Second Quarter 2020

Issn 1944-3188

IAEE ENERGY FORUM

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Published By:

IAEE
WWW.IAEE.ORG
International Association for Energy Economics

PRESIDENT'S MESSAGE

My husband believes that Good times build confidence, Bad times build character, while somebody else said that Good and Bad times build resilience.

It has been two months since I began steering the International Association for Energy Economics as your President for 2020. I am now realizing how far away from the topics of energy and economics the job could be - those topics never even emerge during our Council meetings. My voyage in unchartered territory and open oceans had barely begun that the daily demands and the administration of a BIG SHIP such as IAEE could easily make me forget what I intended to accomplish and what IAEE represents. As I wrote earlier, I am not an academic but more like a student eager to assimilate information and formulate solutions. I am still hoping to introduce initiatives during my term: I am eager to hear from our young professionals and wishing to further engage with the business sector and governments. Those should be the good times and I am confident I can make a small difference.

It has also been two months since the Corona Virus first surfaced and began spreading at an alarming rate. The virus is keeping the world in a state of deep concern and global growth is weakening daily. The simple laws of economics are hard at work with energy demand going down while supplies remaining ample. So far, the $65 per barrel WTI prices of only two months ago decreased steadily to reach $45 by the end of February. The remarkable market gains of the last 6 months on the Dow, Nikkei and other markets have been "wiped out and vanished" in the course of the last week of February. Early indications and expectations are that the economic downward trend will continue for some time. The OPEC+ are busy considering reinforcing their quota while the positive announcements by authorities do not seem to stop the pessimistic trends. Those are the bad times that make all of us alter our plans including those of our prestigious organization. I believe we are facing "a call for collective wisdom" to participate in the debate and contribute to the repair.

In order to prevent the corona virus from spreading out of control, many companies in Japan are now encouraging their staff to practice "telework". After my rather very traditional and conservative office became fully supportive of the idea, we soon realized how easy it is to be connected at all times from home using smartphones, tablets and video conferencing software. We also realized how time consuming and tiring it had been to commute to and from the office. I strongly feel that this "near-pandemic" is one of those events which induces paradigm shifts.

People's way of thinking and lifestyles may change forever. With a push not by politicians but by citizens, the global agenda on climate change, free trade, national and energy security may need to be reassessed. The challenge we face calls for a creative

Continued on page 2

President's Message (continued)

and innovative spirit of getting together and free exchange of views. IAEE's neutral stance can play an important role in facilitating the debate. We are 4000 members and it must be a force to reconed with. We can contribute to further build up resilience.

Now, on a much lighter note, I would like to report on our past and upcoming conferences. As you will see, IAEE has an impressive series of conferences and symposia taking place in Europe and around the world.

The Asia-Oceania conference took place in early February in Auckland, NZ. It was a true success and I must praise the organizers for an excellent program and their strong commitment. Despite a huge and sudden challenge including the loss of many participants and presenters (mainly from China), they successfully altered some of their plans and delivered an excellent program without any loss of quality. I gathered from participants that they enjoyed ample opportunities of networking and the hospitality of New Zealand. I also enjoyed the nature and a bit of healthy Kiwi lifestyle in the form of huge servings of salad with mixed nuts and grains.

I truly look forward to seeing you all in Paris, France, in June for our annual cornerstone conference. It will be the 43rd International Conference (June 21-24) with the theme of "Energy and Climate, Working Hand in Hand". It will be a unique platform for academics, policy-makers and business leaders to present and discuss the latest economic research on pressing energy issues in an open and nonpartisan setting. This conference, taking place five years after the historic Paris agreement, is very promising and will be enlightening to us all.

IAEE is also planning its 3rd South-east Europe Symposium, to be held in Tirana, Albania in 2020. The symposium topic will be "Delivering Responsible Infrastructure and Energy Solutions".

While I continue to work on organizing the Tokyo international conference for July 2021 (next year), the 5th Eurasian conference will take place in Baku, Azerbaijan on 17-19 September, 2020, and the 38th annual 2020 USAEE/IAEE North American Conference will take place in Austin, TX , in November.

Please consider joining us!

Yukari Yamashita

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

Our request for articles on energy tranistion was most gratifying. We devote not only this issue to the topic, but will do the same for the third quarter issue and perhaps have something left over for the final 2020 *Energy Forum* issue. We thank those who have responded so fully.

Ben Schlesinger describes the design and construction of a 5100 sq. ft., zero net energy, carbon neutral home in Maryland on the shores of the Chesapeake Bay. Though the home includes state of the art, commercially available equipment, it is designed to optimized beauty, comfort, ease of operation, style, and resort living – in other words, not really for carbon or energy conservation.

James Dorian, Dale Simbeck and **Malcolm Shealy** write that the world is in an unprecedented period right now as renewable energy prices have dropped significantly in recent years and the use of wind and solar power has skyrocketed. Prompted by energy diversification strategies and the 2015 Paris Climate Accord, numerous countries are actively seeking ways to slow down or scale back use of fossil fuels, raise energy efficiencies, and promote the electrification of their economies. But where do we go from here? How much further can renewables be pushed? What economic, technical, political, and environmental challenges lie ahead? Are there applications in industry and transportation that are best served by fossil fuels? This article explores some of the key questions and key realities surrounding the global energy transition and the big uncertainties that lie ahead.

Mamdouh Salameh argues that there will neither be a post-oil era nor an imminent energy transition or a peak oil demand throughout the 21st century and far beyond. That is why oil, natural gas and LNG will keep renewables stranded throughout the 21st century.

Michelle Foss and **Katherine Zoellmer** consider the specific case of electric vehicle impact on distribution networks. They review the state of EV technology and production, battery science and supply chains, and policy/regulatory "push".

Inês Carrilho Nunes and **Margarida Catalão-Lopes** write that the electric grid must transition from a centralized fossil-fuel system to a clean, decentralized and interconnected system. The most common approach for socio-technical system transitions is the multi-level perspective (MLP). They provides insights on how the MLP can facilitate a transition path in electricity distribution systems.

Kakali Mukhopadhyay and **Vishnu Prabhu** report that India's electricity demand is expected to grow abnormally during 2018-2040 and requires enough power system flexibility in order to adapt itself to dynamic and changing conditions. Further, the ambiguous and complex public-private role in the electricity sector raises concerns in regulation of the sector resulting in technical, economic and operational inefficiencies in India. Restructuring of the existing public private framework of the sector is required to meet needs of rising demand, through digital and physical infrastructure

A report from the **Abu Dhabi Symposium** held in early December details the results of that meeting.

ARE YOU INTERESTED IN SUBMITTING AN ARTICLE TO *THE ENERGY FORUM*?

The IAEE *Energy Forum* is our members' open publication for submissions. If you have an article you would like to have considered for publication, please email us at iaee@iaee.org

Here's what to do:

- Submit a non-technical article, short in nature (750 - 3000 words) in MS Word format.
- Submit any tables/charts/graphics, etc. in four color, following the following specifications:
  - o Greyscale/Color: 266ppi
  - o Combination (tone and text): 500ppi-900ppi
  - o Monochrome: 900ppi+
- Provide a short (30 word) capsule/abstract that overviews your article.
- Include your full name and professional Affiliation.
- Authors are to submit a description of their work for use on the Association's social media accounts (Twitter account @IA4EE / @USA4EE and LinkedIn

  https://www.linkedin.com/groups/3047782/ and

  https://www.linkedin.com/company/usaee) Please submit 2-3 sentences summarizing your research to iaee@iaee.org.

We hope to receive your submission!

Joe Dukert

Dr. Joseph M. Dukert, a longtime member of the International Association for Energy Economics (IAEE), Senior Fellow and Past President of the United States Association for Energy Economics (USAEE) and past Vice President for Conferences and Vice President Chapter Liaison of the USAEE and stalwart member and leader of the National Capital Area Chapter, died on February 5, 2020, to the grief of many friends and admirers across the energy specialties and industries.

Joe was the archetype of "a gentleman and a scholar." Few could claim more credibly to have been a life-long student, as Joe graduated from Notre Dame magna cum laude in 1951, and capped his formal education with a PhD from Johns Hopkins School of Advanced International Studies 54 years later in 2005, with various other graduate programs and degrees in between.

Few could claim to have amassed more knowledge and understanding of the energy sector, summarized in Joe's finale of multiple books, for the Greenwood Press, simply titled "Energy." Few could claim to have traveled so widely, to have been invited to membership in the Cosmos Club, to have learned Spanish well enough to write a dissertation on the Mexican energy sector from original sources, to have been a five-time editor in chief of the Department of Energy's annual National Energy Policy Plans, to have served as an officer in the Air Force, to have been a ten-year member of the State Department's Advisory Panels on Oceans, Environment, Science & Technology and on Antarctica, to have been Chairman of the Republican Party for the State of Maryland, or to have worked on the original Vanguard rocket as an executive with the Martin Company. Joe could have made such claims, but he was too modest to do so, and many longtime friends and colleagues may only be learning of these distinctions from this obituary, as has its author.

Joe is survived by his wife Betty, herself a paragon of graciousness and accomplishment as the multi-decade executive for NBC of its "Meet the Press," putting her in direct contact with the top leaders of the 20th Century. The IAEE, the broader energy community, and intellectually-engaged people everywhere have suffered a serious loss in the passing of Joe Dukert.

John Jimison

Zero Net Energy Home Project in Maryland: First Year Progress Report

BY BEN SCHLESINGER

Introduction

This article presents a progress report on a project aimed at demonstrating to the energy policy and real estate/construction communities whether building a zero-net energy ("ZNE") house in the U.S. Mid-Atlantic coastal region can be economically feasible using existing technology. The premise is that the house uses state-of-the-art renewable energy technology that is readily available to most builders. The ZNE components are largely out of sight and automated, and don't require any training or a Ph.D. in engineering to operate.

The discussion covers the following:

- Rationale and assumptions
- Equipment selections
- Results: First-year electricity flows
- Rough-cut economics
- Deploying the batteries
- Concluding thoughts

No local natural gas distribution is available at the site, hence the ZNE option. Propane is distributed in the house for "esthetics" like fireplaces and cooktops.

Rationale: 'By-the-way' carbon neutrality

The 5,140 s.f. house replaced a pre-existing house located on waterfront property in historic St Michaels on Maryland's Eastern Shore of Chesapeake Bay. Construction took 12 months from 11/2017 to 11/2018. Leading regional homebuilder Paquin Design/ Build was contracted because of their bid, experience, timeliness and quality, as well as enthusiasam for the ZNE program. Architect Charles Paul Goebel of Easton, MD and interior designer Erin Paige Pitts of Annapolis, both also leaders in the region, were chosen because they could best design the appearance, flow and fit of the new house with its extensive water frontage. Hence, the home is optimized for beauty, comfort, ease of operation, style, resort living – not really for carbon or energy. Figure 1 shows some views of the new house.

Ben Schlesinger is a Senior Fellow, University of Maryland, School of Public Policy, Center for Global Sustainability and President, Benjamin Schlesinger and Associates, Bethesda, Maryland. He may be reached at bschles@ bsaenergy.com

The material is this article was presented at the 37th USAEE/ IAEE North American Conference, Denver, CO, November 6, 2019.

See footnotes at end of text.

Figure 1 View of House and Bay Front

Subject to the foregoing, the question addressed is, simply, what about energy? Can a house like this be built with normal real estate criteria and still be ZNE and/or carbon net-neutral?

Equipment selections: best available technology

In light of the foregoing design and construction priorities, the ZNE strategy was to equip the house with the best major energy system components available in the industry when the house was built in 2018:

• "Macro" insulation. The siding is built with 2' x 6' studs in order to allow for 2" closed cell blown-in insulation and 4" fiberglass batting. Likewise, the house embodies a "house within a house" philosophy, i.e., insulated empty spaces sepa-

Figure 2 Geothermal drilling underway on property

rating the upper floors from the roof. Lighting is mostly LED, but kitchen and other appliances were chosen for design and quality, not energy.

- Geothermal energy. Eight 220′ depth geothermal wells were drilled in the front yard in a process that was completed in less than half the scheduled time. It's worth noting why: drilling tech and know-how from hundreds of thousands of gas wells in the region have spilled over to make geothermal drilling more efficient, thus advancing green energy. It took about nine

Figure 3 Solar PV array atop the house

months for the lawn to recover, however, and large sections of the front yard now comprise a "Miss Utility" field with shallow buried glycol feed lines from the field to the house.
- Energy Star leading geothermal heat pumps. Two 4-ton ClimateMaster 45 SEER ground-source heat pumps provide all heat, air conditioning and hot water for the house. Developed at Oak Ridge National Lab, their industry-leading efficiency is achieved by variable speed glycol loops, variable air flows through nine sub-zones, and other improvements and advances. Unlike typical outdoor air-source heat pumps, these are quiet enough to be located inside the house.
- Rooftop solar photovoltaic (PV) energy. As originally conceived, the plan was to install a Tesla solar roof, but this product wasn't available in time for construction. So instead, fifty 360-watt SunPower PV panels are installed, totaling 18 KW of electricity production capacity. Local contractor Sunrise Solar of Chestertown, MD, mounted them tightly on two large, nearly flat sections

Figure 4 Tesla PowerWalls in garage

of roof (see Figure 3) to keep them out of sight from ground level. This orientation is suboptimal because they're not tilted perfectly, but they're nonetheless highly productive.
- Tesla PowerWalls. Three 13.5 kwh lithium-ion battery packs are installed in the garage (see Figure 4), totaling 40.5 kwh of storage, minus various inefficiencies. So far, these have been used mostly to provide stand-by electricity during power outages; indeed, they operated seamlessly during six brief outages in the first year. As long as the sun shines, the batteries' stand-by generation could continue indefinitely. More aggressive deployment of the batteries is planned for the second year, as discussed below.

Results: First-year electricity flows

In the first 12 months after ZNE systems were installed, the house was net negative energy, i.e., a total of 2,033 kwh of electricity was returned to the grid and all household demand was met. This included all electricity for heating, air conditioning, hot water, lighting, appliances, security and even charging the author's electric vehicles for about 3,000 miles worth of travel. In addition (not shown), about 20 gallons of propane were consumed for cooktops and fireplaces.

Figure 5 shows monthly energy flows between the house and the grid. Seasonal variations dominate the picture – the house was a net energy producer until December 2018, then became a net consumer through March 2019, and then was a net producer again through July 2019. Three main reasons explain this seasonality: a) geothermal heat pumps are more efficient on their cooling cycle than for heating, b) winter solar PV production is hobbled by the low angle of the sun, and c) energy demand for lighting is greater on short winter days. Note that the first year in this analysis included the final four months of construction, but builders used HVAC, plug-in construction equipment, some lighting, etc. Still, Figure 5 shows somewhat higher demand during comparable months in 2019, thus portending tighter second-year ZNE results.

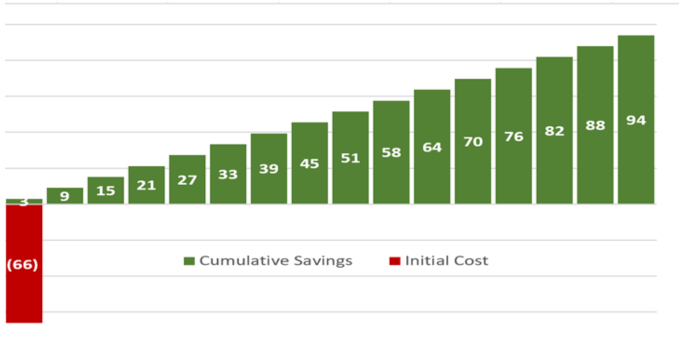
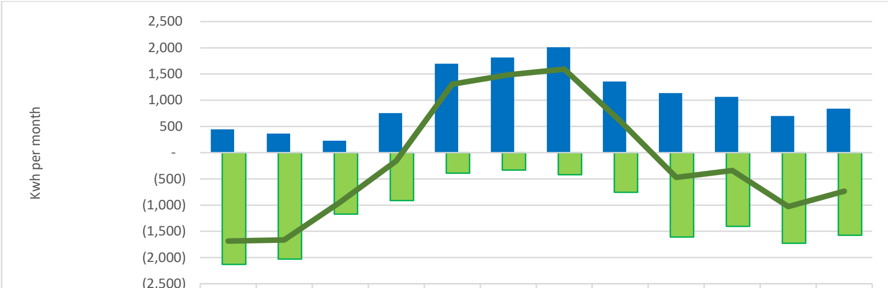


Figure 6 Rough-cut ZNE economics based on first year
Source: BSA 2019, from Choptank Electric Cooperative monthly bills in St. Michaels, and Pepco and Washington Gas bills in Bethesda, and initial capital expenditures (see text).



	Aug-18*	Sep-18	Oct-18	Nov-18	Dec-18	Jan-19	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19
Billed Usage	446	364	230	756	1,697	1,816	2,011	1,359	1,135	1,064	700	840
Billed Generation	(2,131)	(2,027)	(1,171)	(912)	(389)	(331)	(419)	(755)	(1,608)	(1,405)	(1,727)	(1,576)
Net	(1,685)	(1,663)	(941)	(156)	1,308	1,485	1,592	604	(473)	(341)	(1,027)	(736)

Figure 5 Summary of first-year energy production and demand
Source: BSA 2019, from Choptank Electric Cooperative, 2018-2019. Months refer to the preceding sixth day through the fifth day of the month shown. Asterisk denotes the full month consisting of July 12, 2018 through August 5, 2018 plus July 6, 2019 through July 11, 2019.

Unfortunately, there is no submetering in the house, thus no way to track demand from individual sources, appliances, etc. This suggests a project for future years.

Rough-cut economics

Figure 6 compares initial geothermal and solar energy costs with expected cumulative benefits, i.e., savings relative to 2017-2018 energy bills in the author's previous home in Bethesda, MD, with similar climate, demand patterns and size. On this basis, the ZNE components of the new house produce about a 10-year payback. Initial costs include 30% Federal investment tax credit (ITC) taken on geothermal and solar system costs and $4,000 in Maryland grants. The total cost for electricity in the first year was $98, which includes bills paid and payments received from Choptank Electric Cooperative, plus sales of solar renewable energy credits (SRECs, marketed by Sol Systems). In addition to electricity, about $30 was spent on propane in the first year.

Another comparison could be drawn with energy bills in the previous house on the property. During the six months in the author's ownership from April to October 2017, the house used 14,082 kwh of electricity, costing $1,892 – and this period almost entirely avoided winter heating bills. Thus, the new house produced at least a 95% energy cost savings.

The Tesla battery packs on-site were excluded from this analysis because they were installed about halfway through the first year and, again, were used as an emergency stand-by.

These results may or may not be replicable in other regions. Weather data in Figure 7 show St. Michaels is more conducive to ZNE than some places (less snow to block out solar energy than the U.S. average) and worse than others (less sunshine to produce solar energy than Southern California)..

Finally, there's a seemingly endless array of carbon-related choices that this project has not yet addressed but will likely take up in the near future. Three examples:

- The author's EV charging took place partly at home in St. Michaels using solar energy and partly at other locations within PJM's grid, which relies on coal, nuclear, natural gas and some renewable generation fuels. It is unclear whether

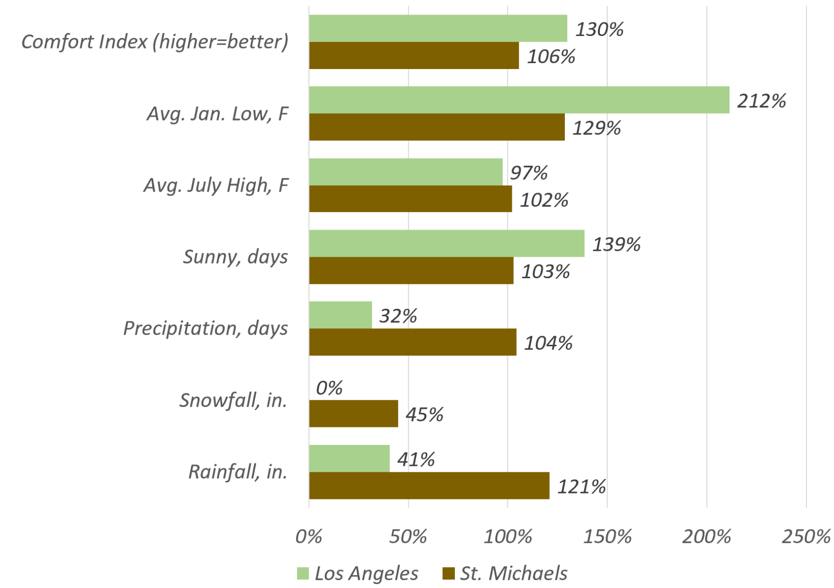


Figure 7 St. Michaels and Southern California weather versus U.S. averages
Source: BSA 2019, from www.bestplaces.net.

electricity used for EV charging at home ought to be part of a separate equation or not, thus future updates will seek to segment EV demand for separate economic analysis.

- The house's two-acre lawn is maintained by a team using gasoline-powered mowers. The author is considering lower-carbon alternatives, such as Ryobi's new 42 in. lithium-ion battery-powered riding mower that could be charged at the house like an EV.
- Waterborne commerce has been fundamental to the long history of St. Michaels, where fishing and commercial fleets were manufactured, and warships too, which attracted fierce British naval attention in the War of 1812. Boating remains popular here and the author is considering a pleasure craft with a lower carbon twist: a Yanmar 200 hp turbodiesel outboard using biodiesel available from local agricultural industries. No decision yet.

Deploying the Batteries

One of the main reasons for building or retrofitting houses to a ZNE standard[1] is to reduce emissions of greenhouse gases, especially carbon dioxide. A basic green energy/economic question is how best to deploy 40.5 kwh of stored electricity on-site to maximize carbon offsets, a concern that's been raised in literature (for example, see Hittinger and Azevedo, 2015[2] and Hittinger and Lueken, 2015[3]). The nascent PJM "duck curve" effect shown in Figure 8 suggests the answer might lie in careful timing: discharge batteries in the evening to maximize offset of on-grid hydrocarbon fuels.

Even more useful would be real-time information about PJM generation, e.g., marginal fuels on a 15-minute basis as Brown et al 2019[4] suggest. This could improve carbon offsets not only from the house but also from EVs, whether charged at home or not. The author plans to attempt this strategy in the second year.

Concluding thoughts

From an economic perspective, a 10-year payback period might be unacceptably long for some homeowners. But since most houses are mortgaged, including this one, it makes sense to suggest that lenders internalize borrowers' enhanced ability to make monthly mortgage payments if they have ZNE houses.[5]

Going forward, the 10-year payback for this kind of project is bound to decline because capital costs for all ZNE equipment, especially PV panels and batteries, are falling to competitive levels unforeseen only several years ago (for example, see NREL 2018[6] and Bloomberg 2019[7]). For example, a 50% reduction in the installed ZNE equipment costs, which appears likely as production increases (Bloomberg 2019), would reduce the pay-pack period by almost 30% even if the Federal 30% ITC is allowed to expire as scheduled. Even today, payback periods could fall through use of lower cost solar and geothermal equipment, i.e., less than the best available.

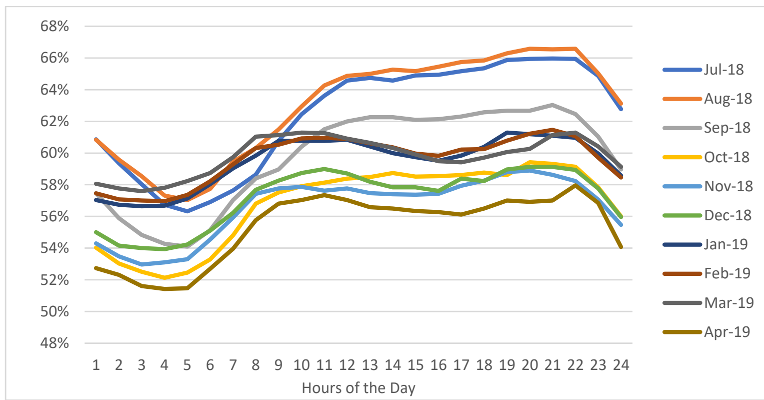


Figure 8 PJM Coal-Plus-Gas% throughout the Day, Average by Month in 2018
Source: BSA 2019, from PJM on-line hourly fuel use data.

Finally, ZNE homes like this, even with battery packs, will not obviate electric utilities because they'll need grid power on cold winter, on every rainy or cloudy day with poor solar, and every night if batteries are 100% dedicated to emergency back-up. But regarding natural gas, this house has no hook-up at all, which implies widespread ZNE could eventually put gas distributors at risk. Globally, natural gas use is increasing and hundreds of millions of buildings rely on gas utilities for heating and other vital energy demands, 60 million homes in the U.S. alone. Therefore, it is hoped that the gas industry will respond to the challenge and turn to lower carbon services and work toward decarbonizing altogether throughout the gas chain.

Figure 9 Historic skipjack passes by house

Footnotes

[1] Required as of 1/1/2020 under California Code of Regulations (Title 24, Part 6), see https://ww2.energy.ca.gov/title24/2019standards/documents/2018_Title_24_2019_Building_Standards_FAQ.pdf

[2] Hittinger, Eric S. and M. L. Azevedo, "Bulk Energy Storage Increases US Electricity System Emissions." Environmental Science and Technology 49. 5 (2015): 3203-3210.

[3] Hittinger, Eric and Roger Lueken, "Is Inexpensive Natural Gas Hindering the Grid Energy Storage Industry?" Energy Policy. 87 (2015): 140-152.

[4] Brown, Patrick, et al., "Optimized PV + Storage System Designs For Nodal Electricity Value" presented at 42nd IAEE International Conference, Montreal Canada (2019).

[5] For example, see https://www.energy.gov/energysaver/incentives-and-financing-energy-efficient-homes/financing-energy-efficient-homes

[6] National Renewable Energy Lab (NREL), "Costs Continue to Decline for Residential and Commercial Photovoltaics in 2018," December 2018, at https://www.nrel.gov/news/program/2018/costs-continue-to-decline-for-residential-and-commercial-photovoltaics-in-2018.html

[7] Bloomberg NEF, "Battery Pack Prices Fall As Market Ramps Up With Market Average At $156/kWh," December 3, 2019, at https://about.bnef.com/blog/battery-pack-prices-fall-as-market-ramps-up-with-market-average-at-156-kwh-in-2019/

Careers, Energy Education and Scholarships Online Databases

IAEE is pleased to highlight our online careers database, with special focus on graduate positions. Please visit http://www.iaee.org/en/students/student_careers.asp for a listing of employment opportunities.

Employers are invited to use this database, at no cost, to advertise their graduate, senior graduate or seasoned professional positions to the IAEE membership and visitors to the IAEE website seeking employment assistance.

The IAEE is also pleased to highlight the Energy Economics Education database available at http://www.iaee.org/en/students/eee.aspx Members from academia are kindly invited to list, at no cost, graduate, postgraduate and research programs as well as their university and research centers in this online database. For students and interested individuals looking to enhance their knowledge within the field of energy and economics, this is a valuable database to reference.

Further, IAEE has also launched a Scholarship Database, open at no cost to different grants and scholarship providers in Energy Economics and related fields. This is available at http://www.iaee.org/en/students/ListScholarships.aspx

We look forward to your participation in these new initiatives.

Herman Franssen

The field of energy economics mourns the passing of one of it's most prominent members, Herman Franssen, who passed away on January 26, 2020, in Mexico City.

Dr. Franssen, 80, was a long-time active member of the IAEE and a frequent speaker at energy conferences around the world. Dr. Franssen came to the United States from his native country, the Netherlands. He went on to receive degrees from Macalester College (BA) in Minnesota and an MA and PhD from the Fletcher School of Law and Diplomacy at Tufts University in Boston.

He was the Executive Director of the publishing firm Energy Intelligence and the organizer of the highly regarded Oil and Money Conference for nearly 40 years. Dr. Franssen was a frequent participant in many IAEE and USAEE events. He began his international energy analytical career with a major study for the Congressional Research Service and then joined the newly created Department of Energy in 1978 as Director of Oil Market Analysis in the Office of International Affairs. Herman became the Chief Economist at the International Energy Agency in Paris in 1980 where he coordinated the IEA's first major World Energy Outlook in 1983.

Dr. Franssen served as senior economic adviser to Oman's Minister of Petroleum and Minerals from 1985 to 1996. He returned to the USA and established his own consulting firm, International Energy Associates. In addition to his role at Energy Intelligence, Herman was affiliated with the Center for Strategic and International Studies, the Middle East Institute and FGE Energy.

Herman, a devoted family man, is survived by his loving wife of more than 50 years, Maureen, two daughters, Michelle and Lynn and 4 grandchildren. He will be deeply missed by his family and his many friends and colleagues.

Guy Caruso

The Global Energy Transition: Where Do We Go From Here?

BY JAMES P. DORIAN, MALCOLM T. SHEALY AND DALE R. SIMBECK

James Dorian is an International Energy Economist based in Washington, D.C. **Malcolm Shealy** is a former Senior Energy Analyst with PCI based in Beaverdam, VA and **Dale Simbeck** is a Former Vice President of Technology at SFA Pacific, Inc., Palo Alto, CA. Dorian can be reached at jamesdorian@yahoo.com

All opinions, analyses, and statements of fact are solely those of the authors and do not necessarily reflect the official positions of any U.S. or international organization or government agency.

Anticipated Changes in World Energy

By 2040, the world is projected to consume 24 percent more energy than today, with developing countries surpassing the industrialized world as the largest group of energy consumers. Fossil fuels, including oil, coal, and gas, will remain the dominant sources of energy, accounting for about 45 percent of the projected increase in energy demand according to the Stated Policies Scenario of the International Energy Agency (IEA) of Paris (2019). Owing to its relative abundance, ease of transport, and relatively low carbon footprint, natural gas will be the fastest-growing fossil fuel, estimated to increase in volume about 36 percent over the 2018-2040 projection period. Oil consumption will also continue to rise, with much of the increase in demand geared to the transport sector. Much of that growth will be for diesel fuel use in developing countries, essential for the poorest people in Africa and Southeast Asia to increase their standard of living via transport and trade. Renewable energy will increasingly contribute to electricity generation, and remain the fastest growing source of electricity supply.

Key Realities

A transition toward cleaner energy is underway, led by Europe and other signatories of the 2015 Paris Climate Accord and its implementation package, which promote significant reductions in CO_2 emissions. Renewables, increasing efficiency, electrification of end-use demand including electric vehicles (EVs) are driving the energy transition. The world is in an extraordinary period right now as renewable energy prices have dropped significantly since 2000, and use of wind and solar power has skyrocketed in many countries. And slowly but surely the world energy mix is changing.

In China, massive renewables growth is strategically important for the country as its economically recoverable coal to production (R/P) ratio is peaking and will begin to decline soon. The U.S., while seeking to be out of the Accord, does deploy some of the most energy efficient and advanced energy technologies in the world that can help countries slow their growth in energy consumption and carbon emissions, including, for example, waste-to-energy plants, super-efficient gas turbine power plants, liquefied natural gas floating storage and regasification units, and small modular nuclear reactors.

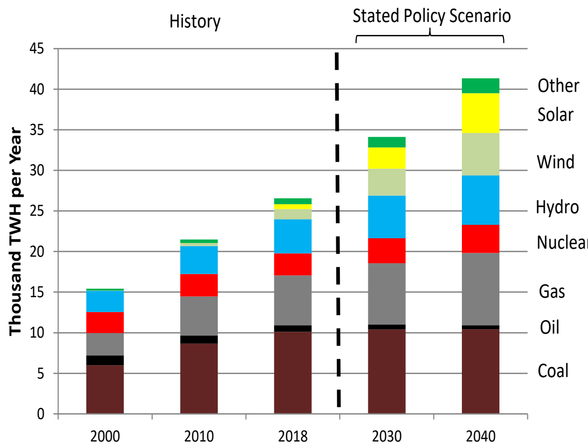
The global energy industry is one of the largest in the world, millions and millions of jobs are tied to energy extraction, production, processing, transportation, and use. Given the size and importance of the industry to the global economy, there are numerous players from the private sector, public sector, and academia that study and evaluate trends, but some of their results can be biased or misleading. We, therefore, describe key realities here as we see them, which we hope will prompt further dialogue and debate.

Future Mix of Fuels for Electricity Generation Will Be Vital

During the next two decades, the mix of fuels used for electricity generation will arguably be the most important variable in the world energy landscape. Developing countries will increasingly rely on renewables, natural gas, and possibly nuclear power rather than coal as the primary electricity generation fuel to meet this growing need during the next two decades, based on market and technology trends and international carbon emissions agreements that include these countries. India, for example, plans to rapidly boost its use of solar and wind to slow or reverse the growth of coal-fired generation as part of efforts to curb local pollution and carbon emissions (International Energy Agency, 2016; Gilblom et. al, 2018; and Krishner, 2019).

The International Energy Agency projects that world electricity generation will diversify and shift toward lower carbon sources by 2040, with renewables—wind, solar, geothermal, biofuels, and hydropower—

Figure 1: World Electricity Generation by Fuel



*Other includes biofuels, geothermal and marine

Source: International Energy Agency, World Energy Outlook 2019 and 2018.

probably overtaking coal in power output just after 2025 (International Energy Agency, 2019). Probably the greatest uncertainty in the future fuel choice for world electricity generation is the role that nuclear power will play, as many countries are now or soon will be facing a decision on what to do with an aging fleet. Figure 1 shows that the IEA expects that the output of nuclear will increase only slightly between today and 2040, as older nuclear power plants are retired and newly-built plants barely compensate.

Non-electricity uses for Renewables Remain Limited

Electricity accounts for only about 20 percent of the world's final energy use, so even if the world could fully decarbonize global power production, that only covers 20 percent of the problem and we still have 80 percent of energy use with few or no alternatives (Heinberg and Fridley, 2016). The other 80 percent of world final energy consumption includes, for example, aviation, shipping, steel and cement production, and plastics manufacturing—all economic activities that also need to be decarbonized if the world is going to meet ambitious carbon reduction targets. The optimal ways to begin decarbonizing these non-electricity sectors would be through efficiency improvements, and by increasing electrification of the various processes, where possible. How far this can go is uncertain.

We're Facing A Shift in Reliance from Oil and Gas to Metals and Minerals

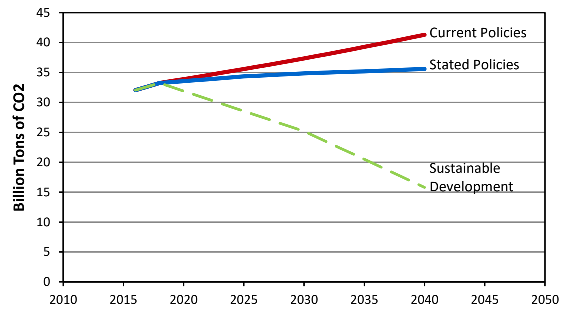
As the global energy transition proceeds over the next two decades, there will effectively be a gradual shift toward and increased reliance on metals and minerals in order to reduce reliance on fossil fuels, for example, the manufacturing and use of solar panels, windmills, and the associated transmission lines and battery storage. Arguably, the metals and minerals requirements for these new advanced energy technologies are a bigger problem than their current costs reflect. The World Bank recently assessed the metal and minerals requirement of a low-carbon world and found that compared to current extraction rates, future demand would soar to levels probably not possible with known reserves, and entail a huge amount of ecological destruction (not to mention the fossil energy required to extract and process all these ores) (World Bank, 2017).

Take copper for example. China uses, on average, about 45 tonnes of copper per MW of installed capacity (including the power plant and all associated cabling, transmission and distribution), and this will rise as solar and wind expands since they are 3-6 times more copper intensive than conventional power plants (and offshore wind the most copper intensive of all). Some studies projecting a total buildout of renewables in China to 15,000 GW by 2050 would thus require about 750 million tonnes of copper (compared to current world extraction of 19 million tonnes a year today). And this is just for China, not even taking into account that the amount of energy consumed per kg of copper produced has quadrupled in the last 8 years and the amount of water used the same, as the average ore concentration drops. Then we have nickel, cobalt, lithium, neodymium, along with a series of others that are all crucial to the manufacturing of renewable technologies

Why Even Discuss the 1.5 C Option?

The world energy economy is still largely carbon-based, with oil, gas, and coal accounting for about 81 percent of global primary energy consumption, and the majority of man-made greenhouse gas emissions. Every November the International Energy Agency (IEA) releases its annual *World Energy Outlook (WEO)*, projecting three scenarios for energy use and fossil fuel CO_2 emissions. The scenarios are the Current Policies Scenario; the Stated Policies Scenario, which includes policies enacted but not yet implemented; and the Sustainable Development Scenario, which reduces fossil carbon emissions to limit warming to about 1.5 to 1.65 C (see Figure 2). But is the 1.5 C scenario even remotely achievable, and if not, why still talk about it?

Figure 2: Scenarios for Fossil CO2 Emissions



Source: International Energy Agency, World Energy Outlook 2019.

At the November 2019 release of the *World Energy Outlook,* the head of the IEA observed that the Stated Policies Scenario falls far short of the Sustainable Development Scenario, and he exhorted governments to do more. The 1.5 C pathway is extremely difficult to achieve. We highlight some of the challenges here by examining the issue on a sectoral basis, and by examining the growing divergence in energy intensity between developed and developing economies.

The Power Sector

Currently the power sector accounts for 42 percent of world fossil carbon emissions. Within the power sector coal-fired power plants account for 73 percent of emissions and generate 38 percent of world electricity. Emissions from coal-fired power plants must therefore be sharply reduced to reach the Sustainable Development path.

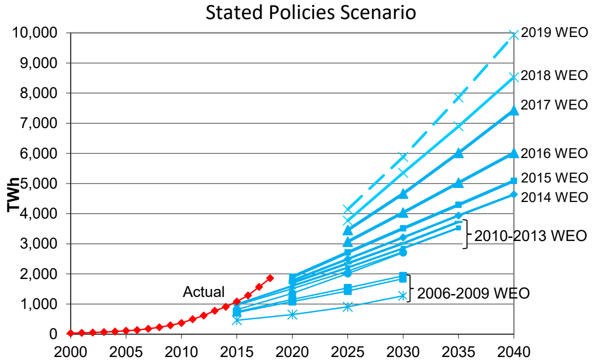
One proposal for reducing carbon emissions from coal-fired power plants is to capture and use or store some of the CO_2 through a technology called carbon capture utilization and storage (CCUS). This technology requires equipment to capture carbon at the plant, pipelines to transport the captured gas, and underground reservoirs into which high pressure CO_2 can be pumped. Progress on CCUS has been slow. Although there is some potential for using CCUS in enhanced oil recovery, in the absence of a high carbon price penalty, few utilities want to incur the extra costs and suffer the reduction in plant efficiency that goes with CCUS. There is also public concern about leakage, based on the toxicity of concentrated CO_2. Given its poor track record, counting on CCUS to contribute significantly to reaching the Sustainable Development pathway is a risky bet. The anticipated contribution of CCUS continues to drop in the WEO projections.

Nuclear power is nearly carbon free but has been losing momentum in recent years, because of very high development costs, cost overruns and fear of accidents. These and other factors have halted most construction in OECD countries. From a climate perspective, early retirement in some OECD countries will reduce generation at a time when carbon free sources are most needed. Developing Asia has seen the largest growth in nuclear generation, but even there the enthusiasm is waning, such as in China and India. The Stated Policies Scenario projections for nuclear generation in 2040 have declined from 4,600 TWh in the 2014 WEO to 3,500 TWh in the 2019 WEO. Although nuclear advocates hope that new designs will calm public fears and reduce costs leading to a resurgence of nuclear, as with CCUS, we cannot count on it.

The best news from the power sector is that the capital cost of solar and wind have declined to the point where they are competitive with fossil fuels in a number of regions, thus spurring rapid expansion of their capacity and generation. Figure 3 shows a series of forecasts of wind plus solar photovoltaics (solar PV) by the *World Energy Outlook* from 2006 through

Figure 3: Wind + Solar PV Electric Forecasts, World

Stated Policies Scenario



Source: International Energy Agency, World Energy Outlook, 2006 through 2019.

2019. Actual generation (in TWh) is shown in red on the left. The upward fan of blue lines shows successive revisions of the WEO electricity generation forecast in the Stated Policies Scenario through time. Clearly these renewable technologies are making inroads to generation faster than the modelers at the IEA can keep up. In the Stated Policies Scenario wind plus solar PV are now projected to provide 24 percent of world electricity generation in 2040, up from 7 percent today.

Complications arise as the penetration of solar and wind grow. One concerns system reliability as large amounts of power must be provided by backup sources on short notice as the sun goes down and the wind falters. This requires careful weather forecasting, the ability to ramp up fossil generation, other renewables, or electricity from battery storage, and the transmission capacity to wheel massive amounts of power where needed. Another complication arises when the capacity of solar and wind grow large enough to compete with one another on a windy, sunny day. This degrades the economics of both. There is also the question of public willingness to tolerate large tracts of land devoted to windmills, solar farms, and power lines.

Despite the good news on solar and wind we cannot run a power grid solely on them and it remains to be seen how far they can penetrate and how fast. The record of WEO projections shows the difficulty of forecasting renewable electricity generation. So far the revisions have all been upward but it is possible for the IEA to overreach. The state of California now has about the same penetration of solar and wind as projected for the entire world in 2040. California can do this is by wheeling power from fossil plants in neighboring states. However it is not clear that the rest of the world can replicate this.

The IEA has expressed some angst over the existence of a large number of relatively new coal-fired power plants, suggesting that these may emit carbon dioxide decades into the future. Coal-fired plants are now sometimes used in load-following mode, which reduces the time they run. If at some point natural gas plants or batteries become a less expensive source of backup power than coal plants, then coal plants will be closed for economic reasons regardless of whether they are still within their design lifetimes. (Similarly, perfectly good buggy-whip factories were probably closed with the advent of the automobile.) Unfortunately, indigenous coal is quite cheap in China and India, and coal mining bolsters employment, which suggests that the decline of coal will be long and slow in that region.

Battery backup for electric utilities is a complicated subject because there are different time-frames for battery storage. Batteries are already cost effective in some seconds-long applications for power conditioning. Batteries are not generally economic for day-long electricity storage or longer. There is much optimism on cost reductions for batteries but still lots of uncertainty on how low the prices will fall, and whether large-scale production might increase the price of critical metals.

Adding other renewables (hydro, geothermal, biofuels) to wind and solar, the share of renewable electric generation is projected to reach 44 percent by 2040 in the Stated Policies Scenario. If we include nuclear power, then non-fossil generation is projected to reach 52 percent by 2040. Despite the rapid projected progress of non-fossil generation, this still falls far short of the Sustainable Development pathway. Why is the Sustainable Development pathway so difficult to achieve in electric generation? In brief there is a great deal of embedded capital, it takes a long time to replace, and some parts of the world still have strong cost and employment incentives to continue with fossil generation.

Transportation

Currently the transportation sector accounts for about 24 percent of world fossil CO2 emissions. Economic and population growth, particularly in developing countries, translates into significantly higher future demand for transportation. More than 1 billion cars and trucks are on the road today and that number will increase to over 2 billion by 2040. Higher efficiency of gasoline and diesel powered vehicles, while useful, cannot satisfy the carbon goals set forth in the Sustainable Development Scenario.

Although EVs have made significant technical progress in the past decades and are beginning to penetrate the market, a variety of drawbacks limit their potential growth and their ability to reduce carbon emissions. Drawbacks include limited range, poor cold weather performance, long charging times, small size, the need for hundreds of millions of charging stations, availability of key metals for large scale implementation and the fuel sources for nighttime charging.

The driving range of EVs has increased substantially since General Motors first rolled out its EV1 in 1996 with an advertised range of 70 to 100 miles. The 2019 Chevrolet Bolt has an advertised driving range of 238 miles, while the Tesla model S gives a range of 370 miles. These ranges are for ideal driving conditions—the range can drop as much as 40 percent in the coldest weather according to AAA (2019). However, even when facing less favorable driving conditions they are still long enough for most round trip commutes. This opens up a substantial market as a commuter vehicle, provided that home or workplace charging is available.

The fuel source for electricity is a key issue for EVs. If the millions of Chinese EVs are charged using coal-fired electricity then the CO_2 emissions may be higher than those from an efficient gasoline-based vehicle, for example one with 35 mpg fuel economy. When vehicles are charged at night the absence of solar means a greater chance of the fuel source for electricity being carbon-based. The real push for EVs should probably wait until after the world moves toward cleaner electricity sources.

Biofuels have been used as a supplement to gasoline and diesel for years. In a low carbon world they could serve as fuels for niche applications, such as long distance trucking, but have a large land footprint and so cannot be scaled up significantly without competing against food. They also have a poor energy balance and very high costs.

Air travel and shipping have unique needs. Although low carbon advances are possible they are probably decades away.

The bottom line for transportation is that the lag times needed for further technology development, tooling up for production, and replacement of the existing global vehicle fleet is in the order of a few decades – too slow to meet the Sustainable Development pathway.

Industry

Many industrial processes use fossil fuels as either a feedstock (as in plastics) or a heat source (as in cement manufacturing). Biological feedstocks are being researched but few are economic at this point.

Industrial heat demands can be lessened by improving equipment and process efficiency. Sometimes a different process can be used to achieve the same end, as in freeze drying to reduce moisture instead of heating. In this example the fuel switches from natural gas to electricity, which can hopefully be powered by cleaner sources. Many industrial processes run 24 hours per day, meaning that even if powered by electricity there is the issue of what is used to generate the electricity, especially at night.

Although industry has been improving its efficiency for decades, it is not clear that carbon emissions can be reduced as far and as fast as required by the Sustainable Development pathway. The embedded capital stock of industrial plants is enormous, and takes time to change.

Residential and Commercial

Although super-insulation for buildings has been technically feasible for decades, governments have been timid in revamping building codes accordingly. Super-insulation is one of the least expensive ways to reduce CO_2 emissions. Such insulation reduces heating and cooling demands 24 hours per day so reduces the need for electricity generation, transmission and storage.

In many parts of the United States however tradesmen have little understanding on how to build double-wall construction and home builders refuse to oversee such a requirement, even if requested by the buyer, given the expense of minutely supervising the tradesmen. Building codes could force the issue, but local jurisdictions have little incentive to change them. Building codes are much stricter in some European countries, such as Denmark.

Combining super-insulation with on-site generation (primarily solar) and effective passive solar design can lead to homes that are close to net zero energy. Retrofitting existing buildings to achieve net zero energy performance is much more expensive than building new.

In developed countries the enormous installed stock of buildings along with the expense of retrofitting to higher standards means it will take decades of building stock turnover to reach the full potential of carbon emissions reductions.

The developing world has a unique opportunity to sharply reduce building energy use as new buildings are constructed. Will this happen, or will future buildings in the tropics compensate for poor insulation with larger air conditioners?

Developed versus Developing Economies

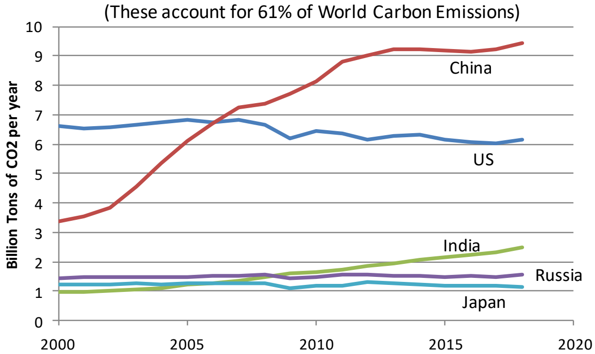
The developed economies have more economic resources than the developing countries, but face an enormous embedded capital stock of electric generation, factories, homes and fleets of vehicles. To reach the Sustainable Development path put forward by the IEA, this embedded stock must be retrofitted or prematurely scrapped--waiting for natural turnover takes too long.

The developing economies have less capital stock so they have an opportunity to install the best sources of electric generation, the most efficient factories, homes, and vehicles at lower cost than retrofitting. Unfortunately these countries have fewer economic resources and there are typically fewer economic incentives to grow on a low carbon path.

Figure 4 shows the top five CO_2 emitting countries in the world, accounting for 61 percent of global emissions. China tops the list and its emissions are still growing. Indian emissions are also growing,

Figure 4: The Top Five CO2 Emitters

(These account for 61% of World Carbon Emissions)



Source: BP Statistical Review of World Energy, June 2019

although from a smaller base. This growth is typical of developing countries. In contrast, the U.S., Japan and Russia show slowly declining or level emissions. In order to transition from the Stated Policies CO_2 path to the Sustainable Development path, the emissions from developing countries would have to start declining very soon. This would need to happen without sacrificing economic growth.

So Where Do We Go From Here?

So where do we go from here? How much further can renewables be pushed? What economic, technical, political, and environmental challenges lie ahead?

Several questions have to be addressed regarding the future of the world energy transition:

- Have renewables now reached a critical inflection point, where their use will accelerate even further in the future, as called for by the International Renewable Energy Agency (2019). Or, will penetration growth rates slow down, as predicted by the Oxford Institute of Energy Studies (2019).
- Are there applications where renewables cannot or should not fully replace fossil fuels or nuclear power? For example, plastics manufacturing, marine transportation, aviation, iron and steel manufacturing, and food production? What about the applicability of renewables in mega cities where 10 million persons or more reside? And what about the use of renewables in military theaters where reliable and consistent energy supplies often means saving lives?
- And finally, can the world thrive on 100 percent reliance on renewables, or 90 percent, or 80 percent, or 70 percent, as is being proposed in many countries, regions, and localities, and at what cost? And with what land requirements?

Here's What We Know

Here is what we know: how far and at what speed the global energy transition will evolve will likely depend on three extremely critical factors: renewable energy penetration rates; EV penetration rates, and energy efficiency gains in industry, transportation, and buildings.

Renewable energy penetration rates

Deployment of renewable energy, in particular solar power, continues to grow faster than industry analysts assess, driven by sharp cost reductions and policy support, such as subsidies and tax credits. This growth in renewable energy use has prompted the International Energy Agency and other energy-forecasting bodies to revise their long-term projections upward each year since 2006, as was highlighted in Figure 3. This graphic demonstrated how fast the uptake in the use of renewables has been over the past decade, far exceeding projections from leading analysts. Nevertheless, as was highlighted in Figure 1, renewables penetration in world electricity generation is less than 30 percent today and is projected to still be slightly less than 50 percent of total generation in 2040.

EV penetration rates

The expected growth in oil consumption for transport use in coming decades could be slowed with the further penetration of advanced transportation technologies, including pure EVs, gasoline-powered electric hybrids such as the Toyota Prius and advanced diesel engines, though governments worldwide will need to take unprecedented policy actions to promote their use. Ultimately clean diesel-powered hybrids may offer even greater fuel efficiency and reduced carbon emissions, as such, we argue that more research and development should focus on heavy duty diesel hybrids and not heavy duty long haul EVs. Longer term, hydrogen fuel cell vehicles including trucks will offer long-distance driving ranges, an ability to carry heavy loads, and a very flexible fuel source. The overall emissions of both hydrogen fuel cell vehicles and EVs can vary greatly, depending on the original energy source used to make the hydrogen and electricity.

The lack of sufficient charging infrastructure for all-EVs is currently an upper bound on just how fast such cars can penetrate world markets. Other challenges include continued efficiency improvements in conventional petroleum-based vehicles, long EV charging times, and EV range anxiety.

Critically, most of the world's population reside in cities or urban areas, largely in apartment dwellings, implying that charging stations would need to accommodate this population category. Any judgment about future EV penetration rates should be based largely on the ability for apartment dwellers to recharge their car batteries. Homeowners with garages are a much smaller segment. We believe that until apartment dwellers are able to charge their EVs either near their residence or at work, there will be an upper limit on EV sales worldwide. With the major source of worldwide electricity generation still from fossil fuels, EVs can have higher overall emissions than high efficiency petroleum-based vehicles.

Energy efficiency gains

Energy efficiency encompasses all changes that result in lower energy use for a given energy service (for example, heating, cooling, and lighting) or level of activity. This reduction in energy consumption can be related to technical changes—such as improving insulation effectiveness for walls and windows—or better practices, management, and organization. Reduction of energy use for specific services or activities can be achieved by various means including energy efficiency improvements, demand-side management, and performance contracting.

The most effective energy efficiency programs—such as in Japan—typically involve a combination of approaches, including mandatory measures and regulations, tax and fiscal incentives, and public education. A worldwide ramp-up in energy efficiency improvements is technically possible if financial barriers—including risk exposure and the inadequacy of traditional financial mechanisms for energy efficient projects—are eased and consumer apathy reduced. Other potential barriers include lack of enforcement of building codes and standards and regulatory biases.

The biggest potential for reducing CO_2 emissions is through energy efficiency improvements in industrial, residential, and commercial applications, as well as in transportation. In its outlook for energy to 2040, ExxonMobil (2019) concludes that global energy demand will grow by only about 20 percent from 2017 to 2040 because of continued energy efficiency improvements that will result in large energy savings and a slowdown in growth of carbon emissions. Global energy demand would soar significantly higher—closer to a 100 percent increase by 2040—without the anticipated efficiency gains across the global economy, according to ExxonMobil (2019). Moreover, by 2040, the combined effects of lower energy intensity and less carbon-intensive energy sources could result in a nearly 45 percent reduction in the carbon intensity of the worldwide economy (ExxonMobil, 2019). As such, investments to boost energy efficiencies are likely to increase over the next two decades to help offset the need for new energy production and reduce emissions.

Still, There Are Great Uncertainties

--EV penetration rates:

As discussed previously, the lack of sufficient charging infrastructure for EVs is an upper bound on just how fast such cars can penetrate world markets. Another challenge is the source of the electricity that those EVs use for charging. EVs in China for many years will have significantly higher overall emissions than an equivalent gasoline hybrid electric vehicle due to the use of mostly coal-based electricity. The advantage of EVs for China today is they provide a means of shifting air pollution out of the cities (while regrettably increasing CO_2 emissions).

--Will there be 'clean' coal:

Many recently built European coal-fired power stations are dubbed carbon capture utilization and storage, or CCUS, capable, implying that when CCUS technology becomes economically viable, the stations can add the equipment to reduce or eliminate the carbon emissions. While no immediate breakthroughs with CCUS technology are expected, should the technology become viable and widely available, it could favor continued coal development in the developing world, where electricity needs are projected to continue rising at a robust pace through 2040. However, CCUS is very site specific and will be limited to areas with large nearby safe deep underground CO_2 sequestration. Moreover, adding CCUS to an existing plant would significantly reduce the net power plant capacity and efficiency—by as much as 1/3 if fuel rates are constant—while adding substantially to net unit capital costs.

While carbon trading is intended to help signatories move towards their CO_2 reduction targets, in the end, their ambitious targets will probably only be achieved through a major curtailment of use of coal, a continued ramp-up of renewables, some reliance on nuclear power, and major efficiency and conservation gains.

--Nuclear power phaseout?

There are 443 operating nuclear power plants in the world, accounting for about 10.3 percent of world electricity consumption (World Nuclear Association, December 2019). France relies on nuclear energy for the greatest share of its electricity output, about 72 percent, although the government plans to reduce that reliance to about half of the country's electricity mix by 2025. The United States has the largest nuclear power plant fleet—96 operating units—whereas China has the most plants now under construction, at 12. Importantly, as many as half of the world's existing nuclear power plants are expected to end their life cycles over the next 15 years, and numerous countries such as the UK will have to decide what to do with their nuclear power industries—extend the lives of the existing plants, replace the plants with other energy sources such as natural gas and renewables, or build new nuclear power plants using state of the art designs. Retiring nuclear plants face high decommissioning costs as well as long-term storage challenges for highly radioactive components and spent fuel.

Clearly, it should be recognized that any large-scale global retreat from nuclear power will almost certainly make global climate change goals more difficult to achieve, which rely on accelerated use of low-carbon energy technologies by 2030. Nuclear power is one of a few nearly carbon free sources of energy, as extracting uranium, processing it into nuclear fuel, and constructing plants release only a modest amount of emissions. Countries such as Brazil, France, Sweden, and Switzerland, along with regions such as Ontario, have decarbonized their electricity supplies by using nuclear power with other low carbon sources. Yet, in many countries nuclear power is not officially linked in with clean energy initiatives, or even ignored entirely.

--Confronting cyber threats to grids:

As the world becomes increasingly electrified including a rapid push toward EVs and charging stations, cyber threats will become more widespread and commonplace. Greater digitalization of renewables-based electricity grids, including the "smart" grid, will certainly increase cyber threats and raise prospects for remote hacking and disruption from adversary sources. How will governments and country leaders respond? Will protection technologies and software be able to keep pace with increased cyber threats?

--How far can solar and wind really be pushed?:

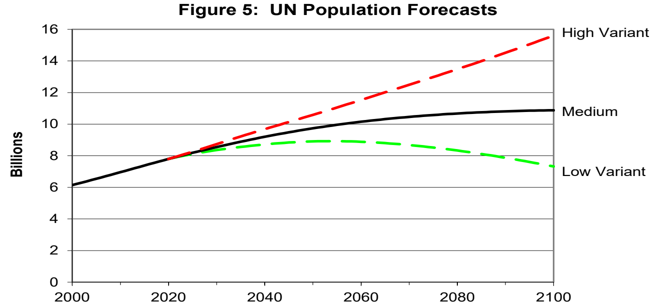
Relatively low capacity factors for wind and solar power imply that large land areas will be required to generate large volumes of electricity and compete with baseload generation provided by fossil fuels and nuclear power. For example, we calculate that to replace the electricity generated by a 1-gigawatt nuclear power plant running at 80 percent capacity factor would require over 1,000 3-megawatt windmills with a 25 percent capacity factor. Such wind capacity would require over 2,000 acres of land. As more and more large-scale wind farms and solar arrays are contemplated, it is possible that communities will begin pushing back, as they already are in parts of the United States and Europe.

Land requirements matter not only in terms of acreage needed, but also in terms of opportunity costs. In Culpeper, Virginia, for example, there is a proposal to cut down more than 800 acres of forested land, to build a "solar power farm" of 270,000 solar panels, to produce 80 MW of electricity. (For perspective, in nearby Chesterfield, Virginia, there is a coal-fired power plant that generates 1640 MW.) In Spotsylvania, Virginia, there is a second proposal to cut down 6,500 acres, to locate 1.8 million solar panels, producing up to 500 MW. Nearby communities are pushing back, and asking if clear cutting makes sense from an environmental perspective. We ask whether such projects would be economically viable without the tax credits, subsidies, and mandated renewable portfolio standards, and why wouldn't such large solar arrays be more appropriate in desert climates or other open space environments?

With wind, we believe that over the long term the most probable areas for large scale deployment will be offshore, which can take advantage of generally advantageous wind regimes and not necessarily become an eyesore. Offshore wind unit capital costs are much higher compared to onshore facilities, but have higher annual load factors to help cover the higher capital costs.

We're Downplaying Other Potential

Figure 5: UN Population Forecasts



Source: United Nations, World Population Prospects 2019.

Solutions for Global Warming

Most solutions being discussed by energy and climate advocates are supply-oriented, that is, how do we produce and use more renewable energy? Other possible solutions that are mentioned only briefly, if at all, include slowing population growth rates, further boosting energy efficiencies, and assessing geoengineering opportunities.

Current population forecasts call for an increase from 7.7 billion people today to about 10.9 billion people in 2100 despite gradual reduction in the population growth rate (United Nations, 2019). Speeding up the reduction in population growth rate by even a small amount can greatly reduce the 2100 population, as demonstrated in Figure 5. This can probably be achieved non-coercively through improved education and empowering women in developing countries according to some demographers (Bongaarts, J. et. al, 2012; Worldwatch Institute, 2012). This is a win-win approach as it helps eradicate poverty while reducing climate pressure associated with population.

Energy efficiency improvements are the least costly and yet most meaningful ways to curb energy consumption growth and, as a result, greenhouse gas emissions. Major efficiency improvements reduce energy use and emissions per unit of GDP thus enabling GDP growth while at the same time reducing fuel, emissions, and costs. Although energy efficiency is referred to in the aggressively in some sectors in some scenarios.

Solar geoengineering is deemphasized by some in the climate community for fear that it could have unintended consequences. However, some of the geoengineering ideas are inexpensive and relatively easily reversible, which means we can experiment with them with minimal cost or risk. If the costs of climate change are high, why are we not experimenting more with geoengineering to at least bridge the time gap needed to fully implement renewables, efficiency changes and other measures? Current funding for solar geoengineering is very small.

Conclusions

The world is currently in a transitional, and sometimes turbulent, period for energy. Although renewables and other new technologies promise far lower carbon emissions in electricity generation and transportation, there are major uncertainties and challenges in how far the world can push and how quickly. Climate scientists have warned repeatedly that time is of the essence. Yet the amount of capital needed to replace existing carbon intensive technologies is enormous, while at the same time the world economy and population are growing, requiring more and more energy services.

The 1.5C to 1.65C Sustainable Development pathway proposed in the *World Energy Outlook* is quite impractical, as was shown in Figure 2 and discussed at length. However, despite the large gap between the desired trajectory and the Stated Policies Scenario, energy analysts and governments cling to the notion that the aggressive pathway is within reach simply with greater efforts. We argue that the energy community is too narrowly focused on increasing the supply of renewables and other low-carbon energy sources, rather than also having a serious focus on demand-side management. By broadening the scope of the global energy transition to include options for greater emphasis on efficiency, the use of solar geoengineering and other technological means to reverse carbon levels, and slowing population growth rates, we can greatly increase the chances of averting serious climatic consequences while the new energy economy is being established.

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Will Electric Vehicles Transform Distribution Networks? Only Time will Tell

BY MICHELLE MICHOT FOSS AND KATHERINE ZOELLMER

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See footnotes at end of text.

Around the world, governments and societies are pursuing transformations to energy systems. Most of these involve "electrification": electrification of the vehicle tailpipe, i.e., displacing internal combustion engine (ICE) transport with partial or fully electrified versions. Pure battery electric vehicles (BEVs) would likely, perhaps overwhelmingly, rely upon local electric distribution company (disco) networks for recharging as would plug-in hybrid electric vehicles (PHEVs). All electrification scenarios bear implications for power generation (technology and fuel mix), transmission (for remote and intermittent generation) and distribution (for all of the end use applications). These efforts are being undertaken with beliefs that: net reductions in carbon can be achieved without sacrificing reliability and security of energy systems and economies; open, competitive market regimes are compatible and can be preserved; the scope of policies and mandates are complementary with consumers' willingness and ability to pay the consolidated costs. Are these assumptions accurate? Is there sufficient scrutiny to support beliefs? What are the missing links and considerations?

Zoom-Zoom

The energy transformation stakes are highest when it comes to views about the future of transportation and mobility, because these entail enormous shifts in technology, materials, supporting supply chains, consumer tastes and preferences, demographic and geographic context. It should be no surprise that pace and timing of electrification are expected to be quickest in urban corridors, the denser the better, tapping into discos that are often old and expensive to maintain and repair (much less to improve). Conventional wisdom has it that metropolitan markets around the world can accommodate increasing shares of various types of electric vehicles, all integrated into local distribution grids for charging and/or balancing energy flows, with interactive metering to convey signals between supply and demand. EVs generally fit into ambitions for distributed energy resource (DER) approaches that offset or supplement disco operations. Balancing these views are standalone, self-sufficiency concepts for remote energy capture – solar, for instance – with EV and other battery energy storage. Nirvana! But what really is going on in the auto world with EVs?

The range of possibilities and associated challenges means outlooks for EV growth and market share vary greatly in both methodology and results. Where some organizations project to 2025, others look much further to 2100 for detectable alterations. Where some consider policy or consumer preference as primary drivers, others attempt to account for both while adding other factors such as technology. All are moving targets, of course. It is not only the values across the different projections that differ. The range of possibilities provided within individual outlooks are broad as well, contingent upon scenarios. For instance, in its May 2018 *Global EV Outlook*, the International Energy Agency (IEA) projected global EV deployment ranging from 40 million to 70 million by 2025, while the U.S. Energy Information Administration (EIA) in its January 2019 *Annual Energy Outlook* has 8 to 26 percent of the global fleet electrified by 2040. Bloomberg New Energy Finance in their 2019 *Electric Vehicle Outlook* puts 559 million EVs on global roads by 2040, or 55 percent of new car sales. The span of possibilities constitutes a "5x" spread for 2030, a relatively close time target.[1] For proper perspective, these outlooks and projections compare to a U.S. private, light duty vehicle fleet of more than 275 million cars, with annual sales of new autos at about 17 million and used of about 40 million, and a worldwide auto fleet of about one billion.

Against these wildly varying aspirations and forecasts, the auto and electric power industries and their myriad suppliers and vendors must make hard decisions while at the same time operating their core businesses soundly if they are to survive and thrive with ability to invest in the murky future. And so forecasts from original equipment manufacturers (OEMs) are equally varied. Volvo announced that by the end of 2019, each of its vehicle models will be electrified. This comes in the form of fully electric vehicles, plug-in hybrids, and mild hybrid vehicles that do not require charging. Additionally, the company plans to release five new fully electric models by 2021 and aims to have over one million of their electric vehicles on the road by 2025. Similarly, BMW announced they will release five new fully electric options by the end of 2021. BMW's target increased to a total of 12 electric and 25 hybrid models by 2025. The company stated a goal of putting half a million electric vehicles on the road by the end of 2019. BMW can manufacture the engines for battery electric, plug-in hybrid, and internal combustion vehicles on the same production line, which helps the company to streamline manufacturing and increase efficiency during its transition to increased electric options. Along with shifting portfolios of vehicle models are corporate goals for their own operations. For example, Toyota turned its attention to the manufacturing process and set numerous sustainability goals for the company. Overall, the company aims to have a net-zero environmental impact through maximizing the efficiency of their water usage, ensuring recycling, and addressing vehicle-related emissions. Toyota's goals include zero carbon dioxide emissions from new factory plants as well as achieving a 90 percent reduction in carbon dioxide emissions from their vehicles by 2050 as compared to the 2010 values.

There are, of course, alternative designs that OEMs are developing, like hydrogen fuel cell vehicles (HFCVs) and ICE vehicles coupled with cleaner fuels of various types. Toyota's long-term goal of pursuing fuel cell vehicle options is one of the more aggressive, with active partnerships and investments in hydrogen fuel and infrastructure to support vehicle sales. Other OEMs have HFCV designs although most opinions are that it is likely to take longer for alternatives like HFCVs to penetrate the market in meaningful shares; for many OEMs HFCVs are geared toward the heavier duty vehicle markets where re-fueling can more easily be integrated into commercial fleets. OEMs also readily acknowledge that improvements, some quite deep, still can be made to ICE vehicles that may prolong competitiveness of conventional transportation and fuels. Transportation fuel suppliers and OEMs also are pursuing new fuels that may offer substantial environmental benefits. Coupled with the performance metrics already prized in the higher energy density petroleum-based combustion engine design, ICE vehicles may persist longer than many expect.

Building global aspirations and outlooks for possible and potential EV penetration is one thing. Auto makers cannot respond unless vendors and suppliers are able to rise to the occasion. OEM commitments for different models mean required changes in manufacturing. Manufacturing typically does not come into play directly in outlooks; clearly, the more aggressive an energy transformation/electrification view of the future, the more likely it is that underlying manufacturing constraints are assumed to be met. Yet fundamental, structural changes will be necessary to ramp up production if forecasted EV growth is to be met. Global OEM vendors and suppliers have increasingly taken note of ambitions for electrification and are beginning to make changes in their business models. These changes typically include investments in technology such as battery cooling systems and electric motors, as well as including electric drivetrain manufacturing.

We surveyed a number of OEM suppliers, finding strongly divergent responses. For instance, Continental AG has begun to further develop its powertrain division, which became an independent group in the beginning of 2019. In addition to ICE powertrains, the group also covers electric vehicle and hybrid parts. Because of the increased costs associated with this transition, the corporation noted a decrease in earnings expectation in the short term (considerations for earnings as companies weigh strategic responses is a common theme, including for OEMs and fuels suppliers). Despite this, Continental AG's powertrain division has continued its investments, developing a plant in China, a common destination.

Like Continental AG, Bosch formed a new powertrain solutions division in 2018, which focuses on three market segments: passenger ICEs, commercial and off-highway transportation, and electric vehicles. In addition to electric powertrains, Bosch is also developing an e-axle for heavy trucks with fuel cell powertrains. The company understands the importance of electrification for stated policy goals and greenhouse gas emission targets; however, Bosch expects a slow transition to fully electric vehicles, as even new combustion engine powertrain technology can help in emissions reductions. Given that perspective, Bosch is continuing to develop a variety of components for ICE, hybrid, and fully electric vehicles.

Increasing its options of electrifications products, Denso offers car drive systems, power supply, starting system parts, and small motor systems for hybrid and electric vehicles. Additionally, the company is working to enhance the efficiency of ICE vehicles in developing countries, where the key to promoting environmentally-friendly vehicles in these countries is by optimizing and reducing the cost of the existing technology. The company reported an eight percent increase in revenue from electrification systems, citing increased sales of electric products for hybrid vehicles in Japan and China. Denso has recently developed a new flow valve for improved fuel economy through temperature management in battery hybrid and electric vehicles.

In spite of a temporary shut-down at a location in Ohio, Hyundai Mobis sales increased in 2018 in part due to increased production volume of BEVs. Hyundai Mobis reported a year-over-year increase from 2017 to 2018 in part related to electrification.

Shifts in the transportation industry are leading to new partnerships between companies and across industries. For example, Bosch collaborated with Nikola Motor Company to develop an electric powertrain and "eAxles". The company also partnered with NIO, an electric vehicle manufacturer, for advanced sensors, automated driving technology, and electric motor management. Similarly, Denso is working with Toyota to further electric vehicle technology. Magna International has entered into a joint venture with Beijing Electric Vehicle Company to build an EV production facility in China, with the capacity to build up to 180,000 vehicles per year. The goal of the partnership is to advance the EV market in China.

In sum, many other partnerships are forming as companies begin to further explore the future of electrification and deal with opportunities and challenges. While vehicle manufacturers are beginning to offer more electric models to match apparent policy goals and shifting consumer preferences, the supplier responses are likely to dictate the pace. Many suppliers are beginning to invest in research and development regarding electric vehicles, with some adjusting their business models to accommodate R&D commitments. Overall, however, it is apparent that many suppliers see this as a slow transition, and so are focusing on maximizing the efficiency of current ICE vehicles and promoting hybrid vehicle technology.

Digging (Literally) into the Details

In making their announcements, BMW noted that its fifth generation electric engine does not require rare earth metals, one of the minerals suites that have presented distinct constraints for many technologies. As such, the BMW statement serves as a commentary on a core constraint underlying all assumptions for battery energy storage and applications – minerals and materials constituents for effective batteries.

The fundamental challenge with all alternative energy schemes is that energy storage, an attribute inherent in conventional fossil fuels, nuclear material and reservoirs for hydro facilities, must be replaced with something else if those other fuels and technologies are not used. Ergo, battery energy storage for vehicles, to substitute for the foregone benefits of energy storage in conventional vehicle fuels. The same holds for many power grid storage and balancing applications, in particular where intermittent renewable energy sources are included. A chemical battery is an energy storage device; capacity and performance are a function of battery design and chemistry – the combination of minerals and materials that enable charging and release of electricity over multiple cycles and stave off degradation. A wide variety of battery designs exists but additional constraints come in the form of battery weight, safety, and other characteristics that will make a battery design more or less favorable for EV use. Batteries can be significant components of EV cost, including life-time cost with battery replacement. While the main component of commercial EV and grid storage batteries today is lithium, many other minerals and materials are in the mix to solve the gamut of problems and ensure performance.

It is an old rule of thumb that battery storage for mobility is quite a different challenge than for electric power grids which use fixed batteries or other forms of energy storage (water for hydro, again, or compressed air or other solutions, not least advances in the long-time standard, lead acid). Battery designs for mobility must be light and compact, otherwise vehicle designs become unwieldy. EV batteries must meet an assortment of criteria that are essential for consumer acceptance and adoption. “Range anxiety” is a common terminology that captures a first-order priority – EV customers would like these vehicles to travel some distance before batteries must be re-charged. Satisfying performance metrics is essential, especially if electric vehicles are to be successful on a standalone basis, meaning that they are affordable and desirable without public support to close the gap between customer preferences and EV performance.

A current dilemma is that while alluring for many reasons, mainly low weight and high specific energy which have made lithium the preferred material for cathodes, lithium based battery designs are not perfect. Lithium is reactive; cobalt has been used to increase stability but sensitivities around cobalt extraction and supply have triggered a broad search for substitutes. Leading battery scientists believe that batteries need basic re-designs in order to obtain better energy density relative to gasoline (the best lithium batteries still provide 11 or more times the usable energy, even accounting for energy loss during gasoline combustion) and to slow degradation (and prolong battery life). The drive to improve performance puts battery safety at risk. Attempts to store more energy in lithium batteries means risks associated with overcharging, overheating, short circuits and other hazards. Lithium batteries increasingly are treated as hazardous materials for purposes of shipping and cargo safety. Battery production is energy and thus emissions intensive. Assembly of a typical lithium battery today requires 400 kilowatt-hours of energy for one kWh of energy with 75 kilograms of carbon dioxide released. Battery science is moving toward “sustainable” battery chemistry to achieve improvements in life time and safety. Advances are likely to include new chemistries with responsive battery management systems – new sensors with better state of health measurements; better understanding of degradation; new designs that could be commercialized like redox flow batteries.[2]

The changing landscape for battery science has bearing on minerals and raw materials demand and associated resource governance and geopolitical risk factors, how supply chains will evolve, whether effective solutions for recycling can be achieved, how ultimate disposal should be managed, how hazardous materials and other public interest risks are managed throughout. The combination of pressures associated just with chemical batteries and supply chains are such that new frameworks will be required to ensure that public interests are met.

Caveats Emptor

Government jurisdictions at all levels are devising policy/regulatory pushes to encourage, or to force, electrification. Much of the action is at the metropolitan level, in keeping with the urban context we noted earlier. A common approach is to propose bans on ICE vehicles, or at least sales of new ICE vehicles, sometimes with aggressive targets for timing. None of the bans we researched have been enacted into law. Bans have the obvious potential consequence of creating economic distortions and we have found some occasions in which bans are proposed or commitments made subject to economic feasibility.

(concluded on page 28)

Conference Theme and Objectives

The development of energy as we know it, from production to conversion to end-use, whether from fossil-fuels, renewable power or other sources, results from an ongoing dynamic interaction between market needs and preferences, progress in technologies and public policy initiatives. Cutting across this to make sense of the ever-changing landscape is the analysis and language of energy economics: the essential ingredient that brings a common understanding of the forces and drivers in play.

The 38th annual USAEE/IAEE Conference provides a forum for informed and collegial discussion of how energy economics is contributing to the current and future thinking of businesses, consumers, technology developers and public policy institutions in North America and around the world as they drive towards the future world of energy.

In 2020, our conference takes place in Austin, Texas. Texas is a state rich in the history of energy as well as a vibrant proving ground for major changes in energy markets. In oil and gas, Texas was the home of the historic Spindletop discovery early in the 20th century; was at the heart of the US oil and gas developments for its first 70 years; and where the Texas Railroad Commission became a globally important regulatory authority. More recently, Texas has seen the birth of the US unconventional oil and gas business with the Barnett Shale in north Texas and the prolific Permian basin. Downstream, Texas is home to major refining and petrochemical plants as well as hosting new LNG export facilities. In electric power, Texas was a pioneer in opening up the market to retail competition and remains one of the few jurisdictions in the US where this remains the norm. And Texas has seen a huge build-out of low-carbon power generation, particularly wind energy, making the state a leader in this field. And last, but not least, Texas institutions like The University of Texas, Rice University, and an engineering school on the mid-Brazos, have been at the forefront of thinking and research about energy science and economics. There is indeed much to discuss and study just in relation to Texas energy markets and we expect conference delegates to benefit from this context.

As in previous years, the conference will highlight forward-looking energy themes at the intersection of economics, technology and public policy, including those affecting energy infrastructure, environmental regulation, markets, the role of governments, and international energy trade. Participation from industry, government, non-profit, and academic energy economists will enrich a set of robust, diverse and insightful discussions.

Topics to be addressed include:

The general topics below are indicative of the types of subject matter which may be considered at the conference. In practice, any topic relating to energy economics, markets, energy policy and regulation, energy trade, energy pricing, drivers of energy demand, adoption of new energy technologies etc. will be considered.

* Global impacts of growing US energy exports
* How are energy markets responding to the shift of U.S. energy policy?
* Pathways to decarbonization of energy and the economy
* Oil prices, the role of OPEC and OPEC/non-OPEC cooperation
* Energy implications of environmental regulations: future and impact
* The role and impact of distributed energy resources in developed and developing countries
* How are digital technologies, including blockchain and artificial intelligence and the Internet of Things impacting energy supply and demand
* What next for electricity storage technologies?
* Drivers and challenges for accelerated electric and autonomous vehicle adoption
* Effective policies to support growth in low-carbon energy
* The role of natural gas in the energy transition to a low-carbon world
* Other topics of interest including shifts in market structures and fundamentals, including those induced by policy and technological forces.
* Drivers and challenges for accelerated electric and autonomous vehicle adoption
* Role of natural gas in the energy transition to a low-carbon world
* Role and impact of distributed energy resources in developed and developing countries
* Evolution of electricity storage technologies
* Financing conventional and renewable energy
* Who is financing what and why it matters?

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Advance call for Concurrent Session Presentation Proposals

We are pleased to announce an advance call for Concurrent Session presentation proposals for the 38th USAEE/IAEE North American Conference, Energy Economics: Bringing Markets, Policy and Technology Together, to be held November 1-4, 2020 at the Sheraton Austin Hotel in Austin, Texas, USA. The deadline for receipt of proposals is May 31, 2020.

Concurrent Sessions

The concurrent sessions at the USAEE/IAEE conference offer opportunities for students, academic staff, as well as energy economists and practitioners in the business, government and research communities to present current analysis, research or case-studies on topics related to energy economics and energy markets. Presentations may be based on academic papers, but this is not a pre-requisite requirement. We stipulate that presentation proposals submitted for inclusion in the concurrent sessions should not have 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. Those interested in organizing a concurrent session should propose a topic and possible speakers to David Williams, Executive Director, USAEE (usaee@usaee.org). Please note that all speakers in organized concurrent sessions must pay speaker registration fees and submit abstracts.

Concurrent Session Presentation Proposal Format

Authors wishing to make concurrent session presentations must submit a proposal that briefly describes the topic, research or case study to be presented.

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

a. Overview or summary of the topic including its background and potential significance
b. Description of the context, data used, or illustrative example of the topic
c. Summary of key insights, results or further questions
d. Conclusions: Lessons learned, business or market implications, recommendations for further work

Please visit www.usaee.org/USAEE2020/PresentationProposalTemplate.doc to download a proposal template. All proposals should conform to the format structure outlined in the template. Proposals should be submitted online by visiting www.usaee.org/USAEE2020/submissions.aspx Proposals submitted by e-mail or in hard copy will not be processed.

Presenter attendance at the conference

At least one presenter of an accepted concurrent session presentation proposal must pay the registration fees and attend the conference to make the presentation in person. The person submitting the proposal must provide complete contact details—mailing address, phone, e-mail, etc. Presenters will be notified by July 13, 2020 whether their proposal has been accepted. Presenters whose proposal are accepted will have until August 24, 2020 to submit their final papers for publication in the online conference proceedings. While multiple submissions by individuals or groups are welcome, the proposal selection process will seek to ensure as broad participation as possible: any person may present only one topic at the conference. No person should submit more than one proposal as its single author. If multiple submissions are accepted, then a different presenter will be required to pay the registration fee and present each paper.

Students

In addition to the other 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 June 29, 2020. Visit www.usaee.org/usaee2020/bestpapers.html for full details.

Students may also inquire about scholarships covering conference registration fees. Please visit http://www.usaee.org/usaee2020/scholarships.html for full details.

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IAEE - APEEN Student and Young Researchers Prizes–2019

The Portuguese Association for Energy Economics – APEEN – with the support of the International Association for Energy Economics (IAEE) gave three prizes last year: the Young Researcher Award, and two IAEE Student awards, given to the best paper presented in two APEEN scientific events.

APEEN gave the Young Researcher Award at the 4th Annual APEEN Conference - *Energy Demand-Side Management and Electricity Markets*, that took place in the University of Beira Interior, Covilhã, Portugal, on 17th and 18th October, 2019. This prize has the objective of rewarding scientifically relevant work in Energy Economics by young researchers, and promoting the growth and renewal of this scientific area in Portugal. The Young Researcher award has a monetary value of 1000€ and the candidates have to send an article published in a scientific journal, be at least 35 years old, and be an APEEN member. This year the winner was **Tiago Oliveira**, with his paper *Wind power and CO_2 emissions in the Irish market*, co-authored with Celeste Varum and Anabela Botelho and published in the journal, *Energy Economics.*

Additionally, two prizes were promoted and offered by IAEE, in an effort to encourage more students to join the Association, and to provide research in the Energy Economics area. A prize of $300 was given to the best article/presentation at the 6th International Meeting on Environmental and Energy Economics (ME3), on 29th May (University of Aveiro, Portugal), to **Diogo Santos Pereira**, for his paper, *An econometric approach to assess and design policies and measures for electricity Demand-Side Management: France as a case study*, co-authored with António Cardoso Marques.

The second IAEE Student prize, of $350, was given to the best article/presentation at the 4th Annual APEEN Conference 2019. The winning student was **Santtu Karhinen**, for his article/presentation entitled *Emissions reduction by dynamic optimization of distributed energy storage under aggregator's control,* co-authored with Hannu Huuki and Enni Ruokamo.

IAEE and APEEN also guaranteed the membership dues of $50.00 for each of the two Student IAEE winners to APEEN/IAEE for one year.

IAEE Student Prize – ME3: Diogo Pereira

IAEE Student Prize – Annual APEEN Conference: Santtu Karhinen

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A Mandatory Energy Transformation Wouldn't Work

BY MAMDOUH SALAMEH

Mamdouh Salameh is an international oil economist. He is also a visiting professor of energy economics at the ESCP Europe Business School in London.

See footnoes at end of text.

What is an Energy Transformation?

Energy is the fundamental need of our everyday life. So much so, that the quality of life and even its sustenance, is dependent on the availability of energy. Hence, it is imperative for us to have a conceptual understanding of the various sources of energy, the conversion of energy from one form to another and the implications of these conversions.

Energy in its various forms may be used in natural processes, or to provide some service to society such as heating, refrigeration, light, or performing mechanical work to operate machines. For example, an internal combustion engine (ICE) converts the potential chemical energy in gasoline and oxygen into thermal energy which, by causing pressure and performing work on the pistons, is transformed into the mechanical energy that accelerates the vehicle and pushes it up hills. A solar cell converts the radiant energy of sunlight into electrical energy that can then be used to light a bulb or power a computer.[1]

Energy transformation is the process of changing one form of energy to another. Changes in total energy systems can only be accomplished by adding or removing energy from them, as energy is a quantity which is conserved, as stated by the first law of thermodynamics.[2]

On the other hand, energy transition is generally defined as a long-term structural change in energy systems. These have occurred in the past, and still occur worldwide. Contemporary energy transitions differ in terms of motivation and objectives, drivers and governance.[3]

However, I am using the terms transformation and transition alternately in this article to mean a transition from hydrocarbons (oil, natural gas and coal) to renewable energy.

The Global Energy Transformation

Increased use of renewable energy, combined with intensified electrification, could prove decisive for the world to meet key climate goals by 2050. Ramping up electricity to over half of the global energy mix (up from one-fifth currently) in combination with renewables would reduce the use of fossil fuels, responsible for most greenhouse-gas emissions.[4]

A study from the International Renewable Energy Agency (IRENA) envisages energy transformation would also reduce net costs and bring significant socio-economic benefits, such as increased economic growth, job creation and overall welfare gains.

Achieving a climate-safe future, however, depends on swift global action. Current plans and policies fall far short. Energy-related emissions have risen around 1% yearly since 2015.[5]

For instance, the flaring and venting of natural gas in the U.S. continues to soar, reaching new record highs in recent months. The volume of gas that was burned or simply released into the atmosphere by oil and gas drillers in the Permian which is the heart of U.S. shale oil production reached 1.28 billion cubic feet per day (bcf/d) in 2018, according to the International Energy Agency (IEA), up from 0.772 bcf/d in 2017. The practice is a disaster on many levels. It is wasteful, it worsens air quality and it exacerbates climate change. Venting gas is much worse than burning it since it releases methane into the atmosphere, a potent greenhouse gas.[6]

Based on IRENA's analysis, energy-related CO_2 emissions would have to decline 70% by 2050 compared to current levels to meet climate goals. A large-scale shift to electricity from renewables could deliver 60% of those reductions; 75% if renewables for heating and transport are factored in; and 90% with ramped-up energy efficiency.[7]

With electricity becoming the dominant energy carrier, global power supply could more than double, the report finds. Renewable sources, including solar and wind, could meet 86% of power demand.

The energy transformation would also boost gross domestic product (GDP) by 2.5% and total employment by 0.2% globally in 2050. Health and climate-related savings would be worth as much as $160 trillion cumulatively over a 30-year period, the report finds. It is estimated that every dollar spent in transforming the global energy system provides a payoff of at least $3.0 and potentially more than $7.0, depending on how externalities are valued.[8]

Separating the Wheat from the Chaff

There is no doubt that climate change is happening. But the continuous bombardment of its destructive impact on the globe by media, environmental scientists and doomsday seers is not only infuriating a huge section of the world's population but it is also putting their backs out.

There were many instances where environmental scientists and University professors have massaged facts and stretched them to breaking point just to justify their research or their political leanings.

Even where events like solar storms are projected to happen with destructive magnitude in the future, why talking about them when even scientists can neither predict their time of occurrence nor will humanity be able to protect itself against their impact. It only worries people unnecessarily about things that may or may not happen.[9]

If solar storms were until recently believed to be a rare occurrence—only happening once every couple of centuries or so, what has changed to make scientists think there is reason to believe they may happen a lot more frequently? Could they let us know the scientific evidence they discovered to justify their claims and to reach the bombastic conclusion that solar storms could be the worst-case scenario for space weather events against the modern civilization?[10]

Moreover, how did astrophysicist and aerospace engineer Robert Coker calculate that the fallout from a severe solar storm could cost up to a trillion dollars? Is his estimate based on real science or fiction? Furthermore, how would humanity prepare against some mythical event that might or might not happen anyway?

Even if hypothetically scientists were able to provide humanity with near real-time information about upcoming storms, such storms could happen so fast that humanity would not have noticed them until the world has gone in smoke.

May be environmental scientists and doomsday seers could temper their doom and gloom projections and let humanity cope with daily life chores rather than worry about scientific hallucinations.

An Imminent Energy Transition Is an Illusion

With the world consuming 100 million barrels of oil a day (mbd) and growing, the notion of an imminent energy transition is an illusion.

Four pivotal principles will govern the global energy scene well into the future.

The first is that there will be no post-oil era throughout the 21st century and far beyond.[11]

The often quoted statement attributed to the former Saudi oil minister Sheikh Ahmad Zaki Yamani that "the Stone Age came to an end not for lack of stone and the Oil Age will end long before we run out of oil" is not strictly accurate. The Stone Age has never ended. It is still with us to this very moment in the form of the stones we continue to use to build houses, bridges and monuments. What has ended is only an aspect of the Stone Age, namely tool-making from stone, which has been substituted for practicability by bronze and metal tool making with the advent of metalworking, namely, smelting of Bronze and Iron. The same logic applies to oil. There could never be a post-oil era throughout the 21st century and far beyond because it is very doubtful that an alternative as versatile and practicable as oil, particularly in transport, could totally replace oil in the next 100 years and beyond. What will change is some aspects of the multi-uses of oil in electricity generation and water desalination which will eventually be mostly powered by solar energy. However, oil will continue to be used extensively in global transport, the petrochemical industry and other industries and outlets from pharmaceuticals to aviation and computers to agriculture without which it will never be able to feed 7.5 billion of the world population.

The second principle is that there will be no peak oil demand either. Peak oil demand has become one of the most contentious and fascinating debates in the oil industry over the past few years with forecasts for the pending peak seemingly creeping closer to the present with every new publication. The precise dates vary. Royal Dutch Shell, for instance, has said that the peak could come within 5-15 years. BP, for its part, says demand could plateau in the 2030s or 2040's.[12] While an increasing number of electric vehicles (EVs) on the roads coupled with government environmental legislations could slightly decelerate the demand for oil, EVs could never replace oil in global transport throughout the 21st century and far beyond.

Range, charging time and price are only temporary teething problems for electric vehicles (EV).Technology will sooner or later resolve them. However, the real challenge facing a deeper penetration of EVs into the global transport system is the realization that oil is irreplaceable now or ever.

And whilst EVs are benefiting from evolving technologies, ICEs are equally benefiting from the evolving motor technology. As a result, ICEs are not only getting more environmentally-friendlier but they are also able to outperform EVs in range, price, reliability and efficiency.

Therefore, one shouldn't get fooled by the rush of carmakers towards investing in EVs. This is being forced upon them by government regulations and also by wanting to burnish their environmental credentials rather than by business sense.

The third principle is that the notion of imminent energy transition is an illusion. In fact, the percentage of fossil fuels in the world's energy mix—coal, oil and natural gas—is still lingering well above 80%, a figure that has changed little in 30 years. That remains so despite being challenged by serious environmental policies and despite a global expenditure of $ 3.0 trillion on renewable energy during the last decade (see Chart 1). This is a hefty price to pay just to gain only a percentage point of market share from coal.

The fourth principle is that oil and gas will continue to be the core business of the global oil and gas

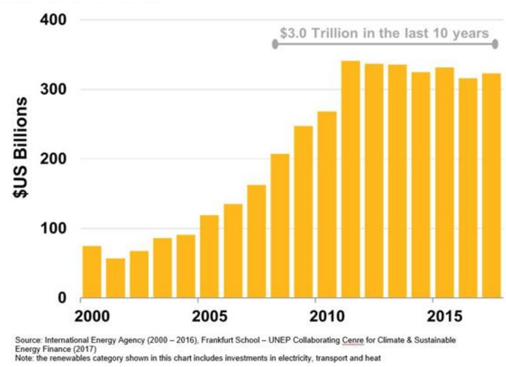

Chart 1: Global Investment in Renewable Engergy Supply Annual 2000 to 2017

Source: Courtesy of the International Energy Agency.

industry well into the foreseeable future.

Still, the oil industry does invest in clean energy solutions and has accelerated such investments in recent years partly to be genuinely involved in the clean energy solutions but the general mood, at least for now, is that it will only move away from oil when this makes commercial sense. Shell's spending on new energy solutions may be huge by some standards at $1-$2 bn. But this is less than 8% of the supermajor's total annual capital spending of around $25 bn.[13]

In recent years, Big Oil has faced increased investor pressure to start addressing climate change risks and set emission reduction targets if the world is ever to achieve the Paris Agreement targets.

For the first time ever, Shell has just signed a $10-billion revolving credit facility, and the interest and fees paid on it will be linked to the company's targets to reduce its carbon footprint. This is an innovative deal which also demonstrates Shell's broad-based commitment to reducing the Net Carbon Footprint of the energy products it sells by 20% in 2035 and 50% by 2050.[14]

Yet, there has been a marked decline in spending on renewable energy projects during the first half of this year with spending totalling $117.6 bn, a 14% less than a year ago and the lowest amount for a comparable period since 2013 according to Bloomberg New Energy Finance (BloombergNEF). The decline was evident in all key renewables markets particularly so in China. The reason: Beijing is cutting subsidies for solar and wind and trying to make them stand on their own two feet without government support.[15]

Interestingly enough, spending on solar and wind also fell by 4% in Europe where governments and environmentalist groups are particularly vocal about their clean energy plans. In the United States, new renewables spending fell by 6%.[16]

Tackling Global Warming Problem

Solving the global warming problem is regarded as the most important challenge facing humankind in the 21st century. The capacity of the earth system to absorb greenhouse emissions is already exhausted, and under the Paris Climate Agreement, emissions must cease by 2040 or 2050. Barring a breakthrough in carbon sequestration technologies, this requires an energy transition away from fossil fuels such as oil, natural gas and coal.

Despite the widespread understanding that a transition to renewable energy is necessary, there are a number of risks and barriers to making renewable energy more appealing than conventional energy. Overall, the transition to renewable energy requires a shift among governments, business, and the public.

An energy transition designates a significant change for an energy system that could be related to one or a combination of system structure, scale, economics, and energy policy. A prime example is the change from a pre-industrial system relying on traditional biomass and other renewable power sources (wind, water, and muscle power) to an industrial system characterized by pervasive mechanization (steam power) and the use of coal.

Many lessons can be learned from history. The need for large amounts of firewood in early industrial processes in combination with prohibitive costs for overland transportation led to a scarcity of accessible (e.g. affordable) wood. When Britain had to resort to coal after largely having run out of wood, the resulting fuel crisis triggered a chain of events that culminated in the Industrial Revolution.

Another example where resource depletion triggered a technological innovation is how whale oil was eventually replaced by kerosene and other petroleum-derived products.

Energy transitions have occurred in the past, and still occur worldwide. Contemporary energy transitions differ in terms of motivation and objectives, drivers and governance.

For now, we're in an era of "energy diversification" where alternative sources to fossil fuels, notably renewables, are growing alongside—not at the expense of—the incumbents.

Still, any mandatory transition to renewable energy and EVs will not achieve the desired outcome without individuals, businesses and governments getting on board about the benefits of transition.

Challenges facing the EU in the field of energy include issues such as the growing threats of climate change, slow progress in energy efficiency and the need for further integration and interconnection in energy markets. A variety of measures aiming to achieve an integrated energy market, security of energy supply and a sustainable energy sector are at the core of the EU's energy policy.

The current policy agenda is driven by the comprehensive integrated climate and energy policy adopted by the European Council on 24 October 2014, which sets out to achieve the following by 2030:[17]

- A reduction of at least 40% in greenhouse gas emissions compared to 1990 levels;
- An increase to 27% of the share of renewable energies in energy consumption;
- An improvement of 20% in energy efficiency, with a view to achieving 30%;
- The interconnection of at least 15% of the EU's electricity systems.

The European Union unveiled recently its 2050 net-zero emissions target, a proposal that calls for 100 billion euros invested in the transition.

However, for energy transition to accelerate, it should have three realistic objectives: benefit to users, practicability and lucrative financial returns from renewables to match those from oil and gas. Mandatory transition will only achieve limited success.

While the global oil industry is investing huge amounts in renewables, such investment pales in size when compared with that in oil and gas exploration and production, refining and petrochemicals. The slower pace of oil majors toward alternative energies is due to two key reasons. First, oil and gas will continue to be needed well into the foreseeable future. And second, and probably much more important, is that financial returns from renewables are nothing compared to the huge bonanzas oil firms are accustomed to rake in when oil prices rise.[18]

Conclusions

It is very probable that oil and natural gas will continue to be the fulcrum of the global economy well into the foreseeable future.

For energy transition to accelerate, it should have three realistic objectives: benefit to users, practicability and lucrative financial returns from renewables at least comparable to those from oil and gas.

This could be enhanced by accurate down-to-earth information rather than bombastic claims about the destructive impact of climate change on the globe. Any mandatory transition measures would only achieve limited success.

Still, decision-makers, environmentalists and futurists may have to accept the notion that there will neither be a post-oil era nor an imminent energy transition or a peak oil demand throughout the 21st century and probably far beyond.

Footnotes

[1] Sourced from the Wikipedia.
[2]-Ibid.,
[3]-Ibid.,
[4]- Global Energy Transformation: A Road Map to 2050 (2019 edition), the International Renewable Energy Agency (IRENA), April 2019.
[5]- Ibid.,
[6]- Nick Cunnigham,"Emissions Sore as Permian Burning Frenzy Breaks New Records", posted on December 14, 2019 and accessed on December 15, 2019.
[7]- Global Energy Transformation: A Road Map to 2050.
[8]- Ibid.,
[9]- My comments on an article titled:" Solar Storms Can Devastate Entire Civilizations" posted by Irina Slav on October 12, 2019 on oilprice.com.
[10]-Ibid.,
[11]-Mamdouh G Salameh, "A Post-oil Era Is a Myth" (A USAEE Working Paper Series No. 16-290 published on 8 December 2016).
[12]-Ibid.,
[13]-Mamdouh G Salameh, "Oil, Natural Gas & LNG Will Keep Renewables Stranded throughout the 21st Century", the IAEE Energy Forum, Fourth Quarter 2019.
[14]-Tsvetana Paraskova,"For the First Time Ever, Shell Signs $10 bn Emissions Linked Financing", posted on December 14, 2019 and accessed on December15, 2019
[15]- Mamdouh G Salameh, "Oil, Natural Gas & LNG Will Keep Renewables Stranded Throughout the 21st Century".
[16]- Irina Slav, "What's Behind the Drop in Renewable Spending?" posted on Oilprice.com on July 16, 2019 and accessed on July 17, 2019.
[17]- Fact Sheets on the European Union (EU) accessed on 14 December, 2019.
[18]- Mamdouh G Salameh, "Oil, Natural Gas & LNG Will Keep Renewables Stranded Throughout the 21st Century".

Foss & Zoellmer (continued from page 21)

Many jurisdictions are trying to couple EV market share targets with build out of charging infrastructure. Given that charging infrastructure would almost always be integrated with disco businesses, a fair number of proposals and pilot programs entail the discos and their utility parents.

In the U.S., while a number of programs have been proposed or are being implemented, most of the effort is at the state level. While some state legislatures, like California's, have been actively legislating to transform and electrify transportation much of the responsibility lies with public utility commissions. PUCs have oversight of electric utilities and utility discos and, in most cases, other disco businesses such as cooperatives or municipals. Several states are in the process of implementing pilot programs for charging infrastructure, including residential charging, that include implications for discos. Issues such as disco capacity and network capability, cost recovery and retail customer pricing including time of use (TOU) are being vetted. Few of the programs we surveyed incorporate investment in distribution networks themselves; the number of EVs and thus demand for charging infrastructure is very low. There are clear indications that utilities and discos see EVs as good business.

In none of these instances can the jurisdictions do much about EV development and deployment, or challenges in battery science and supply chains. EVs are attractive because of perceptions that batteries are cheap. Falling costs of batteries have much to do with the location of some 60-70 percent of capacity in China and the prevailing, commercial lithium-based chemistry. Attempts to locate battery production elsewhere will have implications for labor costs and materials supply chains; changes in battery chemistry to improve performance will have implications for materials inputs and supply chains; and all will become subject to ever more environmental scrutiny. These considerations must be addressed well ahead of distribution networks.

Footnotes

[1] Comment and information provided by Michael Maten, Manager, Energy, Environment and Electrification, General Motors Public Policy.

[2] Input for this section from Clare Grey, Geoffrey Moorhouse Gibson professor in chemistry and Royal Society fellow, Cambridge University. Rice University/Imperial College Workshop on Energy & Minerals, Framing Integration Futures, September 18-19, 2018, Center for Energy Studies, Rice University's Baker Institute for Public Policy.

Transitions in Electricity Distribution: Insights from the Multi-Level Perspective

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As more nations are committing to decarbonize their electricity sector fuel mix, the electric grid must transition from a centralized fossil-fuel based system to an electric power system. This new system will be cleaner, more distributed and interconnected, opening the doors for customers to produce (prosumers), consume and save energy in numerous ways (Glitman et al., 2019). The objective is clear: provide affordable, reliable, sustainable and modern energy for all, while fostering innovation and making cities inclusive, safe and resilient.

The Decarbonization of Electricity Distribution Networks

Until very recently, cost-competitiveness was the major obstacle concerning renewable energy sources. But with wind and solar reaching grid parity and representing more than eighty per cent of new capacity in 2018 (IRENA Renewable Capacity Statistics, 2019), the challenge of clean energy has now shifted from the cost of new generation to the subject of how to integrate these clean but variable and intermittent resources into the grid (Golden et al., 2019). Moreover, in this rapidly changing context, transportation electrification, although offering an opportunity to provide flexible demand and increasing the integration of renewables, which can contribute to power system efficiency, can also lead to grid congestion (Glitman et al., 2019).

To successfully decarbonize the electric sector, utilities will need to tackle the growing load shape challenges driven by the variability of many renewable resources. Behind-the-meter solutions (anything that can be done to reduce the amount of energy being purchased from a utility), namely energy efficiency, demand response, electrification and storage, will play a crucial role providing stability to the grid. Still, these measures will only be effective if they can deliver changes in demand acknowledging the time and locational needs of the grid. Thus the importance of decentralization of energy supply, which in turn generates new needs at the distribution level (Hayes et al., 2020; Golden et al., 2019; Silvestre et al., 2018).

In fact, new innovative architectures are arising (for instance, microgrids or blockchain solutions) and market design and regulatory mechanisms are expected to evolve in order to support and facilitate this transformation. As noted by Glitman et al. (2019), even though the technology necessary to decarbonize, for instance, land transportation exists today, an affordable and reliable transition will require a focus on policy and regulatory changes. Thus, low carbon innovations have the potential to trigger the necessary transition towards new or durably reconfigured socio-technical systems. However, many of these innovations are small in terms of market share and investment, while facing barriers from existing socio-technical systems. Current government interventions focus mostly around cost structures, information provision and regulation, which may be insufficient to generate non-marginal change. Also, these innovations should not not be studied isolated, but in the context of their harmony with and clashes against existing socio-technical systems, as their diffusion does not happen in an 'empty' world, but in the context of existing systems that provide barriers and resistance (Geels et al., 2018).

Multi-Level Perspective

The most common approach for socio-technical systems is the multi-level perspective (MLP). This heuristic approach combines ideas from social construction of technology, regarding social networks and interpretations, with evolutionary economics, that recognize economic dimensions and conflicts between radical innovations and existing systems. Literature concerning socio-technical transitions has been mostly developed by the Dutch school of transitions studies, as a governance approach for sustainable development (Jenkins et al., 2018; Kemp et al., 2007a; Kemp et al., 2007b). This attention on governance means that the socio-technical literature acknowledges the political dynamics present in the process through which innovations scale, diffuse or are established, since, historically, energy transitions emerge together with parallel developments of technological innovations (Hess, 2018; Guidolin and Guseo, 2016).

The MLP identifies three distinct levels: the niche innovations - novelties that deviate from existing systems; the regime - the incumbent socio-technical system; and the landscape - aspects of the exogenous environment (e.g., cultural preferences, demographics, short-term shocks such as macroeconomic recessions or oil shocks) (Geels et al., 2018).

The niche level is usually characterised as the lowest but most dynamic stage, and it is typically considered to be the domain where radical and revolutionary innovations emerge. The innovations generated can have several dimensions, for instance a new behavioural practice (e.g., car sharing), a new technology (e.g., battery electric vehicles), or a new business model (e.g., energy service companies) (Geels et al., 2018; Jenkins et al., 2018; Shum, 2017).

The regime level, also known as the meso-level of the MLP, contains the dominant institutions, policies, consumption patterns and technologies of the current socio-technical system (for instance, infrastructures and energy markets). It changes slowly and, typically, under the influence of niche dynamics (Geels et al., 2018; Jenkins et al., 2018). As noted by Fouquet (2016), transitions encompass not only the decline of incumbent industries but the rise of new ones also. However, as noted by Geels et al. (2018), existing systems may be rearranged through the adoption of multiple innovations, which together lead to broader changes. Car-based systems, for example, can be reconfigured through self-driving cars, congestion charges, on-board navigation tools, dynamic road management, and electric vehicles providing back-up capacity for electricity grids (via power stored in batteries, a practice known as vehicle-to-grid, V2G). Thus, instead of mapping the diffusion of single technologies, it may be more pertinent to ask how multiple innovations can reconfigure existing systems.

The third stage of the MLP model, the macro-level landscape, refers to slow changing, but large-scale, aspects of the exogenous environment. The socio-economic, environmental, and cultural context, within which actors and institutions are situated, as well as

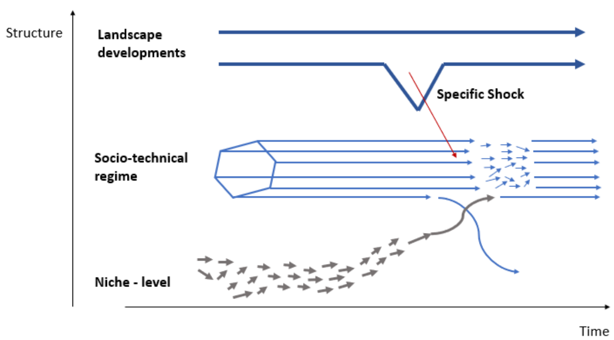

Figure 1: Technological substitution pathway in the multi-level perspective (based on Geels and Schot, 2007)

broader trends and global events, are considered. Accordingly, this level represents the broader political, social and cultural values and institutions of a society (Bataille et al., 2018; Jenkins et al., 2018; Shum, 2017).

Figure 1 depicts the technological substitution pathway in a general conceptualisation of the MLP process.

The intersection of the three stages, socio-technical systems, niche innovations and exogeneous slow-changing developments, is what determines the decarbonization progress.

Conclusion

New societal demands, for instance carbon neutrality, can be originated by exogenous factors such as global warming. These have the ability to push the current socio-technical and innovation systems into change to accommodate the new needs (Wesseling et al., 2017). The force and impact of the new societal demands, coupled with the stability of the system where they occur, influence whether a transition through prevailing technological trajectories arises (for instance, innovations regarding energy efficiency) or a transition to a new system configuration occurs (for instace, innovations in microgrids).

Niches are typically associated with the start of transitions and the major force for change occurs between regime and niche levels. Still, a transition takes place only when shifts in the three levels occur simultaneously. By the same token, the dynamics between the three levels is what creates or restricts technological transitions (Jenkins et al., 2018).

Thus, in order to transition to a decentralized and clean power system, an overall change needs to take place, not only in new businesses and technologies, but also in dominant institutions and in the socio-economic, environmental, and cultural context. While most energy system decarbonization focus is on supply-side opportunities (e.g., renewables), nations should also focus on demand-side drivers and create a diversity of mechanisms, institutional support frameworks and regulations to support them (Barido et al., 2020).

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Debacle of the Power Policy in India: Generation, Transmission, Distribution and Regulation

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See footnoes at end of text.

Introduction

India, being one of the largest economies and with a growing population, aims at inclusive and sustainable growth. India's commitment towards providing 24x7 power for all is aligned with the Sustainable Development Goal (SDG) 2030 of providing accessible, affordable, reliable, sustainable and modern energy for all (Goal 7). India's Intended Nationally Determined Contributions (INDC) also includes generation of 40% of electric power from non-fossil fuel sources by 2030. According to the World Economic Outlook Report (2019), India's electricity demand is expected to grow by 199% during 2018-2040 and requires 484% power system flexibility in order to adapt itself to changing conditions. According to IEA Review Report (2020), the energy efficiency improvements have avoided 15% of additional energy demand, oil and gas imports, air pollution and 300 million tonnes of CO_2 emissions between 2000 and 2018. However, the reliance is still on coal which accounts for two-thirds of electricity generated. Thus, India's effort towards increased electrification has to simultaneously progress with India's energy transition towards a greater share of Renewable Energy Sources (RES) in the total energy mix.

For achieving the goal of universal electrification, penetration of power supply amongst the rural households becomes crucial as 65% of India's population lives there. To achieve this objective, the Central Government launched Deendayal Upadhyay Gram Jyoti Yojana (DDUGJY) in 2015 (PMINDIA, 2015) under which, the target of achieving 100% rural electrification within 1000 days was set. This goal was achieved in April 2018. However, the concern arises with the government's definition of village electrification which declares 100% connectivity 'if at least 10% of households in a village have an electricity connection' (PIB, 2018). This does not give a true representation of the extent to which villages gained access to electricity since the announcement of this initiative. With this backdrop, the government came with Pradhan Mantri Sahaj Bijli Har Ghar Yojana (SAUBHAGYA, 2017). Under the scheme, 4 crore un-electrified households were to be provided with electricity by December 2018, which the government failed to meet. It is only in 2020, as per the Saubhagya Web Portal, that 99.9% of the households have been electrified.

The policy in pursuit of 100% household electrification is based on three parameters, namely, extension of power infrastructure to villages, electricity connection to households and providing affordable and reliable power supply in a sustainable manner (Dutt D'Cunha, 2018). While progress has been made in the last five years on the first two parameters, providing a sustainable power supply is still an issue to be dealt with. As per a survey by the ministry of Rural Development in 2017, only half of the approximately 600,000 villages in India get more than 12 hours of power supply (Sreekumar, Mandal, & Josey, 2019). In addition to this, 25% of health sub-centres and 40% of schools lack electricity connection. Along with the above problems, operational efficiency has also been seen as more than 20% of total electricity produced is lost in Transmission and Distribution (T&D) operations, which is the highest in the world (Zhang, 2018). The Global Competitiveness Report 2019 ranked India 108th amongst 141 countries in terms of electricity supply quality. This efficiency gap in the power sector costs the economy 4% of GDP yearly, which is equivalent to USD 86 billion, in FY 2016. In order to bridge efficiency gaps across all parameters, the government intends to bring about structural reforms in the electricity network of India.

With this backdrop, this article is divided into following sections. Section 2 provides brief account of power sector reforms in India. Section 3 discusses the current scenario with three subsections, each analysing the electricity sector into four segments of generation, transmission & distribution and regulation. Section 4 provides concluding remarks.

A Brief Account Of Power Sector Reform In India

Given the deteriorating financial performance and poor operating performance of the State Electricity Boards (SEBs), the onus of setting up new generation capacities fell increasingly on the Union Government. It was in such a situation that the central government set up two central public sector utilities: NTPC (National Thermal Power Corporation Limited) for thermal generation and NHPC (National Hydro Power Corporation Limited) for hydropower, to provide power to at least multiple states. This integrated policy was brought due to existing imbalances among the states with uneven resources. Moreover, there were difficulties in the interconnection between states (a plant in one state providing electricity to two or three states). Thereby, the transmission network associated with each of these power plants would automatically get extended into other states. And that's how the concept of regional grids came into existence.

Over the 1980s, energy shortages and the poor financial condition of SEBs continued and the cascading effect of agricultural subsidies caught successive governments as subsidies amounted to the majority part of their revenue. This was slowly spiraling into a crisis, which many economists suggested could be resolved by free markets. Power sector reforms began in the 1990s which showed limited results. Indian Electricity Act 1910 was amended to invite investment in power generation by the private sector (including foreign capital). Unbundling was done by separating generation, transmission, and the distribution aspects of the SEBs into three parts for focused attention. Power Trading Corporation (PTC) was set up in 1995 to negotiate between buyers and sellers (SEBs and handlers of Mega Projects). Central Electricity Regulatory Commission (CERC) and State Electricity Regulatory Commissions (SERCs) in 22 states, had been set up whose main function is to regulate the tariffs of power generating companies. A competitive work arena and transparency was required for a well- developed power sector. Distributional efficiencies were addressed by the Accelerated Power Development and Reform Programme (APDRP) introduced by the union government in 2001.

By 2002, The state governments controlled nearly 60% of power generating capacity, 30% by central government, the rest, 10%, was with the private sector (i.e., Independent Power Producers or IPPs). IPPs have been struggling with financial closure due to the weak financial situation of their sole buyer, i.e., SEBs, and lack of demand. Some IPPs could progress beyond the initial stage due to credit enhancement through guarantees from state and central governments as well as allocation of an escrow facility[1]. The states by overstating their escrow capacity signed Power Purchase Agreements (PPAs) which along with an absence of an alternative payment security mechanism, resulted in payment delay. This was done in Dabhol project in Maharashtra which dampened the morale of IPPs and even foreign investors became reluctant due to the bleak prospects in the sector. The cases of Karnataka giving projects to Cogentrix questioned the grounds on which any company is awarded with the contact, indicating transparency problems. Further, companies like Enron hid its mountains of debt and toxic assets from investors and creditors. Dispute over the Enron power project snowballed into a major controversy. Subsequently, the company's collapse affected thousands of employees and had other effects.

It was essential to resolve all the crises of the electricity system - the crisis of capital, performance, equity/access and environment. Solutions that focused on only one of those, for instance the capital crisis in the case of Enron-type deals, were sub-optimal and defective solutions that aggravated other crises. From a long-term point of view, the genuine solution to the crises of the electricity system was a shift to the new electricity paradigm, with the emphasis changing from energy consumption to energy services as an index of development.

In this background, Electricity Bill 2003 was enacted to laws related to generation, transmission and distribution of power. It provided for tariff reforms, separate electricity trading, open access, multiyear tariffs and constituted an appellate tribunal. Multi-year tariffs increased the cost borne by the consumers resulting in public resistance. The overall reform process had been both good and bad encompassing short term and long-term gains. While operational inefficiencies were treated, there was a need to address high electricity tariffs, transmission flexibility, proper pricing and a freely operating sector.

The amendments in 2005 emphasized primarily electricity safety, with the offences relating to theft of electricity, electric lines, and interference with meters as cognizable offences. It specified requirements for captive generation plants, distribution systems and proposed a setting up of grievance redressal cells by distribution licensee. The amendments of 2014 included renewable energy in the ambit, by making it mandatory for entities to procure electricity from a market representing the renewable energy sources. It was also made mandatory to provide an open access to electricity to consumers with a load of more than 1 MW by default, thus, allowing them to enter into bilateral agreements for procurement. Currently, more than one supplier could operate in an area, with giving consumers the power to choose the supplier. The concept of "smart grid" and "smart meters" were also incorporated.

Current Perspective

Currently private sector involvement is restricted to the electricity generation segment, whereas the public sector has a complete monopoly over the power transmission, distribution and regulation of power supply.

Generation of Electricity

By December 2019, 46.5% of all India installed capacity for electricity generation was owned by theprivate sector, followed by 28.3% by the State government and 25.1% by the Central government (CEA, 2019). With thermal energy constituting the largest share (70%), a large number of captive generation plants are run on diesel, which is one of the costliest sources for electricity generation. At the same time, the cost of electricity generation from solar energy is 14% cheaper compared to that of coal in the region (Sengupta, 2019). As a result, the government is steadily moving towards an increased share of RES capacity in electricity generation. The government has announced the target of achieving 175 GW of installed power capacity from RES, primarily from solar (100 GW) and wind (60 GW) energy by 2022. Today, the share of RES in total installed capacity is 22.9% and it is expected to increase to 36.4% by 2022 and 42% by 2027 (CEA, 2019). India has the lowest cost of electricity generation from solar and wind energy, and its power tariff is the fourth cheapest in the Asia-Pacific region. Currently RE is largely cornered towards generation of electricity via micro-grids or solar rooftops. It is time for India to shift its priority from a centralized conventional power infrastructure to a decentralized RE-based infrastructure (NITI Aayog, 2017). However, this energy transition towards increased RES capacity has technical issues such as storage and intermittency which requires investment for adaptation and has a long gestation period. Thus, in the medium-term India will have to invest simultaneously in fossil fuel sources as well as RES. In the long run, the transmission and distribution operations should be capable of incorporating electricity supply via clean energy sources. The government has also proposed another initiative of construction of 'One Nation One Grid' where the regional and state grids are electrically connected to one National grid operating at a single frequency (GOI, 2019). The implementation of a national grid and incorporation of Renewable Energy should improve the efficiency of the T&D operations as well as decrease the cost of electricity generation, thus making it less dependent on power imports. Currently India is a net importer of electricity from Bhutan and exporter to Bangladesh and Nepal. By 2022, India is expected to become an even larger net importer of electricity, with 4500 MW import from Bhutan and 2450 MW export to Bangladesh and Nepal. Power import from Bhutan is primarily for electrification of the rural and underdeveloped areas of the North-Eastern Region (NER) of India. Indian power companies, in joint venture with their counterparts in Bhutan have built hydro-electric power plants, which is a major source of electricity both for domestic demand of the country and its imports to India. The government's bilateral agreement on this shows that import of electricity in NER is more cost-effective than generation of electricity from within India in NER which, has boosted electricity generation and quality of electricity supply. However, the problems in the state distribution segment persists which needs to be addressed for overall success.

Transmission and Distribution of Electricity

The inefficiency of State distribution and transmission comes from the operational and financial stress that public sector companies are facing, which reforms have failed to improve. As a result, generation companies are unwilling to enter into Power Purchase Agreements (PPAs) with state discoms due to fear of default on payments. This problem of debt in state discoms acting as defective intermediary regime, has resulted in stranded generation plants and unavailability of electricity supply even when the end consumer is willing to pay and producers have enough to supply.

In September 2015, the central government came up with the Ujjwal Discom Assurance Yojana (UDAY) which proposes that debt restructuring by states through sharing of burden and state backed discom bonds. This scheme intends to bring the aggregate technical and commercial (AT&C) losses to 15% and elimination of the Average Cost of Supply (ACS) - Average Revenue Realized (ARR) gap by 2019-20. However, ACS-ARR gap has actually increased from INR 0.17/unit in FY 2018 to INR 0.38/unit in FY 2019 and AT&C cost has increased from 18.72% in FY 2018 to 21.35% in FY 2019 (UDAY, 2019). Post UDAY, the debt came down from INR 2.7 lakh crores in FY 2015 to INR 1.5 lakh crore in FY 2017 but is expected to increase to pre UDAY levels in 2019 and 2020 (Thomas, 2019). Further, the average tariff increase reduction in AT&C losses were half of what was intended (CRISIL, 2019), thus, nullifying the positive impact of debt restructuring. However, the significant debt reduction signals behavioral approach of states towards acceptability that debt proposed to be absorbed will not affect their fiscal deficit and in turn will not affect their budgetary allocation from the central government. This positive approach would help in significantly increasing distribution utilities and their procurement of power. Over the years, the government had undertaken the role of lender of last resort. This can provide a disincentive for discoms to reform, as there is no commercial pressure on them to improve their structural orientation. There have been proposed legislative reforms which allows for privatization of the distribution sector and elimination of cross subsidization. The options of choosing the distribution network service from whom it wants to buy electricity, will increase the competition in the market prompting the state discoms to improve their financial health and improve overall efficiency at both the managerial and operational level. The policy proposes complete elimination of cross-subsidization and substituting a progressive tax structure with a common low base rate for all consumer segments. Currently, under cross price subsidisation, the industrial consumers are charged a tariff higher than the average cost of supply (ACS), and the surplus is then redirected towards subsidizing ACS to the vulnerable consumer segment, especially for agriculture consumers by charging a lower tariff. At the national level, on an average the industrial sector pays a tariff 12% higher than the ACS, whereas the agricultural sector, which is the largest subsidized sector pays a tariff which is 55% lower than the ACS (Bhattacharyya & Ganguly, 2017). At present, even the tax structure varies among states. Thus, the disparity between the prices incurred by different segments of consumers still remains large, while discoms continue to incur losses. In line with above, Electricity Amendment Bill, 2019 is awaited which needs to address the possiblity of price rises for agriculture and household consumers (UNI, 2020). Secondly, the proposed amendments will allow private generation companies to operate and distribute electricity directly from the point of generation to the point of consumption, without making any prior investment in transmission lines which are developed and operated entirely by the public sector. On the positive side, privatisation might bring in uniformity in the operation of the sector and reduce multiple entity interest with differentiated motivation and targets. Hence, for overall benefits in long run, major structural changes are much needed for this sector.

Regulation of Electricity Sector

For the fourth segment, i.e., regulation, it is important to understand the framework under which policies are implemented and enforced. Electricity is under concurrent list which lets both Central Government and State Government decide on their policy discourse. The Electricity Regulatory Commission Act 1998 provided for setting up of Central/State Electricity Regulatory Commission to determine powers. However, the setting up of SERC was optional which increased the differences in approach across various states. The need for competitive environment, quality and reliable service to consumers, new concepts like power trading, open access, appellate tribunal, special provisions for rural areas and decentralizing of responsibilities to states resulted in enactment of India Electricity Act, 2003 which necessitated the restructuring and accountable functioning of State Electricity Regulatory Commissions. The key role of State Electricity Regulatory Commissions and Central Electricity Regulatory Commission is to regulate inter-state and intra-state trade, approve of tariffs for the sale of electricity and regulate licenses by setting performance standards and ensuring their compliance. The regulators have failed to ensure that the state discom regularly revise their prices and work on market principles. The functioning of state discoms depend upon how effective CERC is. It is recommended that there is need to improve the working and autonomy of the organisation with appropriate personnel (Standing Committee on Energy (2012). There is need for robust trading system which would promote free and fair competitive electricity market operation (Alagh, 2010). Electricity is traded on both a long term and short-term basis. The Unscheduled Interchanges (UI) mechanism, meant to ensure grid discipline, is being used by many states power utilities as a trading platform which results in high price trading. This results in a distortionary effect, as the buyer states have to pay high prices but the service is provided at subsidized cost. Moreover, the governance of electricity storage In India does not have any regulatory mechanism. The draft policy of National Energy Storage Mission (NESM) for India is under consideration which aims to establish a regulatory framework promoting the manufacturing and deployment of battery storage systems. The regulatory system for RES needs to be addressed so that the sector does not face the issues pertaining to the thermal power sector. This would help in promoting economies of scale in production, reduced losses and surplus being traded at cheaper rates based on market principles.

Conclusion

India's per capita electricity consumption has almost doubled between 2005-06 and 2017-18 (CEA, 2019) and its electrical energy requirement is estimated to grow at a CAGR of 5.84% between 2017-27 (REConnect, 2017). In line with this, the government of India has initiated reforms in the power sector by incorporating structural changes in the existing framework, and simultaneously incorporating RES in mainstream power infrastructure for long run sustainability. However, these come with the understanding of challenges as India's electricity structure is largely centered around the miserable performance and poor efficiency of the financially stressed state discoms. To address this issue, IEA (2020) recommends creation of a competitive wholesale power market which would aid the ambitious project of aa National Grid. In addition to the market-based reforms, privatization and elimination of cross subsidization might promote positive competition and improve quality of electricity supply, as Prime Minister Narendra Modi emphasized at the 16th IEF meeting India's energy future rests on four pillars – Energy Access, Energy Efficiency, Energy Sustainability and Energy Security. To achieve this, An integrated National Market would help in solving the price differences, give opportunities of economies of scale and help in revising the power sector subsidies. This requires combined efforts of legislative reforms and promotion of research and development for technological improvement in power supply. Along with it, there is scope for investigating the role of Artificial Intelligence (AI) in detecting the transmission and distribution losses. Promoting transparent inter-state and intra-state trading of electricity at viable market prices, Smart grids and meters are some of the measures which would help in improving both physical and digital infrastructure. As far as electrification is concerned, progress made in each of these pillars' rests highly on India's continued efforts in bringing reformative measures for the upgrading of its electricity network and incorporation of RE capacity in the power infrastructure.

Footnote

[1] Escrow facility is a special agreement through which IPPs get priority access to SEB revenue. Revenue from SEB customers is deposited in a separate bank account, which can be directly withdrawn by the IPP in case the SEB fails to honor IPP payments.

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Abu Dhabi Symposium Report

BY ASMA ABDULHAKIM AL SHAMSI, HAYA FAHED ALMAZROUEI, ALYA MOHAMED AL MAZROUEI AND SHAMMA ABDULLAH AL SHAMSI

Plenary Session 1

The Future of Hydrocarbons: Changing Demand and Subsequent Impacts

Chairperson
Marianne Kah: Advisory Board Member and Adjust Senior Research Scholar at Columbia University on Global Energy Policy

Speakers
Ed Rawle: Chief Economist in Economic and Competitive Intelligence, Abu Dhabi National Oil Company
Masakazu Toyoda: Chairman and CEO of The Institute of Energy Economics, Japan; Adjust Professor, National Graduate Institute of Policy Studies
Ken Medlock: Senior Director of the Center of Energy Studies, Baker Institute
Bashir Dabbousi: Director of Technology Strategy and Planning, Saudi Aramco

The discussion centered around the extent to which hydrocarbons had staying power in a low-carbon future, the pace of which would be informed by the interaction of variables such as:

- the de-capitalization of international oil and gas companies;
- controlling methane emissions from gas;
- falling costs of battery storage for renewable energy;
- the uptake of electric and hydrogen fuel cell vehicles;
- the consumption pattern of millennials;
- the increasing efficiency of internal combustion engines; and
- the legacy and scale of hydrocarbon-based energy infrastructure.

The speakers noted that although growth in future oil demand is expected to be low, the absolute volume of oil demand will still be high. When peak oil demand will actually occur is less important than being prepared for all scenarios.

Some countries will find it easier to have 100% renewable energy by 2050, particularly those in northern Europe thanks to wind and hydropower resources. 100% renewable energy is unlikely in Asia due to space constraints, population density, the low cost of coal, and the absence of a common electricity grid to facilitate cross-border trade and system stability unlike in Europe.

Of particular relevance to Abu Dhabi and the Gulf states was the discussion about the response of national oil companies to climate concerns. These included the use of carbon capture technologies, reducing methane emissions, reducing the water intensity of the oil extraction process, using artificial intelligence, sensors, and drones to detect and repair leaks to minimize operational downtime, and ensuring the stability of global oil markets and prices.

Plenary Session 2

Shaping the Future Energy Landscape: The Role of Climate Concerns and Technology Innovation

Chairperson
Yukari Niwa Yamashita: Board Member and Director of the Institute of Energy Economics, Japan

Speakers
Robin Mills: CEO, Qamar Energy
Alan Nelson: Chief Technology Officer, Abu Dhabi National Oil Company
Aqil Jamal: Chief Technologist, Carbon Management Research Division, Saudi Aramco
Damien Sage: Acting Senior Vice President Business Development for Hydrogen within Engie Middle East, South Central Asia, and Turkey

This session addressed the significance of climate change and its impact on the Middle East's significant natural resource endowments. The speakers were keen to emphasize that sustainability was good for the energy business, good for innovation, and good for the climate.

Robin Mills explained that major energy companies around the world were aware of the need to be seen to be sustainable in view of their social license and concerns about the bottom line. National oil companies in the Middle East were no exception. To make the most of their comparative advantage in low-cost hydrocarbons, they have been promoting carbon capture technologies as a decarbonizing solution and have supported the use of renewable energy to free up hydrocarbons for export.

Alan Nelson, Aqil Jamal, and Damien Sage provided updates of how their companies were contributing to the sustainability agenda, namely:

- the use of advanced analytics and AI technologies at ADNOC;
- a holistic approach to reducing carbon footprint at ARAMCO based on the circular carbon economy; and
- large-scale green hydrogen solutions at Engie for local and global clients aimed at decarbonizing the planet.

Whether or not more climate-related policies were required to push the sustainability agenda in the Middle East was debatable. On the one hand, consumer choices and preferences are an important driver of change. On the other hand, demand-side management policies to reduce energy and water subsidies as well as improve energy efficiency have been successful in the Middle East.

Plenary session 3

Energy diversification: Renewable and nuclear energy in the Middle East

Chairperson
Adnan Shihab-Eldin: Director General, Kuwait Foundation for the Advancement of Sciences

Speakers
Michel Berthélemy: Senior Economist, Organization for Economic Cooperation and Development
Fatima AlFoora AlShamsi: Assistant Undersecretary for Electricity, Water and Future Energy Affairs, UAE Ministry of Energy and Industry
Maher Alodan: Chief Atomic Energy Officer, King Abdullah City for Atomic and Renewable Energy
Yousif Al Ali: Executive Director, Masdar Clean Energy

The session explored the potential of nuclear (conventional and small modular versions), renewable, and hydrogen energies to complement current hydrocarbon-based energy sources in the Middle East.

The speakers suggested the following advantages of these new forms of energy:

- They have minimal or zero carbon footprint;
- Nuclear reactors can be ramped up and down more easily these days and hence contribute to grid stability;
- Nuclear and hydrogen are energy dense;
- Renewable sources are more sustainable and socially acceptable than hydrocarbons. Wind-with-battery storage or concentrated solar power would reduce the variability in electricity generation of these renewable sources;
- Renewable energies can supplement high peak demand during the summer and avoid the opportunity and environmental cost of burning oil or diesel; and
- Hydrogen can ride on the existing hydrocarbon production and distribution network.

The UAE was cited as an example of a country in the Middle East with a diversified energy mix that included fossil fuels, renewables, and nuclear energy. According to its 50@50 energy strategy, 50% of electricity generating capacity by 2050 will come from low-carbon energy sources.

Small modular reactors were acknowledged to be an exciting field of development for countries with small grids, for desalination purposes, and even for the petrochemical industry. However, SMR adoption will require massive investment in time, money, and testing – especially for international licensing – before they are deployed commercially.

Plenary Session 4

Geopolitics: Issues Facing the Region Today and Tomorrow

Chairperson
Adam Sieminski: President, King Abdullah Petroleum Studies and Research Center

Speakers
Majid Al-Moneef: Secretary General, Higher Committee for Hydrocarbon Affairs, Saudi Arabia
Bassam Fattouh: Director, Oxford Institute for Energy Studies; Professor, the School of Oriental and African Studies, University of London
Amena Bakr: Deputy Dubai Bureau Chief, Energy Intelligence
Adnan Amin: Senior Fellow Harvard University, Kennedy School of Government

The speakers presented what they felt to be the key geopolitical opportunities or constraints on energy markets.

Majid Al Moneef acknowledged the risks governments and people face in an uncertain geopolitical environment that affects energy markets and reliability of supplies. He noted that Gulf governments were not panicking about stranded assets since oil demand will still be high in the future. Referring to the ARAMCO IPO, he suggested it was meant to finance projects without burdening the treasury and was not a sign of divestment due to a lack of faith in the future of oil.

According to Bassam Fattouh, the following energy trends were especially significant in their geopolitical impact:

Political leaders in the Middle East continued to be drivers of the energy transition. Unfortunately, their failure to sometimes meet people's basic needs imperiled the energy transition;

The U.S. has become a source of instability in the global oil market due to shale oil, imposition of sanctions on energy exporters, and trade wars;

Closer Gulf-Asia energy ties go beyond trade to include investments in the energy sector; and

The dynamics within OPEC+ are fundamentally changing; members cooperate but also directly compete with each other in many energy markets.

Amena Bakr shared her insights on the impact of U.S. sanctions on Iranian oil exports and the global oil market, pointing out that Iranian oil was still being exported despite sanctions.

Adnan Amin cautioned against overly optimistic views of the future of hydrocarbons for the following reasons:

Social movements will put pressure on major energy companies and their focus on hydrocarbons, as well as on state responses to climate change;

Energy systems will increasingly be decarbonized, decentralized, and digitalized; and

Peak oil demand will happen sooner rather than later.

(continued on page 40)

EURASIAN CONFERENCE SERIES

Oil and gas producing countries in the Caspian basin and Central Asia region have experienced rapid economic growth over the last decade under high energy prices, while suffering from highly volatile global energy prices. These countries have rich hydrocarbon, hydro, renewable and alternative energy resources and geopolitical advantages. There are issues with rational use and effective management of these energy resources. Playing an important role for Europe's energy security, the efficient use of investment and innovative opportunities in the energy sector of these countries and the formation of a regional energy market are among the most crucial issues.

To address the energy challenges in Eurasia region, the IAEE has started conducting a series of Eurasian conferences. Previous IAEE Eurasian Conferences were held twice in Baku, Azerbaijan, once in Zagreb, Croatia, and Nur-sultan (Astana), Kazakhstan. Check their programs and photos at www.eurasianconference.com/eurasianseries

CONFERENCE OVERVIEW

The 5th Eurasian Conference will take place in Azerbaijan Technical University and Baku Higher Oil School, Baku, Azerbaijan, on September 17-19, 2020.

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.

TOPICS TO BE ADDRESSED INCLUDE:

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

- **Petroleum Economics**
- **Economics of Gas Trading**
- **Geopolitical Competition in the Caspian Basin and Middle East**
- **Energy Modeling**
- **Energy Markets and Regulation**
- **Challenges in Gas Supply and**
- **Transportation**
- **Energy poverty and Subsidies**
- **Regional Energy Markets**
- **Energy Policy for Sustainable Development**
- **Energy Supply, Demand and Economic Growth**
- **Security of Energy Supply**
- **Regional Electricity Trade**
- **Energy Efficiency and Storage**
- **Regional Strategies for Alternative and Renewable Energy**
- **Energy Finance and Asset Valuation**
- **Risk Management in Energy Eurasian Energy Outlook**

CONFERENCE VENUE :

Azerbaijan Technical University & Baku Higher Oil School

www.eurasianconference.com

5th IAEE EURASIAN CONFERENCE CALL FOR PAPERS

We are pleased to announce the Call for Abstracts for the 5th IAEE Eurasian Conference.

"Energy supply, sustainability, electric mobility: Regional challenges and opportunities" to be held September 17 -19, 2020, in Baku, Azerbajan.

Join us for IAEE's fifth Eurasian Conference!

The deadline for receipt of abstracts for Concurrent Sessions is **Friday May 8, 2020 .**

Concurrent Sessions

There are two categories of concurrent sessions:

1) Academic research on energy economics, and

2) Case studies involving applied energy economics or commentary on current energy-related issues.

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 sponsorship opportunities.

www.eurasianconference.com/sponsorship

Presenter attendance at the conference

Authors will be notified **by May 29, 2020**, 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 **July 10, 2020,** 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.

Abstracts submitted by e-mail or in hard copy will not be processed.

Paper submission is optional.

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.eurasianconference.com/abstractformat to download an abstract sample and template.

All abstracts must conform to the format structure outlined in the template. Abstracts must be submitted online by visiting

registration.ccevent.org/baku2020

Abu Dhabi Report (Continued from page 37)

Closing Plenary Session

Chairperson
Steve Griffith: Senior Vice President, Research and Development and Professor of Practice, Khalifa University

Speakers
Adam Sieminiski: President of King Abdullah Petroleum Studies and Research Center
Marianne Kah: Advisory Board Member and Adjunct Senior Research Scholar, Columbia University Center on Global Energy Policy
Omar Al-Ubaydli: Director, Studies and Research, Bahrain Center for Strategic, International & Energy Studies (DERASAT)

The speakers reflected on the key takeaways from the IAEE's first ever symposium in the Middle East.

Marianne Kah noted the lively exchanges about hydrogen's potential as storage for excess electricity, its applications in transport, and the different ways to produce it. Whether gas will be a 'bridge' or 'destination' fuel will depend on its cost relative to coal and renewable sources.

Omar Al-Ubaydli recalled that while changes in technology, economy, and politics have contributed to global energy developments, it was important to consider how the latter have also influenced trends in the former.

Adam Sieminiski agreed that technological innovations in energy would go a long way in achieving sustainable development. However, these innovations need to be accessible to all, particularly those in third world countries. Consequently, multilateral policies and monetary commitments will be required to accelerate and widen the scope of the low-carbon energy transition.

WELCOME NEW MEMBERS

The following individuals joined IAEE from 10/1/2019 to 1/31/2020

Magnus Abraham-Dukuma
University of Waikato
NEW ZEALAND

Philippe Adam
ABB
FRANCE

Ardak Akhatova
TU Wien
AUSTRIA

Rai Alan
Australian Energy Market Commission
AUSTRALIA

Ilker Alatas
IDTM
TURKEY

Younes Alblooshi
UNITED ARAB EMIRATES

Ahmed Almezail
Saudi Arabian Monetary Authority
SAUDI ARABIA

Ana Maria Alvarado Moctezuma
Engineering Science
NEW ZEALAND

Muhammetmyrat Amanov
TAPI Pipeline Company Limited
UNITED ARAB EMIRATES

Vikram Anenden
AUSTRALIA

Catarina Araya Cardoso
University of Westminster
UNITED KINGDOM

Julio Areas
Department of Energy
USA

Dini Ariani
Engineering Science
NEW ZEALAND

Joe Ascroft
NEW ZEALAND

Juliano Assuncao
PUC Rio
BRAZIL

Gigih Udi Atmo
Asia Pacific Energy Research Centre
JAPAN

Foluke Timothee Attikpati
CentraleSupelec Univ Paris Saclay
FRANCE

Benjamin Aust
Technical University Freiberg
GERMANY

Patrick Balducci
PNNL
USA

Santacruz Banacloche
Ciemart
SPAIN

Justine Barden
US EIA
USA

Jean-Pierre Barral
AFD
FRANCE

Anne Baschwitz
CEA
FRANCE

Joseph Daniel Batamack
Ecole Centrale Supelec
FRANCE

Romanic Baudu
Universite Savoie Mont Blanc
FRANCE

Benjamin Bedouet
RTE
FRANCE

Anoucheh Bellefleur
FRANCE
Vincent Benedikt Pohle
GERMANY

Dumisani Bengu
Wits Business School
SOUTH AFRICA

Francois Benhmad
University of Montpellier
FRANCE

Marion Bertholon
FRANCE

Swetha Bhagwat
Florence School of Regulation
ITALY

Jorge Blazquez Lidoy
SPAIN

Ayodele Peter Boglo
Univ of Johannesburg
SOUTH AFRICA

Anouar Bouden
Engie
FRANCE

Guillaume Bourgeois
GAEL
FRANCE

Dylan Brewer
Georgia Tech
USA

William Bryan
Georgetown University
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Francois Caffet
TOTAL
FRANCE

Luca Casamassima
TU Wien
AUSTRIA

Ernesto Casetta
University of Udine
ITALY

Zuhtu Celenk
Istanbul Enerji
TURKEY

Mehmet Ata Ceylan
Elektronik Yusek Muhendisi
TURKEY

Philippe Chalmin
Université Dauphine
FRANCE

Pradip Chanda
NTPC School of Business
INDIA

Sushanta Chatterjee
Central Elect Regulatory Commission
INDIA

Christine Chauvet
CRE
FRANCE

Charn-Ying Chen
Inst of Nuclear Energy Research
TAIWAN

Jixin Cheng
Chongqing University
CHINA

Wenting Cheng
The Australian National University
AUSTRALIA

Mzwandile Ciliwe
Wits Business School
SOUTH AFRICA

Giordano Colarullo
Utilitalia
ITALY

Taylor Collins
University of the Incarnate Word
USA

Laurence Confort
AFG
FRANCE

Annie Curran
UNITED KINGDOM

Shyamasis Das
AEEE
INDIA

Enrico De Girolamo
CV Trading Spa
ITALY

Emmanuel Decena
University Of Auckland
NEW ZEALAND

Julien Defays
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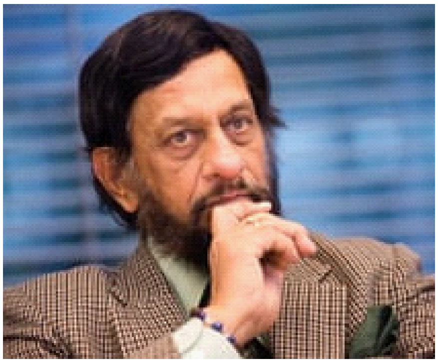

Rajendra Pachauri

The Indian environmentalist Rajendra Kumar Pachauri, under whose leadership a UN climate change panel shared the 2007 Nobel peace prize, has died after recent heart surgery. He was 79.

Pachauri's death was announced late on Thursday by the Energy and Resources Institute (TERI), a research group he headed until 2016 in New Delhi.

He chaired the Intergovernmental Panel on Climate Change panel from 2002 - 2015

The IPCC and the former U.S. vice-president Al Gore were awarded the 2007 Nobel Prize for their efforts to expand knowledge about anthropogenic climate change and lay the foundations for counteracting it.

Pachauri had undergone surgery in a New Delhi hospital this week. He died at his home on Thursday, the Press Trust of India reported.

Pachauri won civilian awards from India's government in 2001 and 2008.

TERI's chairman, Nitin Desai, hailed Pachauri's contribution to global sustainable development. "His leadership of the Intergovernmental Panel on Climate Change laid the ground for climate change conversations today," Desai said.

Professor Jean-Pascal van Ypersele, the IPCC vice-chairman from 2002 to 2015, said coming from a developing country Pachauri should be credited for drawing the attention, long before others, to the importance of finding synergies between climate policies and sustainable developing agenda.

Pachauri was IAEE President in 1988. He is survived by his wife, a son and a daughter.

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Dec. 18th 2019 – New Delhi
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Thank You !
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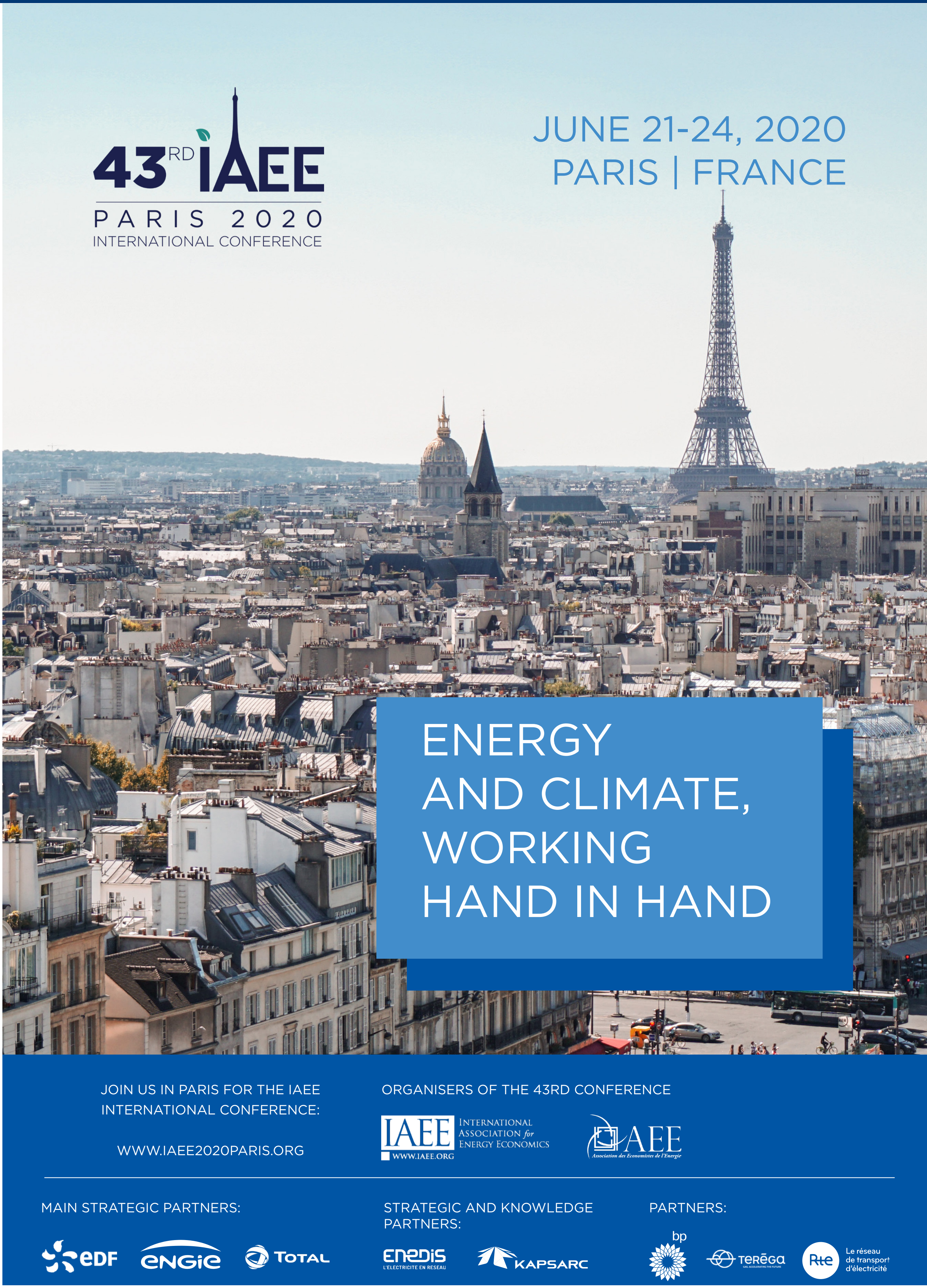
IAEE/Affiliate Master Calendar of Events

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

Date	Event, Event Title	Location	Supporting Organization(s)	Contact
2020				
May 13-15	5th Annual HAEE Symposium: *Energy Transition V: Global & Local Perspective*	Athens, Greece	HAEE	Spiros Papaefthimiou http://haee.gr/
June 21-24	43rd IAEE International Conference *Energy Challenges at a Turning Point*	Paris/France	FAEE/IAEE	Christophe Bonnery https://www.faee.fr/
Sept 18-19	5th IAEE Eurasian Conference *Energy Supply, Sustainability and Electric Mobility: Regional Challenges and Opportunities*	Baku, Azerbaijian	IAEE	Vilayat Valiyev https://www.eurasianconference.com/
Sept 22-23	BIEE Oxford 2020 Research Conference *Energy for a Net Zero Society: Achieving a Just Transition*	Oxford, U.K.	BIEE	Debbie Heywod http://www.biee.org/
November 1-4	38th USAEE/IAEE North American Conference *Energy Economics: Bringing Markets, Policy and Technology Together*	Austin, TX, USA	USAEE/IAEE	David Williams http://www.usaee.org/usaee2020/
2021				
March 21-23	8th Latin American Energy Economics Conference	Bogota, Colombia.	ALADEE	Gerardo Rabinovich
July 25-28	44th IAEE International Conference *Mapping the Global Energy Future: Voyage in Unchartered Territory*	Tokyo, Japan	IEEJ/IAEE	Yukari Yamashita https://iaee2021.org/
August 29 – September 1	17th IAEE European Conference *The Future of Global Energy Systems*	Athens, Greece	HAEE/IAEE	Spiros Papaefthimiou http://haee.gr/
2022				
February 6-10	45th IAEE International Conference *Energy Market Transformation in a: Globalized World*	Saudi Arabia	SAEE/IAEE	Yaser Faquih
September 4-7	18th IAEE European Conference *The Global Energy Transition: Toward Decarbonization*	Milan, Italy	AIEE/IAEE	Carlo Di Primio https://www.aiee.it/
2023				
June 25-27	46th IAEE International Conference *Overcoming the Energy Challenge*	Izmir, Turkey	TRAEE/IAEE	Gurkan Kumbaroglu http://www.traee.org/
2024				
May-June	47th IAEE International Conference *Forces of Change in Energy: Evolution, Disruption or Stability*	New Orleans	USAEE	David Williams www.usaee.org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The IAEE Energy Forum is published quarterly in February, May, August and November, by the Energy Economics Education Foundation for the IAEE membership. Items for publication and editorial inquiries should be addressed to the Editor at 28790 Chagrin Boulevard, Suite 350, Cleveland, OH 44122 USA. Phone: 216-464-5365; Fax: 216-464-2737. Deadline for copy is the 1st of March, June, September and December. The Association assumes no responsibility for the content of articles contained herein. Articles represent the views of authors and not necessarily those of the Association.

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IAEE ENERGY FORUM – Vol. 29, Second Quarter 2020

IAEE Energy Forum
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