels have, over the years, reduced carbon emissions, and especially particulates emitted into the atmosphere, which contribute to urban smog. The smog issue remains a major challenge for many of the world's largest cities that are primarily located in developing economies. These emissions are the impetus to clean up the atmosphere by reducing the use of fossil fuels, and substituting the preferred alternative of electric vehicles (EV). That said, projections show that in many developed economies such as the U.S., without significant transportation emissions reductions, the country will not meet its Paris Accord commitments to cutting pollution.

There are between 800 million and one billion light-duty vehicles on the world's roads today

The challenge of operating fewer ICE vehicles is highlighted by the estimates that there are between 800 million and one billion light-duty vehicles on the world's roads today. Estimates suggest that by 2040, there will be somewhere between 1.6 to 2.1 billion vehicles. The World Energy Council (WEC) projects the world fleet growing from 900 million vehicles in 2015 to 1.45 billion by 2040, of which about 100 million will be battery and plug-in EVs. While BP plc (BP-NYSE) and Exxon Mobil Corp. (XOM-NYSE) see the world fleet growing more than the WEC, they both see about 100 million EVs on the road. OPEC sees the world fleet more than doubling over the 2015-2040 period, but it sees only about 140 million EVs. Then we have the Bloomberg New Energy Finance (NEF) study. It projects the global vehicle fleet growing from 1.1 to 1.6 billion units by 2040, with EVs being 33% of the world fleet, or about 530 million cars.

What these forecasts mean is that even with the most optimistic EV forecast, there will still be a billion or more ICE vehicles in the world's fleet in 2040

What these forecasts mean is that even with the most optimistic EV forecast, there will still be a billion or more ICE vehicles in the world's fleet in 2040, but the number will begin to shrink fairly rapidly thereafter. Some analysts believe the NEF forecast may be closer to what will occur based on the current dynamics of the auto marketplace. Supporting their position, they point to numerous government announcements of banning ICE cars in the foreseeable future, as well as other governments mandating auto manufacturers offer more EV models, or be restricted from selling any vehicles in those countries. These governments plan on continuing to provide subsidies to EV buyers to ensure that a market develops.

There are other technologies such as autonomous vehicles and ride-sharing that could help boost EV acceptance faster than currently thought

Many of the optimistic EV forecasts assume EV adoption will happen much like that of consumer electronics in the past several decades. Without improved vehicle performance and reduced costs, the acceptance of EVs may not follow the path of cell phone ownership. On the other hand, there are other technologies such as autonomous vehicles and ride-sharing that could help boost EV acceptance faster than currently thought. However, some of those technologies rely on government policies to promote their growth.

In order for a forecast such as NEF's to prove correct and oil company projections too low, a series of obstacles need to be overcome. We would list the following as hurdles needing to be overcome for the NEF projection to prove right.

1. Battery technology needs to improve; range needs to increase; battery life to be extended.
2. Battery costs need to decline further.
3. Battery technology needs to evolve to be less reliant on rare earth metals found in unsafe locations.
4. Battery charging times need to be reduced.
5. Battery charging infrastructure needs to be built out.
6. The electric grid will need to be refined and expanded to handle the increased EV charging requirements.

These hurdles must be overcome without government-provided subsidies to buyers. Based on auto manufacturer comments, their losses per EV ($9,000 to as much as $30,000 per vehicle) exceed the current subsidies offered EV buyers. In other words, delivering EVs is a money-losing proposition – look at Tesla's (TSLZ-Nasdaq) financial results.

For an environmental perspective, when a battery-powered EV leaves the showroom floor today, it comes with a significant CO_2 legacy that is only erased with years of driving. The CO_2 legacy for an EV, due to its battery, is substantially greater than for an ICE vehicle, as demonstrated by researchers in Sweden and China.

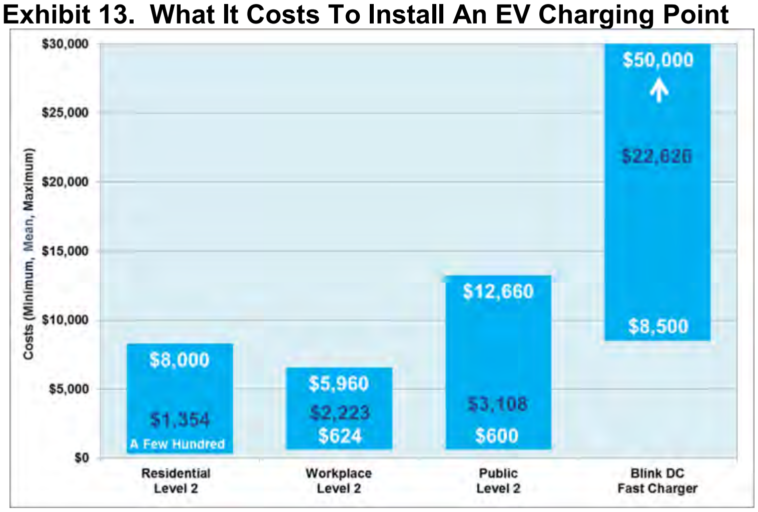
Battery performance is impacted by driving habits – no super-fast driving – and the environment

Addressing battery limitations, EV range is being extended by adding additional battery cells, i.e., making the batteries larger. Of course, larger batteries add weight to the vehicle, which impacts range. At the same time, battery performance is impacted by driving habits – no super-fast driving – and the environment. Extremely hot and cold weather takes a significant toll on EV range. Use of vehicle air conditioning and heating also reduces the performance life of a battery. This proved a problem for numerous EV drivers in Beijing during last year's extremely cold winter when cars could not generate sufficient power to exit parking garages.

The average cost of a home EV charging station, based on data from Home Advisor in 2016, was $675, with a range of $200-$1,500

The average cost of a home EV charging station, based on data from Home Advisor in 2016, was $675, with a range of $200-$1,500. That is not a deal breaker for people currently considering buying an EV. Commercial charging stations, on the other hand, have a wider cost range depending on whether they provide conventional charging speeds or are fast-charging. To access fast-charging stations, EV buyers other than Tesla owners need to purchase an additional plug-in connector, costing about $750 per vehicle. The cost ranges for charging stations shown in Exhibit 13 come from two studies done in 2011 and 2012, but a Rocky Mountain Institute report in 2014 supported the estimates as accurate at that point.

Exhibit 13. What It Costs To Install An EV Charging Point



Source: ***Inside EVs***

The big question about the charging infrastructure is how many stations will be needed and where they will be located. So far, we see charging stations installed at gasoline service centers on highways, but that does not provide a sufficient number of locations.

Less than 5,000 are responsible for over 12% of gasoline volumes

As merchants install chargers to draw shoppers or diners, the population will grow. There are about 156,000 gasoline retail outlets in the U.S., but less than 5,000 are responsible for over 12% of gasoline volumes. Much longer EV charging times versus gasoline fill-up times remains a psychological hurdle for EVs, and dictates there needs to be many more charging points. A study in California showed that when charging stations equaled one for every three EVs, EV sales increased.

Virtually all homeowners in an area, when provided EVs, charge them at the same time of day

At the present time, most EV owners recharge their batteries at home over night, although studies in the UK and Austin, Texas, have shown that virtually all homeowners in an area, when provided EVs, charge them at the same time of day, which unfortunately, coincided with increased air conditioning loads, increased lighting needs, and more dinner-related power. As a result, the electricity grid can suffer, meaning it may need to be upgraded with additional capacity required at the exact same time of the day when most renewable power drops off. More batteries, or pricing electricity based on time of day, are suggested as possible solutions. In many neighborhoods, too many homes charging EVs at once can overload local transformers, causing them to fail and create power outages, necessitating repairs and/or upgrades to prevent future blackouts.

EV critics point out that the true cost of these vehicles is greater than perceived

EV critics point out that the true cost of these vehicles is greater than perceived. They cite that EVs are not necessarily “green” due to their CO_2 legacy and how the electricity that powers them is generated – more fossil fuels versus renewables. The critics also question where battery raw materials will come from, but maybe more importantly, what happens when EV batteries are exhausted? We know their capacity deteriorates over time and with use. At the present time, there is no recycling industry for EV batteries because there are is an insufficient number to justify the cost of establishing such a business, and lithium is too cheap. Used EV batteries can be used as a back-up power for fixed renewable power facilities, but that is a slowly developing market.

An advantage for EVs is that most cars are driven under 50 miles per day, within the range of a battery charge

An advantage for EVs is that most cars are driven under 50 miles per day, within the range of a battery charge. As larger batteries are employed, increasing EV range to 225 miles or more, most people can have their transportation needs satisfied with EVs. This is especially true in urban areas, where speeds are low due to congestion. That is an ideal market for EVs. The downside is that many of the people living in these areas do not have easy access to charging stations since they do not have their own garages where they can install a home charging unit.

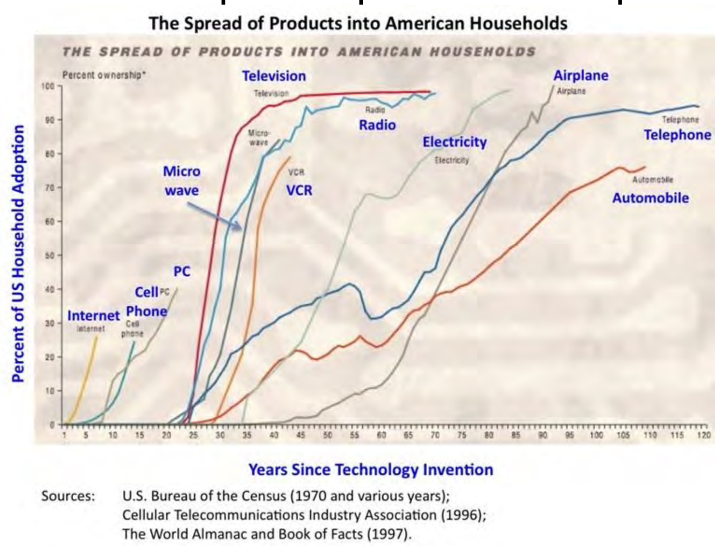
One of the major emerging EV markets is China. Its urge to electrify its transportation system is driven largely by its growing dependence on oil imports, the rapidly deteriorating air quality in its major cities, and a desire to capture an emerging technology that Chinese companies can export and compete with around the world. The

Because the country has a network of high speed rail transport and an extensive air traffic network, long-distance trips can be done efficiently by rail or air, rather than driving

structure of China's economy and its geography further support the push for EVs. Of the world's cities with populations of 10 million people or more, China has five of the top 18 cities. In the next tier, represented by cities with five to ten million people, there are 15 Chinese cities out of a total of 39. With at least 1.25 billion citizens in China's cities, there is significant traffic congestion, resulting in poor air quality. Also, because the country has a network of high speed rail transport and an extensive air traffic network, long-distance trips can be done efficiently by rail or air, rather than driving, reducing the need for long-range EVs. Not all other countries have such an option.

On the issue of rapid acceptance of EVs, the case for them is built on several key assumptions. First, the rapid consumer acceptance of new technology products is cited as evidence of why EVs will be among that group. Citing Exhibit 14, EV boosters point to the rapid acceptance of items such as the Internet, cell phones and television, which demonstrate how fast acceptance can happen. We would point to the much slower acceptance of electricity, airplanes, telephones and automobiles as a counterpoint.

Exhibit 14. The Speed Of Important Product Adoptions



Source: ***Smart-future.org***

Automobile purchases are not frequent as demonstrated by the average ownership duration of autos

Automobile purchases are not frequent as demonstrated by the average ownership duration of autos. According to a 2015 article by *CNBC* auto reporter Phil LeBeau, "On average, buyers hold onto their new vehicle for 6.5 years. That compares to 2006, when new vehicles were held for an average 4.3 years." That analysis was based on data from IHS Automotive. This lengthening of initial holding time fits with the auto financing industry offering loans of 72, and now 84 months, or 6-7 years. At the same time, the average age of automobiles has reached 11.5 years, as prices rise and quality improves. The point of this is that people are not buying cars

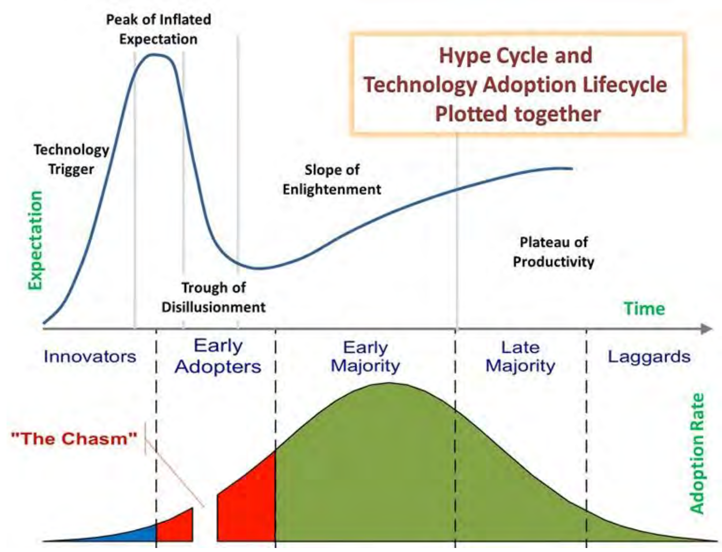
Modeling EV purchases based on a pattern that follows consumer high-tech products may overstate the speed with which EVs will be adopted

with the frequency of cell phone or PC purchases, or switching Internet providers. When the cost of an automobile is in the $20,000 and up range, with monthly financing bills in the $500-$800 per month range, which happens to be the cost of many cell phones, why will people quickly dump their perfectly good autos for new, clean versions? Therefore, modeling EV purchases based on a pattern that follows consumer high-tech products may overstate the speed with which EVs will be adopted.

There is a peak in the "hype" for a new technology product, which then experiences a sharp decline

There is another phenomenon about new technology acceptance that is being applied to EVs. The concept is shown in Exhibit 15. The top chart shows a curve of acceptance of technology products developed by a technology market research firm. Note that there is a peak in the "hype" for a new technology product, which then experiences a sharp decline as the product fights through a period of questioning of its value proposition. Usually, a successful product proves its worth in some form of a cost/benefit analysis by consumers, after which product volumes grow.

Exhibit 15 – The Technology Adoption Curves



Source: Technology Trend Analysis

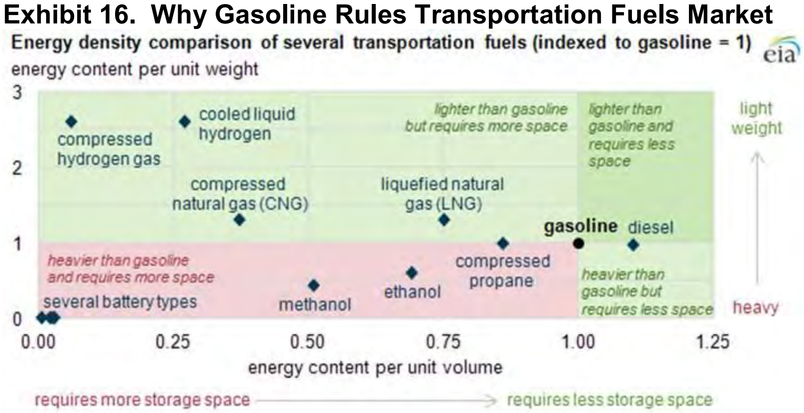
The Chasm happens to coincide with the period in the Hype Cycle when expectations have peaked and then drop into the "Trough of Disillusionment"

In the bottom chart, we see a description and percentage of total customers of technology adopters. The Innovators represent 2.5% of the market, while Early Adopters account for another 13.5%. Note the break in the segment called "The Chasm," which represents the point at which a new technology needs to establish its legitimacy. The Chasm happens to coincide with the period in the Hype Cycle when expectations have peaked and then drop into the "Trough of Disillusionment." If a product survives that experience, it will prove successful. Thinking about where we are in EVs in the world, they currently account for about 1% of vehicles, which puts them in the middle of the Innovators segment, and a long way from The Chasm. EV penetration is still in the "believers" category, which is a long way from mainstream technology acceptance.

The volume of fuel needed to travel the same distance will be greater than for gasoline

At the end of the day, a key determinant for EVs, as well as all clean energy, is the history of energy transitions, which has moved from fuels with less energy density to those with more. The new, more powerful energy sources also need less space, but that is a more appropriate discussion for the fixed energy transition. The Energy Information Administration (EIA) presented a chart showing energy densities of liquid fuels relative to that of gasoline. What the chart shows is that all the other fuels, whether lighter or heavier than gasoline, have less energy density, meaning that they will not deliver the same amount of energy per unit of fuel. Thus, depending on the price of these alternative transportation fuels, they may or may not be competitive with gasoline. It also means that the volume of fuel needed to travel the same distance will be greater than for gasoline. This is especially true for batteries, which are described in the chart as being "heavier than gasoline and requires more space." This is an issue that needs to be balanced against cost and vehicle range.

Exhibit 16. Why Gasoline Rules Transportation Fuels Market

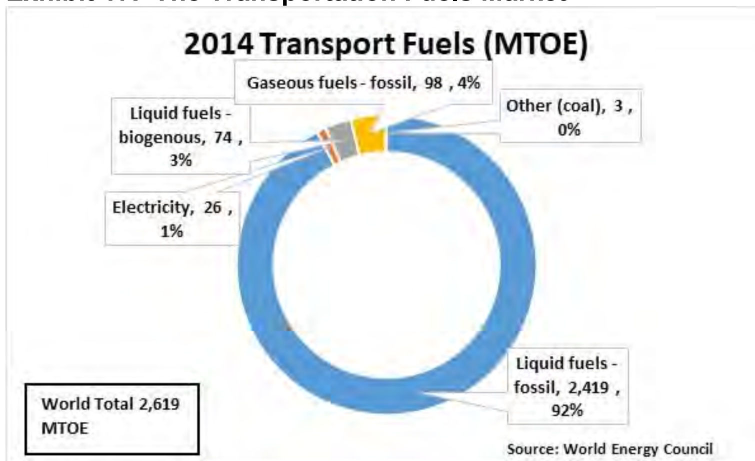


Source: EIA

Electricity, the supposed clean fuel alternative, only met about 1% of global transportation fuel needs

As Exhibit 17 demonstrates, the world today runs largely on fossil fuel energy – either liquid or gaseous. Electricity, the supposed clean fuel alternative, only met about 1% of global transportation fuel needs. As cited above, there are many issues, which need to be addressed if the world is to transition to a totally decarbonized transportation fuel market. We suspect this transition will take longer than the optimists forecast, but will occur faster than traditional oil market forecasters anticipate.

Exhibit 17. The Transportation Fuels Market



Source: World Energy Council, PPHB

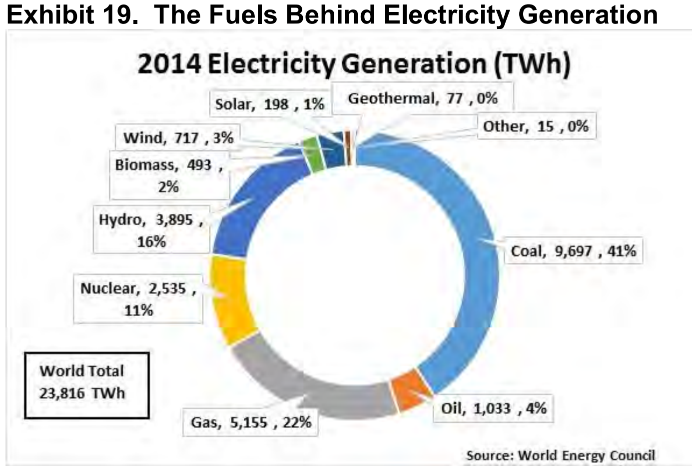
In reaching our conclusion about a slower transportation market transition, we have only considered light-duty vehicles. We have not factored in fueling the planes, trains and boats, which are an integral part of the global transportation sector. Each of them presents its own challenges, further complicating the transition pace.

Transitioning Energy Fuels In The Fixed Power Sector

The challenge of decarbonizing the world's fixed power sources may appear a little easier

The challenge of decarbonizing the world's fixed power sources may appear a little easier than in the transportation sector due to not having to worry about the fuel moving with the vehicle. On the other hand, the composition of the fuel structure for the global electricity business is different, i.e., more diverse sources of fuel. But, in many cases, more capital has been invested in existing plants that are functionally perfect, thus creating a financial hurdle if they are to be shut down prematurely.

Exhibit 19. The Fuels Behind Electricity Generation



Source: World Energy Council, PPHB

Coal is the dirtiest fuel by the volume of carbon emissions

As shown in Exhibit 21 (page 21), coal is the predominant fuel in the world. However, it is but one of nine different fuels powering electric generating plants around the world. Coal is the dirtiest fuel by volume of carbon emissions, but in many geographic regions it is the cheapest and most available energy source.

The major differentiating characteristic among the various fuels is the degree to which the electricity they generate can be dispatched without help

The major differentiating characteristic among the various fuels is the degree to which the electricity they generate can be dispatched without help. As discussed in our opening article, the issue of replacing high density, dirty fossil fuels with clean, renewable fuels often revolves around the ability to dispatch the electricity when the market needs the power. This introduces the need to develop low-cost energy storage systems to enable intermittent power to be saved when it is generated and available when it is needed.

In terms of government commitments to clean up the atmosphere, coal, oil and natural gas are the primary energy polluters, ranked by order of maximum to minimum carbon emissions. These are the fuels targeted for elimination, along with nuclear power for other social concerns.

One fuel, natural gas, has experienced both the support, and now the distain, of environmentalists

One fuel, natural gas, has experienced both the support, and now the distain, of environmentalists. In the early 2000s, when natural gas prices in the United States were in the range of $8-$12 per thousand cubic feet (Mcf), it was the favored fuel. It was called the "bridge fuel" to a cleaner future. Environmentalists loved gas because it had a fraction of the carbon emissions of coal or oil, but importantly, the high gas price provided competitive protection against even higher cost renewable fuels. When the U.S. gas shale revolution boosted supplies and the recession after the 2008 Financial Crisis cut energy demand, gas prices dropped substantially, settling out around $3/Mcf. The low price undercut expensive renewable fuels as they were fighting for market share.

The two fuels continue to battle for market supremacy, but the outcome is now dependent not just on respective fuel prices, but also on government policies

What came from the drop in natural gas prices was a more attractive fuel than coal, and in terms of competitive pricing, a much cheaper fuel for utilities. As a result, natural gas in the U.S. took substantial market share away from coal and, for a while in 2015, was the primary fuel for electricity generation. The two fuels continue to battle for market supremacy, but the outcome is now dependent not just on respective fuel prices, but also on government policies. As the American utility industry moves away from coal fueling electricity generation, natural gas will likely become more entrenched as the dominant fuel until another better one comes along.

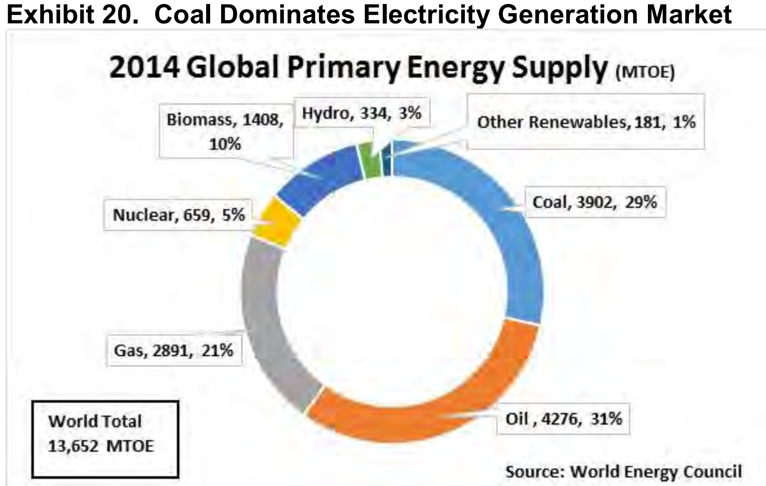
Globally, the battle between coal and natural gas is much more centered on the environmental considerations of nations and their access to reasonably priced fuels. In Germany, the government moved to shut down its nuclear power industry following a 2010 tsunami flooded a Japanese nuclear power plant, raising concerns about the safety of Japan's remaining nuclear power stations. The

Germany's carbon emissions are rising and more citizens are falling into energy poverty

push for a renewables-based power grid in Germany has led to the highest residential electricity costs in Europe and forced local electric utilities to import coal to generate electricity when intermittent renewable power is not available. The unintended consequence of this energy policy is that Germany's carbon emissions are rising and more citizens are falling into energy poverty (spending more than 20% of one's income on power).

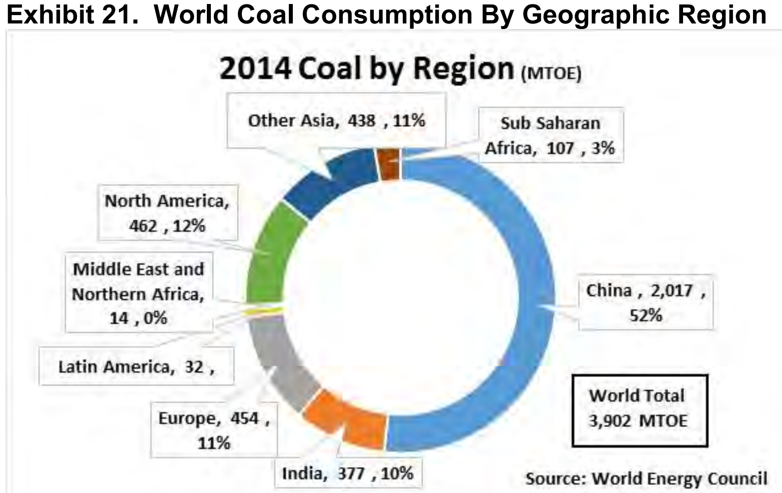
A series of charts highlights the challenge of decarbonizing the global electric sector. First, it was the world's primary energy supply for 2014, and continues to occupy that position today. Then we show coal and natural gas supplies by geographic region.

Exhibit 20. Coal Dominates Electricity Generation Market



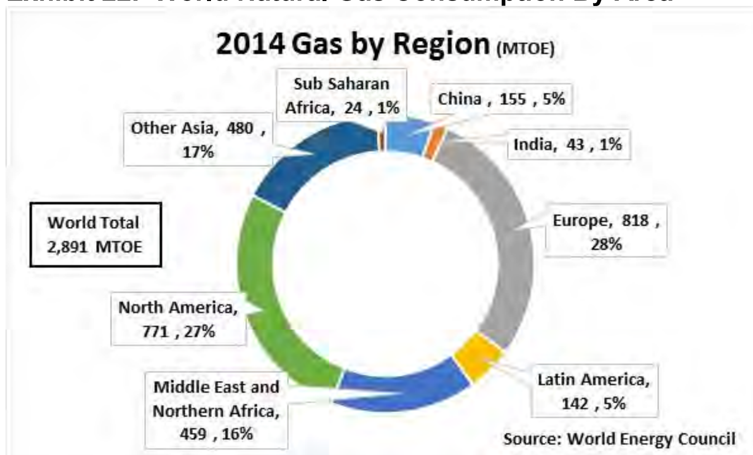
Source: World Energy Council, PPHB

Exhibit 21. World Coal Consumption By Geographic Region



Source: World Energy Council, PPHB

Exhibit 22. World Natural Gas Consumption By Area



Source: World Energy Council, PPHB

The country currently has more installed renewable capacity than it can deliver to the market

One quick observation is that North America uses less coal than natural gas, while China and India are the opposite. This helps explain why those two countries, with their huge populations and smothering carbon emissions issues, have become aggressive buyers of liquefied natural gas (LNG). In China's case, it is also aggressively pushing its renewables industries, but due to the lack of transmission infrastructure, the country currently has more installed renewable capacity than it can deliver to the market.

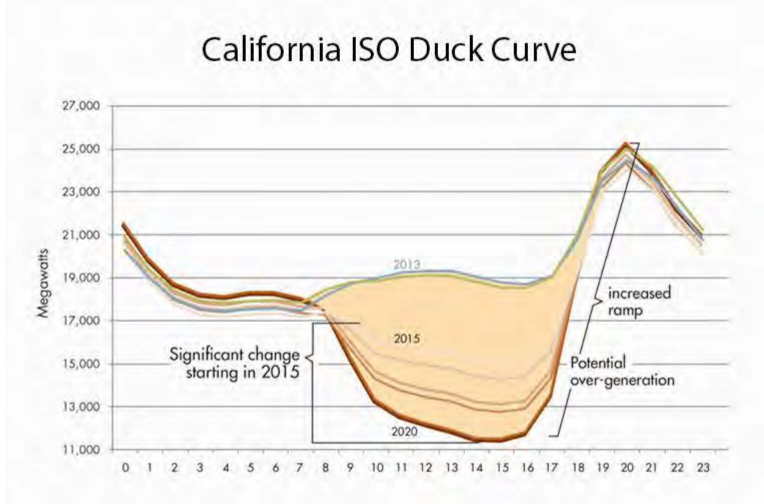
This problem points to the need for increased power storage, primarily batteries now, but possibly other forms later, to mitigate grid instability

While increased renewables are creating greater instability in the power systems of countries such as China and India, the immense control their governments exercise over its industries and citizens makes government mandates a powerful tool for minimizing the fallout from a less-stable power grid. This problem points to the need for increased power storage, batteries now but possibly other storage forms later, to mitigate grid instability. A few countries use pumped water, which is released to generate electricity when the backup power is needed. This is an attractive environmental solution, but limited in application due to geographic constraints.

Suddenly these fossil fuel plants must ramp up output quickly to meet the increased power needs that come at sunset

California has been among the most aggressive governments mandating increased renewable fuel use for producing electricity. After years of aggressively building renewable power generating capacity, the California Independent System Operator, which oversees the region's electricity system, began noticing a problem. During daylight hours, renewable power squeezed out of the system the power generated by fossil fuel plants. However, when the sun set and the wind stopped blowing, suddenly these fossil fuel plants must ramp up output quickly to meet the increased power needs that come at sunset. Based on projected growth in renewable capacity, the California ISO projected its needs for conventional power generation while dealing with more renewable power during the day. The shape of those curves became known as the "Duck Curve."

Exhibit 23. How Renewable Fuels Create Power Grid Issues



Source: cleanpowerexchange.org

For utility companies who own generating facilities, when they are squeezed out of the market, the company loses revenue

The issue of cheap, renewable power forcing traditionally generated power out of the market, while needing that power to survive the balance of the day, is a growing problem for electric grid management. For utility companies who own generating facilities, when they are squeezed out of the market, the company loses revenue while it still needs to maintain its power plants in standby mode – a non-recovered cost. This phenomenon has driven down the earnings and value of traditional utility companies in Germany, which is leading the European renewable energy charge.

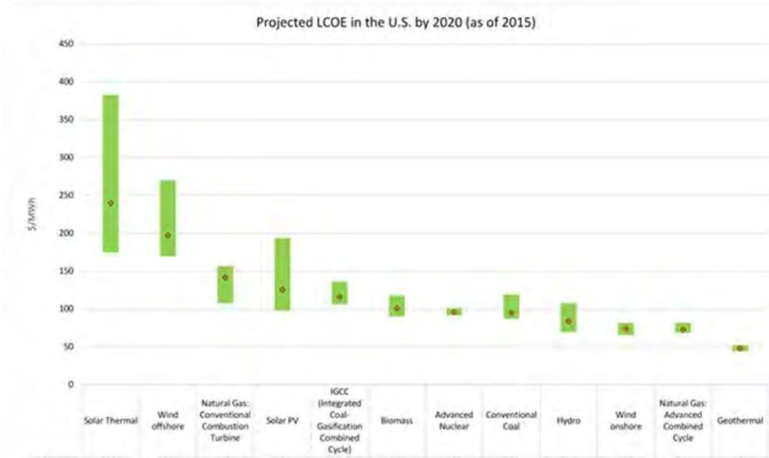
For utilities dealing with growing rooftop solar power installations, there is an additional issue. Homeowners need access to power at times, but they are not paying sufficient amounts to cover the cost of maintaining the transmission and distribution costs of the power system they are relying. Resolving this fairness issue is a problem.

Determining the LCOE of a fuel is equivalent to establishing "the average minimum cost at which electricity must be sold in order to break-even over the lifetime of the project."

Another issue impacting renewable energy is using "levelized cost of energy" calculations when determining which power should be brought into the grid in the future. LCOE is defined as "An economic assessment of the average total cost to build and operate a power-generating asset over its lifetime divided by the total energy output of the asset over that lifetime." In effect, determining the LCOE of a fuel is equivalent to establishing "the average minimum cost at which electricity must be sold in order to break-even over the lifetime of the project."

LCOE is often invoked when the discussion focuses on the rapidly falling cost of renewable power, but the calculation can often distort the comparison with traditional fossil fuel power plants. In the analysis, the financial structure for financing new power facilities is kept constant regardless of the fuel source. While that is fair, the length of time a facility will operate can distort the annual

Exhibit 24. Levelized Cost Of Power Supplies



	Solar Thermal	Wind offshore	Natural Gas: Conventional Combustion Turbine	Solar PV	IGCC (Integrated Coal-Gasification Combined Cycle)	Biomass	Advanced Nuclear	Conventional Coal	Hydro	Wind onshore	Natural Gas: Advanced Combined Cycle	Geothermal
Minimum	174	170	107	98	106	90	92	87	69	66	69	44
◆ Average	240	197	142	125	116	101	95	95	84	74	73	48
Maximum	383	270	156	193	136	117	101	119	107	82	82	52

Source: EIA

depreciation and interest charge. If a combined cycle natural gas plant is estimated to only last 20 years, when they last 40, then the true cost of this energy is penalized in the LCOE calculation.

LCOE should include the cost of backup power for those times when the sun doesn't shine and the wind doesn't blow

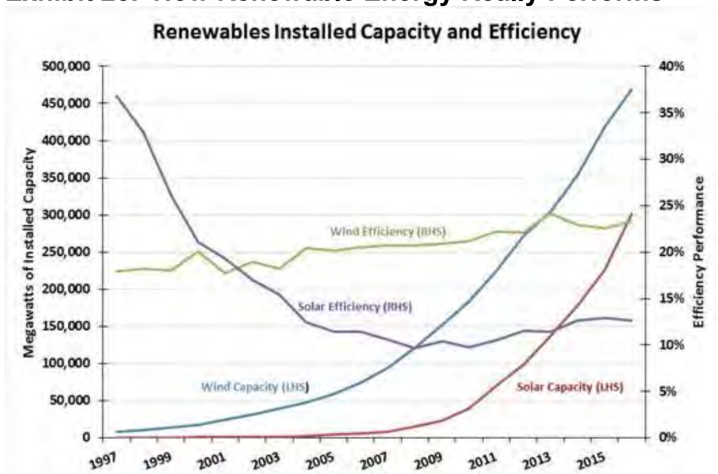
Additionally, in LCOE calculations, all kilowatts are considered equal in value, when in reality, those that cannot be dispatched are worth less than those that can be dispatched. As a result, LCOE should include the cost of backup power for those times when the sun doesn't shine and the wind doesn't blow. Also, in the case of wind and solar plants, many are located in very favorable regions for generating that low-cost power, but the cost to build the necessary transmission lines from those plants is not considered in the LCOE calculations.

We would also caution that when examining LCOE studies, one should closely examine the assumptions regarding the capacity performance of the power source. For example, some wind LCOE determinations use a 55% capacity factor, when statistics as reported by the U.S. Department of Energy in its 2015 Wind Technology Report show an average of 32.8% for 2011 to 2015, 31.8% for 2006 and 2010, and 30.3% between 2000 and 2005.

Taller wind turbines with longer blades will probably have higher capacity factors, but unlikely to reach 55%

New, taller wind turbines with longer blades will probably have higher capacity factors, but unlikely to reach 55%, which has been used in recent studies. That high of a capacity factor is cited by wind project developers planning on using these taller wind turbines in their arguments for why their project should advance. The higher factor makes wind look cheaper, something that is touted in competing for new wind projects. A similar situation exists with solar panels. Exhibit 25 shows the global capacity and output data reported by BP plc (BP-NYSE), which supports the U.S. DOE data.

Exhibit 25. How Renewable Energy Really Performs



Source: BP, PPHB

Area and power ratios are inversely related

A final consideration about fixed power is the issue of power density. A table prepared by Robert Bryce for his book, Power Hungry, shows various fuels ranked by the surface area required to produce energy, along with the resulting horsepower per acre and watts per square meter ratios. Exhibit 26 shows how area and power ratios are inversely related. When thinking about returning to a world totally dependent on renewables, we will have to devote much more land than now to producing energy, and likely still not have sufficient energy for the global economy. That reality dooms many of the people currently living without access to electricity or living in energy poverty to remaining trapped in that condition, rather than enjoying the benefits of higher living standards.

Exhibit 26. Power Requirements And Output By Fuel

Fuel	Area (Sq Miles)	Power Density (hp/acre)	Watts/square meter
Corn ethanol	21,267	0.25	0.05
Biomass-fueled power plant	2,606	21.00	0.40
Wind	869	6.40	1.20
Solar PV	156	36.00	6.70
Oil Stripper Well (10 bbls/day)	39	148.50	27.00
Avg. US Natural Gas Well	20	287.50	53.00
South Texas Nuclear Plant	19	300.00	56.00

Source: Robert Bryce, Power Hungry

64%, or 75,000, of the 117,000 manufacturing jobs lost in Ontario Province, was a direct result of the province's green energy policy

Transitioning the planet's electricity system from fossil fuels to renewables can be done, but it will occur with costs not fully acknowledged by those promoting the shift. For example, Canada's Fraser Institute determined that between 2008 and 2015, 64%, or 75,000, of the 117,000 manufacturing jobs lost in Ontario Province, was a direct result of the province's green energy policy. Between

2010 and 2016, electricity costs for small industrial consumers rose by 50% in Ottawa and 48% in Toronto, compared to an average 15% increase for the rest of Canada. Besides sharply rising electricity prices, grid instability has grown, increasing the instances of brownouts and blackouts. Over time, given sufficient investment in battery or other storage systems, it is possible this risk can be mitigated. Power prices, however, would likely not come down.

Contrary to LCOE calculations, renewable power costs have merely chased fossil fuel costs down, but have yet to fall below them without government subsidies

Contrary to LCOE calculations, renewable power costs have merely chased fossil fuel costs down, but have yet to fall below them without government subsidies. While OECD countries have the wealth to absorb higher energy costs, the developing economies of the world do not have this luxury. What they do have are governments exercising greater control over their economies. If a policy decision is made to adopt renewables, regardless of the economic consequences, a transition can occur, but we can only speculate on how economies will fare going forward.

The Transition Underway Among Energy Exporters

"Lower for longer" became the mantra for the global oil industry barely two months after oil prices crashed in November 2014 following Saudi Arabia's abandoning support for OPEC oil prices. People wonder whether this mantra will become "lower forever," as global oil supplies continue to exceed demand. Oil prices are currently being supported by OPEC's and Russia's output cuts.

Their leaders are concerned about the long-term future for oil and gas, given the global push to decarbonize the world's economy

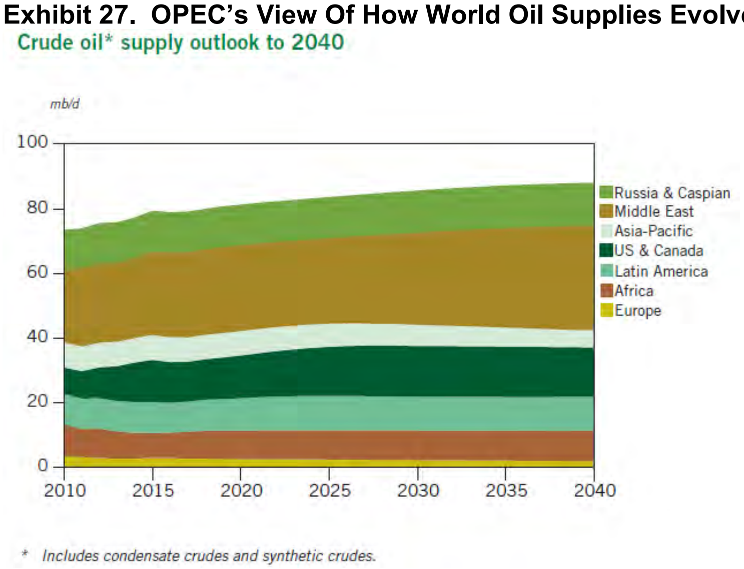
These major exporters are struggling to transition their economies away from nearly total dependence on petroleum for income. Their leaders are concerned about the long-term future for oil and gas, given the global push to decarbonize the world's economy. In extreme cases, these countries could see their hydrocarbon resources stranded and having little or no value. That scenario would fulfill the observation of former Saudi Arabia Minister of Oil and Mineral Resources Ahmed Zaki Yamani about the long-term challenge for oil. He said, "The Stone Age didn't end for lack of stone, and the oil age will end long before the world runs out of oil."

His Vision 2030 is struggling to gain traction as structural impediments must be overcome

The most aggressive country addressing the possibility of the Petroleum Age ending is Saudi Arabia. Crown Prince Mohammed bin Salman, now positioned to lead his country, has set forth a plan to transform the country's economy and reduce its reliance on oil exports. His Vision 2030 is struggling to gain traction as structural impediments must be overcome. The recent royal decree allowing Saudi women to secure driver's licenses is a step in expanding the country's labor force. It could also send one million-plus expats working as family drivers home, boosting the nation's disposable income by more than $8 billion annually. There are reports other social restrictions may be eased, further modernizing the economy and society, and appealing to its youth-oriented population.

A bullish oil outlook comes from OPEC in its World Energy Outlook 2016. We have borrowed two charts – Exhibits 27 and 28 – to show OPEC's view of future world energy supply. While it may be difficult to see, the slope of world oil supply was rising steeply between 2010 and 2020, but slowed its ascent, thereafter. The regional supply trends in Exhibit 28, (next page) show North America growing, Asia-Pacific declining, and significant growth in the Middle East.

Exhibit 27. OPEC's View Of How World Oil Supplies Evolve



Source: OPEC

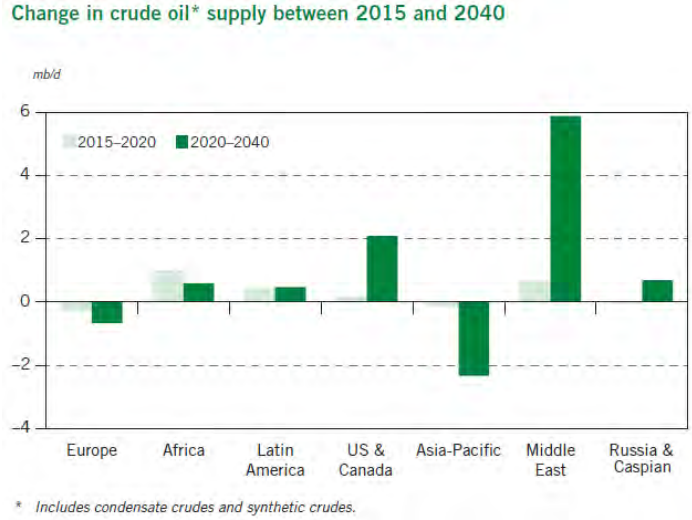
What Saudi Arabia has to be concerned about is whether OPEC's demand growth projections post 2020 materialize

The chart shows Middle East output growing by nearly six million barrels per day between 2020 and 2040, with U.S. and Canada output increasing by just over two million b/d. Russian and Caspian output will increase by roughly 600,000 b/d. What Saudi Arabia has to be concerned about is whether OPEC's demand growth projections post 2020 materialize. OPEC is calling for an 11 million b/d demand increase, with developing economies needing over 19 million b/d more and developed economies needing 8.6 million b/d less. In the developing world, China and India are expected to see their consumption grow by five million b/d each, which, when combined, accounts for over half of the total growth projected for developing countries.

You have to be concerned

If you are Saudi Arabia, a one-product (oil) economy, and you are watching the aggressive adoption of government policies around the world to stop the sale of internal combustion engine cars, you have to be concerned. Given that France and the UK have announced bans on the sale of ICE vehicles by 2040, auto industry executives are assuming China will adopt a similar date. The Netherlands just adopted a 2025 ban on the sale of new ICE cars, with a 2030 date for all ICE cars to be off Dutch roads.

Exhibit 28. How World Oil Supply Will Evolve



Source: OPEC

Which will have a material impact on Saudi Arabia's long-term oil export opportunities

For China, the world's largest car market, having sold over 28 million cars last year (nearly a 14% year-over-year increase), the banning of ICE vehicles will shrink the need for, and eventually eliminate motor fuels, which will have a material impact on Saudi Arabia's long-term oil export opportunities. When considering that Saudi Arabia has been fighting Russia and Iran to gain an increased share of the Asian, and especially Chinese, oil markets, anything threatening the long-term success of that fight is of concern, even if it is a future event.

Current industry developments and future prospects are similar to the forces that drove OPEC's formation in 1960

Is the industrial policy to ban ICE vehicles a signal of the impending end of the Petroleum Age, much like Sheik Yamani predicted? Is that prospect part of the motivation behind Crown Prince Salman's plan to sell off a portion of Saudi Aramco, either in an initial public offering or through a direct sale to sovereign wealth funds to raise money now for diversification investments? In a way, current industry developments and future prospects are similar to the forces that drove OPEC's formation in 1960. A brief review of history may help put into perspective why OPEC is struggling to remain relevant now, and will likely continue to struggle in the future.

U.S. oil production rose from 2.0 to 2.6 million b/d, but it was clear that cheap oil imports were a growing threat to domestic oil producers

In the late 1950s, the U.S. found that although it was an oil exporter, it was importing increased volumes of cheaper oil, primarily from Latin America and the Middle East. Imports rose from 850,000 b/d in 1950 to 1,248,000 b/d in 1955, and grew to 1,815,000 b/d by 1960. During this time, U.S. oil production rose from 2.0 to 2.6 million b/d, but it was clear that cheap oil imports were a growing threat to domestic oil producers. To protect U.S. producers, the federal government created the Mandatory Oil Import Program (MOIP), which imposed both quotas and import licenses in order to stimulate domestic oil exploration and to increase U.S. refining capacity. Because Venezuela was restricted from exporting oil into the U.S. under the MOIP, it rallied its Middle East oil exporter brethren – Saudi Arabia, Kuwait, Iraq and Iran - to band together to counter the U.S. move. OPEC was created in 1960, 18 months after the MOIP program started.

That act became the catalyst that emboldened OPEC to push back on the oil companies' pricing of crude oil

The final push to form OPEC came in a battle over global oil prices. As global supplies grew, oil prices fell, but the international oil companies, who held the production concessions in the Middle East, were victimized by their agreement with the countries to pay taxes and royalties based on a posted oil price, which was well above the market price. Oil companies were hurt financially by this pricing structure. In August 1960, they cut the posted price by 4-cents a barrel. That act became the catalyst that emboldened OPEC to push back on the oil companies' pricing of crude oil.

Another major event in the evolution of OPEC's power was the 1975 agreement between the U.S. and Saudi Arabia to price oil in U.S. dollars, leading to the creation of petrodollars that were then reinvested in the United States. The tie between the U.S. and Middle East oil producers grew tighter over time.

Both have established relationships with China, which, despite banning ICE cars, will have a need for substantial oil volumes for many years

Fast forward to now and we see OPEC oil, primarily Saudi Arabian oil, being restricted from global markets by government edicts to destroy the oil industry's demand machine - ICE vehicles. With substantial volumes of oil now in the market, including oil exports from the U.S., OPEC members are fighting over market share. The battle comes as OPEC has had to choke off output, with support from Russia, to balance global oil supply/demand balance and support higher oil prices. The recent meeting of Saudi Arabia King Salman and Russian President Vladimir Putin may signal an early step in the formation of an alliance to help them gain market share and improve their oil incomes. Both have established relationships with China, which, despite banning ICE cars, will have a need for substantial oil volumes for many years.

China is pushing to price oil in yuan and compete with the U.S. dollar

Another ingredient in the current energy industry transition may be the rumored agreement for China's wealth funds to purchase 5% of Saudi Arabia's state oil company, Saudi Aramco. This deal would reduce pressure on the kingdom for an IPO, with the proceeds helping to build its sovereign wealth fund and investments in the local economy. China is pushing to price oil in yuan and compete with the U.S. dollar. Could such a pricing arrangement be part of this reported Chinese/Saudi Aramco investment agreement? It would also allow China to play Saudi Arabia's oil supplies off against the long-term energy supply deals it has with Russia, while Iran continues knocking on China's door. The Saudi Arabia/Russia rapprochement might also help counterbalance Russia's support for Iran, Saudi Arabia's bitter rival in the Middle East.

The net result of deals between these two leading oil exporters and their potential ties to the world's leading oil importer could spell the demise of OPEC. It would come partly because of a lack of unity among the OPEC members on critical oil pricing policies that is rendering the organization impotent. OPEC might continue to exist to facilitate periodic shopping trips and dinners in Vienna for its members, but as an enforcer of oil pricing discipline, OPEC is largely impotent.

Global oil production growth, coupled with projected declines for oil consumption in developed economies, has created long-term oil market uncertainty

The growth of shale oil output has restored the U.S. to the ranks of one of the top oil producers in the world. Moreover, that U.S. oil export growth is a new dynamic that is disrupting traditional oil trading relationships. Global oil production growth, coupled with projected declines for oil consumption in developed economies, has created long-term oil market uncertainty. New relationships are being formed that will perplex market observers until they become clearer. In the meantime, believing that one knows how the various market players are going to act in any given situation may prove to be a mistake. Be prepared to consider previously unthinkable scenarios.

Understanding The Magnitude Of The Energy Transition Issue

As extensive a discussion as the foregoing has been, we know it has only touched lightly on many of the key topics shaping our energy transition. We will use this discussion to guide us toward better understanding of the critical topics that will shape the future of the transition. Our goal in future Musings will be to visit these topics, along with current market and energy event analyses. We welcome comments, questions and guidance from our readers

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