

DIALOGUES- HOUSTON CONFERENCE EDITION

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 practice 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. Photos courtesy of Carol Dahl (Colorado School of Mines).



CASE COMPETITION

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 organized 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-Saclay.

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 competition 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 Pontificia 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 Ladislav, 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.

Ladislav 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 Ladislav 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, Ladislav cites, also prefers bilateral agreements and has a dislike for institutions. This too will greatly affect the landscape in the near future. Ladislav 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 order 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 experiences, 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 US'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 US 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 is 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, US 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, a \$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 Vaishnav (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 Soummame 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 are 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 as 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.