Four Ideas to Consider When Analyzing Long-Term Prospects for Oil and Natural Gas

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Dr. Bluford Putnam, Ph.D., Chief Economist of the CME Group, presenting at the JPMCC's 2nd International Commodities Symposium, which was held at the University of Colorado Denver Business School on August 14 through August 15, 2018. Dr. Putnam lectured during the first day's plenary session, participating in the conference's Applied Commodity Research Leaders Forum. He is also a member of both the JPMCC's Research Council and its Advisory Council.

Periodically, analysts and forecasters benefit from spending some time thinking about what might be the most disruptive developments that could materially change the way we analyze markets over a long-term horizon. In this research, we provide a perspective on four developments that may shape oil and natural gas markets as they evolve during the 2020s. We want to explore (1) the evolving nature of oil production sensitivity to price changes, (2) the role of U.S. exports in the globalization of oil and natural gas prices, (3) the impact of electric cars and increasing transportation efficiencies on the demand for oil, and (4) the trends in the generation of electrical power away from coal and towards natural gas and alternative sources.

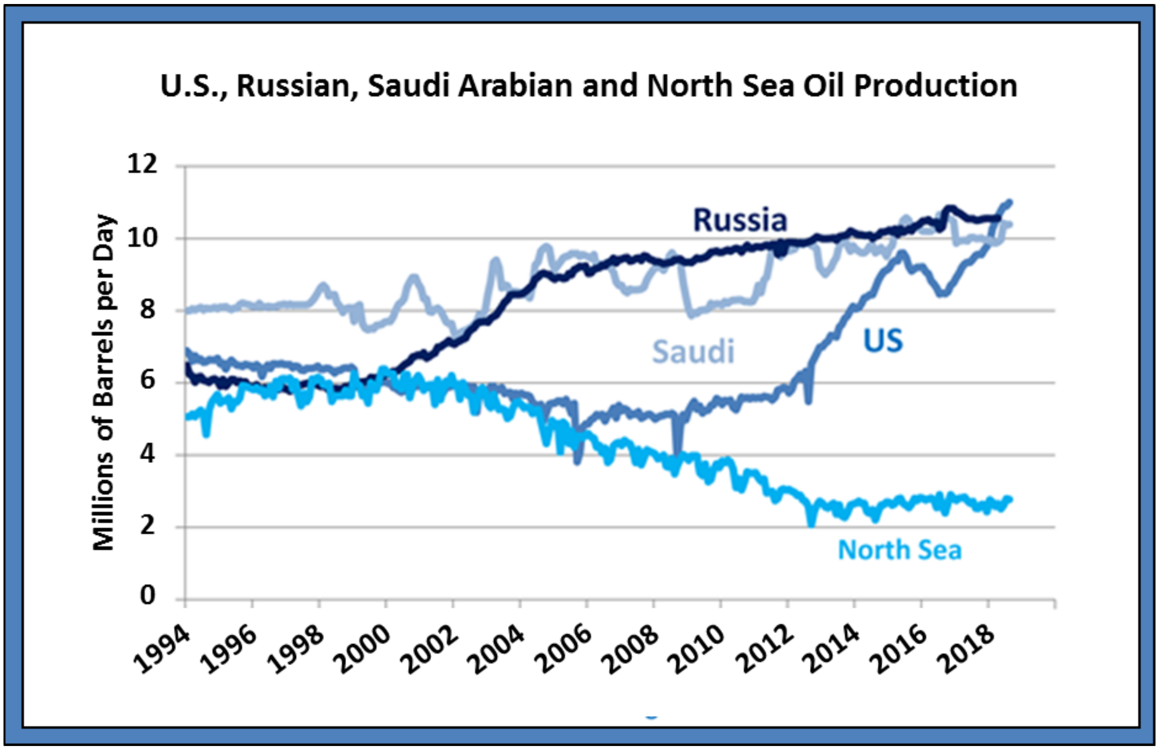
1. Increasing Medium-Term Elasticity of Oil Supply Effectively Makes U.S. the Swing Producer

Traditional oil wells can keep on pumping for decades, and once they start producing oil the marginal cash costs of keeping these wells operational and pumping are extremely low. The difference with shale wells could not be more striking.

Shale oil wells have a very predictable two years or so lifespan from when drilling begins to when the well has pumped its last drop and been shut off and sealed. Once a shale oil well has started production, it will almost always be allowed to run its course. The question is: does the production company drill more wells? The answer depends critically on a number of factors, of which price is extremely important. If the price of oil is such that the all-in capital and operating costs can be covered and leave a reasonable profit given the risks and financing costs, then the producer will consider drilling new wells. An important note here is that when we speak of the price of oil in this sense, we are talking about the fully hedged estimated production of the shale well over its expected lifetime – that is, the spot price is interesting, but what matters in terms of price is the shape of the oil futures maturity curve over the expected life of the well. The producer may or may not choose to hedge or to hedge only part of the expected production, but our price analysis starts with the fully hedged assumption.

Other factors beyond price also play critical roles. Shale oil wells require workers with specific skill sets. Large quantities of sand and water need to be available at the drilling site. Drilling processes involve specialty steel – is the steel available and at what cost? Unlike traditional wells, shale oil wells use a lot of electricity, which must be delivered to the well site. There is considerable truck traffic involved. Can the roads handle the traffic? Once the oil is pumped, how will it be delivered to the nearest storage terminal or port? And, of course, there are the financing challenges. Can the well's capital costs be financed from the free cash flow of the production company, or does the investment capital need to be borrowed or equity raised? All of these factors – workers, sand, water, steel, electrical grid, road traffic, pipeline and storage facilities, and financing costs – may come with variable prices and serious timing constraints, depending on market conditions.

Figure 1
Major Sources of Oil Production



Source: Bloomberg Professional (DOETCRUD, OPCRSAUD, DWOPRUSS, PIWANORT).

The point is that one may have a pretty good sense of the all-in costs of a shale oil well from start to finish, but there are plenty of potential challenges that must be overcome beyond just the price of oil before the well goes into production. So, while knowing the oil price and shape of the oil futures maturity curve is critical, the oil price is not remotely the only factor determining future production.

Even with these caveats, shale oil well production is likely to be much more price sensitive than existing traditional oil supply. If the oil price drops dramatically, as it did in late 2014 and 2015, then shale oil production will decline, too, by a large amount, but with a lag, which can be seen in the abrupt change in U.S. oil production in Figure 1. Existing wells will be run until they are done. The production adjustment lag will come as new wells are not drilled at the former pace. And, if the oil price rises materially above expected costs, financing may become abundant, and the new wells will be put in place at an ever increasing pace, subject to the constraints of workers, sand, water, steel, and the road, pipeline, storage, and electrical infrastructure.

As we look back from 2018, we only have two meaningful observations of the price sensitivity of U.S. shale oil production – the oil price decline of Q4/2014 through Q1/2016, and the oil price rise in 2017 and 2018. In both of these two cases, with a lag, production responded very aggressively as suggested here. The only non-shale supplier of oil that is price sensitive is Saudi Arabia, and that is because they have historically made a choice to buffer the volatility of oil prices and serve as a swing producer, the economic value of which is estimated in Sieminski (2018). The implications of this analysis are that the elasticity of U.S. shale oil production in the medium-term will serve as a powerful offset to the ability of Saudi Arabia to influence global prices in the way they were once able to do. This in turn may make Saudi Arabia less willing over time even to serve as a swing producer. And from an econometric forecasting perspective, if one's model is based on legacy price-production elasticities, pre-shale revolution, then those model's may be very far off the mark going forward.

2. U.S. Exports Will Speed the Globalization of Oil and Natural Gas Prices

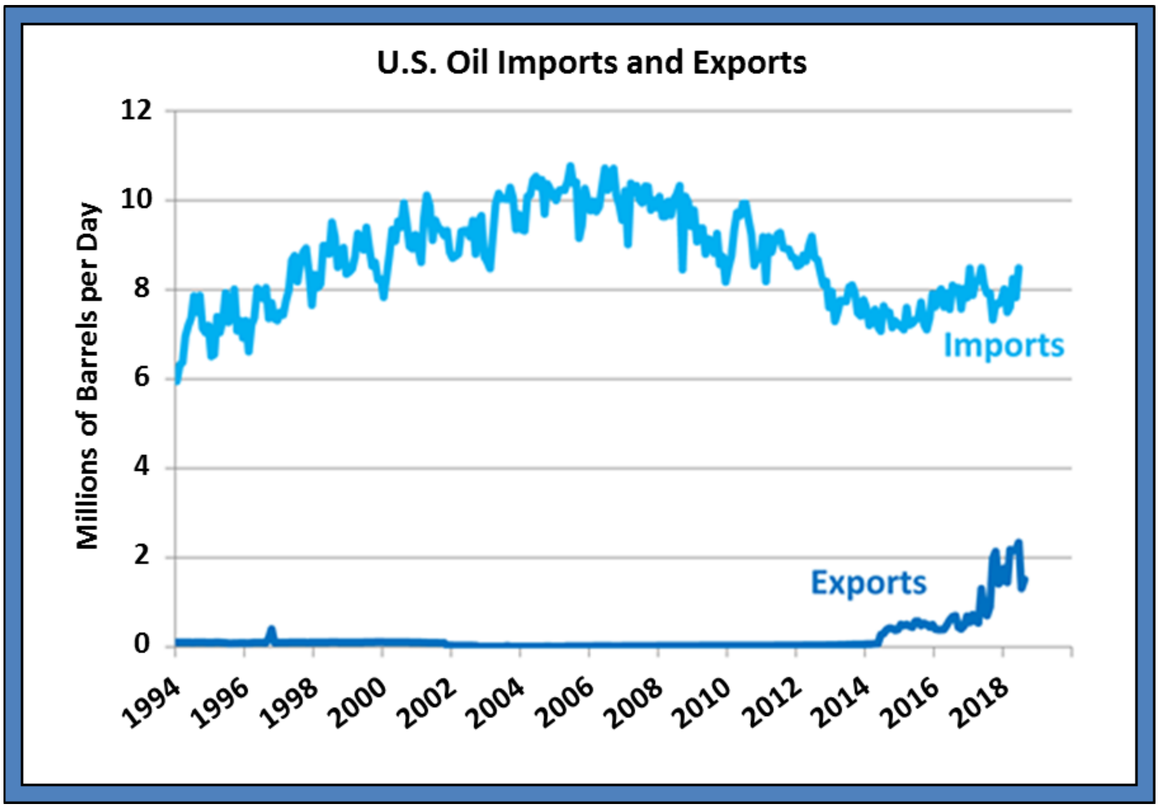
In December 2015, the U.S. lifted its ban on oil and natural gas exports, which had been in place as a response to the large oil price rises engineered by the Organization of Petroleum Exporting Countries (OPEC) back in the 1970s. While the U.S. remains a large importer of oil and petroleum products, the export response has been rapid and impressive, as shown on the next page in Figure 2. And the implications are huge for the price interactions between U.S. produced oil and natural gas and production elsewhere around the globe.

Take the Brent (North Sea) oil price spread relative to the U.S. West Texas Intermediate (WTI) crude oil price. Before the U.S. shale oil revolution, the price spread between Brent and WTI was volatile yet close to zero. Then, in 2012-2013, U.S. shale oil production overwhelmed the pipeline infrastructure and U.S. oil prices became disconnected from the rest of the world. The price of Brent relative to WTI moved above $10/barrel and then above $20/barrel. Market forces involving the transportation of oil came into play, especially rail transport from the Bakken shale oil fields of North Dakota to the refineries in New Jersey. Rail transport costs were in the $10/barrel range to get the shale oil to the east coast refineries where it directly competed with North Sea oil and Middle Eastern oil benchmarked to Brent. The spread dropped to around $10/barrel. As the pipeline infrastructure improved as well, the Brent-WTI spread collapsed further. The removal of export prohibitions also changed the price spread dynamics by placing the point of direct competition in Europe and China, and the Brent-WTI spread entered a new phase. In 2018, two old themes reappeared. U.S. shale oil production in the Permian basin expanded so rapidly with rising prices that the infrastructure to get the oil to Texas and Louisiana export terminals was again overwhelmed at the same time as production dropped in Venezuela and Libya due to internal political turmoil and in Iran due to the bite taken out of production by U.S. economic sanctions. The Brent-WTI spread responded by widening as it became clear that Saudi Arabia was not as aggressive a swing producer as it might have been in the past (see the conclusions to the price sensitivity section above.)

The bottom line is that with the U.S. serving as a serious oil exporter, the Brent-WTI price spread is going to respond to the relative dynamics at the point where these strains of oil meet in direct competition. As the U.S. infrastructure challenges are resolved, the price spread is likely to be driven more by shipping costs to the points of competition, say China. In this sense, futures contracts such as the Houston physically delivered product (HCL) can be viewed partly as a transportation-driven spread relative to WTI (CME Group, 2018b).

The analysis with natural gas exports is similar but with longer time lags due to the costs of building the U.S. export infrastructure. Billions upon billions of dollars, however, have been put to work turning former import facilities for liquefied natural gas (LNG) into export facilities and building large capacity facilities to convert natural gas into LNG so it can be exported. Exports are increasing rapidly and a number of new export facilities will come on line over the next few years, allowing exports of LNG to ramp up even more. One should also realize, though, that not all the expansion of export facilities are in the U.S. Competing countries, such as Canada, are building natural gas export facilities. A planned LNG facility costing upwards of $40 billion is likely to be built in Kitimat, British Columbia, on the Pacific coast. Compared to shipping LNG from Sabine Pass in the Gulf of Mexico, the distance to Shanghai or Tokyo will be cut by half or more, lowering shipping costs.

Figure 2
U.S. Oil Imports and Exports and Imports



Source: Bloomberg Professional (DOCRTOTL, DOEBCEXP).

And similarly to crude oil, one of the key pricing factors in the analysis of the spread between U.S. Henry Hub natural gas and natural gas pricing at the ports of entry in consumer countries such as China, Japan, and the European Union will be shipping costs, liquefaction costs, and de-liquefaction costs. In this sense, one should think of LNG not as a separate product from natural gas, but as a transportation product allowing natural gas to be used in places far away from its point of extraction. And again, futures contracts, such as the one based on the LNG delivery point at Sabine Pass are essentially going to serve as price discovery points for the all-in transport costs relative to the Henry Hub natural gas price (CME Group, 2018a). The relevant shipping distances from Sabine Pass are shown on the next page in Figure 3.

What we have developing here is a "Transpread" or transportation spread for crude oil based on Houston crude oil export terminal prices and for natural gas based on LNG export terminal prices. The "Transpread" is essentially just like the "crack" spread between crude oil and refined products like gasoline (RBOB), or the "crush" spread between soybeans and processed products such as soybean oil or soybean meal.

Figure 3
Shipping Distances

Distance from Sabine Pass	
Discharge Port	Nautical Miles
Gateway (NL)	5002
Tokyo	15762
Tokyo (via Panama Canal)	9209
Tokyo (via Suez Canal)	14521
Shanghai	15098
Shanghai (via Panama Canal)	10081
Shanghai (via Suez Canal)	13854

Source: SEA-DISTANCES.ORG, https://sea-distances.org/.

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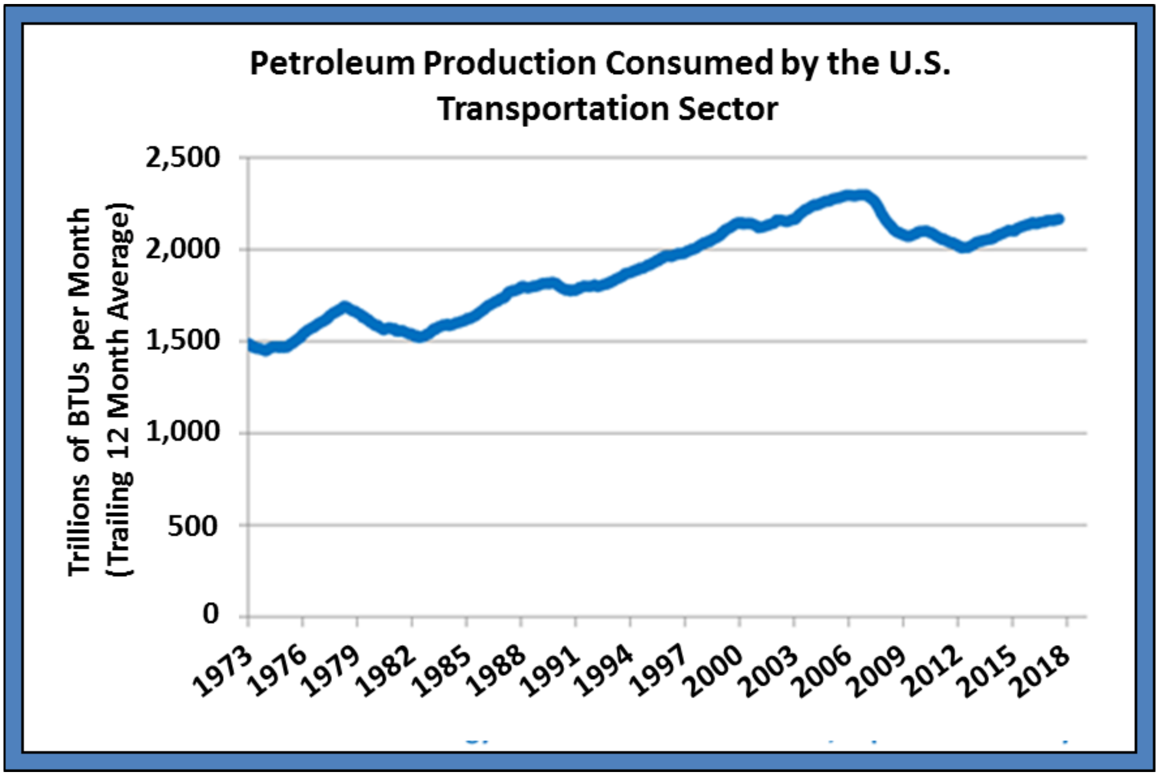
3. Electric Cars and Increasing Transportation Efficiencies Eventually Will Dampen Oil Demand Relative to GDP Growth

In 2018, and for a very long time into the past, in its refined state, oil has been mostly used as a transportation fuel. For example in the U.S., some three-quarters of crude oil find its way into the transport sector. The trend in petroleum consumed as a transportation fuel is shown on the next page in Figure 4. For countries that depend more heavily on diesel oil or heating oil to run electrical power plants or heat homes, then this percentage may be a little lower – for now. Nevertheless, the key issue for the 2020s will be whether transportation efficiencies have a material and negative impact on the global demand for crude oil.

We expect continued efficiencies in shipping and in airline travel to have steady and incremental impacts on the demand for oil relative to GDP growth. That is, the elasticity of oil consumption relative to GDP is likely to slowly decline.

The real game changer may be electric automobiles. Of course, this game changer has been promised for a long time (if not by yours truly) and the demand impacts have been extremely small. Electric vehicles are available, but in 2018 they represent only a very tiny proportion of vehicles or total miles driven. Will that change in the 2020s? And if electric vehicles gain traction will that have a noticeable impact of the demand for crude oil relative to GDP growth?

Figure 4
Petroleum as a Transportation Fuel in the U.S.



Source: U.S. Energy Information Administration (EIA), *Monthly Energy Review*, September 2018, Table 2.5, "Transportation Sector Energy Consumption."

Our answer to the first question is that electric vehicles, including hybrids, are going to have a major impact on the automobile market in the 2020s. The reason is that these electric vehicles are going to change the way people drive, not just change the way the automobile is powered. This is a critical distinction. Electric vehicles will be loaded with the latest in artificial intelligence to enable (semi-) self-driving capabilities that will mean much safer driving along with more efficient driving times. The analogy is with smart phones. Smart phones added so many features, from photography to social networking that they were hardly at all like legacy cell or mobile phones. The advent of the smart phone was only a decade ago, and it changed everything. That is the point we are making with electric vehicles – they will change car-buying and driving habits in a material way. The key to this development is the commitment from the major automobile producers to embrace electric vehicles, and their capital expenditures testify that this is happening, even if the promised sales explosion may not happen until the mid-2020s. The other game-changers for electric vehicles will be the vast expansion of recharging facilities, improvements in the speed of recharging, and potential new government regulations promoting electric vehicles in place of gasoline engines and possibly eliminating the production of new diesel vehicles for automobiles if not trucks and farming equipment.

Besides the question of future consumer preferences, there are infrastructure impediments to the expansion of electric vehicles – namely the rare earths used in battery technology. It is worth pointing out that rare earths are not actually that rare. But in mineral deposits, they come in various combinations of rare earths and the isolation and extraction processes can be extremely expensive. This means there are some important challenges technically to be solved before we see a massive expansion of electric vehicles on the road.

If electric vehicles do gain traction in the 2020s, what does it mean for oil demand? Well, if one believes the past is a good guide to the future, then one would make some calculations such as the time it takes to turn over the automobile fleet given an average age well above a decade. Then, one would also calculate the actual fuel savings based on current technology. This detailed, bottom up, historical approach will probably leave one unconvinced that an electric automobile revolution will have a material impact on the long-term demand for crude oil. The problem we have with this approach is that we do not believe that the past is necessarily a useful guide to the future. If electric automobiles are more like smart phones, if driving habits change materially, if regulations incent the use of electric vehicles over gasoline-powered vehicles (for example, in China or the European Union, if not in the U.S.), then the aging fleet of gasoline-powered vehicles could turn over in record time with no regard to the current average age of an automobile on the road in 2018. These are truly big “ifs” and the detailed historical analysis may prove correct. Time will tell, yet our view is that automobile buying preferences will change dramatically in favor of electric automobiles, that driving habits will change, and that regulations will change on a global scale such that the growth of demand for oil will be reduced in relation to GDP growth.

Of course, this also implies that the global economy will require considerably more electrical power generation. If gasoline is being displaced by electricity, what power source will drive the expanded electricity demand? Yes, one might have guessed – natural gas.

4. Role of Natural Gas in the Generation of Electrical Power to Increase Sharply Around the World

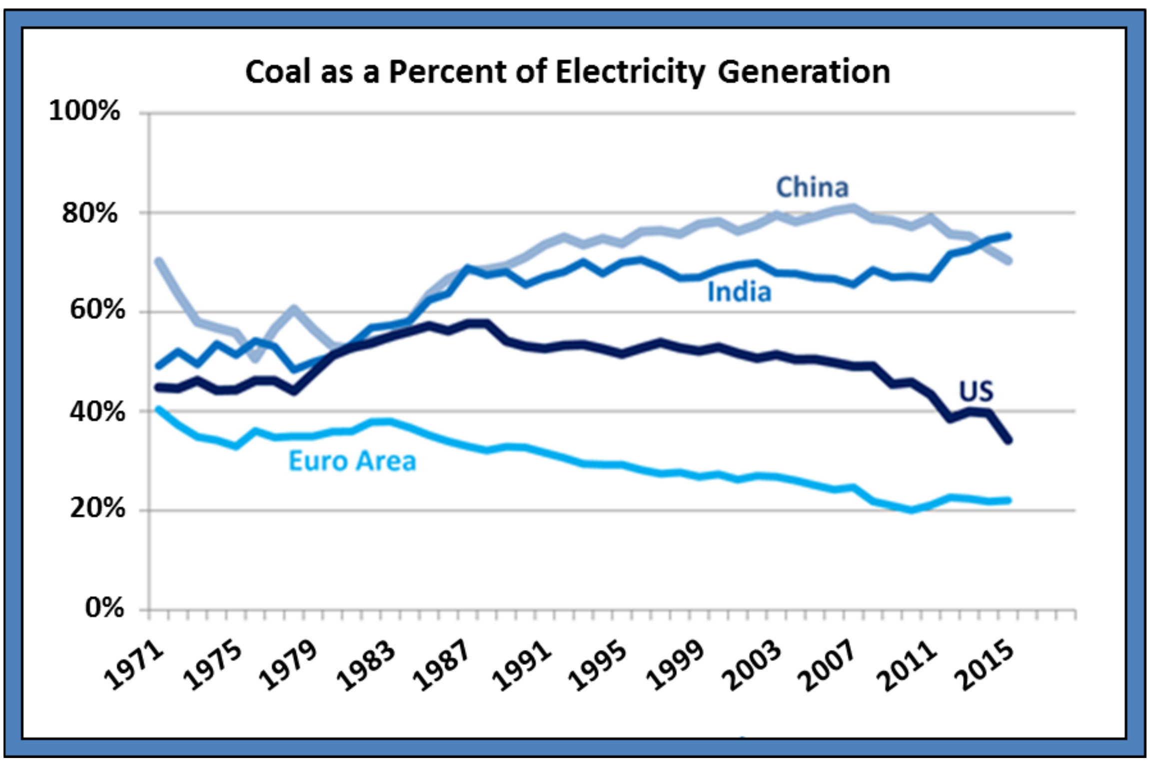
Despite the U.S. regulatory thrust in the other direction, natural gas and other alternative fuels are gaining market share from coal as a fuel for electrical power generation. The trend, as seen in Figure 5 on the next page, is quite powerful and being driven by demographic and economic forces. As countries acquire wealth and as their populations live longer, there is naturally an increasing desire for wealth preservation and improved health systems. With regard to the latter, the environmental gains from switching electrical power generation from coal to natural gas and other alternatives are considerable. Moreover, the potential supply of natural gas from new fields such as the huge Delaware basin within the Permian region of Texas and New Mexico, or more production of natural gas from Saudi Arabia, or even increased production as costs are reduced over time by China and East Asian countries suggest that the economics puts natural gas in a favored position to increase market share in a rapidly expanding market for electrical power generation. At this point, a few country-by-country comments are worth noting.

China has a major push underway to relieve its dependence on coal for electrical power generation in favor of natural gas and other sources. In this case, other sources involve hydroelectric facilities as a number of very large dams are under construction, as well as subsidizing solar power farms. Still, natural gas is likely to be a major contributor to the objective of reducing dependence on coal. And, given the costs of natural gas as an LNG import, China and other East Asian countries will have powerful incentives to expand their own production of natural gas as extraction technologies to get at deep underground basins of natural gas become more economical.

India is still expanding the market share of coal in electrical power generation. Pollution is a big challenge, but for now it is overwhelmed by cost considerations. India's ability to increase use of natural gas in electrical power generation may well depend on whether less expensive sources of natural gas will be coming from Saudi Arabia if it ramps up natural gas production to compete with Qatar over the next decade. As discussed earlier, shipping costs are critical, and if more close-by sources develop, this could lead to faster adoption of natural gas for electrical power generation in India.

In some countries, such as Mexico, natural gas is taking market share from oil. As typical, infrastructure issues will play a role in how fast Mexico expands natural gas inputs. In this case, there are likely to be more pipelines built inside Mexico to connect to U.S. pipelines coming from the Permian basin.

Figure 5
Market Share of Coal in Electrical Power Generation



Source: International Energy Agency (IEA) Statistics © OECD/IEA (http://www.iea.org/stats/index.asp).

Japan is an interesting case, and one in which politics may play a large role. The U.S. approach to North Korea as well as the U.S.-China trade tensions has made some Japanese politicians, including Prime Minister Abe, even more interested than perhaps they already were in the building up Japan's military capabilities so it can take care of itself and not depend on the U.S. Now that Prime Minister Abe has a secure hold on the leadership of his Party, he can expect to cut the ribbon at the 2020 Olympics as well as push for changing the constitution to allow more than a defensive military capability. This, in turn, suggests that the Prime Minister may well buck popular opinion and proceed more rapidly than expected with restarting nuclear power facilities shut down after the earthquake and tsunami of 2011. After the nuclear facilities were shutdown, natural gas picked up a large share of electrical power generation. Then, oil also gained due to the high cost of importing LNG. In the 2020s and into the 2030s, and we are indeed talking decades here, the political analysis suggests that nuclear power will regain some market share, oil and coal will lose market share due to environmental concerns, and natural gas will be the beneficiary along with nuclear.

Bottom Line

- U.S. shale oil production will respond with a one-year or so lag in an aggressive manner to future changes in the price of oil. Interestingly, this may make Saudi Arabia less willing to be a swing producer.

- U.S. exports of crude oil and LNG will increasingly link markets around the world. In this regard, shipping costs will be one of the critical factors in the spread between U.S. WTI crude oil and various Europe and Middle Eastern oil supplies, just as these costs will also be critical to the price spread between Henry Hub natural gas and regional natural gas markets in Asia, India, and Europe. New oil delivery futures contracts based on Houston ports and LNG futures contracts based on Sabine Pass can be considered as transportation links to U.S. domestic prices, creating a kind of "Transpread" to mirror the "crack" spreads from oil to refined products and "crush" spreads from soybeans to meal and oil.

- The impact of electric cars and increasing transportation efficiencies on the demand for oil may be material if electric cars change driving habits like smart phones changed communications and social media.

- The global trend in the generation of electrical power away from coal and towards natural gas and alternative sources will continue and possibly even get much stronger.

Endnotes

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We must thank Professor Ron Ripple, Mervin Bovaird Professor of Energy Business and Finance, Collins College of Business, University of Tulsa. Professor Ripple is a forceful advocate of thinking of LNG as a transportation device for natural gas rather than as a separate product with its own market dynamics. The reality is that no one uses LNG as a fuel source since it must be de-liquefied back to natural gas before being consumed. The fuel source is natural gas. LNG is the transport vehicle.

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