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IAEE Energy Forum

First Quarter 2018 | International Association for Energy Economics | ISSN 1944-3188

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INTERNATIONAL ASSOCIATION for ENERGY ECONOMICS

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Editor: David L. Williams

President's Message

Coming out of a couple of tough years for energy markets, and for energy-related professional associations, 2018 has the potential to be a very positive year for the IAEE. Efforts to expand the geographic footprint and balance the organization's age distribution are well underway, thanks to an active year by 2017 President Ricardo Raneiri and Executive Director Dave Williams Jr. with the help of several others. Going forward, building on the 2017 momentum will be a prime objective challenge and one I will relish. The IAEE and its later-established U.S. affiliate have provided a professional home for me during a career in energy economics going on a half-century. I have been involved since IAEE was founded in 1977-78, both in the U.S. and subsequently while I was at the IEA in Paris. My career has also spanned many areas, initially as a government econometrician, forecaster and energy policy analyst, then as an energy market advisor within a large bank, and then an energy macroeconomist and securities analyst for a private banking firm, before serving as a senior official with an international energy organization. Since returning to the U.S. in 2000, my role has been as an energy journalist and editor for *Energy Intelligence*, a longstanding private energy publishing company.

Through all this, the IAEE has been my professional touchstone, as a critical resource for professional connections and a friendly forum for discussion of an increasingly broad set of interdisciplinary topics related to the broader energy context. I decided a couple of years ago it was time to "give back" and my offer was accepted with more enthusiasm than expected and I had positive responses from many old friends who have grown up professionally in the IAEE and an increasing number of younger members who are the future life's blood of this organization. In my year as President-Elect it has been a distinct and not at all unexpected pleasure working with Dave Williams Junior and Senior and Rebecca, whom I have named "Wonder Woman."

In the next issue of the IAEE Energy Forum I plan to make some observations on my main area of interest over the last few decades, oil markets, that touches on many other areas of energy economics and other disciplines that pack our conference agendas and our industry, academic and government membership and conference audiences. The disconnect between the short-term and longer-term drivers of oil supply and oil demand offer a "Twin Dilemma for Global Oil Markets." All of economics is about transitions and energy economics is particularly susceptible given the linkages to geopolitics, technology, government policies, regulations and financial markets. One of the enduring pleasures of having chosen this profession is picking up the newspaper every morning and finding something interesting and relevant on nearly every page. Early in one's career it is about gathering as much information as possible, later in one's career a prime contribution is to discard as much irrelevant

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President's Message (continued from page 1)

information as possible

When I was in Oslo last year giving a talk organized by the Norwegian affiliate as part of the Distinguished Lecturers Series, I was introduced as a champion of the environment and of energy economics, because I had reduced the discussion of oil market events from 80 pages when I edited the IEA's monthly *Oil Market Report* to less than 20 pages in EI's *Oil Market Intelligence* during the 17 years I was editor saving not only trees but energy economists time. With advent of "Big Data" the filtering process has become all that much more important for energy economists, energy journalists and related professionals. As a second historical memory, when Global Information Systems were becoming all the vogue, I was asked to build a model of U.S. energy demand, by fuel...by individual. My response was that my training in economics had been about making order out of chaos rather than the other way around, a sentiment I have shared more recently with my friends in the Big Data community.

David Knapp

NEWSLETTER DISCLAIMER

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IAEE Mission Statement

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

We facilitate:

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

We accomplish this through:

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

Editor's Notes

We include reports from a number of conferences, seminars, symposiums and other meetings in this issue. The report from the Houston, Texas, North American meeting covers the plenary sessions of that meeting. Those interested in obtaining the full proceedings of that meeting may order them from USAEE headquarters - see page 28 for details. The report of the South Asia energy summit is also notable.

The articles cover a broad range of topics which we hope you will find of interest.

Samarth Kumar, Dirk Hladik and **Philipp Hauser** note that different aspects of measuring security of supply (SoS) have been structured into uncertainties, systematic and specific risks. Using a proposed framework, they discuss emerging uncertainties and risks in electricity and natural gas sectors and the impact of sector coupling. Suggestions are made on how to proceed with measuring SoS in a changing energy landscape.

Ado Ahmed notes that renewable energy resources (RE) hold great potentials for meeting the energy needs of Nigeria, a country that is aptly described as an energy deficient nation. However, the financing of utility scale RE faces a myriad of challenges related to weak financial markets and weak institutions.

Tunç Durmaz, Aude Pommeret, and **Ian Ridley** investigate a household's willingness to pay (WTP) for a 1.9kW peak PV system, a smart meter, and a home storage battery. They are particularly interested with how and whether the WTP for one of these technologies is affected by the complementary technologies.

Walid El Gazzar posits that as policy makers in developing countries seek to become less dependent on fossil fuels, they need to worry less about increasing RE generation capacity and more about building the institutional capabilities and human resources necessary for this transition.

Austin Zwick writes the energy transition from fossil fuels to alternative energy is being driven by changes to the underlying Energy Returns on Investment (EROI), which are decreasing for the former and increasing for the latter. Though current prices on oil and gas may be low due to temporary boosts triggered by the introduction of fracking, long-run trends indicate that a "Green Day" - the day where alternative energy takes over the majority of consumption - will arrive in the near future as technological breakthroughs are making alternative fuels more energy efficient than their conventional counterparts. Carbon taxes may accelerate the timeline, but they aren't the cause of this trend.

Jan Deller and **Julie Metta** discuss Hong Kong's use of municipal solid waste for the generation of electricity. This use of green technology tackles two issues at the same time, reducing the amount of waste while providing cleaner energy.

Ugranath Chakarvarty discusses the availability of the rare earths and other critical materials that are used in the advance technologies required for the production of many of the renewables that are being counted on to lead to a low carbon economy. He raises the prospect of an OPEC type cartel for some of these needed materials.

Hisham Khatib writes that the new renewables are increasingly being introduced into power systems all over the world. Sometimes this is driven by enthusiasm rather than rational evaluation. He analyzes this.

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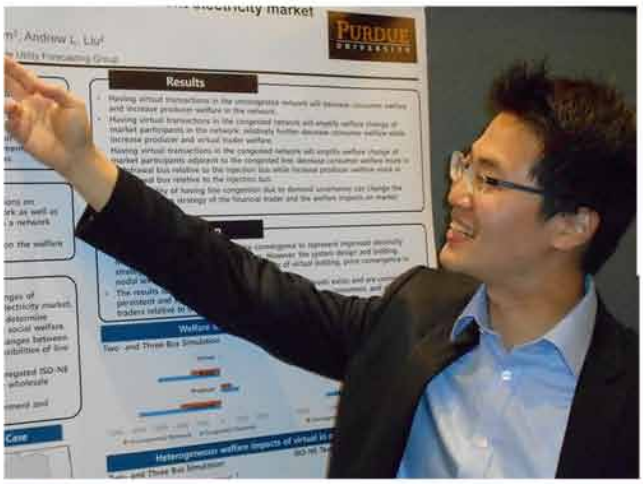
SCENES FROMTHE 35TH USAEE/IAEE NORTH AMERICAN CONFERENCE NOVEMBER 12-15, 2017

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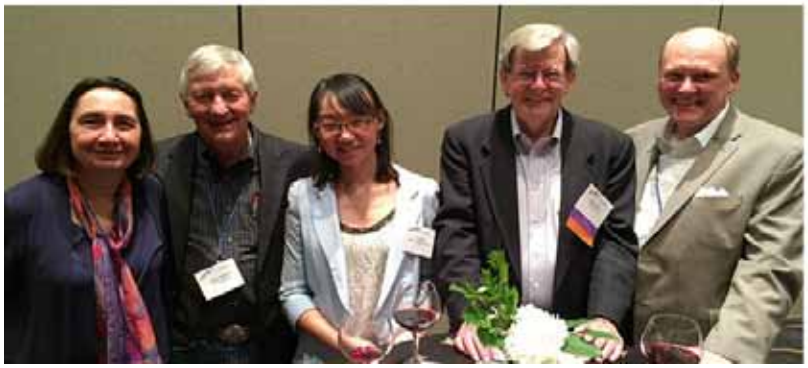

Houston North American Conference

CONFERENCE OVERVIEW

The 35th USAEE/IAEE North American conference was held in Houston, Texas. There were 298 attendees representing 21 distinct countries, 63 of whom were students, and 91 of whom were welcomed as new members to the organization. The backgrounds of the delegates included, but were not limited to, academia, the U.S. federal government, oil and gas companies, utilities, and research and consulting groups. The theme of this year's conference was "Riding the Energy Cycles". The past decade has seen unprecedented extreme volatility in energy markets. In the face of such immense booms and busts the industry has been questioning whether or not we have arrived at a 'new normal' or if the ride is yet to continue. Having been named the 'Energy Capital of the World' there are few better places than to discuss what these cycles mean for the energy sector than Houston, Texas, home to the offices of most major oil and gas companies, the renewable energy innovation headquarters for the state of Texas, and major banks operating in energy trading and financing, to give a few examples of the vibrant energy sector in the city. Throughout the conference, delegates had the opportunity to attend a variety of plenary sessions where expert panels discussed issues ranging from broader discussions of the United States as an international oil and natural gas market maker to the growing influence of Internet of Things technology in the energy sector and what this means for technology, consumer, and security concerns. The Houston conference saw the continuation of the successful Government Track that had been introduced at the 34th USAEE/IAEE North American conference in Tulsa, Oklahoma last year. New to the conference this year, Houston saw the introduction of the PhD Day Session providing a number of students the opportunity to receive more detailed feedback on their papers as they prepared for the job market and practiced presenting their job market talks. Student members were also able to compete for cash prizes in the Case, Poster, and Best Paper competitions with other conference delegates being able to watch the competition unfold and see the best of what USAEE and IAEE student members have to offer. Open to all delegates, technical tours and workshops were also on offer before and after the official start and end to the conference sessions. Finally, as ever, all members were given extensive opportunities to network with other members from a variety of backgrounds. All in all, an engaging line-up of plenary sessions, a plethora of presentations in concurrent sessions, lively lunchtime speakers, and wonderfully pleasant weather in the Greater Houston area provided conference attendees with a comprehensive first-hand exposure to work being done across the world of energy economics and a deeper appreciation of how to best ride the energy cycles of today.

SUNDAY NOVEMBER 12TH

OFFSHORE DRILLING RIG MUSEUM

On Sunday afternoon before the official start of the conference delegates had the opportunity to join a tour of the Ocean Star Offshore Drilling Rig Museum and Education Center. (Photo courtesy of Carol Dahl, Colorado School of Mines).

CASE COMPETITON

The 2017 USAEE/IAEE conference in Houston was the 6th year for the USAEE Case Competition started in 2012. The competition casts participating groups in the role of consultants with clients from government or industry who need them to do a quick, first-order analysis to inform a complex energy-related problem, usually with a technical, economic, and political component. This year's case asked students to advise Mobius Investments, a pension investment firm concerned with their investments in international oil companies and the impact of a tight 2 degrees C climate policy on their valuation and the potential of stranded assets. Teams of 2-5 students were able to submit a report with their recommendation earlier this spring. Of these teams, four were selected to come and present their cases at the Houston conference and compete for first ($2500), second ($2000), and third ($1500) prizes. Participating students selected to come compete for the top three places also won conference fee waivers for the Houston conference for two members of each team.

Generous sponsorship for the competition came from the King Abdullah Petroleum Studies and Research Center (KAPSARC). The Case Competition was organised by Parth Vaishnav (Carnegie Mellon University) with Eric Hittinger (Rochester Institute of Technology), and Nathaniel Horner (U.S. Department of Energy) also helping write the case.

This year, first prize was awarded to the team Energy Wranglers from the University of Texas, Austin. Second prize was awarded to Team Lehigh from Lehigh University and third prize was awarded to team EcoFin Environment from University of Paris-Sanclay.

Last year an exciting development with the USAEE Case Competition was its opening to students all over the world, not just in the United States. This year the Case Competition again saw an exciting development where the first prize winners presented their winning case at the Tuesday luncheon in front of the entire conference delegation. We look forward to more great case competitions in the coming years!

MONDAY, NOVEMBER 13TH

STUDENT MENTORING SESSION

In the morning before the Opening Plenary USAEE and IAEE student delegates were invited to a Student Welcome Breakfast and Mentoring Session. At the session students had the opportunity to network both with one another as well as with a selection of mentors from both academia, industry, and the public sector. This year's mentors were Peter Balash (DOE/NETL), Burcu CigerliEsmerok (Shell Energy), Ken Medlock (Rice University), Martha Goodell (Enigami Partners), and Michael Plante (Federal Reserve Bank Dallas). The mentoring opportunities were organized by John Holding (Independent Practitioner).

WELCOMING REMARKS

The 35th annual USAEE/IAEE North American Conference was kicked off by Shree Vikas (ConocoPhillips), the 2017 President of USAEE. In his opening remarks Vikas made reference to the conference theme of 'Riding the Energy Cycles' and the current volatility in the market that is affecting efforts for the sector to move forward regarding economics, financial drivers, and technology. Geopolitics, Vikas said, also a critical component to where we are headed and references were made to the various plenary sessions that were to cover all of these topics in more depth. One hope from attending the conference would be to come away with practical tools for insights into surviving and adapting to the changing energy markets.

Vikas then moved to thank all those who made the conference successful, particularly Tom Drennen (Hobart and William Smith college), the Plenary Session Coordinator, Peter Hartley (Rice University), the Concurrent Session Chair, John Holding (Independent Practitioner), the Poster Session Chair, Caldwell Bailey (IHS Energy), the Technical Tour Coordinator, Andrew Slaughter (Deloitte Services LP), the Sponsorship Committee Chair, and Melanie Craxton (Stanford University), the Student Program Coordinator. Sponsors were also gratefully acknowledged.

Ricardo Raineri (Universidad Pontifica de Chile), current President of the IAEE, was then introduced and made his welcome remarks. After thanking the conference organizers again, USAEE, the Houston chapter, and sponsors Raineri thanked the founding fathers of the IAEE who initially put the organization together exactly forty years ago in 1977. The organization started small, but has grown to be worldwide with many national affiliates and sub-chapters. The world has changed significantly since 1977, Raineri pointed out, and it is set to change even further in the coming years. By 2040 energy consumption is expected to increase 40% and most of this is due to happen in developing countries. The IAEE is currently present in more than 90 countries and has thousands of members not only in the developed, but also in the developing world. The diversity of the organization was emphasized as a strength and will likely continue to grow stronger in the coming years as the energy landscape changes even further. Raineri closed out his welcoming remarks by citing upcoming USAEE and IAEE conferences.

Before the Opening Plenary commenced Vikas returned to poll delegates with two questions: "What will cause the most oil market volatility in the next five years" and "Over the next five years which energy industry segment will observe the most employment growth?"

Delegates were able to vote for the answer they felt the most appropriate either via their mobile phones or online. In response to the first question the clear winner for what delegates thought would cause the most oil market volatility in the next five years was OPEC and/or supply disruptions from conflict (61%). In second place, global economic growth, transport technologies, and shale technologies and production were just about tied (12-14%). Essentially no delegates thought that service industry cost inflation would be particularly influential in the grand scheme of things. In response to the second question most delegates believed that renewables (i.e., solar and wind) would see the most employment growth in the next five years (63%). The next leader was U.S. shales, but only by a small margin (12%). Close behind came midstream and petrochemicals and energy investing and finance (10%). The segment that delegates believed would observe the least employment growth of those listed was the power market and trading segment (4%).

It was very interesting to be able to take the pulse of how conference delegates felt about these questions before the start of the conference. Over the next few days they were exposed to a thorough program of plenary and concurrent sessions that would serve to potentially change and influence these views.

THE U.S. AS AN INTERNATIONAL OIL AND NATURAL GAS MARKET MAKER – MARKETS, GEOPOLITICS, AND U.S. ENERGY POLICY (OPENING PLENARY)

The Opening Plenary was a panel consisting of Amy Jaffe (Council on Foreign Relations) and Sarah Ladislaw (Center for Strategic and International Studies) chaired by Ed Morse (Citigroup). Morse opened the session by citing the current energy market cycle as having been "particularly brutal and particularly disruptive". In doing so he drew ties to the oil crises of the 1970s. The "old view of how oil markets worked" he claimed was now "impossible to maintain". In attempting to predict energy market movement it was illogical to make linear forecasts, he claimed, as they are inherently driven by a cyclical set of assets driven by investment cycles. The bottom of this current cycle, Morse claimed, was 1998-1999. The world was not investing much and there was a sense that prices were going to be low forever. This led countries that were producing

a lot in the late 1990s to produce half as much in the early 2000's thus causing a scramble for oil resources. In addition to this, new technologies such as shale, oil sands, and deep water drilling allowed for access to resources that were previously uneconomic and inaccessible. 2014, Morse cited, was a turning point both for natural gas and for oil, particularly in terms of the geopolitical landscape. Supply disruptions such as in Libya, the Atlantic Basin going from being in deficit to in surplus, sanctions on Russian companies and its government, the United States becoming an energy hub and its geopolitical retreat were all referenced. The demand scene has also changed dramatically, Morse pointed out. Demand for fuel oil has gone down since 2011 driven not by diesel, as we may have thought, but by petrochemical feedstocks that are gas injected. Most of the oil demanded today is for transportation, Morse said. Finally, before introducing Jaffe and Ladislaw, Morse referenced the growing "bromance" between Saudi Arabia and Russia and that the two of them, plus the United States, are currently and will continue to be, the largest players in the global energy space.

Jaffe then spoke particularly to the demand side of things. In the "old world" she claimed that energy market cycles were approximately five to seven years with a natural tracking to the business cycle where supply lagged demand, but as higher prices drove new investments to bring increasing supply demand would have decreased due to the higher prices just in time for new supplies to come on the market. Jaffe also took this opportunity to say that she hoped the idea that we would ever run out of oil has died. With regards to geopolitics, she pointed out the seeds that are being sown for conflict, but that there are a plethora of technologies that are ready to respond if supplies get cut off. On the demand side, there are also substitutes to driving your car. It used to be, Jaffe pointed out, that when places got wealthier they bought more cars. The current young population does not seem to do this. Congestion is a problem, people have different attitudes about durable goods, and there are other substitutes such as ride sharing. Therefore this time is going to be different and demand models need to take these shifts into account. Jaffe also pointed out that the advent of 3D printing also changes the manufacturing game as parts can now be made on site where before they needed to be shipped around the world. All of this will play a role in energy demand. Jaffe closed out her talk by saying that OPEC was going to have much more difficulty functioning now than they have previously because Saudi Arabia traditionally has been able to maintain some form of order by threatening to flood the market with oil, but they have currently set out not to do so.

Ladislaw followed Jaffe's comments with some key observations. We are on the latter half of the road to rebalance, she observed, though we are not out of the woods yet and cycles are not over. There will be a gap in underinvestment and how we fill that gap will matter. India and China are creating strong economic headwinds and issues such as climate change are getting global attention. There is now huge value in looking at the energy system as a whole rather than as a sum of its individual parts. In terms of geopolitics Ladislaw claimed that we were looking at "the most important geopolitical realignments that we have seen in multiple decades". Currently the U.S. is pursuing a path of "energy dominance" in the sense that it has decided it shall not "lead from behind". National security is becoming increasingly important, particularly in the U.S., and economic nationalism is becoming a stronger force. There is now a third axis in Washington of nationalists versus internationalists and all of this will be important for the energy sector. The current President, Ladislaw cites, also prefers bilateral agreements and has a dislike for institutions. This too will greatly affect the landscape in the near future. Ladislaw concluded her talk with three C's that she believed were going to drive our path: competitive, consumerists, and crises.

AWARDS LUNCHEON

At lunch on Monday the USAEE Adelman Frankel Award was given to Mine K. Yucel (Federal Reserve Bank of Dallas) and USAEE Senior Fellow Awards were given to James T. Jensen (Jensen Associates Inc), Edward L. Morse (Citigroup), and Samuel A. Van Vactor (Economic Insight Inc).

After lunch and the conferring of awards delegates were treated to an extremely engaging and lively talk by Robert McNally (The Rapidan Group) entitled "Welcome Back to Boom-Bust Prices". McNally is also the author of the recent book Crude Volatility: The History of Boom and Bust Prices, upon which his lunch talk was based. The talk started with the question of whether or not $50 oil was the "new normal". McNally argued that we should be very sceptical of this being the "new normal" because the type of volatility that we are seeing is historically unprecedented. McNally then took delegates on a journey back to 1859 to see how oil prices have fluctuated between then and now. The key question, he claimed, as to whether or not prices were going to be volatile or not was whether or not there was a 'supply manager'. Historically Rockefeller was the "first big OPEC" because he put stability into the system by controlling prices. The anti-trust regulation that ended this control was what caused boom and bust to start up again. When the seven major oil companies got together (the 7 sisters) this was another example of a supply manager as was when the Texas Railroad Commission was heavy handed in controlling prices. McNally's argument is that since 2008 we have had no swing producer that is able to stabilize prices the way they have been able to have been historically. Therefore we are not so sure that we are out of the woods yet and that demand side is going to play a big role this time because there is no one around to step in and be a modern day Rockefeller. McNally's entire presentation was accompanied by interesting presentation of data to back up his arguments and an extremely lively delivery throughout. All in all it was an extremely topical and highly enjoyable second half to Monday lunchtime.

INNOVATION IN ENERGY FINANCE AND INVESTMENT – ACCELERATING A TRANSITION (PLENARY SESSION)

[Written by Tade Oyewunmi (University of Eastern Finland)]

This dual plenary session on Energy Finance and Investments focused on innovation and transition towards more sustainable energy mix in North America and across the globe. The session was presided over by Martha Goodell (Enigami Partners LLC), while Jason Blumberg (Energy Foundry), Ric Abel (Prudential Capital Energy Partners) and Caitlin MacLean (Milken Institute) made presentations bordering on the recent trends, risks and critical factors in financing and enhancing sustainable energy investments. The growing demand for more renewable energy, whether in the form of battery storage coupled-with solar or wind power, is spurring new financing mechanisms notwithstanding the peculiar risks and complexities involved. The European Union, for instance, is said to be currently revising its framework for investment funds which will foster the incorporation of social and environmental factors in new financing and investment decisions. Martha Goodell emphasised that innovativeness in financing is helping to drive risk allocation and returns as energy markets transit and adapt to the demands of sustainability. Caitlin MacLean pointed out the role of financing in addressing social and environmental issues, as well as addressing funding gaps in other to support new technological development. She also spoke about the relevance of environmental, social and governance (ESG) factors or strategies as sustainable energy investments gain momentum. Ric Abel discussed the experiences of Prudential Capital Energy Partners' in relation to electricity project finance, market drivers and key factors affecting project viability for renewables. He highlighted the profit maximisation motive of investors as well as the need to reduce transaction costs and mitigate risks in projects financing and development. Lastly, Jason Blumberg pointed out the emerging trends in energy investments and innovation and to what extent disruptions are taking place. He discussed the role of the State in driving new financing instruments for energy projects.

FUTURE OF THE REFINING SECTOR -- TRUMPONOMICS AND LOW OIL PRICES (PLENARY SESSION)

[Contributions by Tina Vital (Aegis Energy Advisors Corp)]

The session Future of the Refining Sector—Trumponomics and Low Oil Prices was presided over by Tina Vital (Aegis Energy Advisors Corp) and consisted of a panel of Carol Dahl (Colorado School of Mines) and Garfield L Miller III (Aegis Energy Advisors Corp). Dahl's presentation focused on factors influencing the demand for refined petroleum products, and how changes in global wealth and economic growth are likely to affect future product demand. As countries get richer, the demand for mobility becomes more price inelastic and as such the demand for gasoline and diesel fuel becomes more inelastic. On the other hand, the sensitivity of fuel demands in the face of rising prices has grown. Policies to encourage greater fuel efficiency can have real impacts, but Dahl also cited an example of the rebound effect in Europe, where fuel efficiency standards encouraged more driving. Garfield Miller's presentation focused on the world of new refinery finance, with particular attention to North America, OECD countries and Asia. He noted that while projections for new refining capacity looked quite bullish in the next five years – around 8 million barrels per day of new capacity, spanning 250 projects globally – these projections do not often do a good job adjusting for risk. This risk appears to be particularly high for Asian refinery prospects.

POSTER SESSION

The student poster session, organized and chaired by John Holding (Independent Practitioner), is an opportunity for students to present their work to a broad audience in an interactive manner. This year the posters were displayed throughout the same room as the Monday night networking session. Judges roamed anonymously listening to competing students present their posters and field a wide variety of questions.

This year's competition had twelve posters representing a diverse set of projects. Topics covered by posters this year included opportunities and risks in constructing solar photovoltaic plants, flat energy management structures for iron and steel enterprises in China, the future of the energy sector and its geopolitical impact, energy efficiency gap evidence from green commercial buildings, considerations of the natural resource curse, off-grid rural electricity generation in Nigeria, optimal virtual bidding in multi-settlement electricity markets with congestion, energy storage, feed-in-tariffs and renewable portfolio standards, complexity in energy systems, stochasticity in grid-evolution models, and energy efficiency and machine learning.

The winner of this year's poster competition, and a check for $1000, was Hyungkwan Kim whose poster was entitled 'Welfare Impacts of Optimal Virtual Bidding in Multi-Settlement Electricity Market with Transmission Line Congestion".

TUESDAY, NOVEMBER 14TH

CHANGING TIES WITH MEXICO (PLENARY SESSION)

[Written by Tade Oyewunmi (University of Eastern Finland)]

Following the ongoing reforms and restructuring of the Mexican energy industry, this session focused on the experi-

ences, projections and expectations of the regulators and operators in Mexico. Alejandra Elizondo (Center for Research and Economic Teaching) presided over discussions, while Guillermo Garcia Alcocer (Energy Regulatory Commission), Jimena Marvan (ASEA), and Hector Moreira Rodriguez (National Hydrocarbons Commission of Mexico) gave very insightful presentations. Guillermo spoke about Mexico's Energy Regulatory Commission taking up a role similar to the U.S.'s Federal Energy Regulatory Commission as an independent economic regulator while the industry is being liberalised to enhance competitiveness. He opined that the ongoing reforms are expected to outlast the coming elections in Mexico, especially since all stakeholders and operators are fully engaged and part of the restructuring process. Guillermo notably mentioned that the Supreme Court recently and categorically held that the reforms are constitutional. Following recent comments by the current U.S. Federal Government pertaining to renegotiating the North American Free Trade Agreement (NAFTA) between Canada, Mexico, and the United States, he opined that there should be little or no adverse implications on the reform process. There are also reports of growth in private sector participation in the energy industry, especially gas sub-sector, in which the pricing and resource allocation in increasingly becoming market-led. Guillermo also highlighted the life-cycle approach to projects, while the industry and regulators are facilitating necessary coordination and communications.

Hector pointed out the emerging trends and opportunities presented by the reforms in Mexico. Notably, free market conditions are being institutionalized, while 'special protection' is no longer being given to any particular incumbent operator. The restructuring of Mexico's energy supply industry is said to be tailored towards the Canadian and American model. There is now guaranteed open access, while the electricity and gas transmission grid is the only section which is reserved for the state's management and control. Hector also reported that in the course of the last ten years, most of the investments in Mexico has gone to the energy sector. Some of the most pressing challenges faced by the Commission, other regulators and operators is the need to improve efficiency in communication processes. He also opined that NAFTA is more than a trade agreement between Canada, U.S. and Mexico, while it remains important to protect investments and ensure North America's energy security and competitiveness. On Mexico's long-term outlook to 2035/2050, Hector noted that the country hopes to become a major industrial economy fueled primarily by gas.

Jimena highlighted a crucial risk-based approach to regulation, as the country's energy industry is being reformed and in the transition towards more competitiveness and security of supply. She pointed out the importance of supporting both economic and environmental concerns as the industry develops. Jimena referenced the considerable efforts towards enhancing safety and environmental protection in the energy industry as well as improving regulatory certainty. In this regard, some of the main objectives has been to achieve effectiveness and reduce costs, while also balancing risks and benefits amongst relevant stakeholders. Jimena discussed the trend towards regulatory independence and also opines that NAFTA is an important vehicle for North American integration.

ELECTRICITY MARKETS (PLENARY SESSION)

The Electricity Market plenary session panel was presided over by Bill Starnes (Resolved Energy Consulting LLC) and the panel was comprised of Michael Wara (Stanford Law School), Elizabeth Wilson (Dartmouth College), Joshua Rhodes (UT Austin), and Jean-Bapiste Galland (Enedis).

Wara started the session by bringing up the important issue of carbon markets and ISO footprints not necessarily being the same, citing the Californian carbon market and California's interconnection with other states in the West without a carbon market. States such as California are experiencing a "Trump effect" in terms of pushing their own carbon agendas now that it is clear that the federal government is unlikely to do anything centrally. In January of 2018 nine states are due to have carbon pricing of some form and therefore this creates lots of interesting jurisdictional and legal challenges across states with and without these policies. California specifically is looking to cut emissions by 40% in the next decade and therefore much higher carbon prices are likely in the near future, but there are lots of technical challenges to match load and dispatch in a system where a carbon price is only in place in one part of a wider commitment market.

Wilson followed up Wara's presentation by continuing to emphasize the difference in footprint size of carbon and commitment markets. Many of the regional transmission organizations (RTOs) she illustrated have confusing boundaries and oftentimes overlap one another. This causes important issues in terms of transmission investments, among other things. Within RTOs Wilson also emphasized there being several key tensions between various groups: reliability versus markets and planning versus reliability, for example. When we are thinking about the future of RTOs and our energy system there are many issues that we have to keep in mind, especially pertaining to governance.

In the infrastructure consideration vein Rhodes then gave a presentation with a more engineering flavor pushing the idea that if you are trying to cut carbon emissions what you really need to do is electrify and if you are electrifying then what you really need is an infrastructure to support it. The infrastructure of today, Rhodes pointed out, is highly depreciated and he estimated that if you replaced everything today with current technology, engineering estimates put it at about $5 trillion (depreciated to $2 trillion). There is great need for replacement of much of the infrastructure, but the stakes of doing so are higher than they have been historically because demand has flat-lined if not decreased. Rhodes ended his presentation by giving a visual illustration of the country's grid and what it would look like to put in a least-cost system of

various flavors depending on assumed capital and operating costs, among other things.

Finally, Galland gave an industry perspective from the European side of things. In terms of distribution and balancing supply and demand he highlighted what he considered to be four to five 'triggers': new technologies, energy transition, local empowerment, data deluge, and new users. Overall, Galland emphasized that new services are required. Yesterday we merely pushed energy to the consumer, but today we need to think more about what is going on behind the meter. Especially as we take on more intermittent generation, demand side management is going to grow in importance. Such concerns have prompted Galland and others to consider the degree of decentralization that is best for different systems. He presented results from a study that suggest that for countries such as France a more decentralized approach with an integrating body might be the best direction to move in. However for countries such as the United States there are so many parties to work with that decentralization should be coupled with disintermediation. Developments of various countries, he claimed, should play to the countries' strengths.

Overall the session provided an interesting insight into an industry at the cusp of great change that is not only highly uncertain, but deeply constrained by a variety of factors economic, political, and bureaucratic.

AWARDS LUNCHEON

At the Tuesday lunch, Shree Vikas (ConocoPhillips), current President of the USAEE, honored John Holding (Independent Practitioner), Parth Vaishnav (Carnegie Mellon University), Tom Drennen (Hobart and William Smith Colleges), and Peter Hartley (Rice University) for their contributions towards the organization and running of the Houston conference. The King Abdullah Petroleum Studies and Research Center (KAPSARC) was also acknowledged for their generous sponsorship, particularly of the Student Case Competition.

Anastasia Scherbakova (Texas A&M University) presented the Dennis J. O'Brien USAEE Best Student Paper Award. Each of the four students who were selected to come to the Houston conference was awarded $500 and the first prize winner was awarded an additional $500. This year fourth place went to Sul-Ki Lee of Colorado School of Mines for the paper entitled 'Fuel Switching from Coal to Gas: The Impact of Coal Stockpiling at U.S. Coal-Fired Plants'. Third place went to Brian Prest of Duke University for the paper entitled 'Peaking Interest: How Awareness Drives the Effectiveness of Time-of-Use Electricity Pricing'. Finally, due to the judges finding the competition too-close-to-call, no paper was awarded second place and instead there were two papers who were jointly awarded first place. The first place papers were Nathalie Hinchey of Rice University with her paper 'Natural Gas Salt Cavern Storage Cost Predictability' and Brian Archsmith of the University of California Davis with his paper 'Dam Spillovers: Direct Costs of Spillovers from Environmental Constraints on Hydroelectric Generation'.

John Holding (Independent Practitioner) then presented the award for the Student Poster Competition, an $1000 cash prize, to Hyungkwan Kim whose poster was entitled 'Welfare Impacts of Optimal Virtual Bidding in Multi-Settlement Electricity Market with Transmission Line Congestion".

Finally, Parth Vaishnaw (Carnegie Mellon University) presented the awards for the Case Competition. Third place went to the EcoFin Environment Team from the University of Paris-Saclay comprising of Salahaeddine Soummane and Fatima Shuwaikh. Second place went to Team Lehigh from Lehigh University comprising of Huilai Gu, Adhitya Jayasinghe, and Salvador (Josh) Tarun. Finally, first prize was awarded to the team Energy Wranglers from the University of Texas in Austin comprising of Scott Vitter, Thomas Deetjen, Phillip White, and Katrina Ramirez-Meyers. Following the conferring of awards the first place team was then given the opportunity to present their winning case to the entire delegation.

GOVERNMENT TRACK – ELECTRICITY SYSTEM FLEXIBILITY

This year's Government Track session consisted of a high-powered panel consisting of Josh Novacheck (National Renewable Energy Laboratory), Abhishek Somani (Pacific Northwest National Laboratory), Fletcher Fields (U.S. Department of Energy), and Mary Wierzbicki (Federal Energy Regulatory Commission) moderated by Eric Hsieh (U.S. Department of Energy).

The focus of this year's government track was the flexibility of the electricity system of today and the future as it faces changing use patterns and more variable energy resources. Existing generation assets face uncertainty regarding their efficient utilization under current market rules and incentives and therefore potentially face threats to long-term viability. The goal of this panel was to bring together experts from both the Department of Energy headquarters and its National Laboratories to review ongoing work that is informing operations, planning, policy, and other decisions in this space. The session also consisted of a presentation about market design efforts to economically efficiently deploy today's available flexible resources by the Federal Energy Regulatory Commission. For anyone working in or interacting with government this session was one not to be missed.

ENTREPRENEURSHIP IN THE ENERGY WORLD (PLENARY SESSION)

[Contributions by Shree Vikas (ConocoPhillips)]

The Entrepreneurship in the Energy World plenary session panel consisted of Brad Burke (RICE Alliance for Technology and Entrepreneurship), Anupam Singh (Saudi Aramco Energy Ventures), Jim Sledzik (Hall Labs LLC), and Surya Rajan (Profitability3) and was presided over by Shree Vikas (ConocoPhillips). This session covered perspectives from four different types

of panelist who have enabled entrepreneurship by funding 'that great idea', by creating an eco-system for new technology deployment or by adopting unique business models and superior execution to deliver extraordinary results. Panelists shared their individual journey towards entrepreneurship, talked about success stories and shared lessons learned.

Vikas opened the session by polling delegates with regards to two key questions. Did they believe that energy entrepreneurship helps to offset energy market volatility caused by geopolitics, conflicts, OPEC actions, and other above ground risks? Also, whether or not we on the threshold of a step change in global energy economies and if so over what time horizon. In response to the first question 60% of those present believed that yes, energy entrepreneurship helps to offset energy market volatility whereas 40% believed it did not. IN response to the second question, 92% of attendees believed that we were on the threshold of a step change in global energy economies, the majority of them believing the time horizon was around 25 years. The least amount of those who believed we were on a threshold believed the horizon was as short as five years.

Each of the panellists was able to get up and give a brief introduction of themselves, their company, how they got to where they were, and what key lessons they learned. A good portion of the session was dedicated to inter-panellist discussion and questions and answers from the audience which really helped facilitate the uncovering of several insights about the space.

Key insights from this session included that new startups are proposing incremental as well as disruptive solutions at a much faster pace for energy production, delivery, and consumption. This is due to high and volatile prices leading to consumers to reduce demand and look for alternatives. It was emphasized that energy innovation is not limited to technology as financing and business restructuring as well as changes to asset ownership are some of the more interesting entrepreneurial endeavours today. Compared to other industries, oil and gas efforts have a much longer timeline, higher risk profiles, and require investments on a larger scale. Many new ventures, it was noted, are too in love with their idea and are not flexible or patient enough to succeed in the space. For a startup to be successful being able to reach breakeven faster, basic financial acumen, the ability to do tasks across many disciplines, risk mitigation strategies, and capital efficiency were cited as being extremely important. Additionally a good network and good partners go a long way in being the good idea that makes it. Emphasis was also made on the understanding of the market, including demand patterns. A cool technology with zero end-user demand is not the way to become a successful entrepreneur.

The panel was closed out with a final question to the audience about what they thought could be the most significant catalyst and enabler of energy entrepreneurship in the next five years. Over 60% of attendees believed this to be individual investors and entrepreneurs, showing the strength in belief in entrepreneurs the audience had. Institutional investors and incubators, accelerators, and academia were second and third with 17% and 11% of the vote respectively. The least confidence in the ability to catalyse entrepreneurship in energy was placed in large corporations and government regulations and policy with 6% of attendees selecting each of these responses.

RENEWABLE ENERGY – INTEGRATION CHALLENGES AND EMERGING SOLUTIONS (PLENARY SESSION)

[Written by Chiara Lo Prete (Penn State University) and Alberto Lamadrid (Lehigh University)]

The Renewable Energy—Integration Challenges and Emerging Solutions Plenary was presided over by Alberto Lamadrid (Lehigh University) and Chiara Lo Prete (Penn State University). On the panel were Benjamin Hobbs (Johns Hopkins University), Michael Robinson (MISO), and Nitika Mago (ERCOT).

The session addressed challenges and emerging solutions for the integration of renewable generation into wholesale electricity markets run by the California ISO (CAISO), the Midcontinent ISO (MISO) and the Electric Reliability Council of Texas (ERCOT). A common challenge for all system operators consists in devising mechanisms for procuring flexible backup capacity for renewables. Since 2014, CAISO has established flexible capacity requirements for load serving entities and suppliers, as part of its Flexible Resource Adequacy Criteria and Must Offer Obligation (FRACMOO) stakeholder initiative. Further, CAISO and MISO have introduced markets for ramp products, called "flexiramp" in CAISO and "ramp capability" in the MISO. ERCOT does not offer a ramp product, but requires wind and solar operators to provide a 168-hour rolling forecast for their resources, which is factored into market operations. ERCOT has also established a grid code for renewable resources, based on which interconnected generators must be capable of providing frequency response and maintaining ramp rate limitations. A second challenge faced by systems relying on capacity markets (like CAISO and MISO) relates to appropriately rewarding renewable contributions to system adequacy. Current methods for calculating the capacity contributions of renewables differ by electricity market, and recent research by Bothwell and Hobbs (2017) shows that inaccurate capacity credits may impact investment choices and result in cost and technology distortions. While CAISO has integrated its real-time market operations with several utilities in the Western interconnection, single area interconnections like ERCOT may face specific challenges related to the integration of renewable sources. For instance, since ERCOT is not synchronously interconnected with any of its neighboring interconnections, frequency response (inertial and primary) must be supplied internally. Nitika Mago reported that some generation intensive pockets (like the Panhandle area of the ERCOT system in Northwestern Texas) have become "weaker", i.e., more vulnerable to system disturbances that may hinder continued reliable operations, such as the unexpected loss of a generator. To address this problem, ERCOT constantly monitors generation levels in the Panhandle region to maintain its Weighted Short Circuit Ratio above 1.5, and introduced

a reserve product (called Responsive Reserve Service) to procure sufficient capacity to respond to frequency excursions during unit trips. A market-based approach for providing inertial support in ERCOT will be a topic of stakeholder discussion in early 2018.

WEDNESDAY, NOVEMBER 15TH

STRATEGIES TO ADAPT, SURVIVE, AND EVOLVE IN THE UPSTREAM OIL AND GAS MARKETS (PLENARY SESSION)

The dual plenary session on Strategies to Adapt, Survive and Evolve in the Upstream Oil and Gas Markets was comprised of Caldwell Bailey (Hi Crush, presiding), John Daniel (Simmons), Ron Guseck (Liberty Oilfield Services), Robert Kleinberg (Schlumberger) and Laura Fulton (Hi Crush).

Daniel provided an overview of the financial situation of the upstream sector as a whole, which he characterized as being very highly leveraged, with many negative earnings margins across the sector. He also discussed how a number of firms were in the process of major financial restructuring. Ron Guseck described some of the special difficulties faced by services firms in the current market environment. Unlike production or mid-stream, in the services sector there is no cash flow unless you are out in the field, and in a low price environment there are naturally fewer field days. Laura Fulton gave an interesting presentation on the market and supply chain situation for the sand used in hydraulic fracturing applications. While much of the sand supply for hydraulic fracturing comes from Minnesota and Wisconsin, Texas has also been identified as having good sand potential. Companies are starting to talk about sand reserves – numbers like 35-40 years at current demand rates. Because sand can have high storage costs and because of the mobility of capital between unconventional oil and gas plays, developing a supply chain for just-in-time deliveries of sand has been very challenging. Kleinberg wrapped up the session with another perspective on how the services sector has been adapting. There has been substantial downsizing in the services sector, with 75% of oil and gas layoffs coming in that sector. Schlumberger, Kleinberg's employer, laid off 50,000 workers alone. As cash flow from traditional services activities has dried up, the line between services and traditional exploration/production firms has become blurred. Kleinberg reported that Schlumberger is now contract operating oil fields on a royalty revenue model. He also drew attention to Schlumberger's efforts to gather data on methane emissions from its operating sites.

INTELLIGENT ENERGY SYSTEMS (PLENARY SESSION)

The Intelligent Energy Systems plenary session panel was comprised of Ram Rajagopal (Stanford University), Zoltan Nagy (UT Austin), and Anna Scaglione (Arizona State University). The panel was presided over by Melanie Craxton (Stanford University). In a world where technology is making things possible that never were before, there is increasing talk of the 'internet of things', and 'Big Data' has become more than just a buzz word the goal of this panel was to consider the impact of this revolution on the energy sector. All three of the experts on this panel were chosen specifically for their expertise in intelligent systems technologies. Interestingly, none of them were economists leading to an informative interaction between them and conference delegates as they each provided a fresh look on the topic.

The session commenced with Rajagopal providing an overview of the potential of intelligent energy systems with a focus on the work that his group has been working on particularly with respect to smart grid technologies and the opportunities for advanced data analysis in this area. In his presentation Rajagopal presented several projects that his group has worked on including VISDOM, VADER, and Powernet. VISDOM (visualization and insight for demand operations and management) is a platform for load analysis and management the goal for which is to allow practitioners to more easily interpret and learn from demand side data to improve demand side management. Among other things Rajagopal highlighted VISDOM's targeting and program measurement and evaluation potential, captured though the use of statistical algorithms and large data sets. VADER (visualization and analytics of distributed energy resources) was highlighted for its role in the integration of large data streams to better understand the role and potential of distributed energy resources in distribution networks and Powernet considered coordination of consumer flexible loads and distributed energy resources. Most of what Rajagopal presented was heavily grounded in big data and analytics tools. The next steps, he claimed, were to collaborate with economists in order to truly build an economically viable intelligent energy system on the grid.

Following Rajagopal's presentation, Nagy gave a very interesting presentation on his work with the Intelligent Environments Laboratory at University of Texas Austin. In his presentation Nagy emphasized the role of artificial intelligence that could learn through reinforcement learning and very simple feedback mechanisms. An example was made of an intelligent building system that was able to control the temperature almost exactly as a human would have with minimal learning without any knowledge of the building dynamics. The goal for such systems would be to better understand distributed PV and individual loads, considering hyper-local demand response possibilities, and being able to develop socio-technical-economic scenarios. The possibilities for artificial intelligence in buildings and urban energy systems are exciting and we are only at the beginning of considering how much they can do.

After plenary session attendees were exposed to intelligent energy systems at work today, and opportunities for the

future, the Scaglione provided an important perspective: that of security. With increasingly intelligent systems we are adding assets to be managed to our portfolios as well as potentially opening ourselves up to new forms of security risks. Additionally, security concerns are, and will continue to be, both in front of and behind the meter so there are roles for individual energy systems users as well as system operators. The openness of many of these intelligent systems is an opportunity because it allows for group thinking and collaboration, but it also means that they may be more open to manipulation and attack. Availability, physical security, confidentiality, and situation awareness were highlighted as the pillars of cyber security today. In her presentation Scaglione cited various recent cyber attacks as well as ways in which to anticipate them. The key to handling these threats will be in infrastructure and reliability; efforts that are very much being worked on today as even modern best practices are not always universally adopted across the grid, for example.

In the question and answer session there were questions about security and overall savings potential of these technologies. This is where the interaction between the economists in the audience and the non-economists on the panel was particularly interesting. There are many technical potential papers for many of these technologies, but we are still at the very beginning of considering the economic side of things. This therefore means there are lots of opportunities to do research in and participate in this space. A closing thought on the development of these intelligent technologies was given by Scaglione who believes that "the cart will come before the horse". By this she meant that she believes that consumers are going to adopt technologies to the point that central systems operators are going to be forced to respond. Change along these lines seems to be inevitable, but there is much still to learn and to understand, therefore making the intelligent energy systems space a particularly exciting one.

PULLING IT ALL TOGETHER: ARE WE CYCLING UPHILL OR DOWNHILL? (CLOSING PLENARY)

The 35th USAEE/IAEE North American Conference was closed out by a panel of Adam Sieminski (Center for Strategic and International Studies), Michael Webber (UT Austin), and Guy Caruso (Center for Strategic and International Studies), presided over by David Knapp (Energy Intelligence Group). The theme of the session was the question "Are we cycling uphill or downhill?"

While the session speakers made brief remarks, much of the session was dedicated to questions from the audience. This was a unique opportunity for conference delegates to interact with three long-time energy industry leaders.

The general consensus among panelists was that long-term oil prices will be low, with the possibility of a rebound in the next year or two due to financial markets, conflicts and other above ground risks. The panelist discussed that it is unclear if shale technologies are transferable among basins and long term global shale potential depends highly on this transferability. If shales can't grow as many believe then the industry will need much more conventional investments to meet growing oil demand and higher prices become likely. Currently, there is a preference in the market for shorter cycle projects (which fits shale leveraged upstream oil and gas players). The view on natural gas growth was more mixed - everyone agreed it had long term growth potential but the disagreement was over whether or not it is a bridge fuel or destination in itself.

The panelists also discussed forces that are likely to affect oil and gas markets in particular in the 2020s. The current decade was described as the decade of shales, but panelists described the 2020s has having the potential to be the decade of disorder in the oil and gas sector. The driving forces here are likely to be prolonged conflict between producer nations and sluggish demand growth owing to energy efficiency efforts and the increased cost-competitiveness of alternatives to petroleum based fuels for some applications.

WORKSHOP: GLOBAL ENERGY RISK MANAGEMENT: TURNING RISK INTO A COMPETITIVE OPPORTUNITY

Following the Closing Plenary delegates had the opportunity to attend a workshop on turning risk into a competitive opportunity. The session was intended to give attendees insight into the basics of energy risk management, real option valuation to address risk and value added strategies, and hedging strategies to add extrinsic value to a company's asset structure. Glenn Labhart (GARP ERP Program; Labhart Risk Advisors) presided over a panel consisting of Spyros Maragos (Direct Energy) and Gordon Goodman (Independent Energy Consultant) to address these issues.

TOUR: PETRA NOVA

The last activity for conference delegates was a tour of the Petra Nova generation and carbon capture facility. In a world where climate change is becoming an increasingly important item on global energy policy agendas, carbon capture technologies could potentially become extremely important to future energy mixes. As it is still a newer technology it was a very exciting opportunity for conference delegates to be able to go visit and tour the facility.

Challenges in Measuring Security of Supply in Changing Electricity and Natural Gas Systems

By Samarth Kumar, Dirk Hladik and Philipp Hauser

INTRODUCTION

Ensuring Security of supply (SoS) in the energy sector is an important goal for policymakers as a shortfall can have significant societal and economic implications. On the one hand, the promotion of renewable energy sources (RES) in energy systems leads to a fluctuating power production in electricity systems and increases the importance of flexible conventional generation capacities, e.g., natural gas (NG) power plants. On the other hand, to reduce CO_2 emissions there is a need to decarbonize the energy system. Technologies like power-to-gas try to link the electricity and NG sector. These developments bring new challenges to measuring SoS, e.g.:

- fluctuating electricity production
- uncertain development of NG demand
- balancing uncertainties due to the linkage of NG and electricity systems

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However, SoS itself is an umbrella term used to cover a broad range of issues to ensure uninterrupted and economic supply of energy for end utility. Against this backdrop, this paper attempts to structure different drivers for SoS. In order to increase the share of RES in the entire energy system, sector coupling is being promoted. We also look at what this could entail for measuring SoS.

CLASSIFICATION OF SECURITY OF SUPPLY DRIVERS

The future SoS in energy system is strongly impacted by developments in many dimensions: politics, technology, markets, environment, etc. Some of these developments can be quantified by using historical data and probabilities. If it is possible to do so, we call them risks. For other developments, it might not be possible to quantify them, as there exists no probability of occurrence or assessment of consequences. Hence, we call them uncertainties. Figure 1 shows the classification of the terms *uncertainty, systematic risk* and *specific risk* that can be used to cluster drivers for the assessment of the future level of SoS.

Both uncertainties and risks influence the future performance of SoS of an energy system. An example for *uncertainties* is policy decisions concerning regulation or climate change effects. A common methodology to assess the future level of SoS taking uncertainties into account is creating scenarios that depict ranges of developments. The model results should not be interpreted as a forecast for future, rather they give an idea of cause-and-effect relationships in complex energy systems.

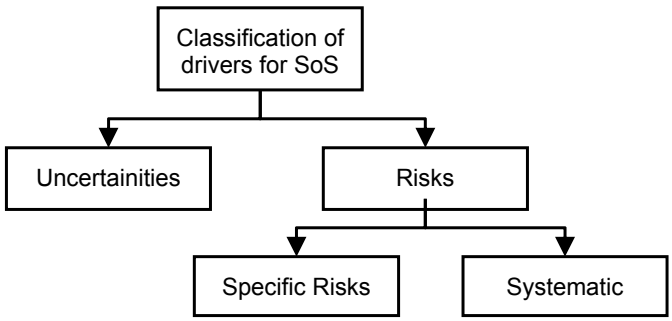

Figure 1: Classification of SoS drivers (own illustration)

In contrary, the usage of *risks* in energy models enables decision-makers to quantify the impact of their measures. In our classification, we distinguish between two kinds of risks. The first group is clustered in *specific risks* that summarize event related risks and occurs e.g., in case of a single event. In some publications, this risk is also called unsystematic risk as it is individual for each player in the market. In general, specific risk refers to risk originating from a particular condition, event or incident.

The second kinds of risks are grouped as *systematic risk*. In finance, systematic risk is also known as the market risk that influences all market participants. Using this definition, systematic risk also occurs in energy systems; e.g., a systematic risk in natural gas markets could be a decreasing NG demand that influences traders, importers and producers simultaneously.

The next step of our analysis is to investigate indicators that enable modellers to quantify specific and systematic risks. In the academic literature there exist a large number of overviews that focus on SoS indicators (e.g., Jansen et al. (2004), Kruyt et al. (2009), Ang et al. (2015)). Due to multi-dimensionality and the broad scope of SoS, it is not possible to create a strict allocation of risk and uncertainties to indicators and vice versa. Rather, the risk classification and the indicators used depend on the stage

of the energy chain and the intended use of the indicators. Hence, this classification also renders itself to interpretations. For example, what might be classified as a specific risk for the gas market, might be considered a systematic risk for the electricity market. This flexibility also enables developing understanding of how risks are perceived by different players. This method of classification helps in clarifying the type of risk and the kind of intervention needed for mitigation of the same.

DRIVERS FOR SECURITY OF SUPPLY IN ELECTRICITY AND GAS SYSTEMS

Electricity Markets and Grids

In the context of rising RES generation shares, nuclear phase-out in Germany as well as liberalised and increasingly connected electricity markets in Europe, new challenges for maintaining a high level of electricity SoS arise. Additionally, the interactions between electricity markets (markets) and electricity grids (grids) are complex and thus there are a number of common risks which we would like to highlight in this section. Central aims of that relationship are on the one hand the physical grid ability to fulfill the market results and on the other hand the provision of market price signals for appropriate spatial generation capacity investments in order to optimally use existing transmission capacities. Regarding the grids, generation adequacy should be able to measure the overall adequacy of the system covering congestions, voltage drops and frequency problems of the grid.

Uncertainties for the markets and grids are often related to policy and regulation developments as well as societal or even climate issues. The following exemplified uncertainties might be considered:

- Extreme weather condition due to climate change (markets and grids)
- Regulatory and government policies (markets and grids)
- Technological breakthrough (markets and grids)
- Impacts of future market coupling activities (markets and grids)
- Delays in grid enforcement projects due to technical reasons or public unacceptance (grids)
- Inappropriate market zones with high spatial imbalances leading to internal congestions (grids)

These uncertainties are hard or nearly impossible to quantify for the future due to limited available data. Hence, they are often treated with scenarios and appropriate sensitivities or cases analysis (Poncela-Blanco et al., 2016). Scenarios are often depicted through the share of RES in the energy mix, demand or efficiency development paths, decommissioning of certain power plants or radical penetration of a particular technology. For example, to model impacts from policy changes different policy scenarios are deployed for instance the EUCO scenarios from the European Commission (EC) to consider different energy efficiency targets (EC, 2017).

Besides uncertainties, it is important to consider *systematic risks in electricity systems*. These risks occur mainly in markets, not in grids, due to the extensive regulation. Systematic risks can emerge from one of the following:

- Missing money
- Fuel supply risk

The missing money problem refers to lack of financial incentives for companies to keep generation capacity operation and/or invest in new required generation capacity. An interruption in fuel supply can affect multiple power plants and hence cause adequacy issues.

The indicators used to measure these systematic risks are not direct measures for SoS but rather proxies to quantify the risk and the change of risk. Commonly used methods to evaluate these indicators are: surveys and collection of market data for the current system and then calculating the value of the indicator using model-based analysis for the future. These risk factors are commonly measured through deterministic indicators for instance the VoLL - Value of Lost load (European Commission EC, 2016), the NEID - net import of energy carrier (Kruyt et al., 2009), the HHI - Herfindahl–Hirschman Index (Sovacool and Mukherjee, 2011) or the electricity prices trend (Winzer, 2012).

Furthermore, there are several *specific risks in markets and grids.* These risks can be quantified with probabilities due to the availability of historical data that can be used to calculate probabilities for the future. The specific risks in the electricity market can originate from following conditions:

- Extreme weather condition and fluctuation in RES (markets and grids)
- Terrorist attacks (markets and grids)
- Planned and unplanned plant unavailability (markets)
- Exceeding thermal limits or other technical restrictions because of high spatial imbalances or human / operational failures (grids)
- Outage or malfunction of technical components (grids)

As opposed to uncertainties, *extreme weather condition* here refers to extreme weather situations as seen in the past. Probabilities for *extreme fluctuation in RES* are derived from long-term weather data collection in high spatial and temporal resolution. *Plant unavailability* can occur due to maintenance (planned or unplanned) or due to exogenous factors like *terrorist attacks* etc. The mentioned specific risks for the grids are often encountered by preventive operational measurements like considering security margins for thermal limits or employing the n-1 criterion. However, these risks are getting more important in the future because of further increasing RES-shares, transmission capacity gaps and integrating new electricity users, e.g., e-vehicles and heating pumps, that could also bring further volatility into the system.

All of these risk drivers can result in supply interruptions either due to lack of capacity to meet the load under a certain set of conditions or inability to match the change in the demand with changes in the supply. Since these kinds of risks can be geographical- or country-dependent, cross border flow can play a critical role in ensuring SoS but may also lead to unintended loop flows which can cause new challenges. In general, we can sum up that all of these factors lead to a higher level of stochasticity in the system, mainly driven by the RES share. Hence, it becomes important to assess these risks using probabilistic approaches. Probabilistic approaches commonly used can be categorised into two types: analytical and Monte Carlo simulations. Typical probabilistic indicators are the Loss of load probability (LOLP), the Energy not Served (ENS), Energy index of reliability (EIR resp. P95) (EC, 2016) or the Total Loss of Power (TLP) (Poncela-Blanco et al., 2016).

Gas Market and Gas Networks

As Germany and Europe have limited NG resources the European energy sector depends on reliable NG imports from non-European suppliers, e.g., Russia, Algeria and Qatar. NG is used for both sectors, power and heat. Additionally, it is used as raw material in the chemical industry, e.g., for producing hydrogen. Following the liberalization process in the electricity system in Europe, the unbundling of market actors leads also to an uncertainty of regulation. Against this backdrop, the awareness of SoS in NG markets is very high in European energy policy in order to ensure a stable electricity system, the production of heat for households in cold winter days and uninterrupted industry processes. There are several risks and uncertainties for the NG system that endanger the SoS. According to our definition, the following are the examples of *uncertainties in NG systems*:

- geopolitics
- resource deposits
- climate change

The following are the examples of *systematic risks*:

- NG price developments
- development of world NG demand

and finally, examples of *specific risks*

- The shortfall in NG supply
- terrorist attacks on critical infrastructure

As with electricity systems, there are several studies that investigate uncertainties in the NG markets. Due to a lack of probabilistic data, many studies use scenarios to cover uncertain paths. A popular application is the assessment of resources, e.g., recent analysis investigates the resource deposits of shale gas in Europe (cf. Riedel et al., 2017). Furthermore, transport conditions in the context of geopolitical strategies are subject to a variety of uncertainties. While Hecking et al. (2015) and Richter & Holz (2015) analyzed different scenarios according to time and volume of interruption price reaction, stress tests were modelled by the European Commission (2014). Systematic risks to geopolitics are addressed by Berk et al. (2017) who analysed Turkey's role in NG systems. Also, Dieckhöner (2012) analysed different pipeline projects to ensure the supply to Europe. The development of NG demand is a crucial uncertainty for the coming years and is analysed by Biresselioglu et al. (2015).

Recent efforts in the field of energy system analysis aim to include risks and uncertainties in energy models in order to improve deterministic model approaches and enable more reliable decisions. SoS indicators support these attempts, as they provide an opportunity to quantify risks and uncertainties in NG markets. Up to now, mainly static indicators are applied to asses SoS and diversification. Cabalu (2010) used the indicator *Gas intensity* that describes the ratio of total NG consumed in a region to gross domestic product (GDP) of a region. This measure is interpreted as an index and exists also for other

units like electricity, emissions, oil etc. *Net gas import dependency* is an indicator that describes the ratio of net gas imports to the total energy consumption of a country or region. *The Ratio of domestic gas production to total domestic gas consumption* focuses on diversification of gas import sources. A measure to evaluate stability in gas-exporting countries is the calculation of *Geopolitical risk* using a politic rating. These ratings give quantifiable data for selected gas-producing countries and are provided by World Bank's Governance Indicators or the Gas Supply Security Index (GSSI). In general, the availability of data is quite well for calculating these indicators. However, until now these indicators follow a deterministic approach and therefore a need exists to extend these to probabilistic approaches.

RELATION BETWEEN SECURITY OF SUPPLY IN ELECTRICITY AND GAS SECTORS

Some aspects classified as risks or uncertainties that were discussed earlier influence both the electricity and gas systems. For example, a cloudy cold period in winter times leads to higher heat and NG demand and lower RES feed in. However, until now, the link between both systems is weak and hence the mutual influence is limited. According to the aim of reducing the usage of fossil primary resources, it is proposed to increase this interaction in the future. Hence, same risk factors (e.g., weather conditions) can influence both systems simultaneously and a coupling could increase the danger of a supply interruption. Thus dealing with a systematic risk in electricity markets, e.g., diversification of fuel supply for power generators, could lead to a specific risk in NG markets, e.g., higher fluctuation of NG demand.

In an energy system that was based primarily on fossil fuels, the flow of energy has been unidirectional. This means the fossil fuels (primary energy as oil, coal or NG) is transformed to final energy as heat or electricity. Figure 2 shows the schematic representation of the energy flow, black arrows show the flow of energy in a system based primarily on fossil fuels, red and green arrow show new flows being created by renewables and sector coupling. Each state can be associated with uncertainties and risks that need to be analysed. In the system based primarily on fossil fuels, the final risk to the disruption of end-utility could be obtained by combining the risks at each stage.

However, with the changing paradigm in energy systems, especially through increasing generation from RES, sector coupling and e-mobility, this unidirectionality would become less valid. As shown in Figure 2 the flow of energy is no longer strictly unidirectional. Energy can enter the system at different stages as in the case of RES connected to distribution grid or rooftop solar. Power to Gas (PtG) is a set of technologies used to convert electricity, primarily at times of high RES generation, to produce fuels like hydrogen or methane. These technologies can result in 'upstream' flow of energy thereby transferring the risks and uncertainties as well. Furthermore, technologies like PtH (Power to Heat) and electric mobility can result in an 'across' sector flow of energy. This results in the more interdependent and interconnected system thereby transferring the risk elements from one sector to another.

As discussed earlier, there is an increasing need to consider stochasticity in the electricity system. Furthermore, sector coupling can result in a spillover effect of stochasticity on security in the gas sector. On the one hand, this might reduce dependence on foreign fuel, thereby decreasing fuel associated risk. On the other hand, the variable nature of RES generation introduces reliability issues. Hence, there is a need to rethink methodologies and indicators used in measuring SoS as the energy system undergoes a transformation to a more interconnected and interdependent system. When analysing energy security in the long-term, researchers and policymakers would benefit from considering a more holistic approach to measuring SoS. As done by Bai et al. (2016), for electricity and NG sector, modellers would benefit from using a combined modelling approach considering different sectors.

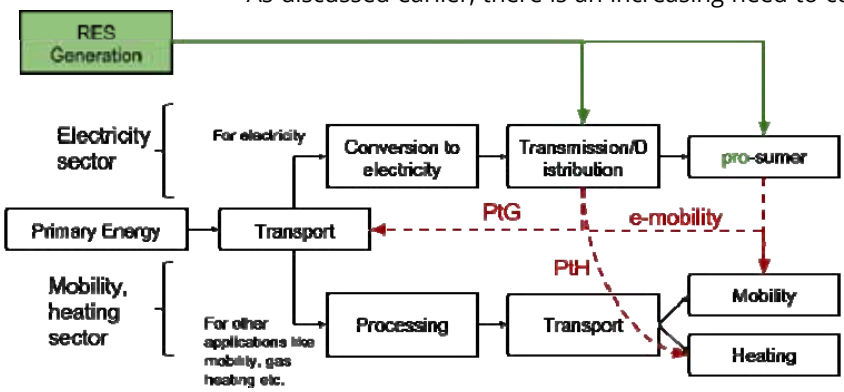

Figure 2: Schematic representation of energy flow (own illustration)

SUMMARY AND CONCLUSION

We started by classifying the different aspects of SoS into specific risks, systematic risks and uncertainties, and applied it to electricity and gas sectors.

In the electricity sector, various sources of uncertainties like political decisions, extreme weather

events etc. are recognised. Due to lack of data and inherent unpredictability in these factors, they can only be studied through scenarios. These scenario-based analyses cannot be interpreted as forecasts for the future but rather provide a causal understanding of the uncertainties. Systematic risks occur mainly in the electricity market caused by the missing money problem or fuel supply interruptions. They are often measured indirectly with deterministic indicators. A wide range of indicators can be found for measuring specific risks for the electricity markets and grids. Overall, it is recognised that as a result of an increase in stochasticity in the electricity system, use of probabilistic indicators is becoming more relevant.

In NG systems many efforts aim to decrease risks of supply interruptions and increase the SoS. Beside technical risks, mainly geopolitical uncertainties drive the need to evaluate the SoS in this field. As recent indicators are static and do not cover system dynamics, new indicators are needed that take into account probabilistic aspects.

Finally, we discuss the relation between SoS in gas and electricity sector. Here it is recognised that due to aspects like sector coupling, distributed generation, electric mobility, etc. the unidirectional nature of the measuring SoS is changing. This introduces new challenges in measuring SoS meaningfully. As coupling of energy systems is driven by the fluctuating RES feed in, future works would benefit from considering time dependency and sector coupling.

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Will the Lights Stay on in the Future?

This hot topic was the theme of the Young Researchers' seminar held by the Finnish Association for Energy Economists (FAEE) in mid October, 2017. More and more electricity comes from variable renewables like solar and wind and though the annual electricity demand is leveling, the demand peaks are not. As affordable electricity storage is yet to happen, balancing the electricity demand and supply becomes increasingly difficult.

The first two presentations in the seminar discussed possible solutions. Hannu Huuki (University of Oulu) presented a model quantifying the monetary savings from optimized use of electric hot water boilers. The annual savings per boiler varied from 13.5 € to 20 € and were smaller the larger the number of boilers being optimized. The system effect was positive.

Eveliina Seppälä (TSO Fingrid) discussed the pricing of operating reserves and balancing power. In ideal markets the reserve price should equal the value of lost load (VoLL). Today VoLL is much larger than the market price for reserves. Adding a scarcity component to reserve prices could bridge the gap and enforce the price signal. Higher price in turn would bring more resources to the market.

The third presentation by Jaakko Jääskeläinen (Aalto University) addressed the risk of effect shortage (system failure) in Finland on a peak day using six scenarios. The stress factor extreme drought was combined with three alternative system developments and the simulations spanned from 2020 to 2030. In 2020 all the scenarios had enough capacity to meet the peak demand. In 2030, capacity in one of the scenarios fell short of demand. According to the research the threat of system failure is not imminent, but should not be ignored by the policy makers.

Lively panel discussion followed the presentations. Heli Antila (CTO, Fortum Oyj) and Asta Sihvonen-Punkka (Senior VP, Fingrid Oyj) joined the presenters in the panel and Roland Magnusson (GreenStream Network) chaired the panel. Not that the 30 strong audience left all the questions to Roland and all the answers to panelists. The discussion ranged from market design to policy measures and investment incentives. As to demand response, it was noted that today demand side already provides half of the balancing capacity in Finland for certain periods. The greatest concern turned out to be the future of CHP production.

Young Researchers' seminar is part of the FAEE's efforts to attract young members and it was now arranged a third time. We were happy to see familiar faces from earlier events and gratefully acknowledge IAEE's financial support for our program.

Virve Rouhiainen
Member of the Board, Finnish Association for Energy Economists

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Overcoming the Challenges of Financing Utility Scale Renewable Energy Projects in Nigeria

By Ado Ahmed

RENEWABLE ENERGY POTENTIAL IN NIGERIA

Renewable energy (RE) resources hold great potential for meeting the energy needs of Nigeria, a country that is aptly described as an energy deficient nation. With abundant RE resources such as biomass, strong winds, unlimited solar potentials, hydro and geothermal resources, Nigeria has sufficient RE resources that could potentially provide a significant proportion of the country's expanding energy needs.

For example, the country has a solar radiation of between 3.5 kWh/m²/day at the coastal areas and 9.0 kWh/m²/day at the northern boundary. This presents a great opportunity for Nigeria to get RE at low cost as well as minimize her dependence on fossil fuels (Oji et al, 2012). In terms of wind resources, the country has an annual average of 2-4m/s at 10m height mainland which has significant potential to contribute to electricity production (Bala, 2014) The country also has sufficient endowment of other RE resources such as hydro resources (a potential for 14,750 MW electricity generation), biomass resources (which run into millions of tons) and geothermal resources among others.

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ENERGY SHORTAGE IN NIGERIA

Despite the country's rich endowment in hydro carbon resources and its heavy reliance on them, energy supply in Nigeria (especially electricity and refined petroleum) has been inadequate and unreliable. This has turned Nigeria into an energy deficient nation compelling widespread dependence on diesel based generators by different classes of electricity consumers. Currently only 40% of urban and 10% of rural residents have access to electricity. Per capita consumption of energy at about 212 kWh (FGN, 2014) is one of the lowest in the world. The consequences of this on business competitiveness and the social lives of the people are enormous. Deficient supply of modern fuels has also compelled a heavy reliance of households on biomass resources such as fuel wood, corn stocks, animal dung, among others, for domestic energy use despite their inefficiencies and health risks. Modern fuel scarcity in the economy and failing electricity supply create a dual energy crisis for Nigeria (Iwayemi, 2008). Studies report that small scale businesses suffer the most from Nigeria's energy poverty. They spend a large proportion of their capital (about 20-25% of their investment) on back-up generating facilities (Lee and Anas, 1991; Foster and Steinbuck, 2008) thus turning the Nigerian economy into a generator economy (Ekpo, 2009)

The economic cost of inadequate and unreliable electricity to the Nigerian economy is huge.

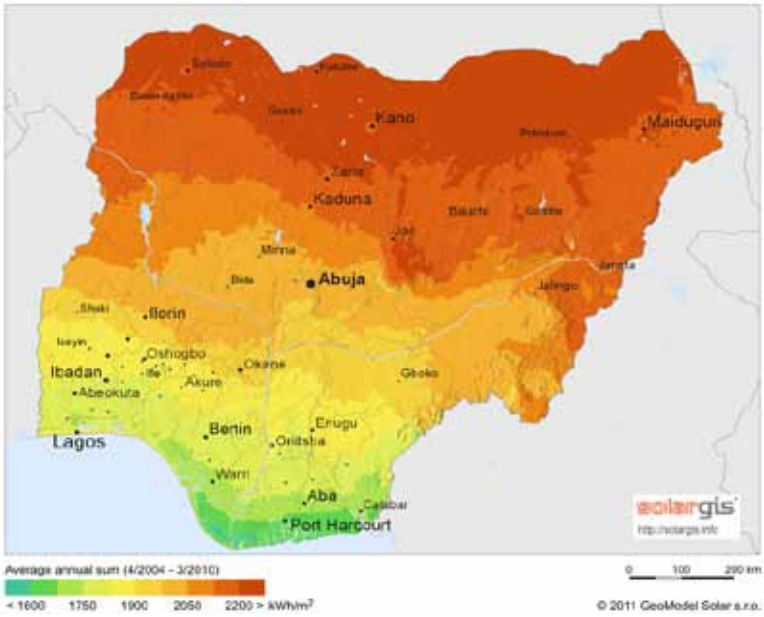

Figure 1: Global Horizontal Solar Irradiation for Nigeria
Source: Sambo, (2011)

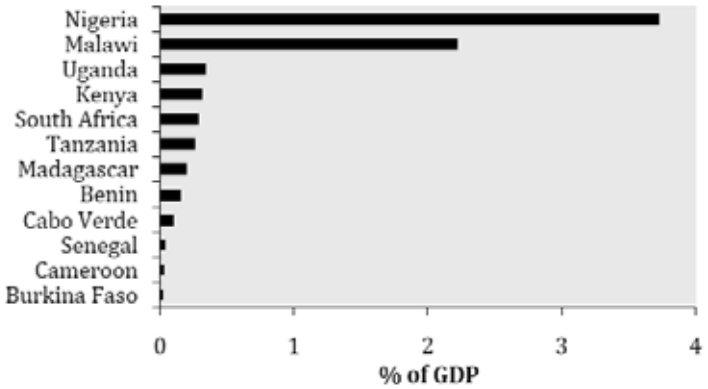

Figure 2: Economic Costs of Power Outages in Selected Countries
Source: Eberhard, et al (2009) reported in Foster and Pushak, (2011)

They cost the Nigerian economy close to 4% of the country's GDP.

Nigeria's energy supply can be altered with the use of RE resources which the country is well endowed with. This could potentially change its current economic status and thus release its growth potentials.

INCREASING ENERGY SUPPLY WITHOUT HURTING THE ENVIRONMENT

Renewable energy investment has today occupied a centre stage in terms of policy and academic research. For example, RE investment rose from about 22 billion dollars in 2002 to about 270 billion dollars in 2014. The share of RE investment for developing countries also rose to 138 billion dollars (UNEP-Bloomberg, 2015). This growth is expected to continue into the future as more countries strive to increase the share RE in their energy mix.

Developing the RE resources of the country will be of immense benefit to the nation in terms of ensuring the security of its energy supply and enhancing the wellbeing of the nation's environment. Consequently the Nigerian government churns out deliberate policies for developing the country's RE resources for electricity supply. Some of these policies include the Light up Rural Nigeria, Feed-in Tariffs, the National Renewable Energy and Energy Efficiency Policy among others. However, developing the huge RE potentials of Nigeria is a daunting task for many reasons.

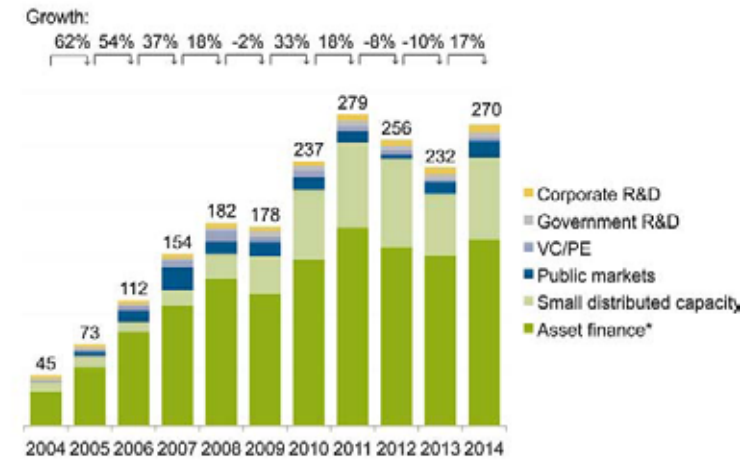

Figure 3: Growth in Global RE Investment2004-2014
Source: UNEP-Bloomberg New Energy Finance, (2015)

IMPEDIMENTS TO FINANCING UTILITY SCALE RENEWABLE ENERGY PROJECTS IN NIGERIA

Though the private sector seems to be interested in the Nigerian energy sector especially the RE subsector, there are several of challenges that slow down the pace of private investment in Nigeria's electricity sector. One of the greatest challenges facing promoters of RE projects in Nigeria is the difficulty of mobilizing the needed investible funds for such projects from the financial markets. Studies have shown the positive impact that financial sector development has on renewable energy production (Brunnschweiler, 2006). The success of private sector investment in renewable energy projects will depend on the robustness of the financial services market and its ability to provide the needed investible funds in RE projects (Babber and Schuster, 1998).

Like most infrastructure projects, renewable energy projects normally require enormous financial resources and long construction and pay back periods. Meeting the financing needs of such projects in a country with an undeveloped financial market is really a daunting challenge. Though such projects have low operational costs, the time they normally take to repay their investments usually make them unattractive to investors.

Another important barrier to renewable energy financing has to with the cost disadvantage that renewable energy projects suffer in relation to conventional energy projects. This arises due to the failure by stakeholders to account for the implicit costs such as social and environmental costs associated with conventional energy projects (WEC, 1998; Handerson, 2007; Brown et, al, 2012). This failure reduces the competitiveness of RE projects in the eyes of investors and other stakeholders. Closely related to the above is that RE projects are relatively new in Nigeria. Stakeholders lack requisite experience in funding or promoting private sector utility scale renewable projects. Though there are few utility scale private sector RE projects such as the 2,600 MW hydro plant in Mambilla (Mambilla project is still at the engineering drawing stage), the 700 MW hydro plants in Zungeru, the 300 MW expansion of the hydro plant in Gurara , Dadin Kowa 34MW hydro project and a few others, none of such projects have become operational despite government support for such projects. The lack of experience and familiarity with RE projects among stakeholders especially policy makers, financiers and bankers add to the difficulties that RE projects suffer in Nigeria, as occurs in many developing countries in raising funds for RE investment.

Other issues that makes it difficult for RE investors to raise funds from the local capital market has to do with the absence of venture capital firms, the very low debt profile of the market, instability re-

sulting from internal conflicts and insurgent activities with Boko Haram insurgency in the North East of the country and the uprising in the Delta region (Pegels, 2009; UN-Energy/ Africa, 2011) The massive devaluation of the Naira poses serious currency risks to promoters of RE projects. This happens due to many reasons. First, with the devaluation of the Naira the cost of imports of the machinery and spare parts has increased astronomically. Tariffs may not readily adjust. The country's multiyear tariff order (MYTO) allows only a gradual increase in tariff. Additionally borrowing or raising funds from abroad will put the project at risk.

The attractiveness of RE projects may be less because the viability of such projects may be affected by the willingness to pay for electricity from RE sources by consumers of electricity in Nigeria. Given the prevailing economic difficulties being experienced in the country due to low commodity prices especially oil (many workers are unable to get their salaries on time and the minimum wage is less than 60 dollars), one may not hastily conclude that consumers would be willing to pay a premium for green electricity. Raising finance for RE projects will therefore be challenging due to issues associated with willingness to pay by consumers.

Financing RE projects in Nigeria is also hindered by weak regulatory and institutional arrangements just like many other developing countries (Brunschweiller; 2006; Brown et al 2012 ;Estache 2005) . These breed unfavorable regulatory and political climates which translate into a lack of sufficient supportive investment policy regimes. The absence of a credible and consistent policy regime for RE investments is a major barrier to RE project investment in most developing countries, Nigeria included.

Technical constraints in the industry also hinder RE projects financing. Most developing countries have a major infrastructure shortage that potentially negatively impacts energy projects. Poor or inadequate transmission and distribution infrastructure in most developing countries hinder additional generation capacity that could materialize through new RE projects. For example, Nigeria's transmission and distribution infrastructure cannot wheel and distribute power beyond 5000MW. Thus new investment that can result from RE projects may not be readily transmitted and distributed to the consumers. There is also a general lack of human capital sufficiently skilled on RE projects. In fact, sufficient knowledge and capacity on RE projects is lacking among the project stakeholders in many developing countries including Nigeria (WEC, 2012).

OVERCOMING THE IMPEDIMENTS TO FINANCING RENEWABLE ENERGY PROJECTS

To fast track investment in Nigeria's RE, government needs to intensify efforts towards creating a robust and functional financial services sector that could channel investible funds to RE projects. This is not going be an easy task. There was a policy to address that. The Financial Services Strategy (FSS 2020) was meant to reposition the financial services sector of the country to meet the financing needs of infrastructure projects. However due to lack of policy continuity by government, the FSS 2020 policy has been abandoned. A functional financial market will assist in mobilizing finance for RE projects.

There is need to encourage venture capital investment in Nigeria as a way of easing the process of raising funds for investors in RE projects. Improving the legal and regulatory environment could help in this regard.

The current economic recession being experienced in Nigeria means that the government's ability to provide fiscal incentives for RE projects is constrained. However, government needs to come in with fiscal supports to RE projects in order to enhance the attractiveness of green energy projects since they suffer a cost disadvantage compared with conventional energy projects. This could help to bring such projects up to par with conventional energy projects whose costs are not normally sufficiently accounted for in terms of their social and environmental impacts.

Though the government has developed some policies meant to support investment in RE projects, the current policies are not sufficiently implemented, thus leaving RE investors without the needed supportive policies. Thus strengthening the implementation process of such supportive policies could go a long way to give the needed boost for RE investment in Nigeria.

Infrastructure investment hardly happens in climes with weak institutions. Nigeria needs to strengthen its institutions especially legal and regulatory institutions in order to give sufficient confidence to the investing public to invest in Nigeria's RE. Normally investment in infrastructure projects require complex contractual agreements that in turn require strong institutions to implement.

There are a lot of technical constraints in the Nigeria electricity supply industry. Manpower shortage is evident and needs to be reversed especially in areas related to RE investment and project management. Other technical constraints have to with the archaic and inadequate transmission and distribution

facilities in the country. Massive investment is required to develop and upgrade these infrastructures. However government does not have the financial resources to do this. The private sector may need to be incentivized to be able to make investment at least in the distribution segment of the industry.

Overcoming the constraints to financing RE projects will go a long way in enhancing electricity supply in Nigeria, in de-carbonizing the electricity sector of Nigeria, in creating employment opportunities for the many youth that are currently unemployed.

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Are Households Ready to Pay for Solar Panels and Smart Grids?

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The authors wish to thank the ANR (project REVE, ANR-14-CE05-0008), French Ministry of Research, for financial support with this project.

Given climate change related issues, it is often asserted that renewable energy (RE), such as wind and solar power, will replace fossil fuels, therefore, justifying public policies that promote RE technologies (Van Benthem et al., 2008; Hirth, 2015). The fact that approximately 28% of global electricity consumption comes from residential buildings, RE investments at the household (HH) level can significantly contribute to the expansion of RE capacity in several regions of the world.[5] However, because the amount of RE generated depends heavily on prevailing weather conditions, and, hence, is intermittent and unpredictable, there are challenges associated with a higher penetration of RE sources (Speer et al., 2015); e.g., decrease in system efficiency, and mismatches between supply and demand.

Such developments call for grid-integration technologies and flexibility options that can enable a smooth integration of intermittent and uncertain RE, with feasible cost and stability. Effective storage capacity and demand management are some of the ways to accommodate intermittent RE (Jeon et al., 2015; De Castro and Dutra, 2011). Motivated by the fact that there is a lack of economic analysis of a decentralized clean energy investment and provision (Baker et al., 2013), we investigate the willingness to pay (WTP) of an HH for a 1.9kW peak PV system, a smart meter, and a home storage battery (Tesla Powerwall). We are particularly interested with how and whether the WTP for one of these technologies is affected by the complementary technologies. Some questions that we seek to answer are: how do smart meters and batteries affect solar PV installations?; or how do solar PV and smart meters affect battery installations? Better knowledge, in this regard, will help policy makers design public policy that is aimed at providing incentives for RE generation.

The economic profitability of PV installations is usually appraised in the literature using the concept of LCOE (Levelized Cost Of Electricity) that completely ignores the intermittency feature of PV electricity generation as it is based on annual electricity generation.[6] An exception is Mundada et al. (2016) that quantifies the economic viability of a system including off-grid PV but also a battery (and a combined heat and power system): to some extent, considering a battery in the system implicitly accounts for the intermittency of PV generation. Nevertheless, even though electricity demand management and smart grids have recently received a lot of attention both in the academic literature (see De Castro and Dutra, 2013, Leautier2014, or Hall and Foxon, 2014 and Bigerna et al., 2016) and in the media (see The Economist, 2009; The Telegraph, 2015b,a), not much work has been done that investigates the WTP of HHs for solar PV systems and smart devices.

MODELLING SMART SYSTEMS

We account for two levels of equipment in smart systems. The first one concerns the installation of smart meters, which are relatively widely used in Europe (e.g., Linky in France). Smart meters allow end-use consumers in electricity markets to monitor and change their electricity consumption in response to changes in the electricity price at different times of day (Durmaz, 2016, Borenstein and Holland, 2005 and Joskow and Tirole, 2007).[3] The second level relates to energy storage. The costs of implementing the smart grid devices is usually assumed to be borne by consumers who may, therefore, have strong resistance to the adoption of these devices (Madigan, 2011). Nevertheless, the cost of dedicated storage is high and Jeon et al. (2015) argue that deferrable demand would be a cheaper way to tackle RE intermittency.

The WTPs are likely to differ, depending on whether the legislation allows grid feed-ins from RE sources or energy storage devices. Feed-ins of power can simply be achieved by net metering, as long as this is not in conflict with the country's legislation. While the European Union and the United States allow net metering, Hong Kong and some African countries do not. Accordingly, we consider both cases to account for the two types of legislation on grid feed-ins.

We generalize Dato et al. (2017) and calibrate it on observed HH behaviors to derive WTP for solar panels and smart devices. Accounting for RE generation intermittency and grid price uncertainty, Dato et al. (2017) analyze the efficient mix of investments in intermittent RE (namely, solar panels) and smart systems (namely, smart meters and batteries). In this model, the HH can choose at each period whether

to feed (resp. purchase) electricity to (resp. from) the grid or to store energy (or to use stored energy) upon RE installations. Results point out that smart devices do not automatically imply less reliance on the electric grid and that curtailment measures to avoid grid congestion can discourage investment in RE generating and energy storage capacities. We generalize the aforementioned study by accounting for more periods within a day (i.e., four periods instead of two) and by considering a whole distribution for PV generation instead of two possible realizations.

CALIBRATING ON AN EXISTING HOUSE

We use the data from a low energy dwelling, the performance of which was extensively monitored, provided by Ridley et al. (2014). This case study was chosen due to the availability of a high quality monitored data. The findings of this analysis are, therefore, based on this particular dwelling and location. The methodology outlined and tested here could of course be applied to any data from other regions and dwelling types of interest or indeed to data produced by simulation exercises.

The house was constructed in 2010 in South Wales, and monitored for 24 months to evaluate the energy and environmental performance. The two bedroom detached dwelling has a floor area 78 m2, is owned and constructed by a social housing provider and rented and occupied by a 3 person family. The low energy dwelling was designed to meet the Passive House standard to minimize space heating and was fitted with a 1.9 KW peak PV installation on the south facing pitched roof. The PV system was designed with the aspiration to produce enough electricity to offset the carbon emissions from heating, lighting and hot water consumption of the dwelling. The dwelling has no electricity storage system, but could sell surplus generated electricity to the grid, at the same price as imported electricity it bought from the grid. The extensive monitoring system logged 85 sensors, including a weather station, in the dwelling every 5 minutes for 2 years, including all electricity sub circuits and the quantity of electricity exported to and imported from the grid. Hourly data from May 2012 to April 2014 was used in this study.

Using the data, we produce three figures (Figure 1). The first figure from the left presents the 2x365x24 observations for solar power generation and electricity consumption for the passive and low carbon Welsh house. While the second figure demonstrates the expected values for solar power generation and electricity consumption each hour, the last figure presents a smoothed version of the second one. As is also indicated in the last figure with the dashed-green line, the first period is the late-night and early-morning period. While the first peak from the left, that is, morning peak load, covers the second period, the midday does this for the third period. Lastly, the second peak, which is the evening peak load, is incorporated in the fourth period. For a constant price of electricity (15pence/kWh during the period in consideration) and for a given amount of consumption, c, the electricity is relatively valued the most on the margin in the evening-peak period. While the electricity is valued relatively less on the margin in the morning-peak period, it is valued the least in the first and third periods. This analysis is carried out for each season.

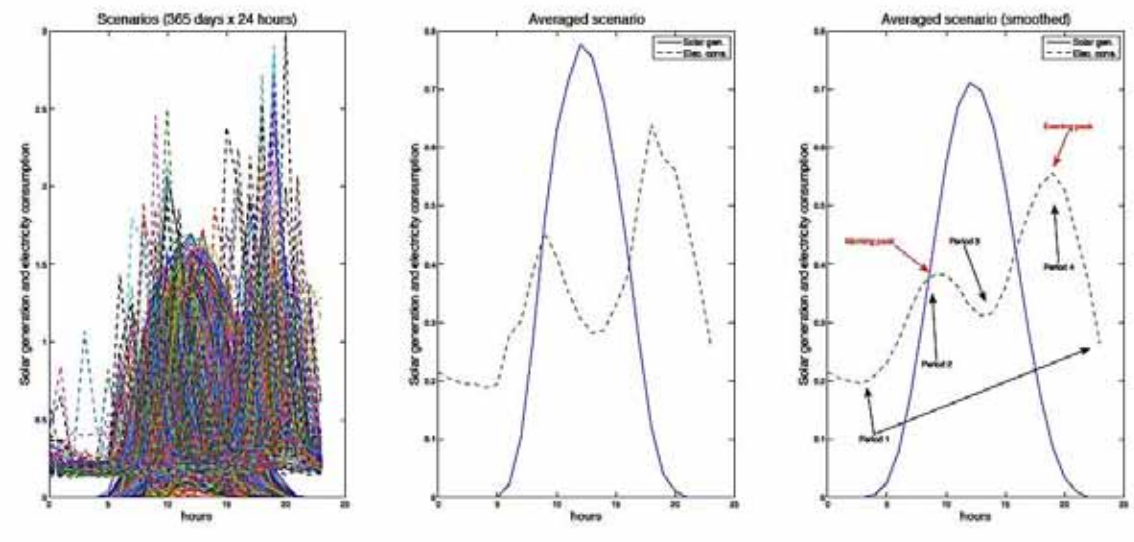

Figure 1: Solar power generation and electricity consumption.

COMPUTING THE WILLINGNESS TO PAY

We consider 8 different scenarios/cases, whose features are described below, and compute the total daily welfare for each season. In all of the cases, electricity consumption decisions are taken optimally.

Case 1. storage + solar panels + dynamic pricing
Case 2. solar panels + fixed pricing (storage is then irrelevant)
Case 3. storage from solar panels only +dynamic pricing (note: we can decide whether to consume or store from PV)
Case 4. storage from solar panels only and PV generation first fills the battery
Case 5. storage + no solar panels + dynamic pricing
Case 6. no storage + solar panels + dynamic pricing
Case 7. no storage + no solar panels +dynamic pricing
Case 8. no storage + no solar panels + fixed pricing (storage irrelevant)

By computing the discounted difference between these welfares, we can derive the WTP for each device. Comparing this WTP with the actual cost of the device we can then conclude whether it is profitable for the HH to install it or not. Our results indicate that having access to a storage device can allow a HH to take a better advantage of a smart meter, whose cost of installation, as put by the Department of Energy and Climate Change (DECC), is £214.50. Complementing the storage device with a PV system induces a further willingness for the HH to install a smart meter. Yet, this impact is rather limited. Having an HH that cannot store energy but can still generate electricity through the PV system would not justify the installation of the smart meter. Considering the 1.9kW peak PV system with an establishment cost of £2755, we find that it would significantly be beneficial for the HH to install the PV system regardless of the pricing scheme and the possession of the storage device. Furthermore, having access to solar PV does not contribute significantly to the willingness of the HH to install the battery pack with a cost of approximately £2300 (3000 USD). While in some regions and countries, such as the European Union and the U.S., net metering is allowed, it is not in some others like Hong Kong and some African countries. Therefore, we also investigate the WTP for smart meters, solar panels and storage devices when legislation prohibits net-metering. Consistent with the intuition, our results indicate that the WTPs for solar panels or smart grid devices are always smaller than the WTPs when the HH can feed-in the grid.

These results suggest that the first public policy to be implemented to foster the adoption of RE should concern the possibility of net-metering. However, net-metering is already possible in some countries and where it is not, this implies changes in legislations that may be difficult to implement due to the lobbying of some reluctant electric utilities concerned with their market shares. In countries where it is already possible to feed the grid, public policy should be focused on storage and smart devices. On the contrary, solar panels themselves seem to be already profitable and do not require any public policy support. In countries where net-metering will not be easily implemented soon, subsidizing storage would have the joined positive effect of making smart meters profitable as well, even without any targeted policy. However, the most efficient public policy should probably focus on solar panels as their net present value is not very negative, meaning that even a small subsidy can be enough to trigger solar PV installation.

Footnotes

[1] The share of the global electricity consumption is calculated from the data provided in Table F1 in EIA (2016).

[2] Note that LCOEs have been computed both in the context of residential systems (Reichelstein et al. 2013 or Branker et al, 2011, and Hagerman, 2016) and at the utility scale (see Darling et al, 2011).

[3] Do note that the export of PV generated electricity to grid can be achieved with the installation of an extra dumb meter that measures generation. Accordingly, it does not necessarily have to be smart.

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Increasing the Share of Electricity from Renewables - Lessons for the Latecomers

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See footnotes at end of text.

Among all sustainability indicators, the share of electricity from renewable sources (SEFRS) is the one that arguably receives the most attention both in the media and in public policy debates. While an increase in this indicator is desirable in principle, the transition to renewables involves much more than increasing RE electricity generation alone. There are a few lessons that policy makers in developing countries need to consider as they strive to increase their reliance on wind and solar energy in their quest for more affordable and secure energy supplies.

Electricity from renewables is a complement, not a substitute to conventional generation: Renewable generation technologies have characteristics that make it difficult to consider them as a pure alternative to thermal generation. Electricity from RE is intermittent, difficult to predict accurately, and is non-dispatchable (supply cannot be increased at will to meet an increase in demand, but is rather driven by the availability of sun and wind). Therefore, an increase in SEFRS does not necessarily imply a decrease in the need for back-up capacity reserves.

Electricity from renewables interacts with conventional generators in complex ways: Renewable generation not only depends on conventional reserves to back it up, it affects incumbents in other ways: First, since electricity from RE has nearly zero marginal cost (the cost of producing one extra unit of electricity), and in the absence of means to store electricity economically, supply priority is usually given to RE, forcing thermal power generators to reduce their production thus reducing their plants' capacity factors (as well as their profits). Second, an overall increase in electricity from RE is likely to decrease average electricity prices, reducing conventional generators' profits further. Third, increased electricity production from RE negatively affects them by reducing thermal plants' efficiency and service life due to the more frequent plant load cycling[1].

A substantial rise in SEFRS involves other considerable hidden costs: The transition to RE will require major expansion of transmission lines in order to connect distant and dispersed sources to centers of demand; for example, Europe needs an estimated 14,000 km of overhead transmission lines directly attributed to the growth of power generation from RE[2]. There is also the cost of road constructions to these sources as well as eventual storage capabilities (whether household or grid level). Then there is the increasingly complex grid management infrastructure that needs to accommodate these wind farms as well as a large number of households with photovoltaic production capacity. While at low shares, integration costs may be zero or even negative, they increase quickly with the share of renewables to the point of potentially becoming a barrier to higher penetration[3]. Of course, these costs may be totally justified in the long run, but are the financial and institutional resources available?

Increasing renewable generation capacity is the (relatively) easy part: For a given RE project, an investor can easily estimate the cost of producing one unit of electricity by averaging the total expected electricity production over the life-cycle cost of the project (which, for this type of projects, is overwhelmingly upfront capital expenditures). If offered a fixed feed-in tariff that exceeds that cost, the investor will effectively have a buyer committed to buying all his or her production at a profit – a very generous opportunity! But from a market's perspective, the value of a unit of electricity is not fixed; in fact the difference between high and low wholesale market prices can differ by four orders of magnitude over the course of a year in some liberalized electricity markets[4]! Thus, a simple feed-in tariff program may turn out to be more successful than anticipated, not only in terms of excessive production at uncompetitive prices, but also because of the choice of less and less optimal locations for projects (with lower capacity factors and higher construction and transmission costs). A study by Siemens found that Europe could save EUR 45 billion by 2030, by choosing optimal locations for sun and wind energy projects[5].

Increasing SEFRS induces positive externalities but they need to be rigorously evaluated: Of course, a rise in RE may induce many positive externalities such as reducing GHG emissions, attracting foreign investment or creating job opportunities. But these benefits cannot just be *assumed* to occur with an increasing SEFRS; they need to be rigorously validated and quantified during the program appraisal phase.

SEFRS can rise without any increase in generation capacity: SEFRS is the ratio of electricity generated from renewable sources to the *gross electricity consumed*[6]. The denominator (gross electricity

consumed) largely depends on factors such as a country's surface area, total population and distribution, extreme weather conditions and industrial energy intensity. But one critical determinant of gross electricity consumption is energy efficiency; indeed there is room for efficiency improvements on both the supply and demand sides that can have a large effect on consumption. In other words, for a given country, SEFRS as an indicator may grow without any change in RE generation - simply by improving efficiency! Substantial gains may be achieved through the modernization of power generation plants, building efficiency programs, energy efficiency standards for appliances[7] and behavioral interventions[8].

The endeavor to increase reliance on renewables also requires building massive institutional capacity and know-how: Designing and controlling a robust grid with high RE penetration, creating and managing a liberalized, efficient and fair electricity wholesale market, designing and reliably evaluating energy programs – all of these are necessary, albeit less salient, requirements for a successful transition to renewables.

Despite their popularity, renewable energy projects can meet local opposition: Noise generated by wind farms, landscape disfigurement due to overhead transmission lines, endangerment of the local fauna, threat to local tourism, encroachment on private property are among the many factors that can generate popular resistance to RE projects, ultimately leading to stalled or canceled projects and frustrated investors.

Priority should be given to the most effective programs: No country has infinite resources, and policy makers are faced with a wide range of (often conflicting) interventions to achieve their goals; making the right choice requires rigorous ex ante evaluations to compare proposed programs according to valid criteria. There is no reason to bypass effective but less glamorous programs without proper evaluation and comparison. Side effects and interactions need also to be considered; merely focusing on subsidizing RE may lead not only to over-capacity but to "overconsumption of electricity and disincentives for energy efficiency."[9] Furthermore, successful design and selection of future programs is highly dependent on the evaluation of past and current ones, a process that would be much more effective if programs were built for evaluation, and if results were made available to all stakeholders.

The purpose of energy policy is to enhance citizens' wellbeing by providing safe, secure, affordable and sustainable energy. This is far from being achieved through increasing SEFRS alone; apart from the prudent increase of that indicator, policy makers need to work on the institutional capacity and know-how this transition requires, as well as choosing the most cost-effective, evidence-based interventions.

Footnotes

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"Green Day": EROI and Why Alternative Energy will be the Future Conventional Energy

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See footnotes at end of text.

"We will make electricity so cheap that only the rich will burn candles," said Thomas Edison as Bell Labs brought about an energy revolution. It was not the first, nor will it be the last. The conventional energy of the future will be created out of our research investments in the present. Coal power plants across the U.S. are currently being retrofitted for – and replaced by – natural gas. These, in turn, will be replaced by a combination of wind, solar, nuclear, and/or another source that has yet to be invented. Petroleum, an ideal transportation fuel as it carries the greatest energy per unit volume[1], too, will eventually be displaced by more sustainable alternatives. Although the day may still be on the horizon, the age of fossil fuels will come to an end. This "Green Day" – defined as the first day in which sustainable energy sources overtake fossil fuels in providing the majority of both (a) transportation fuel and (b) electricity into the grid – will not be forced upon society through a government agenda of enlightened environmentalism, but instead will slowly be a transition as a result of natural market forces. A combination of increasing costs for fossil fuels – the rising of "scarcity rents" as described by Hotelling (1931) – along with falling costs of its substitutes – powered by industrial and technological innovations – will one day tip the scales to turn today's "alternative" fuels into the "conventional" fuels of tomorrow. It is up to energy researchers, planners, and policymakers to ensure that the transition is so smooth that no casual observer notices our impending Green Day.

This future state becomes evident by following current trends in Energy Returns on Investment (EROI) for different energy sources. EROI[2] is the "ratio of total energy produced during that system's normal lifespan to the energy required to build, maintain and fuel the system" (Gagnon, 2008). Similar concepts include energy ratio (Smil, 1994; Uchiyama, 1996), external energy ratio (Mann and Spath, 2001), energy payback ratio (Gagnon, 2008; Meier, 2002) and Lifecycle Energy Assessments (Heinberg 2009; Mulder and Hagens 2008; Murphy et al. 2011). Although these studies have been characterized by differing terms and inconsistent methodologies[3] (Murphy et al., 2011; Brandt and Dale, 2011), they all hint at the same idea: it takes energy to make energy. The more energy that is captured compared to what is needed in its production, the more value can be provided to the user at a lower cost.[4]

No matter the terminology, all use a similar scale where high ratios indicate greater efficiency while lower ratios indicate lower efficiency. Though government policy enacted through taxes and/or subsidies may skew short-term consumption towards a particular source, long-term consumption will always bend towards more efficient sources by the power of market prices. The exception is when global consensus is reached by government entities that a certain form of energy is too detrimental and, therefore, a universal tax is placed on its use with the goal of incorporating the cost of its externalities into its price. If EROI alone was taken into account, coal would still be king at an EROI of 46:1 (Hall et al., 2014). Yet because externalities include sulphur dioxide (a key source of acid rain), nitrous oxide (300 times more potent of a greenhouse gas compare to CO_2), and "air pollutants… known to produce heart and lung diseases, aggravate asthma and increase premature deaths and hospital admissions." (David Suzuki Foundation, 2017)[5], the world is moving away from coal. Universal carbon taxes, equivalent cap-and-trade schemes, or other international government regulation as signposted in the Paris Agreement will further accelerate this process. Canada recently announced a complete transition away from coal by 2030 to meet its climate targets (Viera and McKinnon, 2016), while China suspended the construction of new coal power plants in 29 out its 32 provinces out of health and environmental concerns (Stanway, 2017). How far behind are other, comparatively less harmful fossil fuel sources?

Even without such a tax, fossil fuels are losing their EROI advantage. Figure 1[6] below reflects EROI ratios with current energy returns of fossil fuels with today's technology. An EROI ratio of 1:1 indicates that it took as much energy to produce that unit as is available to consume. Corn-based biofuels show little promise as they have EROI ratios calculated at 1.3:1 (Yaritani and Matsushima, 2014) or even below 1:1 (Pimentel and Patzek, 2005) depending on the methodology, barely more than what it takes to produce them. The incentive for their continued production is based off of continued subsidies by the US federal government. Likewise, the EROI from the Canadian oil sands, because of the necessary inputs on the front-end and the refining on the back-end, is only slightly better at 2.5:1; meaning that

it only produces 1.5 times the energy it took to produce it after costs of production are subtracted. When the price of oil is sufficiently high, profits can still be extracted from these sources – but they still face a disadvantage compared to others. Moving from bottom to top of Figure 1, fracking for shale oil has become considerably more efficient over time and can now be done profitably for as little as $35 a barrel (Mlada, 2017). Fracking for natural gas is only slightly more expensive per MmBTU, mainly due to back-end costs including compression, transportation, storage, and others. If the lower price is sustained, indicating greater energy efficiency, fracking will displace more expensive, unconventional forms such as the oil sands and offshore drilling. But it is impossible to tell how long the current ratios will last. Aucott and Mellilo (2013) find exceptionally high EROIs for the early fracking wells, but they also note their numbers may be misleading because the earliest well sites were in "sweet spots" – places with a combination of favorable geology and minimal government regulation – and will soon be depleted.

This temporary boost in EROIs is underlying cause of the collapse of oil prices in late 2014 as the market became flooded with cheap energy. But this will not last. Yaritani and Matsushima (2014) find natural gas from fracking to be between 17:1 to 12:1 depending on methodology, while Berman (2015) estimates that the EROI of the unconventional natural gas industry will stabilize between 10:1 to 5:1 in the long run. Though the EROI of fracking could be higher as the industry becomes exceedingly efficient, it also may face increased government regulation that offset these efficiencies. This decline in EROIs of unconventional oil and gas would follow the same larger pattern of decline in EROIs for the discovery and production of all petroleum and natural gas over the past few decades (Smil, 1994; Hall, 2008; Guilford et al. 2011; Gagnon 2008). Conventional oil and gas have fallen from 30:1 in 1995 to about 18:1 today (Gagnon, 2008; Yaritani and Matsushima, 2014).[7] These falling EROIs will be reflected in long-run price increases of fossil fuels as "scarcity rents" rise in accordance with the additional expenses to obtain these resources.[8]

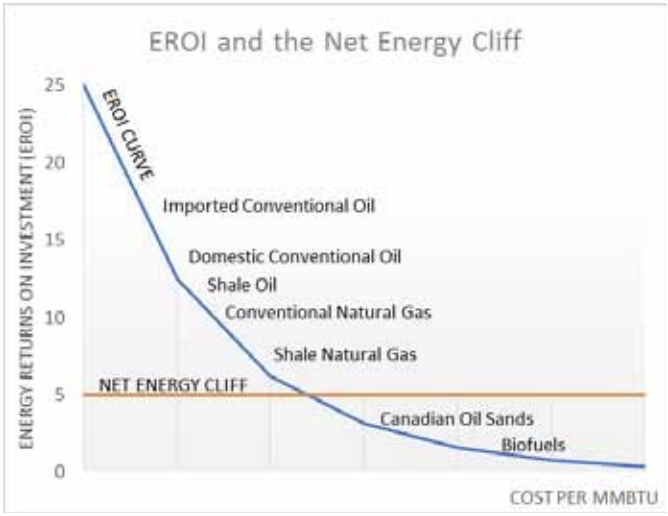

Figure 1: EROI and the Net Energy Cliff

Sources: Net Energy Cliff is EROI necessary for industrial society in Hall (2008); shale natural gas from Berman (2015); all other data as averages from Murphy and Hall (2010).

This would not be a cause for concern itself, except for the fact that high oil prices are directly tied to economic growth. Economists estimate that a 10% rise in oil prices translate to an approximate global GDP loss of approximately 0.55 percentage points (Awerbuch and Sauter, 2005; Birol, 2004; Jones et al., 2004; Mork et al., 1994), while a sustained oil price of greater than $100 per barrel can induce global recession (Rubin, 2009). Furthermore, Gagnon (2008) theorizes that industrial society needs a minimum EROI of 3:1 to stay above this "Net Energy Cliff", a ratio necessary for widespread motorized transit. Hall (2008) similarly argues that an even greater EROI of 5:1 is necessary to maintain even a limited functioning industrialized civilization. As the quality and quantity of each fossil fuel source is sliding down the EROI curve over time, a society dependent solely on fossil fuels would be slowly moving towards the Net Energy Cliff. Though exceptionally controversial, popular literature (Roberts, 2004; Heinberg, 2015; Kunstler, 2012) on "peak oil" warns of a day of reckoning where unprepared "society" is forced to make a sudden transition to alternative energy due to resource depletion, and dire consequences are the result.

The solution to this dilemma is for what is now called "alternative energy" to become the "conventional energy" of the future. This will occur through a combination of nuclear, wind, solar, and other sources. What differentiates these sources from fossil fuels is that the declining EROI framework in Figure 1 no longer applies as these sources (1) will have increasing EROIs over time through continual technological improvement, and (2) do not face resource depletion (scarcity) rents. Nuclear power, though not traditionally considered an alternative energy source, will most likely have a role to help maintain the "baseload" production – the minimum amount of electricity needed for the grid at any given time. Nuclear power allows for electricity creation to respond to fluctuations in demand, as opposed to all other alternatives which merely scavenge energy from the environment on semi-predictable patterns. EROI estimates for nuclear power vary greatly mainly due the many kinds of technology and differing regulatory frameworks that add to the cost of production, with some studies putting the number between 40:1 and 60:1 while others place it much lower. Most studies find that the EROI of nuclear is

greater than or equal to 5 (Lenzen, 2008), which is where Hall (2008) places the Net Energy Cliff.

Wind and solar have competitive EROI returns in the present, but the future is even more promising. Technological breakthroughs for wind and solar power are announced almost on a weekly basis. Recent studies put the EROI of wind power at up to 18:1 in 2010 and then rising to a maximum of 20:1 by 2012 (Kubiszewski et al., 2010; Lambert et al., 2012). The most recent meta-study on photovoltaics put the EROI at 7:1 (Gupta and Hall, 2011), but Mann et al. (2013) describes how the current rapid rate of small efficiency improvements in capturing sunlight is leading to large differences in the EROI. At the current pace of improvement, module efficiency by 2020 will reach 21%, equivalent to an EROI of 25:1, which is a greater EROI for all but the most productive fossil fuel sources. That said, EROIs on renewables need to be tempered, given the current lack of large-scale electricity storage partially mitigates their usefulness.

What is exciting is not where these technologies currently are, but where they are going. And the necessity for them to get there. Carbon taxes may accelerate the trend, but it is not the driver of our future energy transition. Soon enough, due to the increasing EROIs of renewable energy and the decreasing EROIs of fossil fuels, the Green Day will be upon us. It's up to us to make this transition as smooth as possible; one where the only noticeable change is the "engine under the hood."

Footnotes

[1] An observation that was first made by former Secretary of Energy Stephen Chu (Gold, 2014).

[2] Calculated as $EROI=E_{out}/E_{in}$

[3] Disagreements include (1) where to stop counting inputs, from point of extraction to point of use; (2) what exactly counts as inputs; and (3) which variation of a certain technology to include.

[4] The numbers presented in this paper should be understood at averages with their own standard errors, unless noted otherwise.

[5] David Suzuki Foundation in summarizing research from the Pembina Institute, Israel and Flannigan (2016).

[6] Numbers in Figure 1 are not intended to be precise, as significant debate remains on the best methodology. The intention of the graphic is to illustrate (1) the relationship between EROI and market costs and (2) relative position of various energy sources bases on previous literature.

[7] Coal follows this same pattern. Falling from 80:1 in the 1980s to a mean of 46:1 today (Hall et al., 2014).

[8] Hotelling (1931) showed that, for depletable resources, prices should exceed marginal production costs, even if the oil market is perfectly competitive. Profits are derived from these 'scarcity rents, which serve as the incentive for a producer to continue to offer supply in the present instead of withholding supply until the price rises even further. This 'Hotelling principle' is explicably tied to speculation and may be a factor that drives prices even higher in oil markets (Hamilton, 2008).

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Hong Kong's Green Innovations Impact its Energy Market

By Jan Deller & Julie Metta

THE ENERGY MARKET AND ITS INFLUENCES ON THE ECONOMY AND CLIMATE CHANGE

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Climate change is impacting local and worldwide nature, society, economics and politics. To mitigate climate change, one has to take a closer look at the energy market. Indeed, green house gas (GHG) is one of the main drivers of climate change and is mainly attributed to energy production. However, we cannot simply lower energy production to mitigate GHGs as energy plays a key role in the current development model of society and affects both the local and worldwide economy.

In Hong Kong, 70% of the local GHGs come from electricity generation. Moreover, in 2014, Hong Kong emitted 6.2 tons CO_2/capita, which is 22% more than that in 2005 and consumed 157 967TJ of electricity - 9% more than the level of 2005.[1,2] Building green infrastructure and retrofitting old ones are the keys to reducing electricity demand in Hong Kong, as they represent 90% of the electricity consumed.

To reduce the impact of energy production on the environment, and adapt to the increasing depletion of natural and especially fossil resources, a shift in energy production is inevitable. Green technologies are instrumental for climate change mitigation. Industries must develop new technology to generate energy from existing resources. The use of new technology to produce energy impacts the economy and environment at different scales. Indeed, those innovations use local existing resources to reduce the environmental impact not only globally – reducing transportation footprint - but also locally – such as waste to energy solutions, which enables the tackling of two issues at the same time by reducing the amount of waste while providing cleaner energy. Because local resources – such as sun or wind that are often free – are used, the maintenance cost is lower. Green technology also allows new employment opportunities for local residents while reducing their impact on air pollution, and thus creates higher social and health security.

These new energy innovations will lead– if they have not already - to new market scenarios. Europe and California have already seen negative power prices a few times while GHGs were lower than usual thanks to a high supply in renewable energy. However, such success stories depend on many factors. It is obvious that the strategies of the energy providers can influence the market environmentally positive or not. In Hong Kong, energy providers are represented by two companies: China Light Power (CLP) and Hong Kong Electricity. They are regulated under the Scheme of Control and Agreement (SCA) signed between them and the Hong Kong government which is monitoring the electricity market.[3] Other factors including political, geographic and climate affect the deployment of new technology in some areas, compelling some energy providers to invest abroad. CLP is an example for points mentioned above as the company is investing in renewable energy in China and Burma.

INNOVATIONS TO STABILIZE THE MARKET

The diversity of the energy mix will reduce the impact from price fluctuations of a single energy sources. It gives the provider more flexibility to find a replacement when one source experiences a crisis, assuring a more stable and secure energy market. That is the reason to study how energy is produced and how the mix can be diversified. This also applies for the grid. A multiple-scale energy grid is a better feedback loop between supplier and consumer thus a stable price. However, in Hong Kong the energy mix is composed of 48% coal, 27% gas and 23% nuclear, which relies mainly on fossil fuel imports.

One technology with high potential for Hong Kong is one that uses municipal solid waste (MSW) as a resource. In Hong Kong in 2015, 5.51 million of tons of solid waste were disposed in landfills, which is 1.6% more than in 2014.[4] Waste usually goes to landfills which are not sustainable. But MSW – which represents 67% of solid waste in Hong Kong - can be used as a resource to produce energy, either by being burned (T-Park) or transformed into biogas (Organic Waste Treatment Facilities). To deal with the emissions from wastes that are dumped into landfills, technologies such as Combined Heat and Power (CHP) plant can be considered. This solution is a good option for reducing greenhouse gas emissions (methane – which is a more potent greenhouse gas than carbon dioxide) from landfills of municipal waste and cutting the burning of fossil fuels to produce electricity. In Hong Kong since November 2016, Alice Ho Miu Ling Nethersole Hospital has been producing electricity using landfill gas. The plant could help save $2.7 million HKD and 2 000 tons of CO_2 (12% of the hospital's annual emissions) per year.[5]

CLP is awaiting approval from the SAR government for the installation of gas-fired 14 megawatts electricity generating units from a landfill in Tuen Mun. The first phase of the project includes five units, which can produce enough electricity to supply 17,000 four-person households for one year. A second

phase would add two more units to the site, which will cost more than 100 million HKD. The first phase is expected to start in the third quarter of 2018.[6]

Wasted oil can also be converted into low-carbon transport fuel for vehicles such as truck or airplanes– as it has been used at the Hong Kong International Airport (HKIA). With 14 grams of CO_2 equivalent per MJ, such biofuels are lower in terms of carbon emissions than most of the transport fuel currently available on the market. In Hong Kong, ASB Biodiesel, can produce up to 100,000 tons of bio fuel per year by collecting cooking oil from 4000 companies. This is enough to supply all Hong Kong' B10 diesel engines or to offset 257,000 tons of greenhouse gas emissions yearly.[7]

All these technologies diversify the energy mix, expand the portfolio of renewable energy projects and contribute to a more secure energy market. Moreover, such innovations using waste as energy fuel provide a significant improvement in fuel efficiency and so lower the environmental impact of both waste management and energy production. Since waste is used instead of imported raw materials, it may enhance local social and economic development by increasing onsite sustainable jobs. These green technologies usually lead to a structural shift of the economy from the linear model to the circular economy model. In fact, Hong Kong recycles 2 million tons of MSW per year (while 3 400 million tons are disposed in landfills) and 2% (45 600 tons) are recovered locally. It plans to recycle 35% of MSW by 2020.[8]

NEW ACTORS CREATING WAVES IN THE MARKET

So far, Hong Kong has developed very few policy and economic incentives to promote and support such green technologies. Nevertheless, increasingly, new actors from civil society are impacting the supply side of the power market. The former top-down system is now supplemented by inputs from the bottom. As an example, the World Wildlife Fund (WWF) is distributing photovoltaic panels in Tai O, a village in Hong Kong.[9] To prevent the grid from burning out, the supplier, in this case CLP, has to control this new input and thus adapt his tariff system by implementing a feed-in tariff.

These emerging players also create a market for companies to offset their energy production as part of a Company Social Responsibility (CSR) Strategy. NGOs work as middlemen to finance R&D and deployment of renewable energy. In Hong Kong, companies can buy a renewable energy certificate from the WWF as a means to support local renewable energy development. Meanwhile such a certificate allows a quantification and verification of the amount of consumed electricity that is generated from local renewable energy sources. This certificate was so successful that it was even adopted by the Hong Kong government, proving the importance of the civil society in the future market.

Moreover, some businesses are adopting new green technologies in order to reduce their energy consumption or their emissions. The Holiday Inn Express Hotel in Sheung Wan, owned by Yau Lee Holdings Limited, is a good example of such an economic feasibility and viability. Indeed, the building of the hotel that was constructed in 2012, uses 58.5% less energy than the EMSD Hong Kong hotel energy benchmark, saving about $3,400,000 HKD each year and providing a payback period of less than four years.[10] Another interesting example is that researchers from The Polytechnic University of Hong Kong have shown that integrating a solid oxide fuel cell cogeneration/trigeneration system to produce electricity and cooling system could guarantee a 6 years payback period.[11]

Through these initiatives, new actors not only demonstrate the potential of green technology in Hong Kong, but also create a bottom-up policy that tends to increase green technology development and thus affect the energy market. Thanks to such real-life insights, the civil society promotes green innovations and, energy policy and economy dialogue with the government and stakeholders to discuss the incentives for green technology.

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Renewable Energy Materials Supply Implications

By Ugranath Chakarvarty

AN UNAVOIDABLE CHANGE IN ELECTRICITY MIX

World electricity generation amounted to at least 24816.4 terawatt hours in 2016 while still leaving enough scope for capacity additions as 1.06 billion people continue to live without electricity according to the World Bank's Global Tracking Framework (GTF). Not only is the electricity generation and consumption not going to be stabilized anytime soon, even the technological options for electricity provision have expanded reflecting the new energy technologies. What is remarkable in recent times is that for the first time since 1882, Britain experiences a 24 hour period in which not a single power plant burned coal. There is indeed sufficient evidence, according to the IEA, to note a shift in the global electricity mix towards a low-carbon electricity economy. Interestingly, even oil and gas spending has fallen 44 percent in the last 2 years, i.e., a decline from 2014 to 2016.

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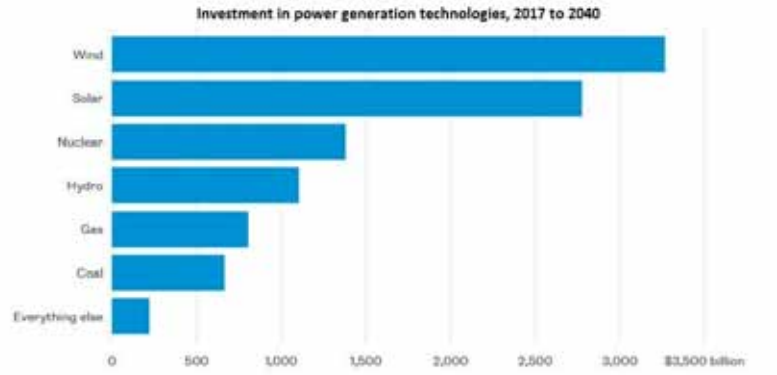
The 2015 Paris Climate Agreement's commitment to limit climate change to well below 2 degrees Celsius and the Sustainable Development Goal 7 "Ensure access to affordable, reliable, sustainable and modern energy for all" has further necessitated aggressive utilization of low carbon or renewable energy technologies for electricity generation and demand-side energy efficiency systems. About 197 member countries have stepped up efforts with strategies, plans and enabling processes as part of Nationally Determined Contributions (NDCs) to achieve emission reduction targets. A striking recent development in the electricity ecosystem is that renewable energy accounted for 62 percent of the net additions to global power generation capacity in 2016. In terms of renewable energy capacity addition solar PV accounted for largest share representing about 47 percent, followed by wind and hydropower contributing 34 percent and 15.5 percent, respectively. This shows that renewable energy is no more in its infancy. In fact the projections from the Bloomberg New Energy Outlook 2017 show that investments in renewables far exceed investments in other conventional generation technologies.



Investment in Power Generation Technologies, 2017 to 2040
Source: Bloomberg New Energy Finance New Energy Outlook 2017

ENVIRONMENTAL AND RESOURCE IMPLICATIONS

In accordance to the 2-degree Celsius scenario, supply and demand side low carbon technologies would be potentially capable of reducing pressure on water by 200 billion cubic meters (per year), avoidance of 17 million tonnes (per year) of particulate matter in PM10 equivalency and 25 billion tonnes of GHG emissions per year by 2050. As mentioned earlier, material supply depletion is the single-most prevalent impact of low carbon technologies deployment which has been estimated to require over 600 million tonnes (measured in iron equivalency) according to ReCiPe method by 2050. Even though the magnitudes of metal demand by low carbon supply and demand-side technologies collectively consume a small share as compared to metal consumption by other economic sectors, there are implications regarding the availability of a sufficient quantity of critical metals for the capacity additions needed, especially in solar PV.

In order to manufacture a solar PV panel, 19 mineral products and metals are utilized. Out of these, eight metals face supply challenges owing to a lack of supply diversity, the complex nature of economies caused by co-production and geopolitical risks. These metal requirements differ widely based on the type of solar PV technologies. The elemental requirements of the specific solar technology are given below:

Crystalline silicon (c-Si) - Ag, Ni, Al, Cu and Fe
Amorphous silicon (a-Si) - Ni, Cr, Ge, Mo, Al, Cu and Fe
Cadmium Telluride (CdTe) – Ni, Cr, Mo, Cd, Al, Te, Cu and Fe
Copper indium gallium selenide (CIGS) – Ni, Cr, Mo, Al, Cu, In, Fe, Ga and Se

Depending on the solar PV technology, there are a number of different element/metal(s) which in turn are derived from a diverse set of ore bodies. Out of the 15 to 20 ores that cater to a range of industrial applications, there are 8 ore bodies which supply the elemental needs of solar PV technologies. These ore bodies are gold ore, nickel ore, chromium ore, molybdenum ore, zinc ore, copper ore, aluminum ore and Iron ore.

ENERGY SECURITY IMPLICATIONS OF RENEWABLE ENERGY TECHNOLOGIES

A key feature of renewables is the usage of rare earth metals. These metals are critical to the renewable energy technology manufacturing value chain. The name "rare earth" is a consequence of seeming scarcity in 18th century in an ore first discovered near Ytterby, Sweden. However it is the availability of economically extractable concentrations that makes them rare.

Like the oil embargo in the 1970s, there is high risk of other embargos driven by changes in development models, innovation and discovery of resource availability. Even if the cartelization of these critical materials is not as influential as the OPEC phenomenon, the ambitious renewable energy use resulting from many nations pursuing renewable technologies, raises the need for caution on the part of consumers of these materials. For example, the materials used for renewable energy technologies are common to other sectors such as consumer products and defense. This poses a potential for competition as well. Rare earth materials such as dysprosium, neodymium, terbium, europium and yttrium are often critical components of renewable energy hardware. Therefore, in order to maintain a conflict-free sustainable development of global renewable energy it is essential to ensure that the OPEC phenomenon does not repeat in the form of cartelization of these rare earth metals. Application of rare earths in almost all modern technologies today, including the next generation of power generation, makes them a critical parameter when considering global renewable energy development.

In terms of all minerals and metals utilized in the solar value chain, the adjacent listing indicates those which are considered critical in nature, i.e., ones which face supply risk issues.

Copper	(wiring, thin film solar cells)	Critical material
Indium	(solar cells)	Critical material
Lead	(batteries)	
Phosphate rock	(phosphorus)	
Silica	(solar cells)	
Selenium	(solar cells)	Critical material
Iron ore	(steel)	
Molybdenum	(photovoltaic cells)	
Cadmium	(thin film solar cells)	
Tellurium	(solar cells)	Critical material
Titanium dioxide	(solar panels)	
Gallium	(solar cells)	Critical material
Metallurgical coal	(used to make steel)	
Silver	(solar panels)	Critical material
Germanium	Critical material	
Tin	Arsenic (gallium arsenide semiconductor chips	Critical material
	Bauxite (aluminium)	Critical material
	Boron minerals (semiconductor chips)	Critical material

Source: Mining for Clean Energy, Clean Energy Canada 2017

In fact the use of critical materials is not limited to solar, but also other forms of clean technologies like wind, vehicles, lighting and phosphors. The use of neodymium and dysprosium is essential to make powerful generators used in wind technologies. Neodymium and dysprosium also find use in making motors for vehicles. In order to make Li-ion batteries for plug-in-hybrid electric vehicles, lithium and cobalt are a critical material requirement. Hybrid electric vehicle using NiMH batteries make use of rare earths such as cerium, lanthanum, neodymium and praseodymium. In order to make fuel cells, critical materials such as yttrium, platinum, palladium and some other platinum group materials are required as catalysts and separators. Lighting (solid state and fluorescent) use rare earths such as yttrium, cerium, lanthanum, europium and terbium as part of the phosphors.

RESERVES AND PRODUCTION SCENARIO

Historically, Brazil and India were the primary sources of the world's rare earths found in placer sand deposits until 1948. After the discovery of monazite in large veins of earth in South Africa around the 1950s, it emerged as the dominant supplier of world's rare earths. The U.S. became a leading source from 1960s to 1980s after the Mountain Mine began processing in California. From 1990s onwards, China became the dominant source of the world's rare earth materials with a share of over 90 percent.

It is worth looking at the major countries with reserves of rare earths as well as the production trends in order to address the security of supplies for renewable energy technology deployment. In many cases countries with large production capacities hold high reserves while some countries have low production and high reserves. This points towards possibility of large producers of rare earths exhausting their domestic reserves while those holding on to lower production but having large reserves

holding greater dominance in the future.

As of 2016, rare earths found their use in diverse applications as follows: catalysts, 55%; metallurgical applications and alloys, 15%; ceramics and glass, 10%; polishing, 10%; and other, 10%.

CONCLUSION

Ongoing and increased exploitation of metals resources that cater to renewable energy futures shall inevitably reduce the global proven reserves of these materials. This increased critical metal use is the bedrock of modern technologies owing to its uses in a wide range of applications. The rare earths and critical metals which are essential to make solar PV and wind power have a potential of become supply constrained as economically viable concentrations of elements such as neodymium, dysprosium, indium, selenium, tellurium, terbium and gallium are found in only a handful of countries. This could shape a new geopolitics of critical metals and rare earths without which renewable energy technologies cannot be developed. This has consequently resulted in a wide consensus of the potential for the cartelization of producers of these essential metals, as was the case with OPEC.

Source	Mine Production		Reserves
	2015	2016	
United States	5,900	-	1,400,000
Australia	12,000	14,000	3,400,000
Brazil	880	1,100	22,000,000
Canada	-	-	830,000
China	105,000	105,000	
Greenland	-	-	1,500,000
India	1,700	1,700	6,900,000
Malaysia	500	300	30,000
Malawi	-	-	136,000
Russia	2,800	3,000	18,000,000
South Africa	-	-	860,000
Thailand	760	800	NA
Vietnam	250	300	22,000,000
World total)	129,790	126,200	121,056,000

Source: U.S. Geological Survey, Mineral Commodity Survey 2017

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We look forward to your participation in these new initiatives.

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The following individuals joined IAEE from 10/1/2017 to12/31/2017

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Bayu Aditya
SKKMIGAS
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IAEE Energy Summit at Pretoria, South Africa

On 1 November 2017, the Department of Economics at the University of Pretoria (UP), in partnership with the City of Tshwane (CoT), hosted the International Association for Energy Economics (IAEE) South Africa Summit at the Protea Hotel Fire and Ice!, Pretoria. The Summit was the outcome of a collaboration between the IAEE President and ex-Minister of Energy of Chile, Prof Ricardo Raineri, Prof Roula Inglesi-Lotz from UP's Department of Economics and Mr Lardo Stander from CoT. Such a meeting was a great opportunity for energy experts from government, business, academia and civil society to share a joint platform to debate the most pressing energy challenges facing Africa, with a special focus on South Africa. The keynote speaker was Prof Ricardo Raineri, while Prof Jenny Hoobler (Deputy Dean: Research and Postgraduate Studies in UP's Faculty of Economic and Management Sciences) and Dr Moeketsi Mosalo (City Manager of the City of Tshwane) welcomed the audience.

The discussions were intriguing and interesting while the participants, that came from all spheres of the energy sector, interacted enthusiastically. Experts from Eskom (the National Energy supplier), academics, policy makers and stakeholders from SANEDI, CSIR, CoT, National Treasury and other governmental institutions, and practitioners from the private sector, such as Deloitte SA and DNA Economics engaged in discussions about crucial topics and important challenges that concern the energy sector in the country but also in the rest of the African continent. Those included energy poverty, access to electricity, lack of skills, the need for clear and sound policies, regional migration trends, poor management, supply mix optimization, technological development and their commercialization, pricing structures, climate change consequences, the involvement of local government in national policies, innovation, and others. Most significantly, the Summit aimed to build and strengthen relations between the IAEE, the CoT and the UP. The long-run prospect of such relations encourages the application of economics across various socioeconomic aspects, from the exploration of our scarce resources, energy generation, transmission and distribution until energy reaches the consumers and energy policy implementation, to directed research and collaborations between policy makers, academia, energy suppliers, and the industry.

The Summit also facilitated the discussion of the conditions and the requirements towards the establishment of the first South African Association for Energy Economics (SAAEE) – the IAEE affiliate in South Africa. The need for a platform that assist further collaboration and promote scientific and fact-evidenced voices of energy experts from all spheres of the energy sector. Prof Roula Inglesi-Lotz is presiding the first council, comprised of the country's esteemed energy experts, namely Dr H Bohlmann (UP), Mr D Joubert (Eskom), Dr R Crompton (Wits – Energy Leadership Center), Mrs N Sokhulu (DNAEconomics), Mr L Stander (City of Tshwane) and Mr R Fourie (CSIR).

The Economics Of New Renewables (without the hot air)

By Hisham Khatib

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New renewables (NRs: wind; solar; modern biomass and bio- fuels; tidal, wave and ocean energy) are widely claimed to be clean, indigenous and sustainable sources of energy. Therefore, they are favoured by many governments and the public as a whole. However, their present contribution to global energy consumption is still limited, about 3% in 2013 (IEA, 2015), and still only 7% of global electricity production, since their economics are not yet favourable. In most instances, they need to be supported by state subsidies and regulations, or by increased energy bills for final customers. In several countries this has raised further concerns about increasing fuel poverty where final customers bear the bulk of costs of renewable energy subsidies.

In most instances, they suffer from high investment costs and, as a result of the intermittent and diffused nature of wind, solar, and tidal, relatively low- utilisation factors. Incorporating new renewables into power grids poses challenges due to dispatching problems and potential needs for transmission extensions, grid reinforcements or investments in energy storage (Khatib, 2016). Already there is grave concern that existing base-load plants are being closed, even relatively recent ones, and new proposals are being withdrawn.

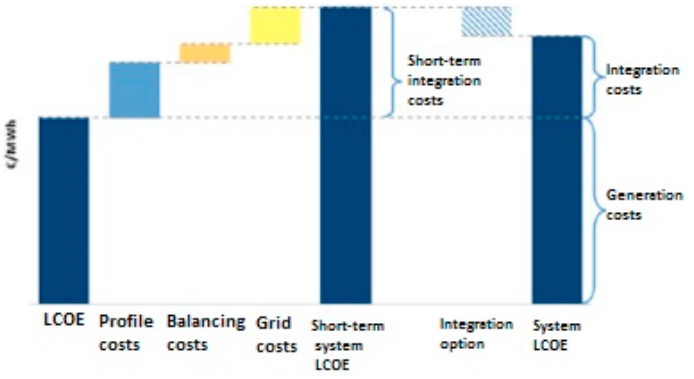
The economics of NRs are often wrongly measured by their levelised cost of electricity "LCOE", as well as "grid parity", sometimes also by the price paid to independent power producers (IPPs). Although these criteria are relevant to established dispatchable technologies firing fossil fuels, nuclear and also large hydro, these do not necessarily apply to NRs. Electrical energy (in kWhs) is not homogenous. A kWh generated by dispatchable technologies is more valuable to system security and economics than a similar kWh generated by wind energy, mostly late at night. Also a kWh of solar facilities which is usually generated at day peaks improve system economics much more than intermittent wind energy, which most of the time has to compete with dispatchable facilities, leading to over generation and under-utilization of base units. Also, sometimes, to the curtailment of the wind source or its export at cheap prices (even negative prices) to neighbouring grids

The renewable energy program in most countries consists of a myriad of implicit and explicit subsidies, and overlapping local and governmental programs. It includes mandates, feed-in tariffs, exemption from taxes, production tax credits, free land and free interconnection to the grid and other tempting devices. This combination of approaches makes it virtually impossible to figure out the amount of the subsidy by adding up the constituent parts. Usually the amounts are high, which completely distorts the true economics of NRs.

The true value of new renewables is the "system cost" which is the cost to the electricity system (and the national economy) after introducing the renewables compared with the cost if these technologies had been absent. System cost is approximately equal to LCOE plus integration costs (profile costs, balancing costs and grid costs). System cost involves the significant cost of transmission and other grid costs which are significant in case of renewables (Hirth 2016); also any governmental or final consumer subsidies.

System cost is defined by adding the three components of integration costs to standard LCOE that reflect generation costs (see Figure). Such integration costs, which are not easy to calculate, vary from one system to another depending on the extent of penetration of NRs, location and the composition of the dispatchable plant in the generation system (such as the availability of rapid ramping up or down units). Before investment decisions are made they need to be computed separately for any national grid in order to compute the true market value of NRs. Therefore, the system costs of NRs can be significantly higher than their LCOE as demonstrated in the figure. The true cost of NRs to the power system is quite different from the LCOE or grid parity. They differ from one system to another and need to be studied and roughly evaluated, before subsidies, prior to investment decisions.

Two criteria improve the true system cost of renewables. The first is "carbon pricing". If this cost, which is often not regulated, is added at an elevated level



System Costs for NRs. (Adapted from Hirth 2016)

then it will significantly improve the system value of the NRs. The other is the "discount rate" utilized in evaluating the cost of the renewables. This can be low since the risks, including regulatory risks, are not high in contrast to nuclear or coal production. The sun will surely rise and the wind will ultimately blow, although sometimes in the wrong period of the day. Also NRs will not suffer from the volatility of fossil fuel prices. However, the discount rate, or the weighted average cost of capital (WACC), can be high in developing economies due to capital shortages.

The future of NRs will be significantly improved by the development of energy storage. Other than well-established pumped storage schemes, the prospect of large storage has hitherto been limited, and there is controversy over how far and fast battery storage can assist. Also the economics of concentrated solar plant (CSP) are not well established yet; it may take some time for this to happen.

Recently there was significant reduction in the price of NRs. Recent contracts for large PV, in favourable sites, were less than 6 cents/kWh and still falling (in rare cases to less than 3 cents). The prices quoted by independent power producers (IPPs) in windy sites both in North and South America are as low as 4.25cents/ kWh, sometimes even less. As pointed out above, the actual system costs are usually significantly higher, sometimes even four times higher (energycollective, 2016). Nonetheless, these are significant developments that are likely to make renewables more competitive and lead to their increased market share in power production. However, as market share increases, the negative impact of NRs on system operation will increase creating more challenges for system integration, dispatching and controlling the system cost of NRs. Renewables are must dispatch electricity, and this can only be at the expense of other base load generation, mainly nuclear and large base load coal firing plants. Correspondingly, the need for solid interconnections and meshing. Most important is the rational evaluation of the true cost of the NRs to the power system (and the national economy). Hitherto there has been a great deal of exaggeration of the performance and speed of expansion that NRs have and will make to global and national electricity supply, with all too many proposed schemes being approved for subsidies which are poorly located. There needs to be much closer discrimination in favour of technically sound schemes, many of them reliant on optimal location.

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South Asia IAEE-NSU Energy Summit Report

17 October 2017

The South Asia IAEE-NSU Energy Summit took place on the 17th of October, 2017 at the campus of North South University, Dhaka, Bangladesh. The event was a collaborative effort between The International Association for Energy Economics (IAEE) and Department of Economics, North South University. The summit was host to a number of high officials from the government sector, eminent academicians and researchers, the present and the immediate past presidents of IAEE, donor agencies, and private sector energy experts. The event was conceptualized to be an ideal platform for panel discussions on the crucial energy sector issues of the country and was also expected to shed light on international energy policies and practices. Helpful insight in dealing with the energy issues of Bangladesh was extracted from the discussions. It facilitated the incorporation of opinions and exchange of ideas from both local and foreign knowledgeable professionals, as well as students who participated. The chief guest was Mr. Nasrul Hamid, MP, Honorable State Minister, Ministry of Power, Mineral and Energy Resources, Government of the People's Republic of Bangladesh. Professor Dr. M. Ismail Hossain, Chairman of Economics Department, Dr. Ricardo Raineri, President of IAEE and Dr. Sakib Bin Amin, Assistant Professor in Economics Department was the summit chair, summit co-chair and summit convener, respectively.

SESSION 1: SOUTH ASIA ENERGY CHALLENGES

The session began with an address by Dr. Ismail Hossain, Professor and Chairman of The Department of Economics, North South University. He highlighted the fact that it was the first time IAEE has collaborated with any university from Bangladesh; making this event, with its scope and focus, unique in the country. He mentioned, in the context of Bangladesh, the lack of high quality energy supply to meet the demands for a growing population and a rapidly developing economy. The participants were informed that this session would focus mainly on the energy challenges and issues of South Asian countries.

Following this, Dr. Ricardo Raineri, President of IAEE, also addressed and extended his gratitude to everyone present. He presented some information about The International Association for Energy Economics, noting that it is a non-profit, non-partisan entity and that the institution is celebrating 40 years of establishment. He was pleased to address the focus of the summit and stated that IAEE wishes to broaden its horizons and work with countries, such as those in South Asia, as they have been underrepresented so far in the institution's affiliate network. He expressed his thanks to all the organizers of the event.

The moderator of this session was Dr. Mohammad Tamim, Professor and Head, Department of Petroleum and Mineral Resource Engineering (BUET). He welcomed the guests and requested the first speaker of the session to begin.

Rahamat Ullah mohd. Dastagir, Additional Secretary, Power Division, Government of Bangladesh

Mr. Rahmat Ullah talked about the correlation between energy requirement and growth. A growing economy like Bangladesh is seeing a larger sustained demand for energy. Our rapidly increasing population means a lower GDP per capita despite our impressive growth rate. He mentioned that electricity has become an essential and inextricable aspect of human life. Mr. Rahmat Ullah quoted Barack Obama, stating that the country that will lead in renewable energy will be the one to lead the world in global politics, in the 21st century. He mentioned that without nationwide access to electricity, none of Bangladesh's SDGs can be properly fulfilled. Currently about 80% of households have electricity access. He outlined the vision of the Government of Bangladesh in improving electricity access nationwide, saying that with the Power Division's achievement in significantly raising electricity output over the last few years, we can envision a 2021 in which all households will have electricity access.

He mentioned the shift in energy sources that we can expect, particularly the shift away from gas dependency by 2030. He went on to state that though coal seems to be an ideal source to generate power at an affordable price, there is the argument of it being a dirty fuel. Bangladesh must lower its dependency on fuel imports and raise its electricity use in the industrial sector as currently, 50% of grid electricity is consumed by households. He highlighted the difficulties in financing energy projects and the lengthy amount of time for a project to be approved. Another major challenge is the lack of expertise in handling power generation from renewable sources and transportation of fuel. He concluded, saying that Bangladesh can hopefully become a middle income country by 2021 and high income country by 2041 and that "a worried person always sees a problem, a concerned person figures out how to solve it."

Dr. Gour Gobinda Goswami, Professor, Department of Economics and Treasurer, North South University

Dr. Gour Gobinda Goswami spoke from his international experience in economics. He put into perspective the urbanization and industrialization of Bangladesh over the last 45 years. All those years ago, rural electrification was not an issue of concern and there was not much difference in the context of electricity, between rural and urban areas. Energy was as he puts it, "A luxury good, even for urban dwellers". However, we have now progressed far beyond that stage, with much greater power output. One reason is because of Bangladesh's economic growth which facilitates power generation. This, coupled with the large demand for electricity, has promoted power generation to the point where load-shedding and power outages which had caused significant loss of economic output even a few years ago, have almost been eliminated. He hoped that with the current policy measures in place, geared to achieving zero load-shedding in a few short years, Bangladesh can progress further down the road of achieving its SDGs. He highlighted the fact that there is not enough research going into the feasibility, safety and sustainability of nuclear power sources, which if utilized could fast-track development. As a tropical country with greater energy demand than non-tropical countries, we can better make use of sunlight and develop solar energy generation further.

He mentioned that the main growth drivers of a developed Bangladesh will be energy and education.

Mr. Tazmilur Rahman, Senior Sector Specialist Energy at KfW

Mr. Tazmilur presented information on German Development Cooperation (GDC). He spoke about KfW which is a development bank in cooperation with GIZ, working in line with the aims of the government in the context of renewable energy development. He spoke about the progress of the German Development Cooperation which started with grant support and has now expanded to a nationwide level, working to improve power efficiency and distribution. They have projects that look into voltage drops in irrigation. A major project involves the set-up of solar home systems in both urban and rural areas. Currently, the number of set up systems is over 420,000. Solar Irrigation pumps and a domestic bio-gas support program have already been set up by GDC. He talked about research ongoing in reducing the amount of waste produced during festive periods such as Eid and recycling to generate power. He also showed the speakers and participants the wind map of Bangladesh, describing how wind energy fits into the energy mix and stating that wind is a feasible and clean energy source with a lot of potential and may see investment in the foreseeable future.

Mr. Daniel Ciganovic, Director Business Development, ME Solshare LTD

Mr. Ciganovic thanked all those present and North South University. The focus of his speech and presentation would be "Bangladesh is one of the superstars in RE". He mentioned that there are 3 stages to embracing renewable energy: making policies, looking at impact of policy and constraints, and eventually tackling bigger projects and small scale privatization. He said that Bangladesh is a special case and can implement in all 3 stages simultaneously. This is because the country already undertakes policy making and integration of those policies as it happens in order to improve renewable energy output. Privatization and the building of larger plants for renewable energy are also taking place at the same time.

He further mentioned that private households in BD were the first to set up solar home systems in the whole world and because of BD's intensive use of solar energy, Solshare has even made new technology such as micro grids for roofs, that is specially designed for BD.

Replying to Mr. Rahamat Ullah, he said that development might not necessarily result in increased energy demand. For example, China's development did not increase demand for energy at the same proportions.

Finally, he concluded saying that embracing renewable energy is a process different from country to country and so Bangladesh must find its own way instead of only looking at the methods of other countries.

Dr. Mohammad Tamim, Professor and Head, Department of Petroleum and Mineral Resource Engineering (BUET)

Dr. Tamim focused on the availability of coal resources in South Asia first. Coming to the context of Bangladesh, he mentioned that we have 3 billion tonnes of underutilized coal resources. He explained that we had 2 challenges: maintaining the supply of sustainable energy and financing the sustainable energy. Bangladesh is importing coal but the infrastructure is failing. The power planning has been done for generations but import planning has been lacking. The government was looking to import-based solutions such as importing LPG which will ease pressure on oil based power plants. He talked about the possibility of oil prices going up and eventually the possibility of electric prices as well.

The scarcity of land was also pointed out in South Asian countries. He stated that with our power plant projects emerging such as Payra and Rampal plants, we could be seeing significant growth in electricity generation. He wishes to see better human resources management on projects to promote efficiency. He concluded saying, "Resources can only be converted to wealth by the human brain." and stated that regional cooperation will be helpful in overcoming energy challenges.

A brief question and answer session followed the speeches by the 5 speakers, in which the importance of Energy Security vs. Renewable Energy Generation, the methods in which HR for energy projects can be improved, the environmental costs to power generation, and waste management were all discussed upon various participants' queries.

SESSION 2: ENERGY ACCESS

The moderator for this session was Dr. Sajjad Zohir, Executive Director, Economic Research Group (ERG).

He began the session by discussing energy access in Bangladesh and how availability, access and security are all concerns. He stated that energy access should not be sector exclusive. He mentioned the importance of regional cooperation in attaining better access to energy.

Dr. Saiful Huque, Professor and Director, Institute of Energy, Dhaka University

He began his speech, urging us to look into country-specific energy access issues. He mentioned renewable energy's role in basic amenities such as cooking. He highlighted the disparity in energy requirement for different demographics of the country and mentioned that we need a long term plan to ensure sustainability and affordability.

He stated that access to energy for the ultra-poor is a major concern. The Power Division of Bangladesh is making significant progress towards this. He also highlighted the under-utilization of resources saying, we have 12000 channels of rivers unutilized. We have thousands of square miles of rivers unutilized that could potentially be used to generate solar power. We can generate about 5-10 Giga watts of energy according to our studies."

He stated that power plants could be set up locally and private entrepreneurs should be given sufficient incentive to pursue these endeavors. He also mentioned the prospects of solar energy in agriculture.

Dr. Sebastian Groh, Assistant Professor, Department of Management, North South University

Dr. Sebastian stated that "definitions and metrics do matter." He went on to say that the paradigm of improving power generation by grid extension has become obsolete and that technical information has risen in importance.

He mentioned that SDG7 is essential for the achievement of the other SDGs. He asked participants what universal electrification means. He said that we must find a specific answer to this question in the context of the country before we can progress towards it.

He mentioned that 6 million solar home systems operate worldwide and 4 million of them are in Bangladesh. According to him, we need to adopt a multi-tier framework that translates into what "Access" means. A tier framework defines access to energy in tiers that include: affordability, quality, and reliability. He said that the Bangladesh Government's plan currently is not sustainable in terms of energy economics. Mini grids and solar homes are better adaptable for sustainability. The private sector's contribution is essential, but they lack incentives and a stable, profitable environment in which to operate.

Mr. Mohammad Hossain, Director General, Power Cell

Mr. Hossain outlined the Vision for the Government of Bangladesh: Providing reliable electricity to all by 2021. He mentioned that accessibility of electricity has risen from 47% in 2009 to a whopping 80% in 2017. Constraints of primary fuel cause inability to generate sufficient electricity to meet standards. He mentioned that we have largely expanded transmission capacity and that net energy generation has risen from 883 megawatts in 1971 to 57000 Giga watts in 2017. He hopes that we can establish regional cooperation. Myanmar is still not ruled out as a regional partner despite political unrest since our regional plans are long term.

He discussed plans for solar power including utilizing hundreds of square miles of uninhabited char lands by setting up cells there. Islands and remote areas and a majority of rural areas will be covered by solar homes. He reiterated that uninterrupted, quality electricity must be provided to all by 2041. He also noted that future plans will include a major shift away from gas dependency for power generation.

The question and answer session discussed various issues such as challenges in being able to establish solar home systems in rural homes, limiting illegal users of electricity who siphon off the national grid, and the importance of being energy efficient when using electricity at home.

SESSION 3: ROLE OF INSTITUTIONS AND REGULATORY FRAMEWORK FOR ENERGY DEVELOPMENT

Mr. Monowar Islam, Chairman, Bangladesh Energy Regulatory Commission

Mr. Islam began with a brief summation of the progress that Bangladesh has achieved in terms of economics growth at a rapid rate, sustained over the last few years.

He mentioned the increase in output from 4000MW to 15000MW under Prime Minister Sheikh Hasina's governance. He also mentioned the role of BERC to ensure good governance, and efficiency in energy. In order to increase efficiency, two visions were formed, of which vision 2021 is near to being successful.

He mentioned that people are not happy with the idea of a regulatory board as it entails strict measures and laws which they perceive as tricky and unpleasant. Goals are to promote equal opportunity for all and to ensure equal justice in food settlement. BERC believes in ensuring energy security for all in the country. He stated that sustainable development is holistic and energy subsidy is a challenge for all of us. A meticulous framework is needed to find balance with economic growth. The public wants to have full access to electricity and energy at lower prices while investors from the private sector seek to maximize profit. A balance must be established.

Mr. Islam mentioned two policies in improving Gas and Energy power generation and access. The policies include:
i. Power Sector Master Plan; to promote uninterrupted quality electricity to all by 2021.
ii. Gas Sector Master Plan: emphasizes gas production and import including ensuring energy security to all stakeholders.

Mr. Tanvir. A. Siddiqui, Vice President & Unit Head, Large Infrastructure Unit, Infrastructure Development Company Limited.

Mr. Tanvir said that energy security is a must, to achieve most of the SDGs. He mentioned that 1.1 mil people in Bangladesh lack access to electricity. Energy development means that we have to primarily focus on production of renewable energy. In Bangladesh, natural gas is the major source of energy production and then comes bio gas. While the rest of the world runs primarily on coal. He noted that BERC considers nuclear power and coal power in its Power Sector Master Plan.

He noted that in Renewable Energy development, there are four types of institutions involved:
i. Government supply, ii. Development agencies, iii. Energy and Planning Institutions and iv. Financial Institutions

He spoke about the LNG sector and how it has been established with companies from the private sector. The issue we face now is the mass use of conventional generation methods. However, both public and private companies are working in energy efficiency and conservation. The government is trying their level best in transferring to "green energy" and "green financing".

Mr. S.M. Zahid Hasan, Component Manager of GIZ Renewable Energy and Energy Efficiency Programme

Mr. Zahid spoke of energy efficiency and governance and how it is essential in achieving SDGs. With better energy efficiency, we can be in a better condition to fight climate change. He stated that energy efficiency is drastically poor right now, providing an example: 'from a mineral source with 100% energy, the user gets 3% as input energy while all the rest is wasted.

He noted that Japan and Germany are ideal examples of optimum energy usage. Mr. Zahid explained energy efficiency governance and how it is the use of political authority and institutions to achieve improved efficiency.

From the context of Bangladesh, we have many steps in this process of achieving efficiency, beginning with a strong vision and mandate and following through with innovation, technology and commitment towards the long term. In Bangladesh, the sustainable and renewable energy commission is funded by the government and they are mostly responsible for maximizing energy and energy efficiency programs. Energy efficiency is not a rational choice for most private sector firms or even households so problems do arise. Monitoring, capacity development and funding are required. To achieve these, fiscal instrument incentives are required. Measures can be taken including taxing and putting tariffs on non-renewable and inefficient sources. Transparency and regional co-operation is also needed to achieve this. He concluded saying a few words about his line of work in which energy efficiency is aided by energy audit regulations. GIZ drafts energy standards and regulations of country. And also has contribution for capacity building programs.

Dr. Gürkan Kumbaroğlu, Immediate Past President IAEE, Professor, Bogazici University

Dr. Kumbaroglu, who was also the moderator of this session, spoke about price determination by demand and supply. He talked about the typical components of the electricity market:
i. Electric energy market – the Day Ahead Market, and the Real Time market.
ii. Capacity Market
iii. Ancillary services market

He mentioned that the international regulatory challenge includes capacity shortage and lack of implementation strategies. He explained in brief, the design stages in order to facilitate successful energy regulation.

Dr. Sakib Bin Amin, Assistant Professor, Department of Economics, North South University

Dr. Sakib, the convener of the summit, expressed his gratitude before beginning his discussion about the issue of energy subsidy in the context of Bangladesh. He noted the importance of energy in moving towards a more equitable and sustainable world with access to electricity and a better life. He remarked that energy subsidies are designed to reduce the cost of consumption and to aid domestic production, ensuring a greater access to energy. However, he observed that energy subsidies might put a fiscal burden on developing countries such as Indonesia, Pakistan, Brunei and Bangladesh; and the net impact of an energy subsidy might be negative as reported by the World Bank in the case of Indonesia. He pointed out that energy subsidies can obstruct other development goals by potentially crowding out important sectors including physical infrastructure, health, education and such. According to Dr. Sakib, these might lead to an adverse impact on the balance of trade through over consumption, cause market distortion and might delay the effect of energy efficiency. Therefore, he noted that despite the short-term benefits, energy subsidies should be removed in the long-run. He concluded by emphasizing the importance of long-term planning, transparency, inclusion of private sector, and effective campaigning to gradually remove subsidies in the energy sector.

In the question and answer session, on request from Dr. Kumbaroğlu to comment on the issue of subsidy removal as presented by Dr. Sakib, Mr. Islam agreed that even though energy subsidy cannot be withdrawn overnight, it could be

removed in the long-run. To answer the question of finding ways to achieve greater energy efficiency in the local context, Mr. Islam noted that Bangladesh has already started using compressed natural gas for several years and the government has decided to import liquid natural gas to ensure energy security. It was also pointed out that use of some traditional biomass such as cow dung as a source of energy is hazardous to health and should be avoided. In answering the question about involvement of universities in achieving higher energy efficiency, Mr. Tanvir proposed that universities such as NSU could play a crucial role in carrying out more studies and sharing the knowledge. To answer the questions on the use of alternate renewable energy sources, Mr. Islam emphasized the use of public transport and better technology, while Mr. Tanvir stressed the commitment of the government to increase electricity generation through nuclear power. Dr. Sakib suggested that decreasing the amount of subsidy as well as diversifying subsidy in the energy sector could be more effective in avoiding market failure.

SESSION 4: ACCESS TO FINANCE

Dr. Ricardo Raineri, President IAEE and Professor, Pontificia Universidad Católica de Chile

Dr. Ricardo Raineri was the moderator of the 4th session and commenced the panel discussion with his speech. The present state of Bangladesh: a developing middle income country with a vision of becoming a developing country in 2041. What this means according to the World Bank is the per capita income of the people of Bangladesh is over $1000 a year but when the country becomes a developing country it means that the income per capita will be around $24,000

In a short period of time Bangladesh has been able to achieve a lot in terms of energy access but still we have a large number of people who do not have access to sufficient energy. An estimate of 40 billion dollars is what is required to connect all the people to the grid. According to Dr. Raineri, a very important word for the energy sector market is "competition". Investments will come together and the market will choose the best projects under healthy competition. Having a master plan is important. It provides a sense of direction as to what kind of investment is needed for the near future. So investors require the proper signal to decide on the appropriate kind of investment. It is important that the state owned enterprises draw up a wall between the government and the management of the government. This allows the state owned enterprise to be free from the conflicts of government bureaucracy to deliver a performance likewise to that of a private enterprise.

The problem lies in the financing of the appropriate resources needed to build a grid that will supply power to all the people. World Bank has a budget of 60-70 billion dollars that they have to distribute between the other developing countries

There is a big challenge as to how the finance will be acquired and so the involvement of the private sector company is important in order to bring in electricity for all and electricity for development.

Mr. Munawar Misbah Moin, Group Director, Rahimafrooz Renewable Energy Limited.

Mr. Munawar explained the need for greater emphasis on the renewable energy sector's finances; energy by itself doesn't solve the problem. Through his speech, the audience learned the need to consider other components like technology, business model, and access to finance.

Bangladesh is ahead in terms of access to energy and the structure for access to finance. Bangladesh has the largest solar roof system in the world. Solar home installation as a source of providing electricity to households is actively being taken into consideration. This was made feasible by a combination of technology and the right business model coming into shape with the addition of finance. In contrast to the situation of Bangladesh in the 90's where our only access to electricity was from India and Africa.

The main concern now is that the mainstream financial distributors have yet to catch up in the area of renewable energy. There are a lot of pilot businesses at play however there is yet a lot to be done in order to make these pilots go full scale. Bangladesh has to decide on an all-encompassing business model which is partly policy driven and consumer demand driven. The Bangladesh government has policies regarding this however these policies are out dated.

According to Mr. Munawar, we need to come up with innovative market driven models like irrigation pumps. This is feasible through payment of water rent. Another innovative financing area in Bangladesh is electric vehicle charging. So there is a significant opportunity for solar charging to be passed on as conventional charging.

Mr. Shams Zaman, Corporate and Investment Banking Head, Citibank NA

He focused on the financing sources of renewable energy projects and the issue of banks overlooking these projects. He mentioned that the size of the project will influence the appropriate source of finance that will be required to facilitate the project. The government is taking a lot initiative and has involvement in the renewable energy sector of Bangladesh. However we need involvement from other private sectors. According to him, we need to check up on the feasibility of the projects in terms of what is workable here in Bangladesh. We must check other alternative sources like solar power, wind energy and the practicality of these projects.

We can invite development institutions from the international market who are interested in investing in our local market and depending on the prospects; they will be interested in doing so. Small projects can pose a greater risk factor than a larger project.

In terms of policy infrastructure, Mr. Shams suggest we need to formulate the right framework for a project in which it will be beneficial for investors to invest. If there are cross-corporate guarantees then it became easier to secure finance for these projects, the risk of success is higher in that case then the risk of failure.

Mr. Thomas Holzapfel, Executive Director, Fichtner GmbH & Co. KG

According to Mr. Holzapfel, on one side we are looking for reliable energy sources and on the other side we are looking for cheap energy. This is the basis of the power generation in Bangladesh. We are still at the burgeoning phase. It is not a question of the places but the finances that are required. He suggested we need to make preparations for the transmission system and then the distribution system for the power energy plants. The larger the power plant, the more energy for the people however the consequent maintenance cost and distribution cost will also be higher.

We need to take into account the feasibility studies, never forgetting the price and the social responsibility we have. Whatever the business model, the investor is looking for a profit. So our investments have to be on the principles of efficiency. Solar power has great prospective in Bangladesh. This is a possibility that can be utilized but, very importantly, the financial details have to be made clear. Without the proper technical model and the feasibility studies and a reliable project we will not be able to attract the investors to support these projects.

Dr. Ahmad Kaikaus, Secretary, Power Division, Government of Bangladesh

Dr. Kaikaus said during his speech, "Power generation has been quite successful in Bangladesh since the last decade. Recently we have allowed 10 projects in the last 2 months. However no one pointed to the fact that we are having problems with the financing of the project. And all these investments came from local investors". According to him, this is the basis to say that wherever there is opportunity finances will come from everywhere.

The government has to create an atmosphere through which we can remove the barriers which will allow markets to participate. Two distinct policies that the government has employed in the power sector are the 'private power generation policy' and the 'government procurement system', this has allowed the ministry to act like private sectors through which projects are picked and negotiated upon. Dr. Kaikaus stated that the number of steps that are needed for the implementation of the project has reduced now, and that is what matters.

He urged energy conservation by saying that instead of thinking that a certain form of energy is renewable, we should actively treat all the sources as limited and focus on efficiency instead. Dr. Kaikaus also said, "We need to understand when to involve the government and when to pull them out of a project. When the private sectors have a good understanding of the project it is best for the government to not interject. "

CLOSING CEREMONY

The closing ceremony of the South Asia IAEE-NSU Energy Summit was presided over by a number of eminent individuals as guests and speakers.

The chief guest was Mr. Nasrul Hamid, MP, Honorable State Minister, Ministry of Power, Mineral and Energy Resources, Government of the People's Republic of Bangladesh. He presented an invigorating speech on the importance of renewable energy and the access to electricity, highlighting Bangladesh's progress to the point at which it is now. He also involved students observing the closing ceremony in voicing their ideas on innovative financing for energy projects to reach the 2021 and 2041 visions of the government in the energy sectors. He urged participation and active involvement of the students in making energy conservation and efficiency a priority issue. He thanked all of the speakers and the organizers of the event and hoped this kind of energy summit to discuss global issues of energy will become a more regular occurrence.

The other speakers at the closing ceremony were Mr. Faisal Karim Khan (Additional Managing Director, Summit Group), Dr. Ricardo Raineri (President, IAEE), Dr. Gurkan Kumbaroglu (Immediate past president, IAEE), Mr. Benajir Ahmed (Member, Board of Trustees, NSU), Professor Atiqul Islam (Vice-Chancellor, NSU), Dr. Mahboob Rahman (Dean, School of Business and Economics, NSU), Dr. M. Ismail Hossain (Professor and Chairman, Department of Economics, NSU) and Dr. Sakib Bin Amin (Assistant Professor, Department of Economics, NSU & Convener of the event).

The event concluded with a presentation of crests by Professor Atiqul Islam to all the Special Guests and the Chief Guest of the Closing ceremony.

Sakib Bin Amin

Current and Future Challenges to Energy Security

2nd AIEE Energy Symposium, 2-4 November, Rome

Following the 1st AIEE Symposium on Energy Security organized in Milan in 2016, the second edition. organized this year in Rome with the LUMSA University. was an opportunity to continue the dialogue and to provide a fresh look at energy security issues concerning the availability of new technologies, the emergence of new market conditions and of new market operators; an opportunity for the delegates from all over the world to explore new and existing energy trends and to share best practice and experience.

A two days conference, where nearly 200 participants from 20 countries, experts, researchers, teachers, managers from major Italian and foreign energy companies met to discuss energy security topics addressing this key issue in an international context, with particular reference to the role of traditional and renewable sources and the effects on the energy markets. At the center of the debate was the economic and technological aspects and the security of global energy systems in the perspective of decarbonisation; a very broad concept ranging from the availability of fossil fuel supplies to the renewable energy sources and the energy storage.

The event was organized in 5 plenary sessions and 22 parallel sessions with 100 presentations.

The international conference opened on November 2, in the presence of the AIEE and LUMSA University representatives. A welcome greeting from the IAEE was expressed by Gurkan Kumbaroglu, former President of the International Association, who introduced the participants to the IAEE role and purpose as an international organization.

The first day on November 3, opened with group of parallel sessions discussing the theme of the European energy union, the market regulation and consumer protection, the overall assessment of energy security and efficiency and sustainability.

The debate continued in two parallel plenary sessions:"EU towards 2030" chaired by Agime Gerbeti (LUMSA University), with a panel represented by Luca Bragoli (ERG), Marco Falcone (ESSO) and Samuele Furfari (European Commission) who discussed the various aspects of European policies by 2030. During the discussion it emerged that European Union energy dependence from oil and gas imports, with the current market condition, does not present significant energy supply problems, especially as regards the natural gas that is imported from diversified suppliers. The ExxonMobil scenario to 2040, foresees a constant consumption of electricity in the industrial sector during this ongoing energy transition, but with a reduction of emissions due to renewable sources and the overall increase in energy efficiency. In achieving the goals by 2030, an important role will also be played by the repowering of wind power plants. The ETS, on the other hand, as the main emission reduction tool does not bring satisfactory solutions because of too low CO_2 prices. In order to raise prices, ESSO proposes extending the EU ETS scope to include road transport. Concern was also expressed regarding the reduction of the refining sector in Europe, favoring the development of refineries in non-EU countries which are not subject to emission limits, resulting in a global increase in overall emissions and loss of European jobs.

The parallel plenary session on "Regulation of energy markets", chaired by Alessandro Ortis (past President of the Italian Authority) with a panel represented by Giuseppe Gatti (Energia Concorrente), Jean-Michel Glachant (Florence School of Regulation) and Pippo Ranci (Catholic University of Milan) discussed the problems of the energy markets of various European countries in relation to the liberalization processes, highlighting the work still to be done in view of the complexity of the EU objectives to 2030. The function of the European Association of Regulatory Authorities has also been discussed hoping that its action may become more incisive assuming also a guiding role for national authorities.

Two other interesting plenary sessions followed in the afternoon: "Economic instruments and transition pathways to a low-carbon economy in the industrial sectors" chaired by Gurkan Kumbaroglu with a panel represented by Simone Mori (Future Electricity), Corrado Papa (Adriatic LNG), Salvatore Pinto (Axpo), Sandro Neri (Federmanager) and Claudio Spinaci (UP) and "Europe Roadmap and the Future Strategies of the Energy Industry" chaired by Giovanni Ferri (LUMSA University) with the participation of Kostas Andriosopoulos (RCEM), Leonardo D'Acquisto (Italgas), Dario Di Santo (FIRE) and Luigi Michi (Terna)

The speakers discussed the security aspects of the various traditional and renewable sources in the transition to a decarbonized economy. They highlighted that the acceleration of innovation and electrical penetration, while leading to major transformations in many sectors of consumption, did not reduce the fundamental role of oil and gas. In the rapid development of low-carbon energy infrastructures, particularly in developing and emerging economies, a vital issue is the financial sector, particularly the increase of institutional investment.

Subsequently, eight parallel sessions followed to discuss a number of topical issues related to energy security: the gas market, the electricity market, energy efficiency in the industrial and civil sectors, energy storage, the use and dissemination of renewable sources and environmental policies.

The second conference day was opened by a plenary session on "Sustainable mobility challenges for the transition goals" chaired by Carlo Andrea Bollino (AIEE) and a panel formed by the leaders of the main transportation associations that discussed how great the challenge is for public transport to reach the challenging international, and European objec-

tives. In the center of discussion the electric car, which however will not be able to completely replace traditional cars. Traditional fuels will continue to have an important role, taking into account their continued qualitative improvements for environmental sustainability.

The day proceeded with other parallel sessions debating issues related to risks and opportunities of the electricity market, cyber security in the energy sector, technological development and network management, scenarios and forecasting methodologies, climate policy and emissions trading, the multiple paths of electricity demand, integration of renewable energies in energy markets, security of supply and bioenergy.

A high scientific contribution was guaranteed by the presence of researchers belonging to most important national and international universities and organizations and experts representing energy companies.

The academic scenario of the LUMSA University, in the heart of Rome, between Castle St. Angelo and St. Peter's Church and the social events organized in the LUMSA 19th Century Chapel and on the Atlante luxuriant rooftop terrace with a panoramic view of the great City by night, offered an ideal platform to promote the exchange of ideas in a relaxed beautiful context.

The conference was an opportunity to discuss in depth the most up-to-date issues of energy security and it has become a recurrent meeting giving its next appointment in December 2018, with its third edition.

The presentations can be downloaded on the conference website: www.aieeconnference2017rome.eu
The volume of the conference proceedings (the abstracts and a selection of papers) will also be online by December 30, 2017.

IAEE/Affiliate Master Calendar of Events

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

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

IAEE ENERGY FORUM *Vol. 27, First Quarter 2018*

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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