IAEE Energy Forum

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Editor: David L. Williams

President's Message

The opening of two new IAEE affiliates, one in Africa and one in south Asia starts off 2018 on a very positive note as we attempt to spread the organization into new areas where better understanding of energy economics can make a real difference. Improving our understanding of issues facing countries outside of our historical footprint also enhances our ability as an organization and as individuals to deal with a changing global context. I intend to visit both the South African and the Bangladeshi affiliates this year. The first visit is already set for April and the latter is tentatively going to occur sometime around the Wuhan conference in China in early November.

Meanwhile in our more traditional spheres, preparations for the IAEE Groningen and USAEE Washington Conferences appear to be going very well with strong program content, excellent speakers being lined up and interesting side events in the works. I plan to participate actively in both meetings, as well as contributing what I can to the Nigerian Association's Abuja meeting in April and the meeting in Athens in May to deepen my relationship with a very active Hellenic IAEE affiliate.

We are continuing our outside relationships with similar organization to ours with several members participating in January's Applied Social Sciences Association meeting in Philadelphia and Peter Hartley and I attending the Global Association of Risk Professional in New York earlier this month.

Our combined member survey has been recently completed and is currently being analyzed and compared with prior surveys to help set direction for the IAEE Council in implementing and evaluating tactics under the organization's Strategic Plan.

I look forward to seeing many of you at one or more of our coming conferences.

David Knapp

(Photo Credit: Reuters)

One of the icons of energy economics, Dr. Alirio Parra, passed away March 9 at the age of 90. He led an extremely distinguished career and was a strong and reliable contributor to the IAEE and its various affiliates, especially the USAEE. Dr.Parra was the President of the International Association of Energy Economics (IAEE) in 1989. He chaired the British Institute of Energy Economics in 1997.

Alirio Para also played an important role in the development of oil markets over his long career, Early in his career he was an assistant to Venezuela's Minister of Mines and Hydrocarbons, Juan Pablo Perez Alfonzo, who was the driving force in the founding of OPEC in 1960. Dr Parra went on to become a founding Board Member of Petroleos de Venezuela SA (PDVSA) in 1975 and spent 15 years shaping PDVSA's future. He was the front runner to become OPEC's Secretary General in the mid-1980s until Iran scuttled his candidacy. Dr Parra was Venezuela's Minister of Energy and Mines and OPEC representative from 1992-94 and served as President of the OPEC Conference.

Dr Parra was a man of deep intellectual curiosity and spent his later years advising many organizations and speaking at conferences around the world including many IAEE events.

Most of all, Dr Parra was a kind and considerate man who mentored many young people and was always available to support his friends when needed. He will be enormously missed by all who knew him.

Guy Caruso and David Knapp

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IAEE Mission Statement

The International Association for Energy Economics is an independent, non-profit, global membership organisation for business, government, academic and other professionals concerned with energy and related issues in the international community. We advance the knowledge, understanding and application of economics across all aspects of energy and foster communication amongst energy concerned professionals.

We facilitate:

- Worldwide information flow and exchange of ideas on energy issues
- High quality research
- Development and education of students and energy professionals

We accomplish this through:

- Providing leading edge publications and electronic media
- Organizing international and regional conferences
- Building networks of energy concerned professionals

Editor's Notes

We have a potpourri of energy related articles in this issue. We move from Nigeria, through India to Canada to the U.S. with discussions of the risks involved in oil transportation, to our ability or lack thereof to measure the cost of carbon, to the question of the continuation of the dominance of oil. We look at the resilience of electricity markets, the security of import supply of and export demand for oil and what's involved in the transit to a low carbon economy. Hopefully, each of us will find something that appeals.

Charles Mason compares crude oil delivery by pipelines and rail. Pipeline spills occur slightly more often, though rail spills are larger and more frequent relative to shipments and transit lengths. He concludes that rail is a riskier method for transporting crude oil than are pipelines.

Doug Reynolds explains economic concepts regarding global warming, as espoused by MIT economist Robert Pindyck, which may affect carbon regulations and thus oil demand. Carbon regulations must take into account economy wide sunk costs and values, world growth and the social rate of discount which make carbon social costs quite low.

Mamdouh Salameh posits that oil will maintain its dominance throughout the 21st century and probably far beyond. However, oil demand growth is projected to decelerate particularly in transport with wider electric vehicle use. Still, there can never be a post-oil era.

Tom Russo writes that future discussions in electricity circles are sure to go beyond electric reliability and include robust discussions of resilience. Sooner or later, all energy projects will be attacked or go down. That is a given, but what really matters is how resilient they are or how quickly they can resume operations.

Ole Gunnar Austvik discusses geopolitics, dependency on oil and gas import and export, and security-of-supply for importers and security-of-demand for exporters He notes that these are important concepts to assess whether a country's energy security is at risk. Foreign and domestic political measures have both the potential to reduce sensitivity and vulnerability dependence.

Michael Diohaa and **Nnaemeka Emodi** write that Nigeria's current climate change conditions and ambitions to transit to a low carbon economy while planning for a long-term fossil fuel energy supply system presents a dilemma. They address this dilemma by presenting options for the future which include the distribution of mitigating efforts, exploiting renewable energy and energy efficiency practices, robust financing, education and awareness for sustainable development, and monitoring low carbon developments in Nigeria. These options are vital in achieving a smooth transition towards a low carbon economy under climate change conditions in Nigeria.

Manuel Frondel, Marco Horvath, and **Colin Vance** investigate the effect of the increase in U.S. oil production due to fracking, on global oil prices, finding a negative relationship. Furthermore, they find a negative influence for OPEC supply volumes that exceed the quota, indicating that OPEC still matters.

David Daniels writes that models exploring the implications of changing energy markets sometimes use oil price projections published by the U.S. Energy Information Administration (EIA) in its Annual Energy Outlook (AEO). He describes the supply and demand assumptions behind the three main AEO oil price paths to inform determinations of applicability for other model scenarios.

Matthew Hansen, Chris Doleman and **Abha Bhargava** use the National Energy Board's Energy Futures series of outlooks to explore trends in Canadian oil supply and demand. Canada is a large producer and consumer of oil, and future trends in both will be affected by both global and domestic technology and policy developments.

Nathaniel Babajide uses basic energy security indicators to examine the economic as well as environmental implications of energy supply disruptions in India. The results reveal that to guarantee India's future energy security, it is important for this emerging economy to curtail its local energy demand, diversify primary energy sources, develop huge renewable technologies and invest in emission curbing mechanisms.

Dave Williams

IAEE/Affiliate Master Calendar of Events

(Note: All conferences are presented in English unless otherwise noted)

Date	Event, Event Title	Location	Supporting Organization(s)	Contact
2018				
April 22-24	11th NAEE/IAEE Conference *New Era in the Global Energy Landscape: Implications for an Emerging Economy*	Abuja, Nigeria	NAEE/IAEE	Wumi Iledare *wumi.iledare@yahoo.com*
May 3-5	3rd HAEE Annual Conference *Energy Transition: European and Global Perspectives*	Athens, Greece	HAEE	Athanasios Pliousis *haee2018@haee.gr*
June 10-13	41st IAEE International Conference *Transforming Energy Markets*	Groningen, The Netherlands	BAEE/IAEE	Machiel Mulder machiel.mulder@rug.nl
September 23-26	36th USAEE/IAEE North American Conference *Evolving Energy Realities:Adapting to What's Next*	Washington, DC, USA	USAEE	David Williams *usaee@usaee.org*
October 18-20	3rd IAEE Eurasian Conference *Energy Security & Investment Opportunities in Eurasia: Regional Energy Trading & Market Development*	Tbilisi, Georgia	IAEE	Vilayat Valiyev *waliyev@gmail.com*
November 2-4	6th IAEE Asian Conference *Energy Exploitation and Cooperation in Asia*	Wuhan, China		Xiao Jianzhong *xjianzhong@cug.edu.cn*
2019				
February 13-15	AAEE Conference *Heading Toward More Democracy in the Energy System – German/English Speaking*	Vienna, Austria	AAEE	Reinhard Haas *haas@eeg.tuwien.ac.at*
March 11-12	7th ELAEE Conference *Latin America: Decentralization, Decarbonization, Efficiency and Affordability in Energy Systems*	Buenos Aries, Argentina	ALADEE	Gerardo Rabinovhich *grenerg@gmail.com*
May 26-29	42nd IAEE International Conference *Local Energy, Global Markets*	Montreal, Canada	CAEE/IAEE	Pierre-Olivier Pineau *pierre-olivier.pineau@hec.ca*
August 25-28	16th IAEE European Conference *Energy Challenges for the Next Decade:*	Ljubljana, Slovenia	SAEE/IAEE	Nevenka Hrovatin *nevenka.hrovatin@ef.uni-lj.si*
October 17-19	4th IAEE Eurasian Conference *Uncapping Central Asia's Potential: How Central Asia can Contribute to Global Energy Security?*	Astana or Almaty, Kazakhstan	IAEE	Vilayat Valiyev *waliyev@gmail.com*
2020				
June 21-24	43rd IAEE International Conference *Energy Challenges at a Turning Point*	Paris, France	FAEE/IAEE	Christophe Bonnery *Christophe.bonnery@faee.fr*
2021				
July 25-28	44th IAEE International Conference *Mapping the Global Energy Future: Voyage in Unchartered Territory*	Tokyo, Japan	IEEJ/IAEE	Yukari Yamashita *yamashita@edmc.ieej.or.jp*

A Comparison of the Risk of Transporting Crude Oil: Rail vs. Pipeline

By Charles F. Mason

On 6 July, 2013, a freight train derailed in the Quebec town of Lac-Mégantic, killing 47 people, spilling over one million gallons of crude oil, and causing widespread destruction. Estimated damages exceeded $100,000,000. Horrific as this event was, it was not singular, nor was 2013 a unique year: statistics compiled by the U.S. Department of Transportation point to a stream of train derailments in the U.S. between 2010 and 2014. Economic damages associated with these train incidents rose from slightly less than $5 million in 2010 to over $30 million in 2014. These patterns are particularly noteworthy in light of trends in U.S. tight oil production over the past decade, particularly from the Bakken play – which was the source of the crude on the train that derailed in Quebec, and which is relatively isolated in relation to the existing delivery infrastructure.

Charles Mason is the H. A True Chair in Petroleum and Natural Gas Economics, Department of Economics, and Associate Dean, College of Business, University of Wyoming. He may be reached at bambuzlr@uwyo.edu *Dr. Mason gratefully acknowledges support from the Charles Koch and Dave True Foundations. All conclusions reported herein are his, as are any errors or omissions.*

See footnote at end of text.

An alternative to using rail to transport crude oil is to expand the pipeline infrastructure. This approach is also somewhat controversial, as evidenced by the recent difficulties experienced in siting the Dakota Access Pipeline and the Keystone XL Pipeline. As with shipping oil by rail, a central concern with the Dakota Access Pipeline was the potential for oil spills.

Combined, these observations point to the policy significance of assessing the risks of transporting crude oil by pipeline and by rail. I undertake that task in this paper. The data that I use in this analysis is mainly drawn from the Energy Information Administration (EIA) website and the Department of Transportation website dedicated to releases of sensitive materials into the environment, under the auspices of the Pipeline and Hazardous Materials Safety Administration (PHMSA)[1].

I start by illustrating trends in oil shipments, both by rail and by pipeline, between 2010 in 2016. (The starting date for this analysis is dictated by a change in reporting at PHMSA, which took effect at the start of 2010). In Figure 1, I show monthly deliveries of crude oil by pipeline (the solid line) and by rail (the dashed line). Rail deliveries of oil experienced a marked increase between 2011 and 2013, rising from a very low level to over 20 million barrels per month; oil shipments by rail then stayed at around 20 million barrels per month through the end of 2015. Over the course of the past few years, however, they have decreased to roughly 10 million barrels per month. At about the same time that oil by rail was taking off, pipeline deliveries experienced a slight decrease – falling from around 55 million barrels per month (in 2010) to close to 40 million barrels per month (in late 2011). Since then, pipeline deliveries have steadily increased, rising to well over 80 million barrels per month by the end of 2016. These temporal patterns provide a useful backdrop to the discussion of incidents associated with the transport of crude oil.

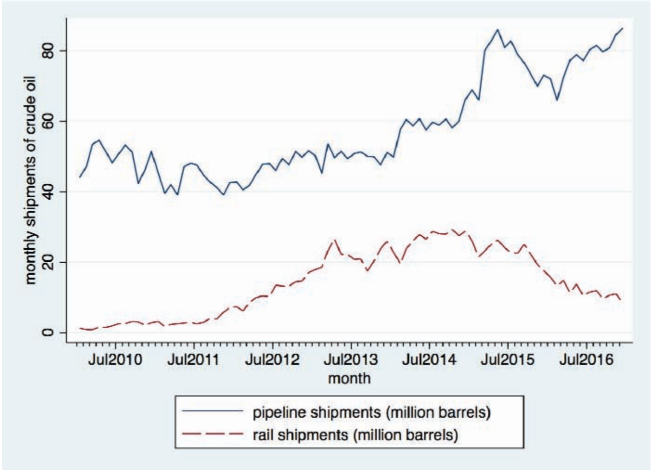

Figure 1: Crude Oil Shipments

Mode	N	mean	median	std. dev.	max
Rail	75	4152	0.570	32558	281989
Pipeline	84	411.1	7.590	1140	8193

Table 1: Summary Statistics for Oil Spills

Information summarizing crude oil spills between 2010 and 2016 is contained in Table 1. Here I show, for each mode of transport, the number of incidents reported during the seven year period; the average monthly amount spilled (in barrels); the median monthly spill size; the standard deviation of the distribution of spills; and the largest reported amount of crude oil spilled. While the number of spills associated with pipeline and rail deliveries was reasonably similar, the average spill associated with rail is an order of magnitude larger than for pipeline. On the other hand, the median spill associated with pipeline deliveries is an order of magnitude larger than for rail deliveries. These two points suggest a significantly skewed distribution governing the size of spills for rail, a point that is corroborated by the significantly larger standard deviation for rail than for pipeline and the substantially larger maximum

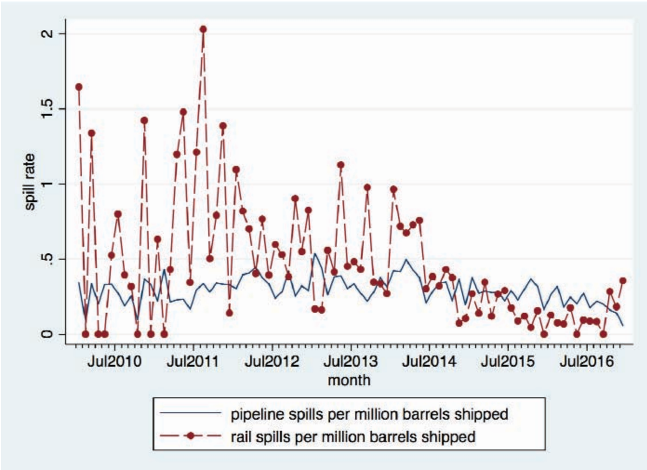

Figure 2: Crude Oil Spill Rates

spill associated with rail.

While the information in Table 1 is evocative, it tells us little about the pattern of oil spills over time. Information on this temporal pattern is conveyed in Figure 2. In this diagram, I show the number of incidents per million barrels shipped for both pipeline (the solid line) and rail (the dashed line with dots). Pipeline spill rates have remained relatively constant, at about one incident per 3 million barrels shipped throughout the sample period. Rail spill rates, by contrast, were dramatically larger between 2010 and 2014. In particular, there were a number of months between 2010 and 2011 in which there was at least one incident for each million barrels shipped. Between 2012 and 2014, rail spill rates tended to hover in the range between on spill for each 1 – 2 million barrels shipped. Since the end of 2014, spill rates for deliveries of crude oil by rail and by pipeline have been roughly the same.

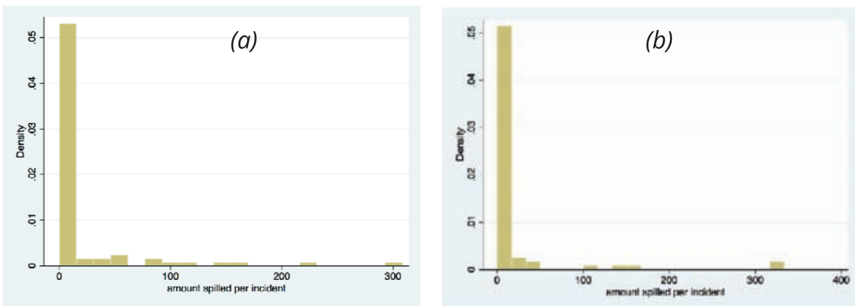

Figure 3: Histogram of Smaller Oil Spills (panel a: pipeline; panel b: rail)

The distribution over the magnitude of these spills also bears some similarities, but only for relatively smaller spills. Figure 3 shows histograms for oil spills associated with deliveries by rail (panel a) and for deliveries by pipeline (panel b); in both diagrams, I show the distribution associated with spills less than 400 barrels. These distributions appear to be quite similar; in particular, there is a pronounced spike for very small spills, with relatively less weight placed on medium-sized spills. In light of the discussion above, this observation points to the likely difference between the pattern of larger spills comparing rail and pipeline deliveries.

Month	Spilled	Shipped	Rate
Rail			
Nov-13	281989	23.681	19.1626
Dec-13	11309	25.876	0.7033
Feb-15	8627	21.506	0.6456
Mar-15	2635	23.14	0.1832
May-15	2336	26.255	0.1432
Jun-16	1011	10.48	0.1552
Pipeline			
July-10	8193	50.619	0.0865
October-14	4009	58.054	0.0369
March-13	3156	53.461	0.0315
June-15	3002	80.832	0.0198
May-13	2371	51.35	0.0247
October-11	2044	41.096	0.0266
July-11	1511	47.477	0.0170
May-12	1500	47.732	0.0168
15-May	1150	85.984	0.0071
10-Sep	1131	51.221	0.0118

Table 2: Major Crude Oil Spills: Rail vs. Pipeline

I investigate this potential difference in Table 2. Here, I list all months with spills in excess of 1,000 barrels, by mode of transport. As with the overall distribution, large spills are a bit more common with pipelines than rail; that said, the largest 3 spills are associated with rail. This observation is consistent with the observations above (that both the average and maximum spills are larger for rail than pipeline).

It is interesting to reflect on these points in combination with the evidence in Figure 1. That visual evidence indicates that pipelines shipped substantially more oil than did rails throughout the sample period. The third column in Table 2 gets at this point, by listing the monthly deliveries of crude oil (in millions of barrels), for each of the two transport modes. It is apparent that not only is the magnitude of oil spills associated with pipeline deliveries somewhat smaller than for rail (when focusing on the largest spills), the volume of crude delivered by pipeline is much larger than that of rail.

These points suggest that the rate at which oil is spilled from any given amount shipped is likely to be larger for rail than for pipeline, perhaps markedly so. On top of that, the distribution network from the major tight oil plays is roughly three times longer for pipelines (entailing some 1872 kilometers) than for rail lines (621 kilometers). Combined with the points made above, this last observation suggests the rate associated with shipments of oil is much smaller for pipeline than for rail, a point that is fleshed out in the fourth column of Table 2. There, I list the ratio of the volume of oil spilled in a given month to the multiple of the volume of oil transported (in millions of barrels) and the length of the transport network (1872 for pipelines, 621 for rail). Clearly, the rate of spillage – measured in this way, and for the largest spills – is much larger for rail than pipeline.

Taken together, these data indicate that the risk associated with shipping crude oil is noticeably larger for rail deliveries than for pipeline deliveries. The number of spills is a bit larger for pipelines, and medium size spills are somewhat more likely with pipelines, but the volume of spills associated with the largest spills is substantially larger for rail. Placing this information in the context of the magnitude of deliveries associated with the two transport modes, in conjunction with the geographic length of the delivery mode, adds further weight to the conclusion that rail is a riskier method for transporting crude oil than are pipelines.

Footnote

[1] The EIA data, at https://www.eia.gov/petroleum/data.php#imports, includes information on shipments of crude oil by rail and by pipeline (the latter is organized as shipments between PADDs); PHMSA provides data on incidents for shipments by pipeline and rail. The former can be accessed at https://www.phmsa.dot.gov/pipeline/library/data-stats/flagged-data-files, and the latter at https://hazmatonline.phmsa.dot.gov/IncidentReportsSearch/IncrSearch.aspx.

"**Transforming Energy Markets**" is the central theme of the 41st International IAEE conference in Groningen, The Netherlands, 10-13 June 2018. This theme will be discussed in 7 (dual) Plenary Sessions, 91 Concurrent Sessions, 6 Round Tables, 4 Master Classes, 2 Doctoral Seminars and 2 Technical Excursions.

The conference will start with a plenary session on Energy in Emerging and Developing Countries (with a.o. Laura Cozzi) on Monday morning while the Closing plenary session on Wednesday afternoon will be on Climate Policy (with a.o. Carolyn Fischer). The other (dual) plenary sessions will focus on Electricity Market Design (with a.o. William Hogan), the Future of Global Gas Markets (with a.o. Hill Huntington), Long-Term Energy Scenarios, Consumer Behaviour (with a.o. Anna Alberini) and Energy in Transport (with a.o. Stef Proost). See our website for the full list of plenary speakers.

The Round Tables are an innovation: in these highly interactive sessions about five speakers from various backgrounds (business, policy, regulation or research) give short pitches after which we will have discussion among panel members and all participants. The topics of the round tables include a.o. Disruptive Challenges for the Energy Industry, Sector Coupling, and Alternatives for Fossil Fuels.

For PhD students and young professionals there are a number of Master Classes on Sunday, just before the Welcome Reception. One of the Master Classes is on Writing in Scientific Journals (by Adonis Yatchew). Doctoral students are also invited to participate in the Doctoral seminars (on 8 and 9 June) where Christoph Böhringer and Richard Green will give lectures on Economics of Climate Policy, and Energy Transition and Power Market, respectively (*application is required before 15 March*).

The conference also offers several opportunities for networking and to enjoy the city and province of Groningen. On Sunday, Monday and Tuesday, there will be social events in the evening. For partners of delegates there is a Partner Programme for each day of the conference with excursions to the city and the region, and, finally, there will be two Technical Excursions: one to the Groningen gas fields on Sunday (10 June) and the other to Groningen Seaports on Thursday (14 June).

Academy building, University of Groningen, The Netherlands, venue of the Master classes and the Welcome reception on Sunday 10 June 2018

Important dates
Deadline application for Doctoral seminar: 15 March 2018
Deadline early-bird registration: 15 April 2018
Final deadline registration: 15 May 2018

E-mail: info@iaee2018.com ; Website: http://iaee2018.com/

Carbon Regulations: Can Economic Science Determine Carbon Costs?

By Douglas B. Reynolds

Douglas Reynolds is Professor of Petroleum and Energy Economics, Department of Economics, University of Alaska Fairbanks. He may be reached at dbreynolds@alaska.edu

One aspect of oil and energy demand is how carbon regulations will evolve. However, the work of MIT economist Robert Pindyck suggests that the world's fossil fuel driven technological structure provides many benefits to humankind which can be considered a sunk value of our existing economic system that would be lost if radical climate change policies are implemented. Even though global climate change due to carbon emissions will create environmental destruction and therefore challenges to the world's economy, nevertheless, there may be some benefits of climate change in many regions even as the costs of adaptation will be lower than expected in other regions. Also, the social rate of discount, which must be used to determine the present value of the future costs of carbon, may be high since fully two thirds of humanity live in developing countries where discount rates as high as 30% can be justified. Plus, developing countries need high economic growth to pay for food and necessities of their poorest people. Taken together, sunk costs, sunk values, the social discount rate and humanities need for growth suggest that there is no economic method for determining the costs of carbon emissions and thus no way to assign a carbon tax, nor a carbon cap.

GLOBAL CLIMATE CHANGE SCENARIOS

An interesting question within the environmental movement is whether you can prove in a court of law what the costs of carbon emissions are to society. For example, a court case could involve determining the social cost of carbon emissions, whereupon a slew of climate change scientists and economists are brought into a court room to prove scientifically what the environmental cost of carbon emissions are. The court case would show evidence that carbon induced climate change is anthropomorphic and will at some point cause detrimental geo-physical and biological changes to the Earth. However, the timing of any climate change, the magnitude of the physical and biological changes, the relationship between the physical and biological changes to social costs, and the social discount rate used to put a value on current carbon releases relative to distant carbon costs would all be difficult to estimate. This brings up the concepts of sunk costs, sunk values and the discount rate as espoused by Robert Pindyck (2007, 2012 and 2013).

What Pindyck shows is that carbon pollution creates very long run damage to the Earth such that the environmental damages transfer across decades and even centuries. However, the link between carbon buildup and the climate system is non-linear and so it is unclear at what level of carbon build-up geo-climate changes will occur, and by what magnitude and by when they will occur. Similarly, the relationship between climate and biological systems and the link between climate and the world's economic system is likewise non-linear. It is unclear, then, how to put a value on future geophysical environmental changes.

Consider two alternative scenarios. One climate scenario suggests that we will have devastating global warming, a melting of ice caps, a rise in sea levels, and very intense storms all of which will create huge human costs in terms of flooded cities, destroyed infrastructure and acidic seas. An alternative climate scenario suggests that global warming will melt glaciers causing fresher water in the seas that will alter the Atlantic Gulf Stream so that less warm ocean currents will thaw the North and South Poles, in which case, eventually, ice will build up at the tip of the Poles. The extra snow and ice reflect more sunlight which causes more cooling until the ice spreads towards the equator and a great ice age could ensue whereupon global oceans will recede. The eventual cold weather will hit normal bread baskets of the world reducing food supplies and causing starvation. The net economic effect of either scenario is hard to calculate. Cities may be flooded and then become high and dry without a port to use, kind of like ancient Ephesus.

However, it is easy to imagine within these two scenarios a kind of tug-of-war between the warming effects and the cooling effects. In this third scenario, the warming occurs, the ocean current changes, the poles cool, but the carbon keeps an ice age at bay. In that case, the effects of the carbon on the physical-biological system are difficult to determine. Likewise, you cannot predict how much flooding will occur or if breadbaskets will be lost or gained, or how dry or wet regions will become, all of which makes estimating climate change economic damages a difficult challenge.

SUNK VALUE

One issue regarding the estimation of the monetary value of potential climate damages due to carbon emissions is that of the sunk costs and sunk values in our existing technological system. Dixit and Pindyck (1994) show how sunk costs and sunk values can cause businesses to change slowly even though certain inputs into production and input and output prices can change fast. For example in the 1920s, after over a hundred years of using coal-fired steam locomotives, railroads had available new types of railroad train engines that could use electricity and diesel fuel, which were advantageous as they would cause less localized pollution and could run faster and with less refilling. However, since most of the train engines in those days were already coal-fired steam locomotives, there was a slow turnover from the steam locomotives to the diesel and electric train engines because coal infrastructure already existed along most railroad lines including coal bins, water tanks and steam locomotive mechanical shops. The coal system had a sunk cost, meaning there is no way to get back the costs invested in building up that infrastructure, but it also had a sunk value, meaning that since the coal infrastructure existed and was "free" to use and possessed much value, then that value was exploited for the benefit of society. Why invest in a changeover when you had a sunk value in existing infrastructure that worked well and had low marginal costs? Which is why coal-trains were used all the way until the 1950s.

Not only did coal fired steam locomotive infrastructure have the advantage of being in place and valuable, but railroads already had their people trained in how to run coal locomotives, which is a human capital sunk value, and they had a sunk value in existing supply chains. Plus, if a railroad made a huge investment into diesel or electric trains, it could not be sure which new technology would be the best. If you had invested the entire railroad's establishment into diesel trains, and then you found out that a new electric train technology would work better, you would not be able to switch again because you will have invested enormous new sunk costs into a new system that you will have to use for decades. So it is better to wait and see what the best technology is, before making the changeover, and that is what happened.

The moral of the story is, if you have a technological system in place and it works, then if you change that system, you lose all that sunk cost and sunk value just to invest heavily in a new and different type of capital infrastructure that may turn out to be less useful than even newer technology as it evolves. Therefore, what railroads did was to keep on using coal-fired locomotives until the need for normal repairs and upgrades were so high that either electric or diesel engines and their ancillary structure were relatively cheaper, whereupon the changeover began. That is, business keeps using existing technologies until it is clear that an upgrade can overcome the loss of the sunk value of the existing infrastructure.

This same idea is true today. It is costly to change our existing fossil fuel driven economy into a "green," low carbon economy because the existing technology has so much sunk value inherent in it. For example, the world currently has existing coal fired power plants, coal mines and general coal infrastructure, all of which has a sunk value that benefits society. The same goes for oil and gas infrastructure. The result is that giving up such infrastructure will mean losing the social benefits of that sunk value. If we outlaw the use of coal then all that sunk value of existing technologies and capital can no longer be used to help society, from creating jobs to increasing government programs for the poor to helping finance health care. Even if you put an emissions fee on the use of fossil fuels to reduce carbon emissions it would not necessarily overwhelm the inherent value of the continuing use of them.

Plus, there is a multiplier effect. If you stop using coal, it is not just a simple case of lost sunk value, you also lose the macroeconomic multiplier effect. A system with sunk value allows people to spend money on other goods and services in other industries which creates even more economic activity, on the order of four times the original value. In addition, more economic growth allows us to develop more technology and knowledge that also has a multiplier effect into the future. Less technological and knowledge growth today will also have a multiplier effect that reduces future technology and knowledge which reduces future economic growth and which reduces our future ability to cope with environmental changes, and that is an unknown cost of reducing carbon now.

Granted, carbon emissions will also have a multiplier effect on the environment for thousands of years into the future, but then you have to ask, how easy or difficult will it be to adapt to those environmental changes?

HUMAN ADAPTATION SCENARIOS

Assuming we can predict with any accuracy the future changes in the physical-biological system due to carbon build-up, then we need to predict the resulting costs to our future economic system. The difficulty inherent in climate change economic analysis, then, is estimating how environmental change inflicts economic costs, which in turn depends on how easily it will be to adapt and how costly those adaptations are. Indeed, technology may come up with ways to enhance positive effects of climate change and thereby reduce the negative costs of climate change on the economy. As one student suggests, we may be able to live in small virtual reality rooms anywhere in the world with only a minimal need for food, transportation and shelter, in which case technology can solve all our problems if we let it develop.

Probably, the food aspect is of paramount concern. As CO_2 increases, climates will warm or cool and weather patterns will change. Certain locations for agricultural production may become better food producers even as other locations may become worse food producers. Therefore, there can be gains as well as losses to food production such that even if one region becomes less productive agriculturally, there may be easy ways for technology to adapt and reduce the loss in productivity. Or alternatively, some regions will become so much more productive than expected due to their improved agricultural climate that they will easily compensate for the regions that lose their productivity. Or there could be a major net loss in food productivity.

On top of estimating costs of adaptations to a business as usual scenario, other factors may erupt long before we have to adapt to carbon induced climate change. For example, there is a good chance that peak oil will occur and the amount of oil available will be significantly reduced. Scientifically speaking, scenarios of peak oil must be included in the future economic estimates of losses of GDP due to climate change. The oil shock scenario in general can affect our entire economy, as it did to the Soviet Union, as Reynolds (2016) shows. This may cause a change in our economy, long before climate change arrives, and mean that climate costs themselves will be much lower than currently predicted. Plus, it is difficult to ascertain which carbon strategies are best to use and so changing the economy now with a carbon tax might push research and innovation into unhelpful directions. If much work goes into solar energy and battery technology say, due to a carbon tax, but then industry becomes more labor intensive in the future due to less oil, then the carbon tax may have pushed research and innovation into unhelpful directions.

Therefore, it is unclear how climate change challenges will manifest themselves given the many other future changes that can occur. What that means is that the loss of economic activity in the future is difficult to estimate and may be low. It may be the case that with less oil, food production will become more labor intensive, and the labor intensity of food production may make it easier or harder to adapt to climate change scenarios.

THE SOCIAL RATE OF DISCOUNT

When climate change will happen, is hard to gauge. Already there are effects in Alaska, such as harsher storms in the arctic, which are considered costs, but also more walrus gatherings near arctic villages, which could be considered benefits, although, the greatest interest is in large effects and costs that will occur in the distant future. This requires us to estimate a social discount rate in order to properly value those costs now. That is we need to estimate a present value of the future costs, and benefits, of carbon emissions in order to estimate a carbon emissions fee or even a carbon cap.

A social discount rate is an interest rate that reflects society's value of the present versus the future. One way to estimate this is to use the market rate of interest, which can be argued is close to 5%, or rates of return for companies in the mid-20th century which were 10%. However, due to the risks and taxes associated with private transformation, the real rate of return for companies could be well above 10%.

Even more interesting is personal time preferences. Lawrance (1991) shows that there is a wide disparity of time preference rates for white people in the top 5% of income, who have a personal time preference of 12%, and non-white people in the bottom fifth percentile, who have a personal time preference of 19%. Thus, personal discount rates for the poor tend to be higher than discount rates for the rich. This also means that developing countries, as opposed to OECD countries, will have different discount rates. Anyone who has lived or traveled in developing countries notices such things as how relatively dangerous driving in those countries is. For example, there may be a bump in the road that could cause a dangerous traffic problem. The money to fix the road, though, is needed for food and water for people and so only high rate of return road projects are initiated, suggesting that the social rate of discount in developing countries may be 30%.

Since two thirds of the world's population lives in developing countries, then 30% may indeed be the social discount rate. Furthermore, many developing countries would actually like to see the U.S. and the EU increase their economic growth more, by not inhibiting that growth with carbon taxes or regulations which helps developing economies to export more. However, if the social rate of discount is 30% then any adverse cost that happens 30 years from now is almost of no value today. For example if we have a $100 trillion future cost of global climate change in 30 years, that is a $38 billion present value cost today which is less than half the value of the damage of Hurricane Maria in 2017.

CONCLUSION

When businesses face input price increases or demand decreases, they tend not to suddenly change their labor, capital and supply chains. First, a business may have a large amount of sunk cost and sunk value invested in its existing human capital, real capital and suppliers that compel it to continue operating in its existing state in order to gain as much of that sunk value as possible. Second, the business cannot be sure that input prices or demand might not revert back to previous levels making a wholesale change in its business practice a loss making venture. Third, the business cannot be sure what new technologies and business environments will emerge such that if it tries to change too fast now, it will miss a better investment opportunity in the future. Therefore it refrains from changing. This implies that the world's current fossil fuel based technologies should not be radically changed as that will reduce the sunk value that the world can continue to reap from its current fossil fuel technologies. By exploiting that sunk value now, new and better knowledge and technology, such as nuclear fusion, can be had in the future that ultimately might work better than the current batch of renewable technology on offer. Plus, the social rate of discount needs to be viewed from the perspective of the poorest two thirds of the world, in developing countries, rather than from the perspective of the richest one third of people, which suggests a social rate of discount much higher than 10%. That means the social cost of carbon emissions could be very low or even zero.

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Oil Will Maintain Its Dominance During the 21st Century & Beyond

By Mamdouh Salameh

INTODUCTION

In December 2017 the oil price broke through the $60 barrier and reached $66.78/barrel for the first time since 2015.

Oil started the year with further price gains touching $70/barrel despite the quick restart of the Forties pipeline in the UK North Sea and the equally quick repairs of a pipeline in Libya. Sentiment on the oil market is more bullish than it has been for a long time.

What will be driving the oil price in 2018 is a healthy global demand for oil getting healthier by the day. The first law of economics is supply and demand. All other factors are extras. The second law is that oil is like a coin: one side is economics and the other is geopolitics and the two are inseparable.

When the glut was rampant in the global oil market during the period 2014-2016, the oil price trended downwards ignoring all the geopolitical developments such as the war against ISIS in Iraq, the war in Syria, escalating tension between Saudi Arabia and Iran, rising tension between Iraqi Kurdistan and Iraq and the war of words between the United States and North Korea.

Mamdouh G. Salameh is an international oil economist. He is also a visiting professor of energy economics at the ESCP Europe Business School in London. He may be reached at mgsalameh@btconnect.com

See foototes at end of text.

Now that the market is fast re-balancing, any small geopolitical event pushes the price upwards.

All eyes will, therefore, be on U.S. shale in 2018 to see whether it can spoil the oil price rally particularly with the U.S. Energy Information Administration (EIA) projecting that shale oil production will rise to 10.5 million barrels a day (mbd) in 2018 and 11 mbd in 2019.[1]

WORLD OIL OUTLOOK

According to ExxonMobil's 2017 *Outlook for Energy: A View to 2040*, oil is projected to account for 33% of the global primary energy consumption in 2040 as it did in 2016 (see Chart 1).

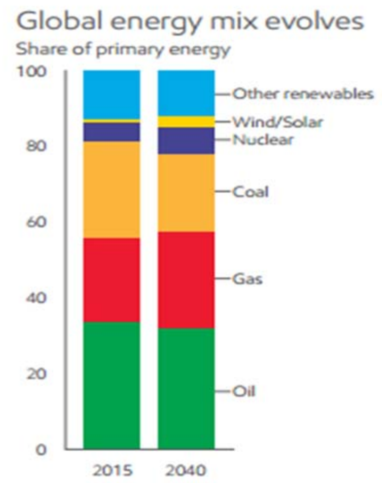

Chart 1
Source: Courtesy of Exxon Mobil 2017 Outlook for Energy

2017 had been an historic one for the Organization of Petroleum Exporting Countries (OPEC) and the global oil industry. It has been a period where the re-balancing of the global oil market has gathered vital momentum, buoyed by positive global oil fundamentals and underpinned by the OPEC/non-OPEC production cut agreement.

The global economy is projected to grow at 3.7% in 2018 compared with 3.5% in 2017 according to projections by the International Monetary Fund (IMF). In the longer term, global growth in the period from 2016-2040 is projected to average 3.5% per annum with most of this driven by developing countries.[2]

In the medium-period 2016-2022, oil demand is projected to increase by 5.7 mbd from 96.6 mbd in 2016 to 102.3 mbd. The outlook for long-term oil demand growth is more optimistic reaching 111.1 mbd by 2040 (see Table 1).

(mbd)	2016	2020	2025	2030	2035	2040
Transportation	55.8	58.1	60.6	62.5	63.9	64.9
Industry	25.2	26.4	27.6	28.6	29.9	30.2
Other uses	15.6	16.2	16.1	16.3	16.2	16.0
World	96.6	100.7	104.3	107.4	109.7	111.1

Table 1 Sectoral Oil Demand Growth, 2016-2040

Source: OPEC 2017 World Oil Outlook 2040 / BP Statistical Review of World Energy, June 2017.

On the supply side, total non-OPEC supply is projected to grow by 5 mbd from 57 mbd in 2016 to 62 mbd in 2022. After 2022, non-OPEC growth begins to slow peaking in 2027 at 63.8 mbd before declining to 60.4 mbd by 2040 (see Table 2).

(mbd)	2016	2017	2020	2025	2030	2035	2040
Total OPEC supply	38.8	38.7	40.4	41.0	44.1	47.6	50.9
Non-OPEC supply	57.0	57.7	60.7	63.6	63.5	62.3	60.4
World	95.8	96.5	101.1	104.5	107.6	109.9	111.3

Table 2 Projected Oil Supply Outlook, 2016-2040
Source: Courtesy of OPEC 2017 World Oil Outlook 2040.

Most of the demand for oil is used for transportation. It is a sector where oil continues to face the weakest competition from alternative fuels. Between

2016 and 2040, the transportation sector will account for two out of every three barrels consumed. Nevertheless, demand growth is projected to decelerate on the back of efficiency improvements driven by technological developments, a tightening of energy policies and a relatively low (albeit increasing) penetration of transportation fuelled by natural gas and electricity.[3]

U.S. shale oil will by far be the most important contributor to non-OPEC supply. Shale oil is projected to grow by 4.8 mbd in the 2016-2022 period before peaking after 2025.

U.S. SHALE OIL

While the U.S. shale production has enabled the United States to reduce its oil imports, there has been a lot of hype surrounding it with regard to its ability to cap oil prices, profitability of the shale oil industry and the continued rise in production.

The U.S. shale oil industry will never be a profitable industry. U.S. shale oil producers are so deeply in debt that they have become like the saying of "robbing Peter to pay Paul". They are heavily indebted to Wall Street to the extent that they continue to produce oil even at a loss just to pay some of their outstanding debts.

There is mounting pressure on U.S. shale producers from shareholders to rein in production growth and start making profits instead.

Because of a very high depletion rate estimated at 70%-90%, U.S. shale producers have to spend billions every year drilling thousands of wells just to maintain production. In so doing they sink deeper and deeper in debt. Sometime in the foreseeable future, there may not be many rich shale plays left in the United States from where to produce oil.

Still, more cracks are beginning to appear that raise serious questions about the long-term future of U.S. shale oil production.

While the U.S. shale industry has boasted of higher initial production (IP) rates from their shale wells in recent years, there is some evidence that suggests those higher IP rates do not necessarily translate into larger gains in the total volume of oil and gas that is ultimately recovered. According to Rystad Energy, an independent Norwegian-based energy research and analysis outfit, a sample of wells in the rich Eagle Ford shale basin in Texas showed that higher IP rates in recent years were offset by steeper declines than before.

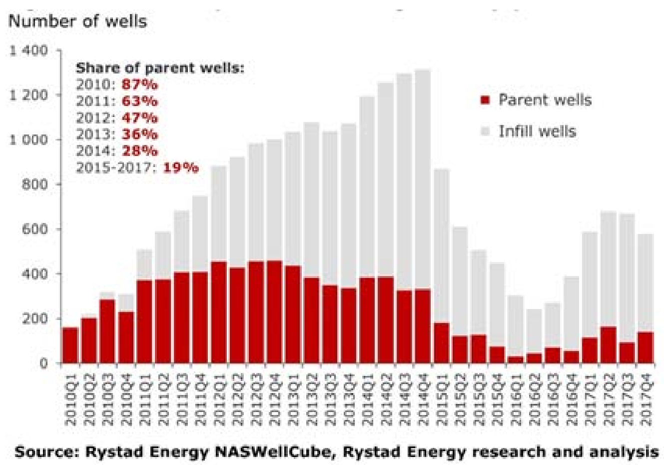

Figure 1 Horizontal spudded wells in Eagle Ford by quarter

The first few horizontal wells in a section are classified as "parent" wells, with follow-up completions described as "infill" wells. In the Eagle Ford, according to Rystad Energy, the makeup of spudded wells has shifted dramatically towards infill wells as many areas of the basin have been worked over. In 2010, Rystad says, "up to 90% of activity corresponded to new pad development. This share declined rapidly over time, falling to 15-20 % in 2015-2017." As such, the rebound in output from the Eagle Ford over the past year has mostly come from infill drilling (see Figure1).

THE INCOMING OIL SUPPLY GAP

With oil prices ebbing and flowing against a background of OPEC and non-OPEC production cuts and U.S. shale oil production inching up, nobody is paying enough attention to the fast-approaching oil supply gap.

Industry experts are predicting a supply gap and rising oil prices by 2020. This is due in large part to an oil investment drought marked by three years of consecutive decline in oil prices, a statistic that has no precedent in the oil industry. Last year a report by IEA projected that if oil investment remains stagnant over the next few years, by 2020 we will see a significant hike in the price of oil. The IEA reiterated its concerns more recently in its World Energy Investment 2017 Report that the rate of new oil discoveries is at its lowest level in more than 70 years.[4]

And by 2020, 15 mbd of new oil supply may be needed to meet a projected annual average rise in global oil demand of 1.60 mbd and also offset an annual natural depletion rate in global oil production estimated by the IEA at 5% or 4.8 mbd, virtually equivalent to losing the current output of Iraq.[5]

According to the IEA, the world needs $44 trillion in investment in global energy supply between now and 2040 to meet the coming global energy needs with 60% or $26 trillion allocated for oil and gas production.[6]

A lack of investment will cause oil production to decline steeply and 80% of the current new oil supply is needed to offset natural declines.

EXPANDING INVESTMENTS IN OIL & GAS IN THE MIDDLE EAST

Oil will remain the backbone of Middle Eastern economies for the foreseeable future. However, natural gas production and exports are emerging as an important and additional source of income for countries of the Middle East.

Despite depressed oil and gas prices since 2014 and concerns about the continued oil glut in the market, oil and gas producers across the Middle East and North Africa (MENA) region are investing an estimated $294bn in projects aimed at expanding oil, gas and petrochemical's production capacities according to according to MEED Insight's 'MENA Oil and Gas Report 2017'.[7]

Iraq has been able to double its oil production capacity through one of the world's largest upstream investment programmes. Iraqi oil production has risen to almost 5 mbd between 2010 and 2016 and is projected to hit 6-7 mbd by 2020/21.[8]

Qatar is planning to boost liquefied natural gas (LNG) production capacity from its giant North Field by 30% from 77 million tons currently to 100 million tons per year. Qatar accounted for 29% of the global LNG market in 2016.[9]

The seven major oil companies in the world – Royal Dutch Shell, BP, Exxon Mobil, Chevron, Total, ENI and Statoil – need a price of $125-$135/barrel to balance their books. They also need certainty about the future trend of oil prices before committing themselves to huge investment in exploration and production.[10]

As a result of declining oil prices, the global oil industry has already sold many of its production assets and cancelled more than $200 bn in oil & gas investments so far, which will eventually translate into a smaller share in the global oil production.[11]

Oil production by Exxon Mobil, Shell, Chevron and ENI has declined from 11.5 mbd in 2003 to 9.5 mbd in 2015. This will be reflected in steeper oil prices in the near future.[12]

At prices much below $75/barrel, some of the North Sea's remaining economically-recoverable reserves, estimated at 15 and 16.5 billion barrels (bb) of oil and natural gas, will end up as so-called stranded assets – hydrocarbons that are simply too expensive to develop.

Moreover, global investment in upstream exploration from 2014 to 2020 will be $1.8 trillion less than previously assumed, according to leading U.S. consultants IHS.[13]

As for the United States, it is doubtful whether the steep decline in oil prices would provide a boost to the U.S. economic recovery. And while the price decline would certainly provide the equivalent of a sizable tax cut for U.S. consumers, it will deliver a major blow to the increasingly important U.S. oil industry which is estimated to employ around 2% of the U.S. workforce. It is also raising the risk of major defaults on the $200 billion in loans that have been extended to the domestic shale oil industry.[14]

TRANSITION AWAY FROM OIL

A few experts have been projecting the advent of the post-oil era within the next fifty years.

Hardly a day goes by without another media report about the impending demise of the Internal Combustion Engine (ICE) as petroleum-powered cars and trucks are replaced by super-clean Electric Vehicles (EVs).

The media claims it is just a matter of time before EVs start to materially reduce global oil demand. They also claim that EVs are yet another reason why the decline of oil production and consumption is inevitable.

Some experts are now saying that widespread electric vehicle use could spell the end of oil. The tipping point, they reckon, is 50 million EVs on the roads. This they believe could be reached by 2024.[15]

However, 50 million EVs could hardly make a dent on the global demand for oil let alone replace it.

Currently, electric and hybrid cars combined number under 2 million cars out of 1.477 billion ICEs on the roads worldwide in 2015, or a negligible 0.14%. The total number of ICEs is projected to reach 2.0 bn by 2025 rising to 2.79 bn by 2040 according to U.S. Research.[16]

In 2016 the world used 35 bn barrels of oil (bb) of which 66% or 23 bb were used to power 1.477 billion conventional cars around the world.17 Bringing 50 million EVs on the roads will reduce the global oil demand by only 0.9 bb, or 3.9%. This will neither be the end of oil as some experts are suggesting nor a tipping point.

A tipping point for oil could only be reached once 739 million EVs (50% of the current global ICEs number) are on the roads worldwide within the next fifty years. This is impossible to achieve within that time frame. One then can only guess how many decades will have to pass before the entire global car fleet of conventional cars is replaced by electric cars.

Moreover, growth in EV sales thus far has been supported by significant government subsidies. Sales would crash once the subsidies are withdrawn according to a report in April 2017 by U.S. auto research firm, Edmunds.

Furthermore, there will be a need for trillions of dollars of investment to expand the global electricity generation capacity in order to accommodate the extra electricity needed to recharge 50 million EVs.

Other alternatives to ICEs include hydrogen fuel cells (FCVs).18 However, experts estimate it will take at least 40 years or more before FCVs could have any meaningful impact on the demand for oil.

WOULD THERE EVER BE A POST-OIL ERA FOR THE ARAB GULF OIL PRODUCERS?

For the Gulf Cooperation Council (GCC) countries - Saudi Arabia, UAE, Kuwait, Qatar, Oman and Bahrain – there would be no post-oil era ever.

Contrary to widely accepted wisdom, oil will remain an integral part of the Middle East economies throughout the 21st century and far beyond. Even if cheap alternatives to oil in transport, water desalination and electricity generation were to become readily available in the future, oil will not be left underground. The Arab Gulf oil producers will use it to power thousands of water desalination plants to generate enough water not only for drinking but also for irrigation to make the desert bloom again. They will also use it to dominate the global petrochemical industries and any industries in which oil is a feedstock.[19]

CONCLUSIONS

Oil is expected to remain the world's primary energy source throughout the 21st century and probably far beyond. Still, demand growth is projected to decelerate particularly in transport on the back of efficiency improvements driven by technological developments, a tightening of energy policies and a wider EV use.

And whilst experts around the world project the advent of the post-oil era within the next fifty years, it will take far more than five decades before EVs could start to make an impression on the global oil demand for transport, let alone replace it.

A post-oil era is a myth. Oil will continue to reign supreme through the 21st century and maybe far beyond.

Footnotes

[1] Mamdouh G Salameh, "OPEC & the Oil Price Will Triumph over U.S. Shale Oil in 2018", posted by the Research Centre of Energy Management (RCEM) at ESCP Europe Business School, London on the 15th of January 2018).

[2] OPEC's 2017 World Oil Outlook 2040, p. 2.

[3] Ibid., p.15.

[4] Mamdouh G Salameh, "Is Saudi Arabia Losing Its War of Attrition against U.S. Shale Oil?**"** (An article posted by the ESCP Research Centre for Energy Management (RCEM) on the 19th of September, 2016).

[5] Mamdouh G Salameh, "Oil & the U.S. Economy" (an article posted by the ESCP Research Centre for Energy Management (RCEM) on the 7th of July, 2016).

[6] Breakdown of Oil Consumption by Sector**,** GlobalPetrolPrices.com, Published October 7, 2015), accessed on 15 November, 2016.

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[9] Reuter's report on the 3rd of July 2017.

[10] Mamdouh G Salameh, "What Is Behind the Steep Decline in the Crude Oil Prices: Glut or Geopolitics?" (A research Paper published by the Arab Centre for Research & Policy Studies, Doha, Qatar, June 2015).

[11] Fatih Birol, Qatar Today, February 2016, p. 20.

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[17] BP Statistical Review of World Energy, June 2017, p.9 & p.15.

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Resilience Finally Debuts in Electricity Markets and Raises 2018 Questions

By Thomas Russo

Thomas N. Russo is president of Russo on Energy LLC. Russo on Energy formed a strategic alliance with Kleinschmidt Associates to strengthen its natural gas, oil, power, and environmental services offerings. He may be reached at tom@russoonenergy.com

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See footnotes at end of text.

Back in May 2015, I presented a paper[1] in Houston on the resilience of natural gas and oil pipelines and their relationship to the power sector. The audience was polite, but few people were interested in resilience. How things have changed!

Secretary of Energy Rick Perry's use of the term "resilience" has created havoc and dismay over compensating coal- and nuclear-fired power plants to participate in energy markets. The resilience genie is out of the bottle and it remains to be seen whether coal, nuclear, or other power plants will be compensated as proposed by the secretary. Nevertheless, future discussions in electricity circles are sure to go beyond electric reliability and include robust discussions of resilience.

MEANING OF RESILIENCY

My view was that sooner or later, energy projects would be attacked or go down for a variety of reasons. That was a given, but what really matters is how resilient they are or how quickly they would be able to resume operations.

While the Federal Energy Regulatory Commission (FERC) staff has asked for definitions of resilience from stakeholders, the United States and the United Kingdom already defined it pretty well years ago (Exhibit 1). I prefer the definition in the UK document "Keeping the Country Running", more for its simplicity and getting past all the noise of a notice and comment hearing at FERC.

It's better to spend time determining if resilience has value to begin with. If it does, then we should be determining which power plants, be they coal, nuclear, or other power facilities and technologies, can provide resilience for the grid, and how much to compensate owners for it.

RELIABILITY RELATED TO RESILIENCE, BUT NOT SAME THING

The North American Electric Reliability Corporation (NERC) defines a reliable bulk-power system as one that is able to meet the electricity needs of end-use customers even when unexpected equipment failures or other factors reduce the amount of available electricity. NERC divides reliability into two categories:

1. Adequacy: Adequacy means having sufficient resources to provide customers with a continuous supply of electricity at the proper voltage and frequency, virtually all of the time. Resources refer to a combination of electricity-generating and transmission facilities that produce and deliver electricity and demand-response programs that reduce customer demand for electricity. Maintaining adequacy requires that system operators and planners take into account scheduled and reasonably expected unscheduled outages of equipment while maintaining a constant balance between supply and demand.

2. Security: For decades, NERC and the bulk power industry defined system security as the ability of the bulk power system to withstand sudden, unexpected disturbances, such as short circuits or unanticipated loss of system elements due to natural causes. In today's world, the security focus of NERC and the industry has expanded to include withstanding disturbances caused by manmade physical or cyber attacks. The bulk power system must be planned, designed, built, and operated in a manner that takes into account these modern threats, as well as more traditional risks to security.

- "To withstand and recover rapidly from disruptions— including from deliberate attacks or naturally occurring threats or incidents." U.S. Presidential Policy Directive 21 February 12, 2013 (DHS.gov: Homeland Security Presidential Directive 7: Critical Infrastructure Identification, Prioritization, and Protection).
- "The ability of assets, networks and systems to anticipate, absorb, adapt to and/or rapidly recover from a disruptive event" (Cabinet Office, UK, "Keeping the Country Running: Natural Hazards & Infrastructure," October 21, 2011).
- "Resilience—the ability of a nation, system or institution to adapt to changing contexts, to withstand shocks, and to quickly recover or adapt to a desired level of stability, while preserving the continuity of critical infrastructure" ("Digitalization and Energy," http:// www.iea.org/digital/).

Exhibit 1. Definitions of Resilience

MEASURING RESILIENCE

NERC's definitions are good starting points for distinguishing resilience from reliability.

But I believe that the significant difference is how quickly a power plant or system can recover and provide those services that electric customers are depending on, as opposed to withstanding an outage.

Looking at actual operating histories of coal and nuclear plants and other plants should shed a great deal of light on their resilience. In the interim, we can look at the operating characteristics of various dispatchable power technologies. This approach is not perfect, but at least it provides insight on how long different types of power plants need to resume full operations from a hot, warm, and cold start-up mode (Exhibit 2).

	Nuclear power plant[a]	New coal-fired plant[b]	Combined cycle plant Siemens F-class Siemens H-class
Hot start-up (time taken to start-up following shut-down lasting <8 h)	60-120 min[c]	80-150 min	30-60 min (potential for <30 min depending on customer)
Warm start-up (time taken to start-up following shut-down lasting <48 h)	2-3 h[c]	3-5 h	1-1.5 h (potential for <50 min depending on customer requirements/ configuration)
Cold start-up (time taken to start-up following shut-down lasting <120 h)	15-20 h	5-10 h	2-3 h depending on customer requirements/configuration
Start-up reliability (%)	Not relevant[d]	87-93% depending on supplier/configuration	95-99% depending on supplier/configuration

Notes and sources:

a. AREVA corporate communication 2010.

b. Experience feedback from start-up of coal fired power plants (Paiton, Kogan Creek).

c. In the event of planned shutdown and subsequent restart from the hot subcritical condition, otherwise restrictions due to need to adjust reactivity control to account for xenon concentration

d. Not relevant since usually only a few start-ups per year.

Source: Balling, L. (2010, December). Flexible future for combined cycle. *Modern Power Systems, 30*, 61–63.

Exhibit 2. Start-up Characteristics of Nuclear- and Fossil-Fired Power Plants

Coal and nuclear do not respond as quickly as gas-fired combined-cycle plants based on Exhibit 2 data. However, the data in Exhibit 2 may not reflect advances made during the last seven years by Siemens and other power equipment vendors.

IS RESILIENCE CODE FOR ENERGY SECURITY?

The International Energy Agency (IEA) uses a tool called the Model of Short-Term Energy Security (MOSES) to take a systematic look at a country's energy security. MOSES looks at threats, vulnerabilities, and risk and also at resilience—a country's capacity to deal with different types of disruptions. MOSES is well-developed for oil, natural gas, and other fuels, and relies quite a bit on infrastructure and the number of fuel suppliers to mitigate threats to fuel security. Unfortunately, analyses of power generation and electricity are still under development at the IEA.2 (See Exhibit 3.)

Nevertheless, MOSES could shed some light on coal and natural gas, which are currently competing fuels in the electric sector.

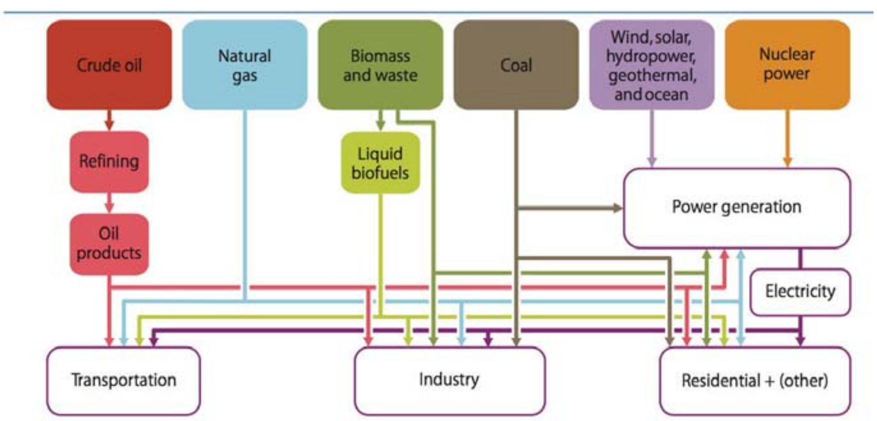

Exhibit 3. MOSES Uses and Energy Systems Approach in Evaluating Energy Security

DO THE STATES HAVE A ROLE TO PLAY?

Thirty-eight states have mandatory renewable energy portfolio standards (RPSs), which, together with the renewable energy production tax credit and other incentives, have seen wind and solar project growth rates climb.

As FERC and the organized electricity markets analyze the secretary's proposal, perhaps more states may want to have a say in matters of resilience and want to incent or require electric utilities to promote resilience in the form of mandatory resiliency standards. There are many reasons for this desire, and all are somewhat related to the cost of natural gas and how states with growing levels of renewables are dealing with increased evening ramp.

Abundant and low-cost natural gas has allowed the states, regions, and organized electricity markets to respond to steep evening ramp-ups with gas-fired power generators and peaking hydropower plants. The cost of doing this has been minimal to electric customers given the low cost of natural gas. However, increased exports of pipeline natural gas to Mexico and greater demand for liquefied natural gas (LNG) from global markets may see prices increase.

Demand for natural gas will increase as the Cove Point LNG export terminal begins operation by year-end and as Freeport, Corpus Christi, and the Cameron LNG export terminal begin operations in 2018.

COAL AND NATURAL GAS PRICE COMPETITION

Coal has had a difficult time competing with natural gas as power plant fuel. However, the rates charged to transport coal and natural gas have to be taken into account when power plant operators compare the delivered costs of each fuel to a power plant.

Natural gas pipeline companies and the gas industry openly acknowledge that the power sector is an important to the growth of natural gas. As such, FERC ensures that natural gas pipeline rates are just and reasonable and that transportation of natural gas is priced accordingly. The same cannot be said of coal transportation.

Coal transportation by railroad is competing with intermodal container shipments. The latter is an important growth area for the railroads. In 2014, agricultural and coal producers were complaining about excessive delays in moving coal and agricultural goods to market. Back then, the rails were doing a brisk business in moving crude oil from North Dakota and responding to increased domestic intermodal container growth. Bad weather also played a part in the delays of agricultural and coal shipments. The latter caused the Surface Transportation Board to take action, and FERC held a hearing as well.

By one published report,3 the railroads are responsible for more of the delivered coal costs than coal producers. Despite efficient coal production from the mines, the higher rates to transport steam coal from the Powder River Basin to the Southwest and Midwest have made it very difficult for coal to compete with natural gas in those areas.

The railroads' response to the severe decline in coal production and consumption during the 2008–2016 time period has also been surprising and instructive. The four major railroads that originate U.S. coal are Burlington Northern Santa Fe (BNSF) and Union Pacific (UP) in the West and CSX Transportation (CSX) and Norfolk Southern (NS) in the East and Midwest.

In the West, UP and BNSF both originate Powder River Basin coals. Most of these coals move long distances at rates that are high relative to the cost of the coals. While mine prices may range from $8–$12 per ton, the rail rates can easily run $25–30 per ton for movements to the Southwest and Midwest. It's also important to note that the railroads did cut rates on coking coal, which is used to produce steel, but despite problems with steam coal and natural gas competition, the rails chose to maintain their profit margins and not reduce rates. Had there been some rate relief, coal-fired generation may have been better able to compete despite the effects of the Environmental Protection Agency's Mercury and Air Toxics regulations and the Clean Power Plan.

Nevertheless, it is not too late for the Surface Transportation Board, which regulates railroads and rates, to take a hard look at coal freight rates and determine if they are just and reasonable.

PROPOSED RULE MAY TRIGGER THE NATIONAL ENVIRONMENTAL POLICY ACT

I believe that the proposed rule envisioned by the secretary of energy and any temporary action approved by FERC to compensate coal-fired power plants to operate would constitute a major federal action affecting the human environment. FERC would have to prepare an environmental impact statement (EIS) that addresses carbon dioxide emission of the anticipated retirements of coal and nuclear plants as well as replacement generation. DOE's staff4 report anticipates that approximately 12,700 megawatts of coal generation will retire through 2020. While the EIA reports that eight reactors representing 7,167 megawatts of nuclear capacity that have announced retirement plans since 20165 before making such a decision. I base my conclusion on the following.

Richard J. Pierce Jr., the Lyle T. Alverson Professor of Law at The George Washington University and a well-known figure in the electric industry, asserted in comments to FERC that the rule would increase dramatically the emissions of carbon dioxide.6 Professor Pierce points out that the Supreme Court has held that carbon dioxide is a pollutant in Massachusetts v. EPA7 and that subsequent courts have upheld that decision.

He also cites a recent decision on three proposed interstate natural gas pipelines collectively known as the Southeast Markets Pipelines pending before FERC. The U.S. District Court decision required FERC to do a greenhouse gas (GHG) analysis and calculation on emissions at the existing and new Florida power plants receiving natural gas from the Southeast Markets Pipeline-Sabal Trail, Hilabee Expansion, and NextEra's Florida Southeast Connection in Sierra Club v. FERC.8 FERC recently complied with the court by analyzing the carbon dioxide emissions. Professor Pierce concludes that the secretary of energy's proposal would have far greater effects on emissions of carbon dioxide than would the authorization to construct three natural gas pipelines and that FERC can take no action of the type urged by the secretary without first preparing an EIS.

FERC normally does not prepare National Environmental Policy Act (NEPA) documents on proposed rulemakings that affect tariff changes. The commission usually concludes in rulemaking orders that neither an environmental assessment nor an environmental impact statement is required under Section 380.4(a)(15) of the commission's regulations. FERC relies on a categorical exemption for approval of actions under Sections 205 and 206 of the Federal Power Act relating to the filing of schedules containing all rates and charges for the transmission or sale subject to the commission's jurisdiction. This includes the classification, practices, contracts, and regulations that affect rates, charges, classifications, and services.[9]

I think that FERC's argument may not be persuasive when challenged in court. Any rule issued by FERC would be targeting coal plants with a 90-day supply of fuel. Also, any temporary compensatory measures to keep coal power plants running while FERC works on a long-term rule will be problematic. In each scenario, the names and locations of the coal plants would be known, and FERC would have no problem assessing the impacts on carbon dioxide emissions from allowing these plants to continue to operate.

Such a NEPA review required by a court might have consequences well beyond the secretary of energy's proposed rule. It may open Pandora's Box and subject FERC's natural gas and hydropower programs to broader NEPA reviews. For example, the courts might find it necessary to require FERC to conduct an upstream analysis that would factor in the drilling and fracking of source gas for proposed natural gas pipelines.

Footnotes

[1] Russo, T. (2015, May 13–15). *Oil and gas infrastructure resiliency*. Presented at the North America Oil & Gas Cybersecurity Conference.

[2] Jewell, J. (2011). *The IEA model of short-term energy security* (MOSES). Paris: OECD/IEA.

[3] Repsher, M., Heller, J., Mann, C., & Gaalaas, T. (2017). *The future of coal versus gas competition*. Retrieved from http://www.paconsulting. com/insights/the-future-of-coal-versus-gas-competition/.

[4] U.S. Department of Energy. (2017, August). *Staff report to the secretary on electricity markets and reliability.* DOE staff report. Washington, DC: Author.

[5] U.S. Energy Information Administration (EIA). (2017, June). *Monthly update to the annual electric generator report.* Form EIA- 860m. Washington, DC: Author.

[6] See Richard J. Pierce Jr. comment on secretary of energy proposal in Docket no. RM18-1-000. Retrieved from https://elibrary. ferc.gov/idmws/common/opennat.asp?fileID=14702680.

[7] 549 U.S. 497 (2007).

[8] 867 F.3d 1357 (D.C. Cir. 2017).

[9] *Regulations Implementing the National Environmental Policy Act,* Order No. 486, 52 FR 47897 (Dec. 17, 1987), FERC Stats. & Regs. ¶ 30,783 (1987).

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The IAEE - APEEN Student Prize for Portuguese Students

On the past 21-22 September 2017, the 4th Meeting on Energy and Environmental Economics – ME^3 organized by the Portuguese Association of Energy Economics (APEEN) and the Research Unit in Governance, Competitiveness and Public Policy (GOVCOPP) was held at DEGEIT, University of Aveiro. The ME^3 is an international meeting which aims at sharing experiences, ideas and results by the Scientific and Business community whose interests are the Economics of Energy and Environment.

The event had parallel scientific sessions and an afternoon of presentations from firms and organizations, keeping the past conferences tradition in order to involve business issues with academics in the APEEN research areas. The keynote speaker was Prof. Dr. Andy Gouldson, Dean for Interdisciplinary Research, Professor of Environmental Policy in School of Earth and Environment, from the University of Leeds, Leeds, UK, which delighted us with his talk "Exploring the Economics of Low Carbon Cities".

There was also, during parallel sessions in the 4th ME^3, presentations of works from master and doctoral students, which were filmed and whose presentations were submitted to an evaluation committee. Prizes were promoted and offered by IAEE, in an effort to encourage more students to join the Association, to the Portuguese APEEN affiliate, and to investigate in the Energy Economics area. From the videos, three won the IAEE-APEEN Student Prizes, and the winners were announced in December.

Continuing the conference held in Porto on May 20, 2016 ("Thinking about the agenda for the energy transition"), the Portuguese Energy Economics Association (APEEN) held a seminar on December 14, 2017 at ISCTE, Lisbon, to discuss possible ways of energy transition and its environmental and economic consequences, entitled: "The energy transition in the Iberian Peninsula".

With the support and participation of the Spanish Association for Energy Economics (AEEE), this seminar offered the possibility of a dialogue between researchers from the two Iberian countries involved in recent studies on the relevant aspects of the energy transition in the two countries.

This year, we will be considering, within the framework of the United Nations, the first collective assessment of the progress made by nationally determined contributions to the implementation of the Paris Agreement. In the European Union, 2018 will be the decisive year for the negotiation of the legislative package "Clean Energy for All Europeans". Each country defines, sovereignly, the national energy transition strategy that it considers most appropriate, within the framework of the international commitments assumed. With this seminar there was a more enlightened public debate on these themes, which are among the most important for contemporary society.

Among the speakers were the presidents of the two associations, Jorge Vasconcelos and Gonzalo Sáenz de Miera, and also Júlia Seixas (with: "Trajectories of decarbonization and impacts on the energy matrix"), Alfredo Marvão Pereira (with "Macroeconomic Impacts of decarbonization"), Alberto Amores (with "Trajectories of decarbonization in Spain) and Pedro Linares (with "Energy Scenarios in Spain"). After the presentations, it was followed a debate between all the speakers and the audience, on the prospects of convergence, in Iberia and Europe and how to reach the desirable "decarbonization".

At the end of the seminar, the winners of IAEE-APEEN Student Prizes (given by the International Association of Energy Economics) were announced. The winners were three Portuguese students for their academic work presented at the meeting of Environmental and Energy Economics held in September 2017 at the University of Aveiro. The first prize of € 350 was awarded to Pedro Palma, for his work "Thermal Comfort in Portuguese Households: Mapping Energy Needs at Civil Parish Level"; the second prize of € 225, went to Rita Mendonça, for her work "Assessing the effectiveness of economic instruments to steer urban sprawl: a hedonic pricing simulation modelling approach" and the third prize of € 125, went to Hélder Marques for his work "Supporting decision-making in energy efficiency from the manager's perspective".

In addition to their prize, these students receive the APEEN membership fee for one year and the possibility of attending free events organized by the association.

The prizes were given at the University of Aveiro on February 8, 2018. The videos will be available on the beginning of March 2018 at https://apeen.pt/.

First, Second and Third place winners of the IAEE-APEEN Student Essay Contest

CONFERENCE OVERVIEW

The Trump Administration and changing geopolitical situations are redefining energy directions, layering additional change over ongoing technological and market changes. Removal or revision of regulations, withdrawal from the Paris climate accord, and shifting geopolitical relations add complexity to an energy portfolio still bracing for cyberattacks and weather impacts against vulnerable grids. These geopolitical shifts, and the reactions to them by OPEC, local governments, and other actors, challenge us to chart a path forward through changed and dynamic domestic and international energy and environmental sectors.

The 36th USAEE/IAEE Conference provides a forum for informed and collegial discussion of how the emerging realities will impact all stakeholders—from populations to companies to governments—in North America and around the world.

Nowhere calls out this urgency more clearly than the mid-Atlantic region. The energy mix includes offshore wind, coal mines, nuclear power, solar, and natural gas. Conference attendees will benefit from access to tour some of these facilities as well as tours of federal energy institutions in Washington, D.C.

The Washington, D.C. metro area is the epicenter of energy policy and home to legislators, regulators, and diplomats. It boasts the greatest concentration of think tanks and is a bastion of energy thought leaders that bolster the value of networking opportunities provided by the conference.

The conference will highlight contemporary energy themes at the intersection of economics, public policy, and politics, including those affecting energy infrastructure, environmental regulation, markets vs. government intervention, and international energy trade. Participation from industry, government, non-profit, and academic energy economists ensures robust, insightful discussion.

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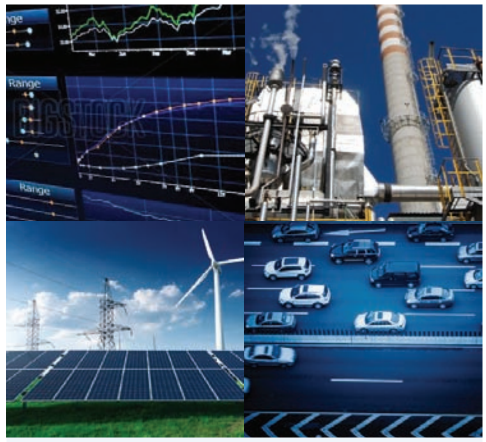

TOPICS TO BE ADDRESSED INCLUDE:

The general topics below are indicative of the types of subject matter to be considered at the conference. A more detailed listing of topics and subtopics can be found by clicking here: http://www.usaee.org/usaee2018/topics.html

- Energy Protectionism in Practice
- Countervailing Winds: International Geopolitical and Domestic Responses to the New Administration
- The New DOE and FERC Agendas
- How Have Energy Markets Responded to the Shift of U.S. Energy Policy?
- Energy Implications of Environmental Regulations: Future and Impact
- International Energy Policy Responses to the U.S. Departure of the Paris Climate Accord
- A Look at Shifts in Energy Supply: Renewables, Coal, and More
- Deregulation of Marine and Land Use: Offshore Access, Extraction, and Pipelines
- Europe, Russia, and U.S. Natural Gas Exports Recent State Energy Policy Developments
- Energy Innovation and Technology
- Other topics of interest including shifts in market structures and fundamentals, including those induced by policy and technological forces.

36TH USAEE/IAEE NORTH AMERICAN CONFERENCE CALL FOR ABSTRACTS

We are pleased to announce the Call for Abstracts for the 36th USAEE/IAEE North American Conference, *Evolving Energy Realities: Adapting to What's Next*, to be held September 23-26, 2018 at the Hilton Crystal City Hotel, Arlington, Virginia, USA.

CONCURRENT SESSIONS

There are two categories of concurrent sessions: 1) current academic-type energy economics research, and 2) practical case studies involving applied energy economics or commentary on current energy-related issues. This latter category aims to encourage participation not only from industry but also from the financial, analyst and media/commentator communities. In either instance, papers should be based on completed or near-completed work that has not been previously presented at or published by USAEE/IAEE or elsewhere. Presentations are intended to facilitate the sharing of both academic and professional experiences and lessons learned. It is unacceptable for a presentation to overtly advertise or promote proprietary products and/or services. Those who wish to distribute promotional literature and/or have exhibit space at the Conference are cordially invited to take advantage of sponsorship opportunities – please see www.usaee.org/usaee2018/sponsors.html Those interested in organizing a concurrent session should propose a topic and possible speakers to Professor Pierre-Olivier Pineau Concurrent Session Chair (pierre-olivier.pineau@hec.ca) Please note that all speakers in organized concurrent sessions must pay speaker registration fees and submit abstracts.

The deadline for receipt of abstracts for both the Concurrent Sessions and the Student Poster Session is Friday, **April 20, 2018**.

Concurrent Session Abstract Format

Authors wishing to make concurrent session presentations must submit an abstract that briefly describes the research or case study to be presented.

The abstract must be no more than two pages in length and must include the following sections:

a. Overview of the topic including its background and potential significance
b. Methodology: how the matter was addressed, what techniques were used
c. Results: Key and ancillary findings
d. Conclusions: Lessons learned, implications, next steps
e. References (if any)

Please visit www.usaee.org/USAEE2018/PaperAbstractTemplate.doc to download an abstract template. All abstracts must conform to the format structure outlined in the template. Abstracts must be submitted online by visiting www.usaee.org/USAEE2018/submissions.aspx. Abstracts submitted by e-mail or in hard copy will not be processed.

Concurrent Session Presentation Format

Objective: To communicate the objectives, context and findings of submitted papers in the most impactful way to a diverse audience of business professionals, academics and government representatives.

We offer two presentation length options:

Option 1: **8 minutes of prepared remarks plus 2 minutes for audience Q&A and discussion**
Maximum of 5 slides allowed (not including a title slide); avoid excessive lead-up (history, background) but get directly to the main research finding

Option 2: **15 minutes of prepared remarks plus 5 minutes for audience Q&A and discussion**
Maximum of 10 slides allowed (not including title slide)

Please select your preferred presentation "Option" on the Abstract Submission page when submitting your abstract. Each concurrent session may have a mix of 8 and 15 minute presentation slots which are in accordance with the session theme.

Format and Structure: Powerpoint or pdf slides are usually an appropriate presentation format. The structure of the presentation should focus on the following:

- Context and rationale for research topic
- Specific issue/question covered
- Main findings, and what evidence supports them
- Implications for (business/investment/markets/policy)

Both presentation options should be able to include coverage of these four areas – the difference is likely to be in the level of detail and/or examples shown.

(Please note that the traditional structure of an academic research presentation, in which major segment of the presentation often includes a series of slides showing equations and the numerical results of statistical analysis, is generally not suitable for the diverse audience attending the USAEE conference.)

Student Poster Session

The Student Poster Session is designed to enable students to present their current research or case studies directly to interested conference delegates in a specially designed open networking environment. Abstracts for the poster session must be submitted by the regular abstract deadline and must be relevant to the conference theme. The abstract format for the Poster Session is identical to that for papers; please visit www.usaee.org/USAEE2018/PaperAbstractTemplate.doc to download an abstract template. Such an abstract should clearly indicate that it is intended for the Student Poster Session—alternatively that the author has no preference between a poster or regular concurrent session presentation. Abstracts must be submitted online by visiting www.usaee.org/USAEE2018/submissions.aspx. Abstracts submitted by e-mail or in hard copy will not be processed. Poster presenters whose abstracts are accepted should submit a final version of the poster electronically (in pdf format) by July 13, 2018 for publication in the online conference proceedings. Posters for actual presentation at the conference must be brought directly to the conference venue on the day of presentation and must be in either ANSI E size (34in. x 44in.) or ISO A0 size (841mm x 1189mm) in portrait or landscape format.

Presenter Attendance at the Conference

At least one author of an accepted paper or poster must pay the registration fees and attend the conference to present the paper or poster. The corresponding author submitting the abstract must provide complete contact details—mailing address, phone, fax, e-mail, etc. Authors will be notified by June 1, 2018, of the status of their presentation or poster. Authors whose abstracts are accepted will have until July 13, 2018, to submit their final papers or posters for publication in the online conference proceedings. While multiple submissions by individuals or groups of authors are welcome, the abstract selection process will seek to ensure as broad participation as possible: each author may present only one paper or one poster in the conference. No author should submit more than one abstract as its single author. If multiple submissions are accepted, then a different author will be required to pay the registration fee and present each paper or poster. Otherwise, authors will be contacted and asked to drop one or more paper(s) or poster(s) for presentation. Where a team of students and/or a supervisor are co-authors of a poster, one student must be designated as the corresponding author, must attend the conference and present the poster—in order to be eligible for the single cash prize.

STUDENTS

In addition to the above opportunities, students may submit a paper for consideration in the Dennis J. O'Brien USAEE/IAEE Best Student Paper Award Competition (cash prizes plus waiver of conference registration fees). The paper submission has different requirements and a different deadline. The deadline for submitting a paper for the Student Paper Awards is May 18, 2018. Visit www.usaee.org/usaee2018/bestpapers.html for full details.

Students are especially encouraged to participate in the Student Poster Session. Posters and their presentations will be judged by an academic panel and a single cash prize of $1000 will be awarded to the student with the best poster and presentation. For more details including the judging criteria visit www.usaee.org/usaee2018/postersession.html

Students may also inquire about scholarships covering conference registration fees. Please visit www.usaee.org/usaee2018/scholarships.html for full details.

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Concepts of Geopolitics and Energy Security

By Ole Gunnar Austvik

Geopolitics is the study of how geography affects international relations, power and vulnerabilities. Rudolf Kjellén (1905) first coined the term, and defined it as the studies of the way geographical (and often also historical and social) factors help explain the power and role in international affairs of nation states. In classical formulations, the links and causal relationships between political and physical power over geographic space were emphasized. Halford Mackinder (1904) described much of the 20th century's geopolitical thought, great power strategies, alliances and military events based on geographic and historic factors. Geopolitics was often considered a competitive zero-sum game played by nation states in their pursuit of power and security, and gains from trade and investment relative to other national competitors (Victor, Jaffe & Hayes 2006:4). Geopolitics was a study of the dynamic or evolving political structuration of space. Greater territory and more resources was the win for one and loss for the other. The outset was that geography (or nature) created various types of societies and cultures as their spatial dimensions implied different opportunities and limitations. Often rivers, mountains, forests, lakes and coasts were borders to human societies.

Ole Gunnar Austvik is professor of political economy at Lillehammer University College and at the Norwegian Institute of International Affairs (NUPI), Norway. He was M-RCBG Senior Fellow at John F. Kennedy School of Government, Harvard University 2015-16. He ay be reached at oga@oga.no

See footnote at end of text.

Because geopolitical thinking was used to defend Lebensraum for Nazi-Germany, social scientists and politicians more or less abandoned the concept after WWII, claiming there was no geopolitical science anymore, only geoideologies, such as Nazism and fascism (Haushofer 1924, Bingen 2014). For more decades, borders and the established geopolitical structures were considered permanent sacrosanct. After the break-up of the Soviet Union, the market became more or less the sole mechanism for allocation of economic resources. Francis Fukuyama (1993) even declared the "End of History". Nevertheless, a rebirth of geopolitical studies emerged in the economically and politically interdependent world of the 1990s, and beyond. Now the concept was adjusted to the international economic and political integration that had taken place, and included how political control over a territory influences power and political and economic outcomes through factors, mechanisms and institutions in the international economic and political system (Agnew & Corbridge 1989). Modern geopolitics became concerned with the political discourse among international actors resulting from all factors that determine the political and economic importance of a country's geographic location. "Relative gains matter, but so (also) joint gains from possible cooperation" (Victor, Jaffe & Hayes 2006:5).

As part of geopolitics is geoeconomics and geostrategy. Geoeconomics describes and analyzes the distribution of resources in and between states, focusing on industrial capacity, technologic, scientific and administrative competence and capacity, finance and the flows of trade in space. Geopolitics is very much a geoeconomic phenomenon and vice versa. Any state's control of a given territory is in the end a question of "economic gain" – how to finance the costs and how to gain an optimal share of the values created or transmitted in/on that territory. Geostrategy has mostly been used as a military concept and describes plans for obtaining physical control of certain areas, or the capability to deny others to control them, irrespective of prevailing geopolitical and geoeconomic structures. Together they presuppose intentionality and are thus not natural phenomena.

GEOPOLITICS AND ENERGY

The energy geopolitics of any region must be understood by both the size and location of own and other natural resources, how available they are, who controls them, their cost, alternative transportation routes, how regional and global markets balance, market mechanisms and regulations, political decisions, and prices in general. Furthermore, as national and international policy-making and business is intertwined, the state is not anymore the only actor that shapes political outcomes. The geopolitical role of a country is influenced by the scale and scope of the dependence it represents for other actors (businesses, countries). Resources affect national policy making by acting upon domestic actors, which in turn affect the domestic political system through associations, state structure and ideology and, hence, business-to-business and business-to-government relations, must be included in the analysis (Austvik & Lembo 2017: 663-666)..

Energy and geopolitics have been closely linked in both old and new formulations. Countries have made and make national strategies and geostrategies to meet their energy needs, reach markets and secure national positions and interests. The securitization of energy policy have contributed to shape bilateral, European and global affairs. Historically, the industrial revolution from the mid-1700s was partly a coal and steam revolution, and an economic backdrop for the build-up of the British Empire in the 1700s and 1800s. One important goal for Nazi Germany's expansion eastwards in World War II was to gain control of oil production in Azerbaijan, albeit stopped at Stalingrad. The motivation was both to secure oil for itself, as well as to prevent the Soviets from using it in its motorized forces. America from the 1900s, and especially after WWII, has been based on imported petroleum, largely from the Middle East, heavily influencing both U.S. as well as Arab foreign and security policy over decades. In some cases, for example in the Soviet era and in Saudi Arabia, oil and gas has been emphasized for geopolitical influence.

In recent decades, climate and environmental concerns and the desire for a greener economy has added to the politicization of the energy sector, and created worldwide pressures and policies for improved energy efficiency, more renewable energy, and less dependence on fossil sources. The climate debate has added to the complexity of the energy industry, not least since fossil energy, still representing as much as 87 percent of world energy usage (2016) is the main source of global CO_2 emissions. Hence, it should be curbed, renewable energy increased, and energy savings encouraged as an alternative source of energy supply competing with all non-renewable and renewable sources. At the same time, while domestic US shale oil and gas resources are about to change American physical dependency on imported energy, and thereby the scope of the geopolitics of oil for the U.S., Europe remain largely dependent on import. Although the shale "revolution" may spread to Europe and elsewhere, and liquefied natural gas (LNG) will transport natural gas globally, new trade routes based on pipeline transportation that can bring gas resources to European markets continue to be central for EU energy dependency and energy security.

SECURITY-OF-SUPPLY AND SECURITY-OF-DEMAND

Energy security and geopolitics links to security-of-supply for importers, and security-of-demand for exporters. For an energy importing country import dependency has been defined as a situation where it does not possess the capacity to produce 100 per cent of its own needs (Hogan and Mossavar-Rahmani 1987:8). A similar definition for a producing country would be a situation where it does not have domestic customers with the capacity of consuming 100 per cent of its production. According to such definitions most countries are dependent on imports of a whole range of commodities, and on exports of fewer commodities (because countries specialize) to pay for the imports. Dependency on exporting and importing goods and services to and from other countries is the normal state of affairs in a modern society, and a consequence of increased economic integration. The political, or strategic, part of it addresses the possibility of major breakdowns in production or infrastructure, caused by either political or non-political events. The IEA (1995:17) set out two broad categories for risks for energy importing countries:

- "Long term risk that new supplies cannot be brought on stream to meet growing demand for either economic or political reasons;
- Risk of disruptions to existing supplies such as political disruptions, accidents or extreme weather conditions"

Both importing and exporting countries are concerned about changes in prices and availability/market access for a commodity. The character of risks connected to it is a function of the magnitude and duration of change, the country's ability to adjust to it, and the importance of the commodity in the economy. Countries can be somewhere in the continuum between *neutral, sensitive or vulnerable* in its dependency when prices and availability/market access to a commodity change (Austvik 2016:375).

- *Neutral dependence* can be defined as a situation when a country exports or imports a commodity, and always has an alternative if one of the customers or suppliers disappears. This is a situation very much equivalent to what is assumed in contestable markets; there are numerous suppliers and customers and none of them has any influence on market outcome. If one supplier or customer, respectively, withdraws from a relationship there will always be someone in the market to fill the empty place. In such a situation, there should be no concern over supply or demand security.
- *Sensitivity dependence* is in this context measured by the degree of responsiveness within an existing policy framework. It may reflect the difficulty to change policy within a short time and/or bindings to domestic or international rules, when price or availability /market access change dramatically (Keohane and Nye 1977:12-18).
- *Vulnerability dependence* is more serious and measure the ability to adjust to changes after policies has been changed (ibid).

In economic terms, vulnerability dependence can be represented by the potential for significant losses of output or welfare. Sensitivity dependence, on the other hand, does not need to induce a welfare loss in the long run when circumstances change. An importing country can become more sensitive or vulnerable in a given state of dependency if the commodity originates from one powerful state, as opposed to if it is multilaterally dependent. An exporting country can become more sensitive or vulnerable if it depends only on one market as opposed to many markets in its exports. It is important whether supplying, respectively purchasing, nations are antagonistic or friendly in their relations in addition to the degree of market power they possess.[1] The dependence between sellers and buyers is reciprocal but not necessarily symmetrical, and the balance may change over time.

Vulnerability dependence is primarily concerning long-term supply and demand issues, while sensitivity dependency largely concerns the risk of disruptions to existing supplies. Sensitivity dependence occurs in "the short run or when normative constraints are high and international rules are binding". A vulnerability dependence occurs when "normative constraints are low, and international rules are not considered binding" (ibid). Thus, a country's vulnerability dependence can be significantly different from its sensitivity dependence, and potentially much more costly. As dependency on imports and exports is a normal state of economic affairs, government policy should aim at eliminating or reducing (potential) sensitivity and vulnerability dependence, while neutral dependency from this perspective is optimal.

DOMESTIC AND FOREIGN POLICY RESPONSE

The politicization and securitization of energy markets has often to do with imperfect market structures, when sellers and buyers are locked-in with each other. The more imperfect markets are, the more important the behavior of the participants is, being political, regulative or commercial. Social first-best solutions as defined in economics may not be attainable in such markets, and policy choices must be found among several alternative second- or third-best alternatives. Policy response depends on political will and ability, resource capabilities as well as on the rules of conduct embedded in international regimes (e.g. WTO-regulations, EU-law).

The challenge is of both external and domestic political nature. Externally, foreign policy can be an important external instrument for reducing sensitivity and vulnerability dependence, in addition to influencing degrees of market imperfections that may exist. When problems cannot be solved through foreign policy or market reorganization, effects of sharp price changes and/or availability, or market access must be addressed by domestic measures. If a country changes from being inelastic (inflexible) in it's demand for imports in both the short and long-term; to inelastic in the short and elastic in the long-term, the country's dependence on imports may change from vulnerable to sensitive. Domestic and external measures to deal with a problem can consequently (partly) substitute each other, which together create the character of a dependency on others, and whether it should be considered a political problem or not.

In this context, natural gas markets based on pipeline transportation differ from oil and LNG markets by the large and irreversible investments made in natural gas transportation. As free market principles of competition is less relevant especially to infantile market situations, case-by-case political decisions and bilateral relations are important for the realization of the huge projects. The advantages of large-scale operation and vertical integration imply that few companies operate as gas transporters in any immature pipeline based gas market. In these markets, as opposed to in mature and often liberalized markets, large and long-lasting business-to-business, business-to-government and government-to-government contracts and agreements across borders are necessary to build costly production and transport installations with reasonable economic security. Demand and supply are two sides of any market, and over time, there is less security-of-supply when security-of-demand is weak.

Important to notice is that sensitivity or vulnerability dependence on imports and exports, respectively, may occur even if the access to physical markets are not considered commercial or politically "risky." An exogenous shock in international markets caused, for example, by a war limiting supplies and disrupting pipelines may dramatically change prices also in "secure" markets. This was much the situation following the two oil shocks in the 1970s. In a price shock situation anyone may sell and buy the commodity (unless it comes to a conflict with the country itself involved). The problem is that if prices increase dramatically, parts of demand will switch to other energy sources and push these prices up, as well. Thus, security-of-supply for an energy consuming country is influenced by both the pure physical access to oil or gas, increased economic costs due to a rise in energy prices, as well as the political pressure that can be brought on them by parties controlling supply elsewhere. Making a market more competitive is a measure to reduce sensitive and/or vulnerable dependency to changes in physical volumes for both exporters and importers, but the price risk may persist and even increase.

Footnote

[1] For example, as an importing country, Ukraine appears to be vulnerable to Russian pressure as they either has to pay a high price for the gas or give political concessions to get a low price. The price of gas was reduced for Ukraine as part of the Kharkov agreement in 2010 to make relations between the two countries more friendly, including the agreement that Russia could use the Sevastopol base on the Crimea for its navy until 2035 (Kremlin.ru 2010). For Russia, as an exporting country, building the Nord Stream pipeline in the Baltic Sea (expanded or not), from Vyborg near St. Petersburg to Greifswald in Germany, is a way to circumvent the transit country Ukraine which has been considered a security-of-demand problem from their side in relation to EU purchasers (Austvik 2009).

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Energy-Climate Dilemma in Nigeria: Options for the Future

By Michael O. Dioha and Nnaemeka V. Emodi

BACKGROUND

The importance of energy in the wellbeing of any society cannot be overemphasized as its scale of use determines the socio-economic development of any nation. Access to a sufficient supply of energy is a major challenge in most economies in the world today because it affects all facets of our lives. Nigeria is undoubtedly the most populous and largest economy in Africa, but about 70% of its population lives below the poverty line, while around 45% do not have access to electricity and 72% still depend on traditional solid biomass for cooking. The annual electricity access situations from 2005 – 2012 in Nigeria are shown in Figure 1.

Michael O. Dioha is with the Department of Energy and Environment, TERI School of Advanced Studies, India. **Nnaemeka V. Emodi** is with the College of Business, Law and Governance, James Cook University, Australia. Michael Dioha may be reached at michael.dioha@teriuniversity.ac.in

See footnotes at end of text.

Lack of access to energy contributes to inequality, poor health, education and poverty in all aspects. A study by the World Health Organization reported that around 95,000 Nigerians die annually from indoor air pollutants produced by the inefficient combustion of solid biomass for cooking (WHO, 2007). Additionally, it has been estimated that indoor air pollutants are the biggest cause of death in the country after malaria and AIDS. Furthermore, the time spent by people (mostly young girls and women) in collecting firewood from the forest can be used for other productive and income generation activities if they had access to modern forms of energy. Moreover, lack of access to electricity prevents many Nigerians from having access to communication, entertainment, news through audio-visual which in turn limits their abilities to access information. While mentioning the challenges faced by those having no access to modern forms of energy in Nigeria, unsustainable consumption of biomass leads to land and forest degradation which also has a negative impact on the climate.

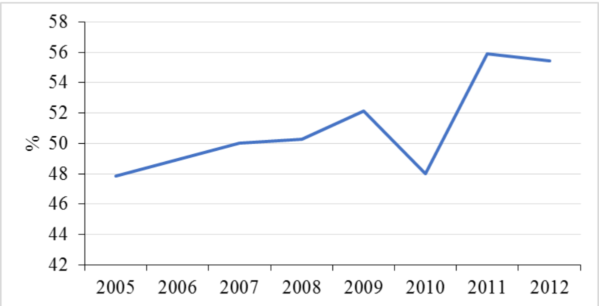

Figure 1: Percentage of population having access to electricity in Nigeria[1]

Given the importance of energy and the challenges faced by those who do not have access to its modern forms, the United Nations declared the 'Sustainable Energy for All' initiative in 2012 with the objective of ensuring universal access to clean, reliable, sustainable and affordable energy for all by 2030. Furthermore, owing to the importance of energy in our everyday life, the Sustainable Development Goals (SDGs) captured energy access as goal number 7. These global initiatives have prompted many governments to pay more attention to the energy sector.

However, over 80% of the world's energy today is supplied by fossil fuel (IEA, 2017). The combustion of fossil fuels for economic activities such as transportation and electricity generation releases greenhouse gases (GHG) which causes global warming and thus leads to climate change. The adverse effects of climate change are being experienced today and it may be seen in the melting of the ice caps as well as rising of the sea levels. In Nigeria, climate change impact has also been felt. For example, the drying up of Lake Chad from around 4000 sq.km to around 3000 sq.km between 1960 and 2007, respectively, may be attributed to the severe impact of climate change in that part of the country (FGN, 2015). Thus, climate change poses a great challenge to the socio-economic development of Nigeria. The total annual GHG emissions in Nigeria from 2005 – 2012 are shown in Figure 2.

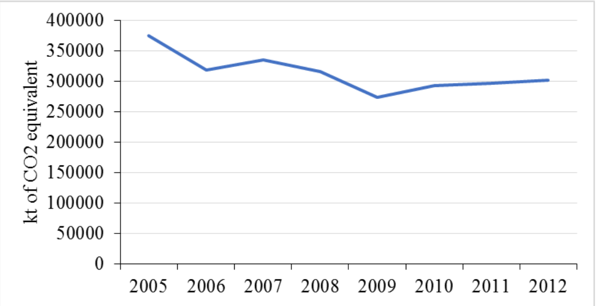

Figure 2: Total GHG emissions in Nigeria.[2]

In an effort to combat climate change, the United Nations Framework Convention on Climate Change (UNFCCC) Conference of Parties, COP-23 held at Paris in 2015 called on all countries across the globe to submit an Intended Nationally Determined Contributions (INDC) to limit GHG emissions. Nigeria is a signatory to the UNFCCC and has been participating seriously in the efforts to combat climate change. Despite contributing an insignificant share to the current climate problem, Nigeria has pledged to become part of the solutions in its INDC to cut down GHG emissions by 20%

below business-as-usual unconditionally and 45% conditionally by 2030.

The current energy supply system of Nigeria is dominated by fossil fuel (85% natural gas) (NPBR, 2015). This implies that for Nigeria to achieve the energy for all initiative as well as its INDC by 2030, its energy system needs to be transformed into a low carbon energy system. The transformation of the energy system from a fossil fuel dominated power supply to a low carbon society under a short time frame might present some challenges which create a dilemma for Nigeria. This dilemma raises questions on what can be done, what options are available to Nigerians, and how to finance an ambitious low carbon future. These questions can be answered through the following options presented in the following sections. Also, the options presented can aid Nigeria in achieving its energy for all initiatives and INDC by 2030.

OPTIONS FOR THE FUTURE

Distribution of mitigation efforts

Although the energy sector has been identified as the largest contributor to Nigeria national GHG inventory (FGN, 2014), efforts toward climate change mitigation should be distributed across all sectors of the economy. This action will go a long way to reduce the stress on the already fragile energy system which will, in turn, facilitate the development of a least-cost energy system that can satisfy unmet energy demand while mitigation efforts in other sectors can compensate for GHG emissions from the energy sector. The agriculture sector contributes around 28% of the total national GHG inventory (FGN, 2014). Hence, efforts towards mitigation may be directed in this sector. Sustainable agricultural practices such as reforestation, low tillage, growing of cover crops and integrated livestock-crop agriculture need to be encouraged in the country. Additionally, there is the need to encourage sustainable lifestyle among the citizens. Nigerians should be encouraged to use public modes of transport as well reduce the consumption of meat as these efforts alone will help to reduce individual carbon footprints and in general, the national GHG inventory. For it is when efforts are distributed across different sectors of the economy and among the citizens can the goal of low carbon development be achieved. Moreover, this will aid in the reduction of carbon constraints of the already existing energy system which will further help in increasing the supplying of energy to all in Nigeria. Still, on efforts distribution, it is worthwhile to note that Nigeria is still a developing country with over half of its population living below the poverty line. Hence, international assistance in the form of technology transfer and capacity building are still required.

Exploiting renewable energies in the country and energy efficiency practice

The energy sector is no doubt the biggest source of GHG emissions in the world as well as in Nigeria. Thus, for Nigeria to achieve its socio-economic development goals while maintaining a low carbon economy, a radical change is needed in the energy system of the country. The role of renewable energy in limiting GHG emissions cannot be ignored. For Nigeria to provide energy for its entire population while limiting GHG emissions, all forms of renewable energies needs to be exploited. Nigeria is blessed abundantly with nearly all forms of renewable energy. Solar energy is the most available renewable energy in the country. Nigeria receives average solar irradiation of 3.5 – 7 kWh/m2 as you move from the southern part of the country to the northern part (Akorede et al., 2017). The country also has large biomass energy resources estimated around 13 million hectares of wood, 61 million tonnes of animal waste annually, and 83 million tonnes of crop residues (Agba et al., 2010). Furthermore, the country also has some margin of wind energy with wind velocity of 3.0 – 3.5 and 4.0 – 7.5 m/s at 10 m height in the southern and northern regions respectively (Dioha et al., 2016). The potential of other renewables such as geothermal and ocean thermal are not yet quantified in the country. However, Nigeria has the option of combining the already mature renewable energy technologies in the country to provide energy for its citizens which will, in turn, decouple adequate energy supply from GHG emissions in the country. For instance, rooftop solar PV technology and solar water heaters can be employed in the residential sector of the country. The residential sector accounts for over 50% of the total energy consumption in the country. This scale of effort alone will go a long way towards reducing electricity demand from the fossil fuel based supply system. Emodi and Yusuf (2015) had earlier opined that the Nigerian government needs to pay serious attention to the deployment of renewable energy technologies in the country if anything near electricity for all in the country is to be achieved in the near future.

While acknowledging the role of renewable energy in low carbon transition, it is also worthwhile to highlight the role of energy efficiency and energy conservation. Energy efficiency practices and energy conservation will go a long way to reduce the demand for energy in the country, which will in turn help in providing energy for those who do not have access to it as well as reducing the combustion of fossil fuel for electricity generation which releases GHGs. With respect to this option, emphasis needs to be laid on demand-side management techniques as well as phasing out of inefficient appliances in the country such as incandescent bulbs in the residential/commercial sectors and sub-critical boilers in the industry sector of the country.

Robust financing mechanisms and fiscal incentives

Financial investment and fiscal incentives are required in the low carbon transition agenda. Thus, there is need to develop innovative financing schemes that will reduce the cost of low carbon technologies for consumers as well as being a profitable project for investors. At a national level, there is the strong need for mobilization of funds both within and outside the country. From within, the federal government of Nigeria needs to apportion a reasonable proportion of the national budget to the energy sector given the importance of this sector in the wellbeing of the country. Taxes and levies should be laid on industries that produce a significant amount of GHG emissions during operation and a low carbon development fund should be established. Since Nigeria is a mixed type of economy, the private sector also has a role to play in the mobilization of funds internally. The government should open up the energy sector in ways that will get the private institutions such as the commercial banks to start providing funds for clean energy development projects. When strong efforts have been made internally, then Nigeria can have a good case when seeking international funds from bilateral agencies and donors to augment whatsoever has been made internally.

To keep the sustainable development agenda on the right track in Nigeria, government needs to incentivize private investors through guarantee schemes, provision of equity in investments, removal of import duties on clean energy technologies, subsidies, and grants as these policies and schemes will go a long way to reduce the bottlenecks that the private sectors would have faced while investing in clean energy technologies. Moreover, these incentives will go a long way to reduce the price of low carbon technologies in the country and thus, the poor can afford them which will, in turn, accelerate the transition to modern energy while limiting GHG emissions.

Education and awareness for sustainable development

Despite global efforts in response to climate change, it may be noted that many Nigerians (especially those living in the remote villages) are not informed about the scale of this problem and its future implications. Knowledge is described as power; it empowers civil societies, communities, and individuals to get involved in government actions and agenda while making their choices in life. Thus, there is a need to scale up efforts in reaching out to those in the remote areas with information about sustainability. This can be done through incorporating the teaching of sustainable development in the education curriculum starting from primary school. Television, radio stations and other forms of media also have a role to play towards achieving this objective. They can provide information for those who have access to these appliances. Information will enable the citizens to know the low-carbon choices available to them and how best they can fall into this sustainable lifestyle campaign. Additionally, emphasis needs to be paid to cultural and religious beliefs. Many Nigerians rely on what their clerics teach without paying adequate attention to scientific evidence. Thus, education needs to begin with the community and religious leaders because it is only when they are properly informed about the current issues facing the society, can they be willing in full capacity to convince their subjects and members of their faith communities. Adopting this option will help to lower other factors that may contribute to GHG emissions and thus expand the carbon space for Nigeria.

Monitoring and evaluation of low carbon development projects

The menace of corruption cannot be ignored in any discourse of socio-economic development of Nigeria. The present energy situation in the country may be partly traced to the severe corruption in the power sector. As Nigeria journeys in the lane of low carbon development, clean energy projects will be developed which will require huge financial investments. For Nigeria to ensure that these finances are used for the appropriate purposes, projects need to be monitored from the conceptual stage to the commissioning stage. In between, frequent evaluations need to be made to ensure that things are working according to plan as well as identifying potential risks for success. To ensure more transparency, experts from donor organizations may also be involved in the evaluation meetings. Additionally, for effective planning and decision making, there is the need for communal participation at all levels in the development of projects. Their presence and inputs will help to guide investments in the appropriate technologies while ensuring fairness and transparency during the entire projects.

CONCLUSIONS

Nigeria has the highest number of persons living without access to electricity and clean-combustible cooking fuels in Africa. It has also been called upon to reduce its GHG emissions in support of global efforts towards combating climate change. For Nigeria to achieve anything near this twin objective of satisfying unmet energy demand as well as limiting GHG emissions, innovative policies and financing mechanisms are needed. Greater emphasis needs to be paid on creating awareness of the severe impacts of climate change while drawing on the full potentials of low carbon energy sources in the country. If eyes are taken away from these options, the double objective of energy access and climate mitigation by 2030 will only remain an illusion for Nigeria.

Footnotes

[1] Source: (World Bank, Sustainable Energy for All (SE4ALL) database from the SE4ALL Global Tracking Framework led jointly by the World Bank, International Energy Agency, and the Energy Sector Management Assistance Program)

[2] Source: European Commission, Joint Research Centre (JRC)/Netherlands Environmental Assessment Agency (PBL). Emission Database for Global Atmospheric Research (EDGAR), EDGARv4.2 FT2012: edgar.jrc.ec.europa.eu.

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The U. S. Fracking Boom: Impacts on Global Oil Prices and OPEC

By Manuel Frondel, Marco Horvath, Colin Vance

The authors are with RWI Leibniz Institute for Economic Reserach, Germany, and can be reached at: frondel@rwi-essen.de, horvath@rwi-essen.de, and vance@rwi-essen.de.

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See footnote at end of text.

After a steady decline spanning several decades, U.S. crude oil production rebounded in 2008 owing to the increased adoption of hydraulic fracturing, a technology otherwise known as fracking. In conjunction with horizontal drilling and micro-seismic imaging, the use of this technology, originally developed for the exploration of natural gas, allows for tapping into oil reservoirs that are trapped in shale siltstone and clay stone formations (Maugeri, 2012). Hence, oil extracted on the basis of fracking techniques is commonly referred to as shale oil to differentiate it from crude oil obtained by conventional drilling methods.

To date, the only country that permits fracking on a large scale is the U.S. (Kilian, 2017). Many other countries are highly reluctant to employ this technology because of its potentially negative implications for the environment, notably hazards that may arise from water pollution and seismic tremors (Jackson et al., 2014). With the beginning of the surge in shale oil production in late 2008 (Kilian, 2017), U.S. crude oil production steadily increased until the end of 2014, with the share of shale oil in total U.S. production rising from about 6% in January 2000 to almost 50% at the end of 2014 (see Figure 1). Owing to fracking, U.S. crude oil production almost doubled over the past 15 years.

Thus, the advance of fracking and the associated recovery of the U.S. oil production is often called a game changer for the global oil market. The peak oil hypothesis – the idea that global oil production will reach a maximum after which production steadily decreases – has thereby been dealt another blow, ignoring as it does the impact of higher oil prices in making more expensive oil extraction technologies profitable (Baumeister and Kilian, 2016). The recovery of the U.S. oil production as a consequence of fracking is just one manifestation of this price mechanism, ensuring the continued satiation of the global demand for oil.

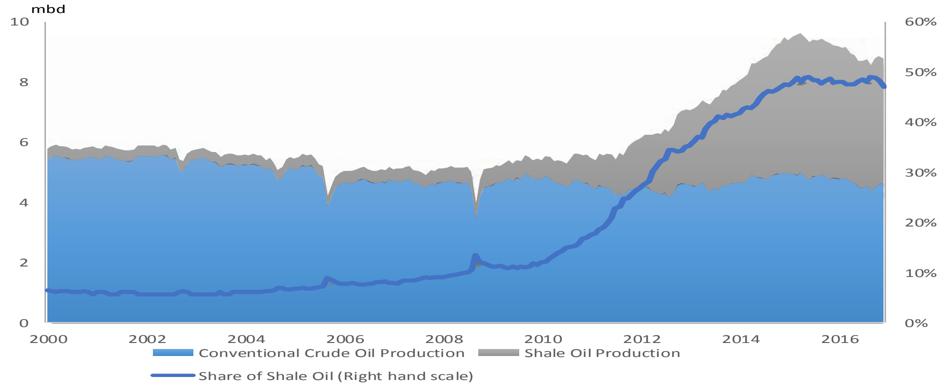

Figure 1 - Shale Oil and Total Crude Oil Production in the U.S. in million barrels per day (mbd) and Share of Shale Oil in Total U.S. Production

The importance of fracking may even further increase given that numerous other Non-OPEC countries contemplate intensifying the usage of this technology. In addition to Australia, India, and Russia, which is among the world's largest oil producers, several European countries, such as the UK and Romania, have commenced investigating the potentials of fracking (EIA, 2013). As a result, media reports frequently convey the impression that the market power of the Organization of the Petroleum Exporting Countries (OPEC), if still existing at all, has drastically diminished. With about 33 million barrels per day (mbd) in 2016, OPEC contributed more than one third to the world's total crude oil production of about 92 mbd and was hence the world's most important crude oil supplier.

Without a doubt, the U.S. fracking boom is an example of a technological change in a single industry of one country affecting international trade worldwide (Kilian, 2017), not least world oil prices and the behavior of the OPEC cartel.[1] With world oil prices shrinking by $49 per barrel (bbl) between June and December 2014 (Figure 2), Saudi Arabia led an effort to reverse OPEC's longstanding strategy of defending oil prices to defending market shares. This entailed refraining from its former behavior of curbing oil production to stabilize world oil prices.

Prior to this change, the 12 OPEC members usually agreed upon individual production allocations for each country that effectively set an upper limit, or quota, for the total OPEC production level. This strategy was predicated on the idea that OPEC's profits could be maximized when the production quota is optimally set (Griffin, 1985). Frequently, however, the actual OPEC production level substantially exceeded the announced quota. In December 2016, for example, OPEC production exceeded the quota by about 3 mbd.

At its November meeting in 2016, OPEC changed its strategy again and, in a broad alliance with Non-OPEC oil producing countries, most notably Russia, decided to cut global production by 1.2 mbd to push world oil prices higher. The cut in OPEC production was officially reconfirmed in January 2017, when OPEC announced the new quota of 32.5 mbd (OPEC, 2016). Recently, OPEC announced that this quota will be valid until December 2018 (OPEC, 2017). This raises the question about OPEC's power to influence global oil prices and the respective role that fracking plays.

Figure 2 - Global Crude Oil Prices

Adapting the supply-side model proposed by Kaufmann et al. (2004) to assess OPEC's long-term ability to influence real oil prices, we have investigated the effect of the increase in U.S. oil production due to fracking on both global oil prices and OPEC's market power. Drawing on monthly data on the U.S. oil market spanning from January 2000 to December 2016, we employ an Error Correction Model (ECM) to gauge the short-run effects of fracking on global oil prices and on OPEC's ability to steer the market. Among our key results based on research that will be published as Ruhr Economic Paper (see http://en.rwi-essen.de/publikationen/ruhr-economic-papers/), there is a statistically significant negative long-run relationship between increased U.S. oil production and global oil prices. A similarly negative influence is found for OPEC supply volumes that exceed the OPEC quota, indicating that OPEC still matters.

The question now is whether the effects detected for the past will also be valid for the future. Presumably due to the recovery of global oil prices in the aftermath of the OPEC decision at the end of 2016, but probably also encouraged by OPEC's announcements with respect to production cuts, U.S. oil production from fracking has been revitalized, which will put downward pressure on global oil prices. It thus seems unlikely that global oil prices will substantially spike in the near future. This assumption seems all the more warranted given that growing calls for massive abatement measures to combat climate change may hasten the arrival of peak demand, that is, the all-time maximum in global oil demand after which demand will decrease. The likelihood that peak demand materializes anytime soon, however, appears to be low. Unfortunately for the earth's climate, the development of global oil demand due to the world's economic performance, rather than any greenhouse gas regulation, is likely to be the driving factor of CO_2 emissions in the near future, confirming yet again Bill Clinton's mantra: It's the economy, stupid!

Footnote

[1] Figure 2 also illustrates the influence that local circumstances can have on price trajectories: The divergence in prices for WTI and Brent seen between April 2011 and May 2014 was the result of an increased shale oil supply, paired with a bottleneck in refinery and transport infrastructure in the U.S. that prevented competition of WTI with imports (Borenstein and Kellogg 2014; Kilian 2016). At the end of 2015, the price differential virtually vanished due to the expansion of transport infrastructure, allowing light crude oil that used to be landlocked in the center of the U.S. to reach existing refineries.

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Supply and Demand Assumptions Behind EIA's Alternative Oil Price Paths

By David Daniels

David Daniels is Chief Energy Modeler at the Energy Information Admihistration. He may be reached at David.Daniels@eia.gov

Analysts often use long-term energy system models to quantify the broader impacts of persistent changes to oil supply or demand. Oil prices are important determinants in these models, and their price paths are typically given as exogenous inputs. This can lead to inconsistencies between the often implicit assumptions used to generate exogenous oil price paths and the assumptions built into a model designed to use these prices, which could result in misleading model results.

Oil prices are exogenous in long-term energy models for a number of reasons. National or regional energy models lack the geographic scope to determine oil prices, since oil is a globally-traded commodity. Global models often lack sufficient representation of either oil producers or oil consumers to determine market-clearing prices. Generating a long-term oil price projection can be problematic, so modelers often rely on an external source for this information.

Short-term models typically forecast oil prices using various time series regression techniques, yet they are seldom used as inputs to long-term models. Ideally, the results from short-term and long-term models should align with each other, since they attempt to describe the same market; but, differences in structure, assumptions, and determinants of oil prices between short-term and long-term models can yield diverging views of oil markets in the medium term. For instance, while long-term energy models typically assume that oil supply and demand will remain at equilibrium over time, short-term models don't always require production and consumption to be equal since period-to-period stock changes are assumed to balance the market.

Some models use oil price projections published by the U.S. Energy Information Administration (EIA) in its Annual Energy Outlook (AEO), including prices from the Reference, High Oil Price, and Low Oil Price cases. AEO results are determined by the National Energy Modeling System (NEMS), which is a modular, partial-equilibrium model of the U.S. energy system that projects the U.S. energy system in annual increments through the year 2050. As with any national model, NEMS relies on an initial, exogenous oil price path, called the World Oil Price (WOP). The WOP is a time series of annual average prices, each meant to represent the market clearing price of a hypothetical global crude oil commodity (i.e., Brent), extending from the last year for which historical prices are available to the end of the projection period. NEMS includes a mechanism to adjust the prices of crude oils of different qualities (e.g., light, sweet crude) due to changes in U.S. production over time. Thus, the prices ultimately published in the AEO Reference, High Oil Price, and Low Oil Price cases can differ from their respective input WOP prices.

Three WOP paths are constructed for each AEO: reference (WOP-R), high oil price (WOP-H), and low oil price (WOP-L). All three price paths incorporate historical annual average Brent spot prices. In the forward projection period, they represent the oil prices one might expect under a given scenario. Importantly, because NEMS models the reaction of the U.S. energy system to changes in the global oil price, all three WOP paths themselves are constructed assuming no change to U.S. supply or demand. Therefore, any differences among the three WOP price paths must be due to changes in supply and/or demand outside the U.S. The reference oil price path, WOP-R, uses a forecast of the Brent crude price taken from EIA's Short-Term Energy Outlook (STEO) monthly forecast, converted from nominal to real dollars and annualized, for the first two years of its long-term projection. Thereafter, a simplified standalone global partial equilibrium model is used to guide the evolution of the price path over time, with changes to supply and demand by region and over time informed by historical trends and analyst judgment. The WOP-R represents the prices EIA analysts would expect under the global conditions represented by the AEO Reference case, which include evolutionary technological change and current laws and policies. Since it is extremely unlikely that no new policies will be enacted that affect the price oil before 2050, this WOP-R path is both extremely unlikely and, moreover, potentially biased after the first two years. For example, additional policy actions outside the U.S. that reduced the global demand for oil would, presumably, lower the future price of oil below the WOP-R. For investment and planning purposes, rational oil market participants would likely anticipate such policy actions to the extent of their ability to do so; accordingly, their forecasts may be systematically different from WOP-R.

The high and low oil price paths (WOP-H and WOP-L) are meant to represent relatively extreme, but non-specific conditions outside the U.S. that cause global oil prices to increase or decrease with respect to WOP-R. Operationally, the High Oil Price and Low Oil Price cases of the AEO are sensitivity cases; conceptually, WOP-H and WOP-L represent a series of regional and global events, both shocks and deviations from long-term trends, whose combined effect changes both non-U.S. oil supply and non-U.S. oil demand. It is necessary to assume near-term shocks in order to move the prices away from the STEO forecast in the first two years; however, global oil markets tend to absorb shocks relatively quickly, and one would expect the prices to revert back to the WOP-R over time. So, in addition to near-term shocks, WOP-H and WOP-L also assume systematic deviations from the long-term non-U.S. supply and demand trends to keep the WOP-H price high and the WOP-L price low.

In the WOP-H case, non-U.S. oil supply is assumed to decrease and non-U.S. demand increase; in the WOP-L case, the opposite is assumed. These are not price-mediated changes to production and consumption, but rather structural changes to the market. For instance, in the WOP-L case, the changes could correspond to additional policy actions and/or consumer choices that combine to keep demand low, additional undiscovered resources and technology advances that enable even lower-cost production of crude oil, global geopolitical conditions that favor oil production and trade, etc. The changes assumed for supply and demand push prices in the same direction (lower in WOP-L, higher in WOP-H), but they push equilibrium quantities in opposite directions. For both alternate oil price cases, it is assumed that the quantity changes induced by the changes to supply and demand roughly offset each other at the global level, keeping global production and consumption levels similar to the levels in the Reference case.

The three oil price paths are used as inputs to NEMS to understand the reaction of the U.S. energy system to different oil prices. As some of the modules within NEMS use perfect foresight, these prices can be interpreted as the market's expected value of average annual oil prices over time. One implication of this is that even the supply and demand shocks assumed in order to generate the WOP-H and WOP-L price paths are anticipated by the market. On top of these expected annual values, NEMS assumes that markets also anticipate price volatility in line with historical price volatility.

While the AEO High Oil Price and Low Oil Price cases are constructed as internally-consistent global scenarios, interpreting the scenarios can be difficult. Technically, the High Oil Price case models a future in which severe supply and demand changes outside the U.S. are anticipated by the market, but none of these changes affect the U.S. supply of or demand for oil at all. U.S. production and consumption are only affected by the different global oil prices. That scenario, though possible, would be extraordinary. The AEO Low Oil Price case is designed to be similarly extreme. Thus, although constructed around internally-consistent global scenarios, the AEO oil price cases are primarily interpreted as sensitivity cases.

The prices published in the AEO are sometimes used by other energy modelers as inputs to their models. Like any other exogenous inputs, such as population or economic growth, the assumptions behind these oil prices should be harmonized with the assumptions of the model scenario in which they are used. For example, in any global normative scenario, changes outside the U.S. could be needed that may reduce global demand for oil below the levels assumed in the construction of WOP-R. Decreased global demand should have an impact on oil prices. It may therefore be inconsistent to assume the same oil prices published in the AEO Reference case (close to WOP-R) in a global normative scenario.

EIA is continually working to improve its modeling capability. While the oil prices published in the AEO are determined largely outside the NEMS model, EIA is currently developing a new global hydrocarbon (oil and gas) supply model (called GHySMo) to be used for its International Energy Outlook. This new model will include the ability to adjust supply assumptions at a very granular level and explore the implications of these changes on global and regional prices. This capability should enable EIA and non-EIA modelers to ensure that oil prices remain consistent with a wide variety of global energy scenarios.

Call for Papers

The 6 th IAEE Conference: Energy Exploitation & Cooperation in ASIA

Wuhan, China - November 2-4, 2018

Dear IAEE Member,

The **IAEE-International Association for Energy Economics** and the **CUG-China University of Geosciences** have the pleasure to invite you to attend this conference entitled

Energy Exploitation & Cooperation in Asia

that will be held at the Optics Valley Kingdom Plaza Hotel **, Wuhan, China**, **2-4 Nov. 2018**. The conference will be organized by School of Economics & Management, CUG(Wuhan), School of Humanities & Economic Management, CUGB, School of Economics & Management, BUAA, Institutes Of Science And Development, CAS and Hubei University of Economics.

Abstract submission deadline: May. 31, 2018

Some suggested topics for discussion (but not limited to):

- Energy pricing issues within Asian economies
- Forecasting Asian energy demands and supplies in total and by primary energy source and geography
- Forecasting needed energy infrastructure investments in Asia
- Opportunity and challenge in energy exploitation and cooperation
- National security and strategic implications of meeting Asian energy growth
- Energy efficiency improvements
- Possible changes in the structure of Asian energy markets
- The Impact of Advanced Energy Technologies
- Energy and Electricity markets reform

- Grid and Power industry
- Climate change policy and effective CO2 removal
- Investment issues in liberalized markets
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- Electricity and Gas Trading
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Authors are encouraged by the Scientific Committee to organize sessions focused on specific topics. Proposals of specific topics should be submitted toiaeeasia2018@cug.edu.cn by **July 12 2018**.

Submitted abstracts should be of one or two pages in length, comprised of: (1) overview, (2) methods, (3) results and (4) conclusions.

A sample abstract and guidance for abstract submission online can be found on the conference website.

Learn more about the conference by visiting

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Wuhan is the capital of Hubei province, China, and is the most populous city in Central China. Because of its key role in domestic transportation, Wuhan was sometimes referred to as "the Chicago of China" by foreign sources. Wuhan is world-famous for its trove of historical sites and enchanting natural scenery attractions, including the Yellow Crane Tower, East Lake Green Road, Hubei Provincial Museum, Jiqing Street and Chu River and Han Street, etc.

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Contact the Conference Secretariat:
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CONFERENCE OVERVIEW

The 3rd Eurasian Conference will take place in Tbilisi, Georgia, on October 18 -20, 2018.

In addition to its rich program, with its informal social functions, the conference will provide a unique opportunity for networking and enhancing communication amongst energy professionals from business, government, academia and other circles worldwide.

The conference program is being prepared by an International Program Committee to ensure that critical issues of vital concern and importance to governments and industries are presented, considered and discussed from all perspectives. In this context, many existing sessions on key current energy issues, featuring internationally established speakers and lively discussions, can be expected. The local arrangements are being planned by a Local Organizing Committee to guarantee excellent logistics at best quality. The Sponsorship Committee works to make sure the rich program and arrangements of the conference get available to delegates at affordable rates.

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The general topics below are indicative of the types of subject matter to be considered at the conference.

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- **Economics of new energy sources and advanced energy technologies**
- **Energy efficiency challenges**
- **Regulation in electricity and natural gas markets**
- **Design of energy markets**
- **Energy policy under emission constraints**
- **Oil and gas transportation and pipelines**
- **Hydropower and renewable energy issues**
- **Geopolitical impacts on the energy sector in Eurasia**
- **Green energy and economic growth**
- **Energy poverty, subsidies and tax policies**
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Conference Venue: Georgian Technical University, Tbilisi

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The deadline for receipt of abstracts for Concurrent Sessions is **Monday May 14, 2018.**

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We are pleased to announce the Call for Abstracts for the 3rd IAEE Eurasian Conference,
"Energy Security & Investment Opportunities in Eurasia: Regional Energy Trading and Market Development"
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The latter category aims to encourage participation not only from industry but also from the financial, analyst and media/commentator communities. Presentations are intended to facilitate the sharing of both academic and professional experiences and lessons learned. It is unacceptable for a presentation to overtly advertise or promote proprietary products and/or services. Those who wish to distribute promotional literature and/or have exhibit space at the Conference are cordially invited to take advantage of sponsorshipopportunities.

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Presenter attendance at the conference

At least one author of an accepted paper must pay the registration fee and attend the conference to present the paper. The corresponding author submitting the abstract must provide complete contact details—mailing address, phone, fax, e-mail, etc. Authors will be notified by **June 25, 2018**, of the status of their presentation. All accepted abstracts will be published in the online conference proceedings while authors wishing to publish full papers can do so if desired. Authors whose abstracts are accepted will have until **August 6, 2018**, to submit their final papers for publication in the online conference proceedings. While multiple submissions by individuals or groups of authors are welcome, the abstract selection process will seek to ensure as broad participation as possible: each author may present only one paper at the conference. No author should submit more than one abstract as its single author. If multiple submissions are accepted, then a different author will be required to pay the registration fee and present each paper or poster. Otherwise, authors will be contacted and asked to drop one or more paper(s) for presentation.

Concurrent Session - Abstract Format

Authors wishing to make concurrent session presentations must submit an abstract that briefly describes the research or case study to be presented.
The abstract must be no more than two pages in length and must include the following sections:
a. **Overview** of the topic including its background and potential significance
b. **Methodology:** how the matter was addressed, what techniques were used
c. **Results:** Key and ancillary findings
d. **Conclusions:** Lessons learned, implications, next steps
e. **References** (if any)

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LOCAL CONFERENCE PARTNERS

Oil Supply and Demand in Canada's Energy Future: Current Context and Long Term Trends

By Matthew Hansen, Chris Doleman and Abha Bhargava

The authors are with Canada's National Energy Board. Matthew Hansen is a Technical Specialist, Chris Doleman is a Market Analyst and Abha Bhargava is the Director. Dr. Bhargava may be reached at Abha.Bhargava@neb-one.gc.ca

See footnotes at end of text.

INTRODUCTION

Canada is a large global producer of oil, and a relatively large user of oil products on a per capita or gross domestic product basis. Canadian crude oil production has increased significantly in recent years, inspired by technological change, investment, and high oil prices. This increase exists in a context of growing global oil demand, and expectations for significant growth in the near future.

While Canadian oil production has increased, Canada has also taken steps to reduce its own fossil fuel use, including oil products. This is reflected in various policies and regulations put in place at various levels of government over the past decade. Like other developed nations, demand for oil products has been flat during this time period. What sets Canada apart is the relative importance of energy production to its economy, as well as the fact that producing energy accounts for a relatively large share of Canada's own energy use (much of which is natural gas) and emissions.

This dynamic makes Canada an interesting case study for the paradox of fast growing global oil demand in the near-term, and expectations that global oil demand will be reduced in the long-term. Using recent projections from the Canadian National Energy Board's (NEB's) Energy Futures series of long-term supply and demand projections, this article contextualizes this paradox from a Canadian perspective.

CANADIAN HISTORICAL CONTEXT

In 2017, Canada produced an estimated 4.3 million barrels of oil per day (MMb/d), about 4% of total global production. Production also increased from 2.6 MMb/d in 2005, an increase of 67% over the 2005-2017 period. The recent increase in Canadian production has mainly come from the oil sands in Alberta. Driven largely by the sustained price signal of near $100 oil in the 2010-2014 period, oil sands production increased from 1 MMb/d in 2005, about 40% of Canadian production, to 3 MMb/d in 2017, nearly 70% of total Canadian production.

Canada consumes a lower share of global oil demand, approximately 2% in 2017. That said, Canada is a relatively intensive user of oil, with the third largest oil consumption per capita among OECD countries. Canadian demand for oil products, such as gasoline and diesel, has been relatively flat over the past few years, although the overall trend masks some interesting dynamics. The 2008-2009 recession reduced Canadian oil demand, and some larger provinces in Canada such as Ontario and Quebec, have not recovered to their pre-recession peaks. Various policy initiatives put downward pressure on oil demand in this time frame, including biofuel blending mandates for gasoline and diesel, new vehicle emission standards, and the introduction of carbon pricing systems in various provinces[1]. Some areas have experienced growth in oil consumption over this period, largely associated with industrial and economic growth related to resource industries. However, in recent years lower oil prices have reduced economic activity in those regions, which impacted oil consumption. For example, diesel used for transportation in Alberta increased by over 50% from 2005 to 2014, but declined nearly 30% from 2014 to 2016 (Statistics Canada, 2017).

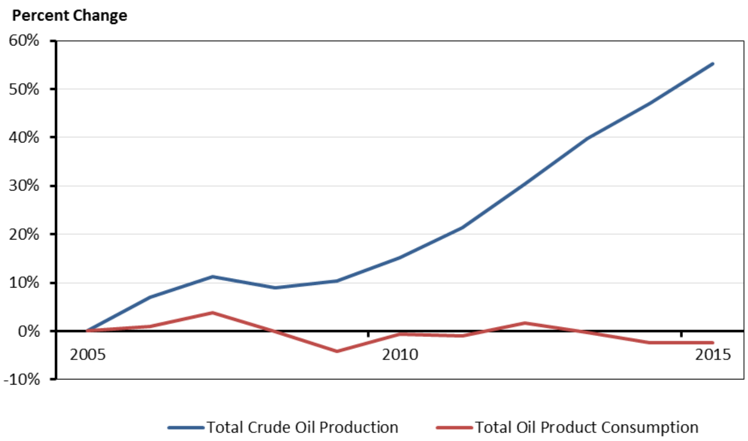

Figure 1: Growth in Canadian crude oil production vs oil product demand since 2005

Figure 1 demonstrates these differing trends. It compares the growth of crude oil production and oil product consumption relative to 2005. While oil production is an important part of the Canadian economy and influences oil consumption, overall Canadian production and consumption trends have clearly moved in different directions in recent history.

FUTURE EXPECTATIONS

Looking ahead, the divergence between production and consumption is likely to continue. The NEB provides outlooks for both Canadian production and consumption in its Energy Futures series of energy outlooks. These outlooks include baseline Reference Case projections, as well as several sensitivity cases to test key assumptions, similar to the U.S. Energy Information Administration Annual Energy Outlook series.

Figure 2 shows the NEB's latest Reference Case crude oil production outlook, Canada's Energy Future 2017: Energy Supply and Demand Projections to 2040 (EF2017). EF2017 projects that Canadian crude oil production will increase 2.3 MMb/d to 6.3 MMb/d in 2040, an increase of 57%. Similar to recent trends, oil sands production dominates the growth. Within oil sands, growth is dominated by in situ production, where oil sands bitumen is generally extracted by injecting steam into reservoirs, and limited long-term increases in large-scale mining and upgrading facilities.

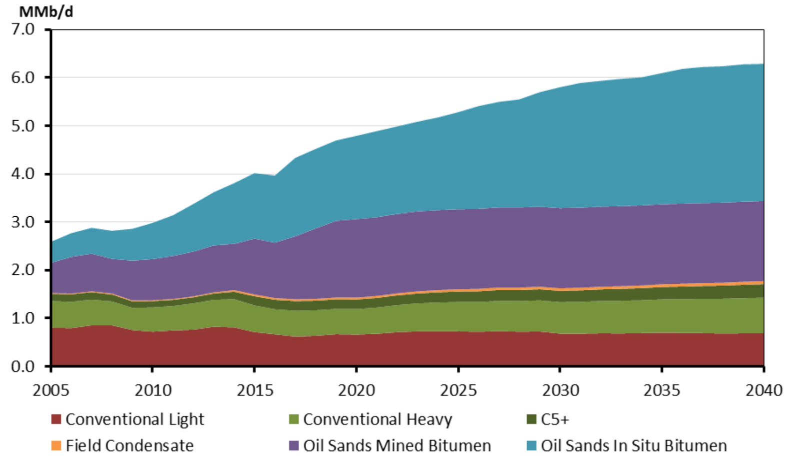

Figure 2: Canadian crude oil production by type

In the longer term, production continues to increase given that the prices assumed in the EF2017 Reference Case ($80 per barrel long term, based on a consensus review of various forecasters) are high enough to incent additional production. Incremental production growth is largely through expansions to existing projects (adding 1.2 MMb/d by 2040) as opposed to greenfield projects (adding 0.4 MMb/d).

In the EF2017 Reference Case, oil product demand remains below its 2007 peak due to numerous factors including macroeconomics, policy, and technology developments.

Perhaps the key policy impact is vehicle emission standards for passenger and freight vehicles, which are expected to increase efficiency across both passenger and freight fleets over the projection period. Another one of the important policy factors is carbon pricing. As noted earlier, some provinces have had some type of carbon pricing since 2008, and in 2016 the Federal government of Canada announced the Pan-Canadian Framework on Clean Growth and Climate Change[2]. One of the cornerstones of this framework is the Pan-Canadian Approach to Pricing Carbon Pollution[3]. EF2017 includes a simplified representation of Canadian carbon pricing where all jurisdictions converge to a $50/tonne price (nominal terms) in 2022 and beyond.

The Pan-Canadian Framework also includes several other initiatives that could have significant implications for oil demand but are still under development as of February 2018. These include a Clean Fuel Standard aiming to reduce the emission intensity of fuels, as well as a national zero emission vehicle strategy. Furthermore, if technology progresses and electric vehicles (EVs) become increasingly popular, increased adoption of EVs will impact oil demand. EF2017 EV adoption varies across the country, relatively higher in provinces with policy incentives, ranging between 5 and 25% of new sales by 2040.

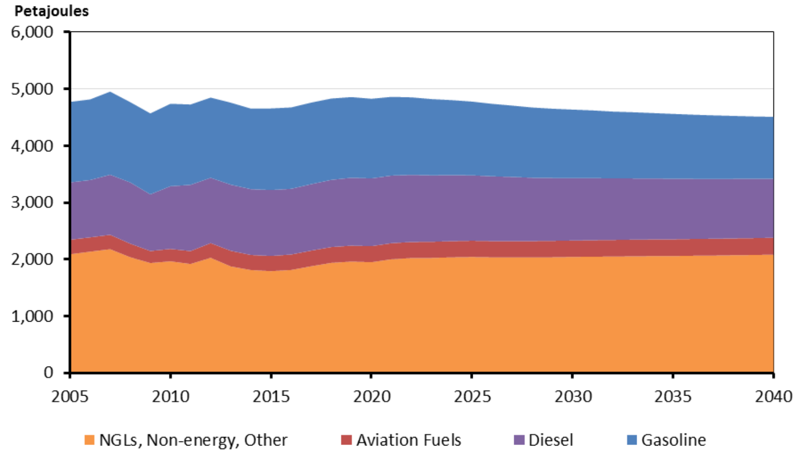

Figure 3: Canadian Oil Product Demand by Fuel

Figure 3 shows total Canadian oil product demand on an energy-equivalent basis. From 2016 to 2040 demand declines by 3.5%. Gasoline demand declines the most as emission standards and other policies reduce passenger transportation use. Aviation fuels and other oil products increase over the outlook, driven by increases in demand for air transport and as petrochemical feedstocks.

LONG-TERM UNCERTAINTIES

The outlooks discussed earlier show a country where, at assumed price levels, production looks to increase significantly in the near and long term. Alternatively, oil product demand looks to increase slightly in the very near term, although remaining below its 2007 peak, and bend downward in the longer term.

This outlook therefore assumes that the excess production will be absorbed by a global market. Specifically, it assumes that "over the long term, all energy production will find markets and infrastructure will be built as needed" (NEB 2017). However, the paradox of near-term growth globally and the possibility for declining longer-term trends pose several key uncertainties for Canadian supply and demand dynamics, and is driving some of the notable recent developments.

First, recent increases in crude oil production in Canada and the U.S. have led to situations where capacity to move oil is challenged, and the gap between regional and global benchmark prices has increased at various times[4]. This notably occurred between Brent and WTI benchmarks in the early part of the decade. For Canadian heavy crude oil prices, discounts to Brent were large in that period as well, and have once again increased rapidly in late 2017 and early 2018 (Leach 2017).

Second, increasing global climate action over the long term also creates several uncertainties for Canadian oil supply and demand, including domestic and global technology and policy trends. The alternate cases in EF2017 look at how these uncertainties might compare to the Reference Case. The Higher Carbon Price Case involves an increasing carbon price over time, while the Technology Case has the same increasing carbon price along with greater penetration of select technologies such as electric vehicles and improved oil sands recovery using steam-solvent methods[5]. These cases also assume progressively stronger global climate action, which will put downward pressure on global oil demand, and therefore these cases have progressively lower crude oil price assumptions. Figure 4 illustrates the crude oil price assumptions, as well as 2040 production and consumption in all three cases.

The long-term decline in global demand for oil is likely to be driven by aims to reduce emissions and increasing costs of carbon pollution, which implies that reducing the emission intensity of a barrel produced will be important for future production to be competitive[6]. Because three of the fifteen global crudes with the highest life-cycle carbon intensities currently measured[7] are Canadian oil sand crudes, using energy more efficiently will be more essential to its future competitiveness than the average global benchmark crude.

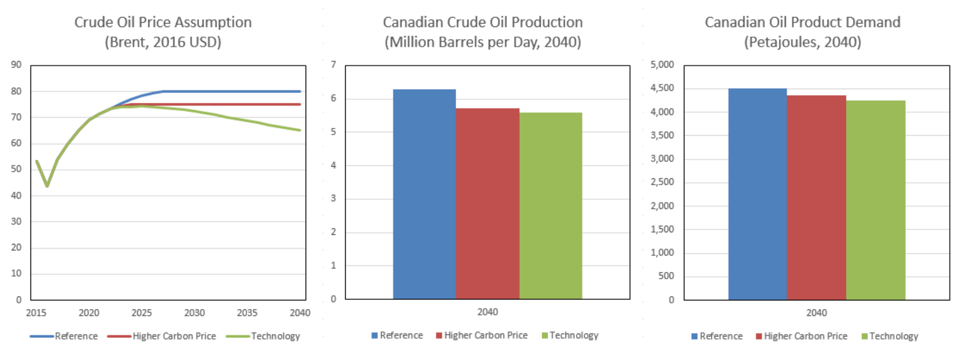

Figure 4: EF 2017 Crude Oil Price Assumptions and 2040 Crude Oil Production and Oil Product Demand Projections

One promising emerging oil sands technology to reduce emissions is by injecting solvents along with the steam into bitumen reservoirs. This will reduce the natural gas use requirements, reduce the emissions intensity, and improve the longer-term economics of in situ production. The EF2017 Technology Case assumes a greater penetration of this technology, which is the key reason why crude oil production remains at levels similar to the Higher Carbon Price Case despite a significantly lower crude oil price (see Figure 4)[8].

The goal of improving competitiveness in a world of reduced emissions and oil demand is central to many of the key policy initiatives that affect the oil producing sector in Canada. In particular, Alberta recently adopted its Carbon Competitiveness Incentive regulation[9], which provides an incentive to reduce emissions while reducing average carbon costs for emission-intensive, trade-exposed indus-

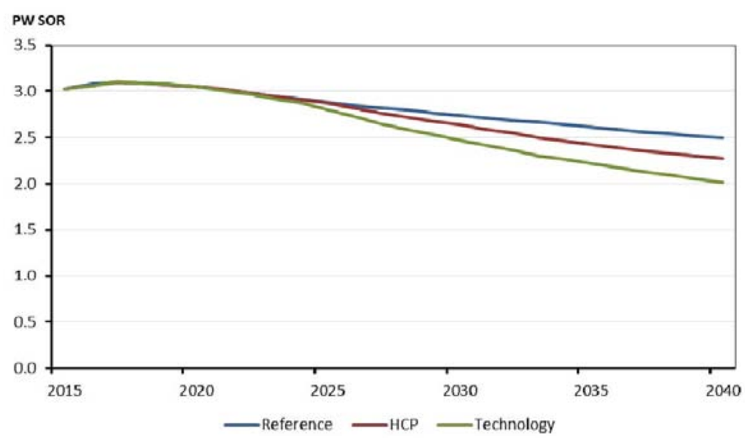

Figure 5: Average Annual Production-Weighted Steam Oil Ratio of Thermal Oil Sands Production, All Cases, EF2017

tries, such as the oil sands. Alberta is also implementing a 100 mega tonne cap on emissions from the oil sands[10], which further incentivizes reducing emissions intensity. Figure 5 shows the steam oil ratio trends in the EF2017 scenarios, which captures the ratio of steam needed to produce a barrel of oil; a key measure of oil sands energy efficiency and productivity. These trends are integral to both reducing Canada's fossil fuel demand trends and increasing production by improving oil sands economics.

CONCLUSION

In reviewing the supply and demand dynamics for Canadian oil, it is clear that the global oil market paradox of increasing supply and demand in the near term, and possibilities for declining demand in the longer term, has been very influential in current Canadian developments, and will likely continue to be so in future trends. Despite strong recent growth in production and demand worldwide, the possibility for longer-term declines in oil use poses additional questions. For Canada, declining domestic oil demand is a result of some of the new policy developments which have occurred over the past few years. If the world acts similarly, a key question for Canada's energy system is if its oil production can adapt through technological developments to maintain competitiveness in a demand-constrained world. Since the oil sands are also an expected demand growth area for natural gas in Canada, this question is also important for that commodity. As natural gas faces a similar paradox, the Canadian context shows the questions on the future of oil supply and demand go far beyond a single commodity.

Footnotes

[1] Alberta introduced its Specified Gas Emitters Regulation, an intensity based approach, in 2007 (this was replaced by the Carbon Competitiveness Incentive Regulation in 2018) B.C.'s carbon tax was put in place in 2008, and Quebec joined the Western Climate Initiative cap-and-trade system in 2013. For a review of how B.C.'s carbon tax has impacted GHG emissions see Murray and Rivers (2015), while Rivers and Shaufele (2015) focus specifically on the carbon tax's impact on gasoline demand.

[2] Pan-Canadian Framework on Clean Growth and Climate Change

[3] Pan-Canadian Approach to Pricing Carbon Pollution

[4] Canada's Energy Future 2016: Energy Supply and Demand Projections to 2040 includes a scenario where crude oil export pipeline capacity is constrained in the long-term. Excess production is then carried by rail, which is more costly, and reduced net back prices paid to producers. This in turn leads to a production outlook that is approximately 10% lower than the Reference Case in the long-term.

[5] Further details can be found in EF2017.

[6] The International Energy Agency's most recent World Energy Outlook includes the Sustainable Development Scenario, which although oil demand does decline long-term, still shows a global demand of over 70 MMb/d to 2040 (IEA, 2017).

[7] ARC Energy Institute

[8] Because natural gas is used to create the steam that is injected into oil sand reservoirs, further inspection of these scenarios begins to hint at another twin paradox that we will not touch on here: the twin paradox surrounding the near and long-term supply and demand balances of Canadian natural gas. If Canadian oil sand producers are successful at achieving SOR reductions and thus reductions in natural gas use, there could be increased pressure to find global markets for the surplus natural gas.

[9] Carbon Competitiveness Incentive Regulation

[10] Oil sands emissions in 2015 were 71 Mt (ECCC, 2017)

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Indian Energy Security Status: What are the Economic and Environmental Implications?

By Nathaniel Babajide

Nathaniel Babajide is with the Centre for Energy, Petroleum and Mineral Law and Policy (CEPMLP), University of Dundee, United Kingdom. He may be reached at ababajide@dundee.ac.uk

See footnote at end of text.

INTRODUCTION

India's energy system is facing a rapidly increasing energy deficit despite the government's keen attention in developing renewable sources of energy, especially nuclear, solar and wind. Statistics from British Petroleum (BP) (2015) reveal that fossil fuels constitute more than 90% of the nation's Total Primary Energy Consumption (TPEC) with coal accounting for 56%, while crude oil and natural gas contributes 28% and 7%, respectively. This couples with the fact that India heavily depends on foreign energy to meet its domestic energy needs.

The purpose of this paper is to examine the economic and environmental implications of energy supply insecurity in India by accessing the extent to which the country's primary energy sources are efficient and diversified. The paper is structured into five sections, including this Introduction. Section 2 provides an overview of the economic, energy and environmental situation in India. Section 3 presents the methodology and results of key energy security indicators adopted. While Section 4 presents the results of the analysis performed on the considered energy security indicators, Section 5 concludes the study.

OVERVIEW OF INDIA'S PRESENT ECONOMIC AND ENERGY SITUATION

Economy and Energy Outlook

India is one of the world's fastest emerging economies despite an estimated population of over 1.30 billion people which makes it the second most populous country in the world after China (World Bank Development Indicators (WDI), 2016). The economic liberalization of 1991 ushered the country's economy into the limelight. The adopted mixed economy system has greatly fostered Indian economic performance in the last few decades and positioned it among the fastest growing economies in the world.

As illustrated in Figure 1, the country's GDP and per capita GDP growth in the last few decades have been intermittent and was sharply altered in 1991 and 2008 due to the global financial crisis but recuperated in subsequent years. In 2010, the economic growth bounced back after which it dropped to 3.7% in 2012. The GDP growth rose from 6.9% in 2013 to 7.3% in 2014 estimated at $1.6 trillion (in constant 2005 US dollar value). In sum, the Indian economy ranked third and ninth largest in terms of Purchasing Power Parity (PPP) and nominal Gross Domestic Product (GDP) respectively, in 2014 (WDI, 2016).

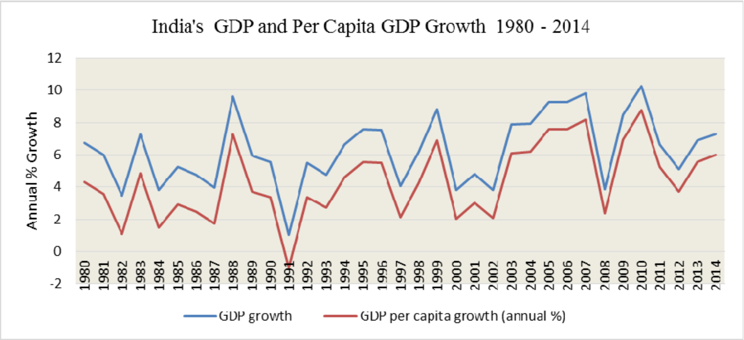

Figure 1: India's GDP and Per Capita GDP Growth 1980-2014
WDI, 2016

By using 6% of the world's primary energy, India is the third-biggest energy consuming nation (after China and United States) and sixth largest LNG importer (Energy Information Administration (EIA), 2015). This originates primarily from the country's limited domestic fossil energy resources which makes it highly dependent on foreign crude oil and natural gas imports sourced predominantly from the Middle East. Nevertheless, India's energy demand has continued to grow at an alarming rate, the pace that led to its emergence as one of the top energy importers in the world, specifically in fossil fuels.

As the most abundant domestic fossil-fuel resource, coal constitutes the lion's share of its total energy consumption. The recent growth in its coal demand has been startling, from 260.2 million tonnes oil equivalent in 2010 to 360.2 million tonnes in 2014 (BP, 2015). Like many other countries, coal is the backbone of electricity generation in India; over 60% of power production emanated from coal. After coal, oil contributes the second largest share of energy consumption as the country consumed roughly 3.85 million barrels of oil per day in 2014. This value depicts a 4.4% increase over the 2012 consumption estimate of 3.69 million b/d. Although natural gas accounts for about 7% of total energy consumption, its contribution has been declining in the last few years; it declined by 19.3% from 56.4 million toe in 2010

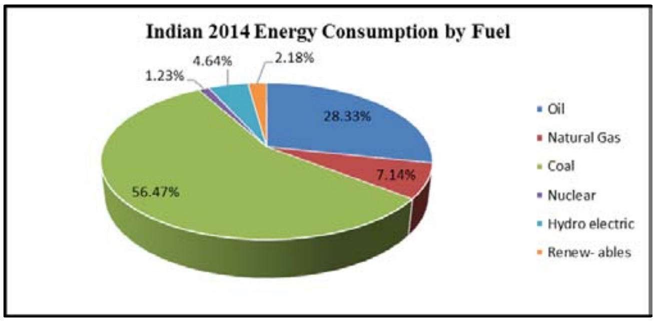

Figure 2: India's Energy Consumption by Fuel in 2014
Source: BP, 2015

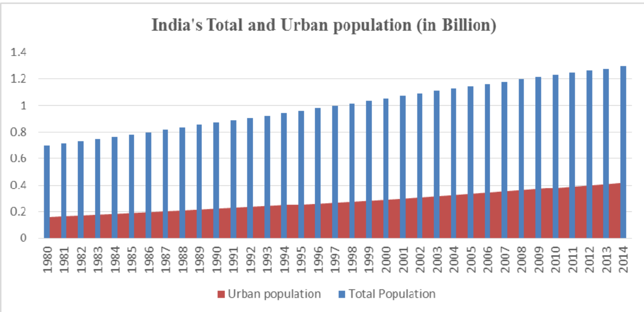

Figure 3: India's Population and Urbanisation Trend: 1980-2014 in Billions
Source: WDI, 2015

to 45.6 million toe in 2014 (BP, 2015). However hydro, nuclear and other renewables are responsible for the remaining 8%.

Moreover, the nation's population and urbanization growth rate has undoubtedly propelled a robust increase in its energy demands (WDI, 2015). Though the country launched its family planning policy as far back as 1952, it has not been able to bring its budding population growth rate under control. With the current population of 1.30 billion people and an annual growth rate of 1.23%, India is the world's second most populous country after China. This signifies that about 18% of the world's population resides in India. In a similar vein, since independence, rural- urban drift in India has been escalating as the United Nations (2007) report on the state of world population revealed that the Indian urbanization rate is faster than that of the rest of the world, and projected that by 2030, 40.76% of India's population will be dwelling in urban centres compared with around 28.4% in 2007. Therefore, India's rising population and urbanization growth places intensified pressure on energy use, urban infrastructure and environment and occurrence of any supply disruptions can cause severe strain on economic growth.

As of 2014, about 21% and 30% of India's total and rural population was respectively without electricity access (WDI, 2015). In recent years however, the country has made notable strides in improving modern energy access to the citizenry. Even with that, about 240 million people (19% of the population) are still without electricity access) while the electrified regions are still characterized by rolling electricity blackouts (EIA, 2015). The vast majority of the population without access is concentrated in few states with almost two-third residing in two most populous northern states of Uttar Pradesh and Bihar. Additionally, over 80% of population without electricity access dwells in rural areas (IEA, 2015).

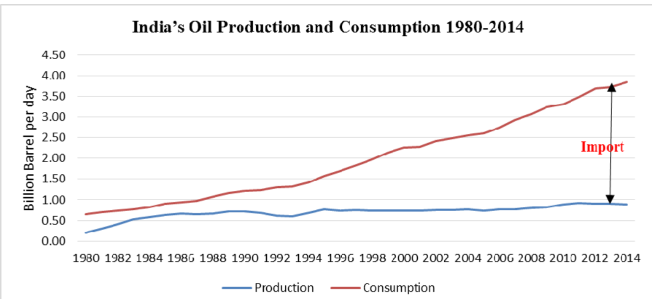

Figure 4: India's Oil Production and Consumption 1980-2014
Source: BP, 2015

Indian Oil Production, Consumption and Import

Indian energy policies are principally dominated by the issue of growing demand deficit, soaring import dependence and increased focus on renewable energy sources mainly nuclear, wind and solar energy. However, rapid economic growth has placed greater emphasis on its increasing energy demand as a source of energy insecurity. Limited fossil fuel reserves and static local production capacity are the basic characteristics of India's evolving energy insecurity. With heavy reliance on foreign energy sources before the 1980s (As depicted in figure 4), the nation's rapidly growing economy is becoming more vulnerable to the likely risks of global and regional energy supply interruptions.

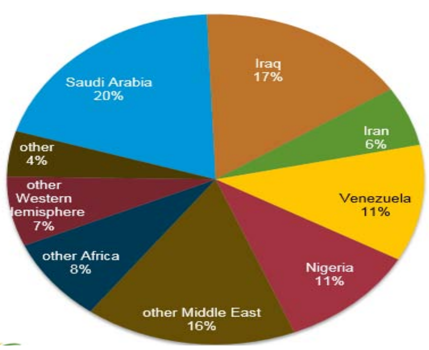

Figure 5: India's Crude Oil Imports by Source 2015
Source EIA, 2015

The Indian oil requirement has grown swiftly over the last decade while local production is relatively stagnant. The nation's domestic production can meet just about 25% of the national oil needs thereby making the country a leading net oil importer, with import volume in 2014 being 3.3 times higher than local production. With approximately 3.0 million b/d import volume, India is the third-largest crude oil importing country, behind the China and U.S. About 75% of the Indian oil requirement is imported from of a number of oil exporting countries (including Saudi Arabia, Iraq, Nigeria, Venezuela, Iran etc.) as presented in Figure 5.

In summary, the largest share of India's oil imports came from

OPEC member countries which as of 2015 accounted for about 70% of the total import while non-OPEC members supplied the remaining proportion.

Indian Energy Related Emissions and Environmental Implications

Due to its rapidly growing fossil fuel consumption and low level of energy efficiency, India presently occupies third position among the world's biggest emitters. The vast majority of greenhouse gases such as carbon dioxide (CO_2), methane and sulfur oxides emitted by India emanated from its energy sources principally through consumption of solid, liquid, and gas fuels and gas flaring. Figure 6 reveals the increasing CO_2 emission trend in India, rising rapidly from 990.98 million metric tonnes (Mt) in 2000 to 1834.11Million Mt in 2012, denoting about an 85% increase within this period. Coal is vividly highlighted as the greatest source of increasing CO_2 emission in India accounting for 69.8% of the total emission, followed by oil (23.7%) while the remaining 6.5% stemmed from natural gas in 2012. The increasing fossil fuel combustion give rise to the quantity of sulfur dioxide (SO_2) released into the atmosphere which in turn reacts with atmospheric oxygen to form acidic rain and also causes global warming.

At present, fossil fuels constitute more than three-quarter of the world's primary energy consumption and this heavy dominance of hydrocarbons accordingly poses GHG emissions and climate change threats on the world. The condition is further aggravated by high energy-consuming countries like China and India that use fossil fuels to meet their increasing energy need. Consequently, a majority of the Indian cities and towns are now facing various forms of environmental degradation signaling a global warming danger for India and world at large.

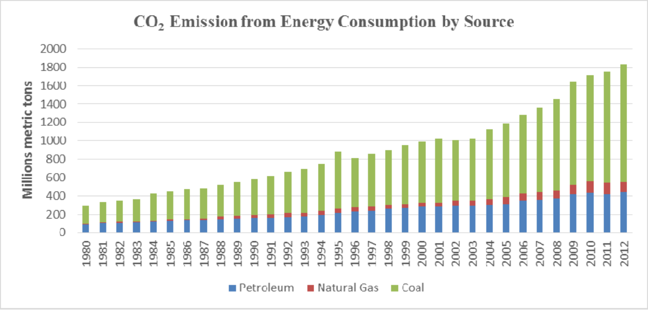

Figure 6: India's CO_2 Emissions from Energy Consumption by Fuel 1990-2012

Source: Author's computations from EIA, International Energy Statistics, 2014

In conclusion, the era of energy surplus has gone in India, and energy shortages, import dependency, supply disruptions and power failure has become the order of the day. The country is equally faced with sequential energy intensity increases thereby making its energy supply strongly susceptible to external vulnerabilities. The widening dominance of coal in the country's primary supply mix also imposes mounting environmental risk on the nation and the world at large. Therefore, the expanding economic growth, widening energy demand, accumulating supply shortages, rising oil imports and growing environmental threat have raised the need for a lasting solution to India's energy problem.

METHODOLOGY

Basic Energy Security Indicators[1]

To compute the security of energy supply in India, analysis of the country's primary energy was conducted and the adopted key energy security indicators stated in APERC (2007) and Bhattacharya (2011) namely:

Diversification of Primary Energy Supply (DPES)

This indicator was derived by modifying the Shannon bio-diversity Index which reflects the significance of energy diversification in relation to abundance and conformity of sources. This is calculated as;

$$DPES = ß / \mathrm{Ln}\ \eta \qquad but\ \ \beta = -\Sigma\,(Q_i LnQ_i)$$

Where: β is the Shannon's bio-diversity Index and Q is the fraction of energy source in TPES, Ln is the Natural log, i is the sources of energy and η is the number of energy sources used.

Net Energy Import Dependency (NEID)

NIED is the DPES import adjusted version and it is calculated thus;

$$NEID = \{1 - (Y / EDI)\} \quad \text{While } Y = -\sum (a_i Q_i \ \mathrm{Ln}\ Q_i)$$

Where Y is the import reflective PEDI, ai = (1-ki) and ki is the fraction of net import in PES of energy source (i). All other variables remain as earlier defined.

Net Oil Import Dependency (NOID)

NOID measures India's net oil import dependency by considering the oil imports and exports and is likewise adjusted for oil consumption intensity as a primary source of energy. It is estimated thus:

NOID = [Importoil / PESoil] × [PESoil / TPESenergies]

Middle East Oil Import Dependency (MEOID)

The MEODI estimates the extent to which India relies on oil imports specifically from the middle-east oil exporting countries and is obtained as follows:

MEODI = {Middle-East Importoil / PESoil} × 100

Carbon Free Energy Portfolio (CFEP)

It shows the share of non-carbon energies in the nation's overall energy portfolio. This indicator evaluates the extent of India's efforts to shift away from a carbon concentrated energy mix to a carbon free energy portfolio by measuring the share of hydro, nuclear, and other renewable in TPES. The metric is evaluated thus:

CFEP = [PES hydro + PES nuclear + PES renew] / [TPESenergies]

It thus reveals the environmental challenges emanating from energy sources.

INDIA'S ENERGY SUPPLY CHALLENGES: EVIDENCES AND TRENDS

This section presents the outcome of various measures of Indian energy security employed. To begin with, the Indian energy diversification index reveals that the degree of diversification of primary energy supply (DPES) in the country is apparently high, increasing over the last three decades-most significantly in the 1980's through 2000 rising from 68 to 83 (see Table 1) - signifying a considerable degree of energy source diversification. However, the rate of stagnancy as well as decline in the diversification index between 2000 and 2012 is too obvious and demands significant attention. Customarily, the DPES values below 50 infers countries that heavily rely on few energy sources to meet their domestic demand while the higher value (above 50) denotes a reasonable level of diversity in the nation's energy sources. Hence, India's higher DPES suggests that the nation is less prone to energy supply security risk because of availability of sizeable energy supply sources for its economy.

Years	1980	1985	1990	1995	2000	2005	2010	2012
Normalised PEDI	68	74	79	81	83	83	84	82

Table 1: India's Diversification of Primary Energy Supply from 1980 - 2012
Source: Author computations IEA, 2014

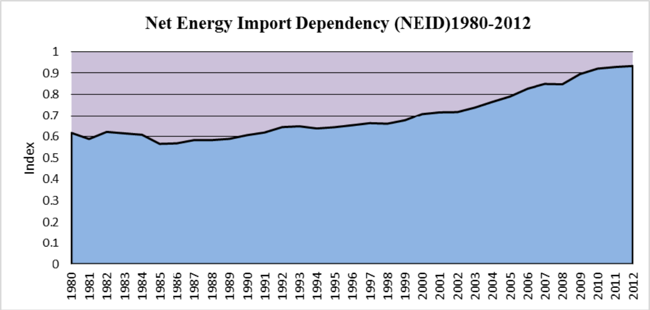

Figure 7: India's Net Energy Import Dependency (NEID): 1980 – 2012
Source: Author computations IEA, 2014

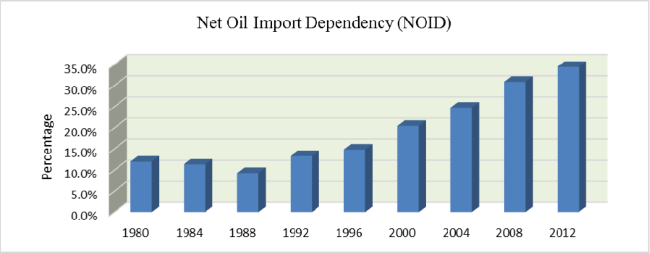

Figure 8: Net Oil Import Dependency (NOID): Selected Years
Source: Author computations IEA, 2014

In spite of the fact that Indian DPES predicts a minor energy supply risk, the impact of import reliance on the nation's energy supply configuration is confirmed in the Net Energy Import Dependency (NEID) as presented in figure 7. This measure (NEID) depicts the level of total primary energy supply that is weighted by the supply intensity of each energy source. The NEID estimates reveal that Indian's net import dependency is relatively high indicating that the country principally depends on foreign energy supplies to meet its local primary energy demand. From 1980, India imported more than half of its primary energy so as to meet its growing national energy requirement.

With the deduction that oil is currently the prime source of energy in India, obtaining sufficient oil supply constitutes a concern for India's energy supply. To this end, the net oil import dependency (NOID) together with the middle-east oil import dependency (MEOID) tends to reveal anticipated vulnerability associated with securing adequate volume of this vital energy resource. Evidence from NOID (calculated by the share of oil in TPES) exposes a sharp upsurge in Indian net oil dependency rising from about 12% in 1980 to more than 34% in 2012 – an increase of roughly 187% over the period of 32 years as indicated in figure 8 below. This also portrays the need for more diversified primary energy sources in order to achieve a secure and efficient energy portfolio.

Furthermore, the result of MOID provides the historical account of India's heavy reliance on foreign oil supply specifically from the middle-east. This index reveals that India had progressively relied on Middle-east oil to satisfy its domestic oil needs. In figure 8, India imports about 20% of its foreign oil requirement from the Middle-east countries while in 2010 the oil supply obtained from this region has increased to around 36%. Hence the result from NOID also suggests that Indian oil import will vividly rise in future unless appropriate measures are adopted to avert this trend.

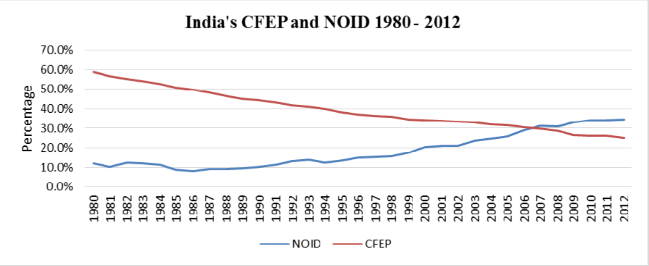

Figure 9: India's Carbon Free Energy Portfolio (CFEP) and NOID: 1980 – 2012

Source: Author computations IEA, 2014

With growing global campaign for clean primary energy sources, as means of curbing energy-related GHGs emissions, the CFEP measures country's level of diversification towards renewables and low-carbon energy resources. As evident in Figure 9, India's CFEP trend has been declining over the years due to its increasing utilization of fossil fuel in meeting its widening energy demand. This trend signals the country's increasing vulnerability to environmental degradation and climate change threat. As such, the Indian government needs to expedite action towards halting the increasing proportion of fossil fuels – principally coal and oil to avert this declining CFEP trend over time.

CONCLUSIONS

The objective of this study is to examine the economic as well as environmental implications of energy supply security in India. Investigation of the key features of the contemporary and the future projections of Indian primary energy supply structures were carried out to identify the inimical challenges facing the India energy system. In its 2050 energy security pathway, India has a boisterous ambition of providing 200GW of energy from solar radiation, reducing energy consumption and promoting environmental sustainability.

In pursuit of energy security in the future, there is need for massive and strategic construction of energy reserve facilities to guard against supply disruption risks and energy market instability. Also, utmost priority should be given to the development of renewable and unconventional technologies as this will ultimately yield astounding economic benefits and reduce environmental degradations.

Footnote

[1] Data used for the analysis was sourced from International Energy Agency (IEA -2016 Edition) via UK ESDS.

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Calendar

07-10 May 2018, Energy Storage & Grid-Connected Electric Vehicles (EVs) at Singapore. Contact: URL:http://www.infocusinternational.com/energystorage/index.html

08-09 May 2018, Argus Mexico Fuel Markets Summit at Four Seasons Hotel Mexico City, Paseo de la Reforma 500, Mexico City, 06600, Mexico. Contact: Phone: 7133607566, Email: bel.cevallos@argusmedia.com, URL: http://go.evvnt.com/200720-0?pid=204

14-16 May 2018, Global Experts Meeting on Neonatal Nursing and Maternal Healthcare at Singapore. Contact: Email:neonatalnursingcongress@nursingconference.com, URL: http://neonatal-maternal.nursingconference.com/

16-18 May 2018, CEM The 13th International Conference and Exhibition on Emission Monitoring at Novotel Budapest City, Alkotas u 63, Budapest, 1123, Hungary. Contact: Phone: 01727 858840, Email: marcus@iet-pub.com, URL: https://go.evvnt.com/121572-0

21-22 May 2018, Argus Latin America LNG Summit at Sheraton Grand Rio Hotel and Resort, Avenida Av. Niemeyer, 121 - Leblon, Rio de Janeiro, Brazil. Contact: Phone: 713-360-7566, Email: bel.cevallos@argusmedia.com, URL: http://go.evvnt.com/177229-0?pid=204

22-24 May 2018, Argus Rio Crude Conference at Sheraton Grand Rio Hotel and Resort, Avenida Av. Niemeyer, 121 - Leblon, Rio de Janeiro, 22450-220, Brazil. Contact: Phone: 713 360 7566, Email: bel.cevallos@argusmedia.com, URL: http://go.evvnt.com/177295-0?pid=204

24-25 May 2018, Argus Latin America Motor Fuels Conference at Sheraton Grand Rio Hotel and Resort, Avenida Av. Niemeyer, 121 - Leblon, Rio de Janeiro, Brazil. Contact: Phone: 713.360.7566, Email: bel.cevallos@argusmedia.com, URL: https://go.evvnt.com/177298-0?pid=204

30-31 May 2018, Data Driven Drilling & Production 2018 at Hilton Houston Post Oak by the Galleria, 2001 Post Oak Blvd, Houston 77056, United States. Contact: Phone: +44 02074224313, Email: lvye@upstreamintel.com, URL: https://go.evvnt.com/168545-0

04-06 June 2018, Masterclass in LNG Industry at Barcelona, Spain. Contact: Phone: +31 (0) 88 1166837, Email: bakker@energydelta.nl, URL:https://www.energydelta.org/mainmenu/executive-education/specific-programmes/master-class-lng-industry-lng-training-course

05-07 June 2018, Ecwatech Water Exhibition and Forum at VDNH, Russia. Contact: Phone: 4952255986, Email: martynova@ecwatech.ru, URL:https://go.evvnt.com/60711-0

06-07 June 2018, Argus Biomass Asia 2018 at TBC, Singapore. Contact: Phone: 64969932, Email: josephine.pulvera@argusmedia.com, URL:http://go.evvnt.com/179795-1?pid=204

07-08 June 2018, US Offshore Wind 2018 Conference and Exhibition at Boston Park Plaza Hotel, 50 Park Plaza at Arlington Street, Boston, 02116, United States. Contact: Phone: 02073757239, Email: adam@newenergyupdate.com, URL: https://go.evvnt.com/166790-0

19-20 June 2018, Global Offshore Wind Manchester June 2018 at Manchester Central Convention Complex, Windmill Street, Petersfield, Manchester, M2 3GX, United Kingdom. Contact: Phone: 02079013000, Email: David.Moyle@renewableuk.com, URL: go.evvnt.com/144243-0

21-22 June 2018, 2nd Annual Congress on Environmental Pollution and Global Warming at Osaka, Japan. Contact: Phone: 6508894686, Email:environpollution@earthscienceconferences.com, URL: https://pollution.conferenceseries.com/

25-29 June 2018, 27th World Gas Conference 2018 at Walter E. Washington Convention Centre (WEWCC), 801 Mount Vernon Place NW, Washington, DC, 20001, United States. Contact: Phone: 44 20 7978 0019, Email: vjolly@thecwcgroup.com, URL: https://go.evvnt.com/74583-0

25-27 June 2018, Electric Utility Cost Estimating 2018 Conference New Orleans, Louisiana at Ace Hotel New Orleans, 600 Carondelet St, New Orleans, LA, 70130, United States. Contact: Phone: 17135548380, Email: info@hansonwade.com, URL: http://go.evvnt.com/203795-0?pid=204

09-11 July 2018, Engineering, Procurement and Construction (EPC) Contracts for Energy Industry - Johannesburg at Singapore. Contact: URL:http://www.infocusinternational.com/epcenergy/index.html

03-06 September 2018, ECMOR XVI: 16th European Conference on the Mathematics of Oil Recovery 2018 at World Trade Center, Edif. Este, Moll de Barcelona, s/n, Barcelona 08039, Spain. Contact: Phone: +31 88 995 5055, Email: ecmor@eage.org, URL: http://go.evvnt.com/154381-0

04-07 September 2018, Mastering Renewable & Alternative Energies - Johannesburg at Johannesburg, South Africa. Contact: URL:http://www.infocusinternational.com/renewable/index.html

10-14 September 2018, Gas / LNG Contracts: Structures, Pricing & Negotiation at Port of Spain, Trinidad and Tobago. Contact: Phone: +65 6325 0274 , Email:abigail.harris@infocusinternational.com, URL: http://www.infocusinternational.com/gascontracts

13-15 September 2018, 10th Argus Americas Crude Summit at Hilton Americas, 1600 Lamar Street, Houston, 77010, United States. Contact: Phone: 7139680000, Email: umer.qureshi@argusmedia.com, URL: http://go.evvnt.com/136463-1

13-15 September 2018, WC Climate Change 2018:Impacts & Responses at Holiday Inn Rome Pisana,Via della Pisana, 374,00163 Roma RM, Italy. Contact: Phone: +1 408-352-1010, Email: climatechange@innovinc.org, URL: https://climatechange.innovincconferences.com/

17-20 September 2018, Power Purchase Agreement (PPA) - Johannesburg at Johannesburg, South Africa. Contact: Email: vincs@infocusinternational.com, URL:http://www.infocusinternational.com/ppa/index.html

18-19 September 2018, BIEE 12th Research Conference at Blavatnik School of Government, Oxford OX2 6GG, UK . Contact: Email: conference@biee.org, URL:http://www.biee.org/conference-list/consumers-heart-energy-system/

14-19 October 2018, The Society of Exploration Geophysicists 88th Annual Meeting at Anaheim Convention Center, 800 W Katella Ave, Anaheim, CA 92802, United States. Contact: Phone: 1 (918) 497-5500, Email: meetings@seg.org, URL: http://go.evvnt.com/151569-0

15-17 October 2018, Hydro 2018 - Progress Through Partnerships at Gdansk, Poland. Contact: Phone: 44-20-8773-7244, Email: hydro2018@hydropower-dams.com, URL: www.hydropower-dams.com

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