IAEE Energy Forum

Third Quarter 2017 | International Association for Energy Economics | ISSN 1944-3188

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INTERNATIONAL ASSOCIATION *for* ENERGY ECONOMICS

CELEBRATING 40 YEARS ANNIVERSARY

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Editor: David L. Williams

President's Message

Dear Fellow Members:

This is an exciting year for IAEE since we are celebrating our 40th anniversary after a group of visionaries created this great organization in 1977 as a forum for communication and the exchange of ideas for all those interested in energy economics. We have just closed our 40th IAEE International Conference, which took place in Singapore, The Lion City, with the participation of about 500 members, and the theme "Meeting the Energy Demands of Emerging Economies: Implications for Energy and Environmental Markets". I'm convinced that the theme could not have been timelier and more challenging, as we expect that energy demand will grow in the next two decades by almost 30%, and by more than 50% in emerging economies. And most of this will take place in Asia. The conference was a big success and has been the largest IAEE conference in the region.

Some other recent IAEE events this year are:

- 6th Latin American Energy Economics Meeting "New Energy Landscape: Impacts for Latin America", April 2-5, 2017, Rio de Janeiro - Brazil.
- 10th International Conference of the Nigerian Association for Energy Economics (NAEE) "Energy, Economy & the Environment: The Interplay of Technology, Economics, and Public Policy", April 23 – 26, 2017, Abuja – Nigeria.
- 2nd International Conference of the Hellenic Association for Energy Economics (HAEE) "Energy The Landscape in the New Era of Energy Transition: Challenges, Investment Opportunities and Technological Innovations", May 18-20, 2017, Athens - Greece.

All of them garnered a large local and international audience with the participation of government officials, leaders from the parliament, business executives, academics, students, representatives of the media and energy analysts. Also, I can comment that each year IAEE is receiving an increasing number of requests to hold conferences, workshops, and seminars. And already we have flagged events in the calendar up to 2021. I invite you to note these exciting events on your agenda:

- 3rd IAEE Summer School in Beijing, China, "Energy Market: Models and Practice", July 6-15, 2017, IAEE - School of Humanities and Economic Management, China University of Geosciences, Beijing - China.
- 15th IAEE European Conference "Heading Towards Sustainability Energy Systems: by Evolution or Revolution?", September 3-6, 2017, AAEE/IAEE, Vienna - Austria.
- 2nd IAEE Eurasian Conference, "Energy in Eurasia: Economic Perspectives on Challenges, Risks and Opportunities", October 13-14, 2017, Croatia Association for Energy Economics CAEE, Zagreb - Croatia.
- 35th USAEE/IAEE North American Conference "Riding the Energy Cycles", November 12-16, 2017, USAEE, Houston – Texas - USA.
- 41st IAEE International Conference "Security of Supply, Sustainability and Affordability:

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President's Message (continued from page 1)

Assessing the Trade-offs of Energy Policy", June 10-13, 2018, BAEE/IAEE, Groningen - The Netherlands.

- 42nd IAEE International Conference "Local Energy, Global Markets", May 26-29, 2019, CAEE/IAEE, Montreal - Canada.
- 43rd IAEE International Conference "Energy Challenges at a Turning Point", June 21-24, 2020, FAEE/IAEE, Paris - France.
- 44th IAEE International Conference "Mapping the Global Energy Future: Voyage in Uncharted Territory", July 25-28, 2021, IAEE/The Institute of Energy Economics, Tokyo - Japan.

In IAEE we are also committed to the identification of opportunities to expand our footprint and enlarge our community in regions that are underrepresented, for example, Africa and Asia. And for that, we are in a permanent effort of identifying key local partners who can work with us in achieving our goals.

Lately there have been large fluctuations in the energy sector, and despite lower energy prices, our membership has remained strong. The number of members coming from new regions and developing countries is growing steadily, given the IAEE efforts in those areas. Currently, we have over 4,100 members; where 20% of them are students, almost twice the number that we had a decade ago.

The IAEE has three leading publications, *The Energy Journal, Economics of Energy & Environmental Policy*, and *The Energy Forum*. *The Energy Journal* is published 6 times a year and was founded in 1980 to promote the advancement and dissemination of new knowledge concerning energy and related topics. The editors strive to publish a blend of theoretical, empirical and policy related papers in energy economics. It has a five-year Impact Factor of 2.466. Our newest journal, *Economics of Energy & Environmental Policy* (EEEP), established as an IAEE publication in 2012, is a policy oriented journal and published twice a year. It has a five-year impact factor is 1.582 and has become a leading journal in energy, the environment, and economic policy. *The Energy Forum*, our newsletter, is published quarterly and covers current energy matters such as renewable energy, smart grids, transportation and electromobility, regional energy issues, electricity, oil, natural gas, coal and nuclear matters, etc. As well, complementing our flagship publications, IAEE with USAEE provides all USAEE/IAEE members a chance to increase the visibility of their research, by submitting their research for publication in the USAEE/IAEE Working Paper Series, which is a part of the Social Science Research Network (SSRN) Research Paper Series. I invite you to consider IAEE publications as your first choice to submit innovative research, policy issues, case studies, and innovative applications in the areas within the scope of energy economics and energy policy.

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

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Within this 40 years many things have changed, but what has not changed is the quest for energy security, an area where IAEE has been a front runner in dissemination and the exchange of ideas, experiences and best practices. Today, when energy security is changing its balance from the access to subsurface energy resources to the mastery of technologies, the need to exchange ideas and experiences is in high demand.

Creative destruction is a concept which gained popularity among the economics profession in the 1950s from the works of the Austrian-American economist, Joseph Schumpeter. The simple but powerful idea behind this concept is one that describes the "process of industrial mutation that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one." Today, and in a context of a changing and powerful civil society, with new and giant environmental challenges, and increasing energy needs, the renewed path of the energy sector is innovation and disruption; where, new technologies which have enabled the access to new energy sources and higher efficiency levels in energy consumption, are reshaping the energy sector. The advancement of drilling and other energy technologies has allowed the access to new subsurface resources, of non-conventional energy sources, and the harnessing of energy from the wind, sun, and oceans, among others. All these innovations and new energy sources are biting the power that used to have the traditional energy producers, who sometimes also are in regions exposed to unstable conditions.

The industry is experiencing a deep change, from a centralized structure to a decentralized one. And, as in the electricity sector, distributed generation, the integration of a system with a large number of players, places new challenge which requires greater communications, smarter metering and the management of larger data, where demand side management and storage can become a key contributor on the systems levels of energy security. As new technologies come to the market, new concepts are as well enlarging our vocabulary as the idea of the prosumers and more recently the one of prosumage, referring to agents who participate in the network as producers, consumers, and providers of storage services (a term coined by Richard Green).

For investors, there is a need for clear leadership on where investments should go, and governments have a key role in signaling and promoting an enabling a business environment that does not distort markets conditions. No one, even the government, knows today the technologies that will be the winners of tomorrow, and policy should not decide who are the winners or the losers, where extensive subsidies, can send twisted signals and lead to investments which are not sustained on the advantages of the technologies being supported. Governments, research organizations and the scientific community have a key role in advancing the frontier of what is feasible and on the understanding of the most proper technologies and business models to manage the transition to a more decentralized system.

The levels of commitment of an economy to a low carbon economy need clarity and stable long-lasting rules from government authorities. The Paris agreement has been signed by the large majority of countries and ratified by countries that represent more than 80% of global CO_2 emissions. More than 160 parties have submitted their Intended Nationally Determined Contributions (INDCs) that indicate the steps that each party will take to address climate change, and for reducing emissions, considering its domestic circumstances and capabilities.

The transportation and electromobility (E-Mobility) revolution that's taking place, supported by innovations in storage technology, is closing the gap of these technologies to compete hand in hand with conventional combustion vehicles. As charging stations get deployed, we might expect deep changes in the transportation sector, with important impacts on the demand for oil, and other resources.

New business models will emerge as well as new technologies, where exist a greater need for collaboration among players. This will need improvements in the countries institutional frameworks, where natural tensions will come up as newcomers pressure for a space in the market, while incumbents get exposed to new forms of competition. How the government authorities manage the transition, will be key in speeding up or slowing innovation, and technological change, where the support for research, development, and pilot projects, as global public goods, is essential.

The countries that become the front-runners in this technological revolution, will take the industrial lead and will become the partner of choice for many others that are looking to serve their energy needs in a more sustainable and secure manner. Major global players who take a leadership role in the transition to advanced energy, by stepping up research and development in technologies such as non-conventional, renewables, nuclear power, energy efficiency and electricity storage, and who move aggressively and strategically, will gain hegemony in this new energy landscape.

The process of rapid technology change, innovation, and disruption we are experiencing is one where IAEE has played an important role as a forum to gather and exchange ideas, and to underscore the leading trends in supply, demand, technology, institutional, business and financial models, environmental challenges, social preferences and geopolitical issues which affect the energy sector.

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Editor's Notes

In this issue we conclude our coverage of *Energy Policy in the New U.S. Administration* and begin our coverage of *Renewables and Conventional Energy Resources: Challenges, Opportunities, Complementarities, Rivalries and Game Changers.* Readers have a lot to say on this subject and so we'll continue it in the forth quarter issue. Also included in this issue are summaries of three very interesting conferences, one in Greece, another in Rio and finally one in Britain.

Marilu Hastings writes that climate advocates and funders are dismayed by the Trump Administration's pledge to halt progress on clean energy. Conservatives can find a model with proven results by looking to the accidental clean energy story in Texas. The state already beats the Clean Power Plan through smart policies, timely investments and market forces.

Thomas N. Russo reports that failure of the U.S. and Mexico to renegotiate NAFTA will severely impact Mexico's efforts reduce costs and green its electric power and natural gas sectors. U.S. natural gas pipeline investments to flow gas to Mexican markets would depend largely on LNG exports to maintain profitability.

Stephen Poletti analyses the long-run effects of a shift to real-time pricing (RTP) of electricity when there is market power in electricity generation. He finds that an increase in customers on RTP contracts decreases peak prices and increases off-peak prices. Consumer surplus and welfare increase while the generators' profit decreases.

Julie Carey and Maggie Shober investigate the influence of shifting federal energy policies away from the Obama Administration's clean energy policy agenda toward a pro-fossil fuel policy focus under the Trump Administration on the U.S. and global energy industry. Federal, state and international energy policies are evaluated along with recent energy market dynamics from oil, gas and renewables to evaluate the full impact of a Federal policy shift. The article also provides guidance on a path forward to achieve collective goals surrounding the economy, the energy industry, and the environment, recognizing the substantial economic benefits from a diversified energy portfolio, inclusive of oil, gas, and renewables.

Roy Boyd, Alejandra Elizondo and Maria Eugenia Ibarrarán note that the current Mexican Energy Reform relies on FDI to boost oil and gas E&P in the next decade, and on close trade with the U.S. Recent political developments bring uncertainty on this future partnership. Fossil fuels could be subject to tariffs, and other economic and political factors may also conspire to negatively impact FDI.

Tim Nelson examines an 'energy-only' market in a high penetration renewables system, with a particular focus on the vertically and horizontally restructured Australian National Energy Market (NEM). He finds the 'energy-only' market can indeed work within a decarbonised energy system but extreme pricing volatility within spot markets is likely to be required to ensure system reliability. 'Unintended consequences' of adjacent climate change policies will need to be corrected for to ensure: successful retail competition; appropriate new investment is forthcoming; and pricing outcomes are acceptable given real-world political economy constraints.

Maximilian Eissler, Clemens Gerbaulet, Ralf Ott, Charlotte Rochell and **Philipp Zorn** analyze distributed solar PV and recent trends in energy generation in California and other jurisdictions. Households invest in PV and batteries to generate and store electricity for self-consumption. They focus on the costs and business opportunities in California and compare the costs of residential PV in international context.

Chen-Hao Tsai and Gürcan Gülen note that Increasing penetration of wind generation in the ERCOT market has brought new operational challenges to the grid operator, as well as downward pressure on the financial viability of conventional thermal generators. Nonetheless, spatio-temporal wind penetration changes significantly and results in very different impacts to market prices.

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President's Message (continued from page 3)

Our main objective in IAEE is to be your focal point for the exchange of ideas in energy and the economy, where our members are the heart of the association. And thus, your word and opinion are key for us to serve you in a better way. For any suggestion you might have, please do not hesitate to reach out to us.

Finally, I like to express my gratitude to all who collaborate and contribute with their time, effort, and resources for the success of IAEE. And, also want to thank all you for engaging in our activities, for committing your research in our conferences and publications, and for being part of this great Association.

Ricardo Raineri Bernain

15th IAEE European Conference

3rd to 6th September 2017
Hofburg Congress Center | Vienna | Austria

Early bird registration until June 30th

HEADING TOWARDS SUSTAINABLE ENERGY SYSTEMS: EVOLUTION OR REVOLUTION?

CONFERENCE OVERVIEW

In recent years, energy systems as well as energy markets underwent remarkable changes world-wide. Developments in oil, natural gas as well as electricity markets brought challenges of redesigning these markets. In addition, to cope with the problem of global warming and heading towards sustainable energy systems a global climate policy is required. Global change in thinking is required and solutions must be sought that can cover the diverse needs like affordability, environmental compatibility and economic feasibility.
The conference focuses on new developments of energy conversion technologies, energy policies and their effects on individual countries as well as at a global level, the efficient use of different types of primary energy resources and possible solutions to stop global warming.
The main question of this conference will be: In heading towards sustainability – is an evolutionary steady development possible or is a revolution necessary? This question will be discussed in eight plenary- and 64 concurrent sessions.

TOPICS TO BE ADRESSED

The general topics for this conference include:

- Review and redesign of electricity markets
- Efficient exploitation and use of renewable and exhaustible energy sources
- Review of national and international energy and climate policy strategies and scenarios
- Evolving geopolitics: The economics of changing oil and gas markets
- Energy demand and greenhouse gas emission modelling
- Energy asset valuation and energy sector investment
- Adaptation technologies for climate change
- Exploitation of demand-side efficiency in all end-use sectors: households, industry, transport and commercial buildings
- New business models and fundamental change in doing business in energy markets
- Sector coupling and storage

Venue, activities and accomodation

Hofburg Congress Center, located in the very centre of the city, offers a unique ambience for hosting the 15th IAEE European conference. Until 1918 the Hofburg Palace was the seat of the Habsburg dynasty. The conference can be held today in the same halls where the Emperors held their audiences, gala dinners and royal balls, or where Empress Maria Theresia was baptised on May 15, 1717. Vienna is well-known for the Viennese Waltz, the Vienna Philharmonic Orchestra, the Vienna Boys Choir, Wiener Schnitzel and St. Stephens Cathedral. Art, culture and the city itself make a unique mix of tradition and modern times.
Technical tours on September, 7th lead us to the world's most famous waste incineration plant Spittelau and to Austrias Nuclear Power plant in Zwentendorf. This nuclear power plant never went online but produces electricity by photovoltaics. Besides technical tours there will also be social and sightseeing tours for accompanying persons and for those who want to experience Vienna from it's most beautiful side.
Also, delegates are offered any category of accommodation they desire in Vienna. For more information see https://www.aaee.at/iaee2017//accommodation

STUDENT ACTIVITIES

Special activities and events for students and young researchers are offered in the course of the 15th IAEE European Conference.
On Sunday, 3rd September, the 5th IAEE European PhD Day in cooperation with YEEES (Young Energy Economists and Engineers Seminar), takes place at TU Wien. Students and junior researchers who are not presenting a paper are cordially invited to attend the PhD Day as listeners. Participation and all provisions at the PhD Day are free of charge!
An excellent opportunity for informal fellowship and networking is provided through the special Student Reception following the official Welcome Reception on Sunday evening. Moreover, everyone is encouraged to attend the IAEE Best Student Paper Award Competition, which allows selected students to present their papers and compete for the top prize of US$1000 in front of a panel of energy economics expert judges.
For more information see the student section on https://www.aaee.at/iaee2017/students_overview

e-mail: iaee2017@tuwien.ac.at

Official website: www.aaee.at/iaee2017

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Important Dates:

Full-Paper Deadline:
30th June 2017

Early bird registration:
30th June 2017

Conference Program:
15th July 2017

Conference:
3rd - 6th Sept. 2017

Member-Get-A-Member Campaign

IAEE Members:

IAEE's Member-Get-A-Member campaign continues in 2016-17. IAEE believes you know quite well the value of membership in our organization. Furthermore, membership growth is one of the Association's top strategic initiatives. With your knowledge of our organization's products/services, publications and conferences, we know that you are in the ideal position to help us grow. The process to win rewards for yourself is quick and easy!

Here's How the Program Works:

- For each new IAEE member you recruit, you receive THREE months of membership free of charge.
- New Members must complete the online IAEE membership application form at https://www.iaee.org/en/membership/application.aspx Make sure the member(s) you refer mentions your name in the "Referred By" box located on the online membership application form.
- The more new members you recruit the more free months of membership you will receive. There is no limit to the number of new members you may refer.

Membership Recruitment Period and Additional Incentive:

- This special program will run from May 1, 2017 – July 31, 2017.
- The Member that refers the most new members to IAEE during this timeframe will receive a complimentary registration to attend the 15th IAEE European Conference in Vienna, September 3-6, 2017 (this prize may be assigned by the winner to another member, yet must be used for complimentary registration to attend the Vienna conference only).

IAEE Tips for Success:

- Promote the benefits of IAEE membership - Share your IAEE passion with others! Visit https://www.iaee.org/en/inside/index.aspx for a brief overview of IAEE.
- Connect with colleagues – Invite your co-workers, colleagues and friends to IAEE conferences.
- Keep IAEE membership applications at your fingertips - Please contact David Williams at iaee@iaee.org and request that membership applications are mailed to your attention. Feel free to hand these out on your travels.
- Let IAEE do the work for you – Send us an email at iaee@iaee.org letting us know who should be invited to join IAEE (we need full name and email address) and we will contact who you refer to see if they have an interest in joining IAEE. If the member joins during the time frame above, you will be given three months of membership free per member you recruit!

We encourage all members to help our organization grow. At the same time, you will be rewarded with free membership months and an opportunity to have your conference registration fee waived at a coming IAEE conference.

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A Model for Clean Energy in a Conservative America: The Texas Surprise

By Marilu Hastings

Marilu Hastings is Vice President at the Cynthia and George Mitchell Foundation, Austin, Texas. She may be reached at mhastings@cgmf.org

On February 17, 2017 former Oklahoma Attorney General Scott Pruitt was confirmed as the new administrator for President Trump's Environmental Protection Agency (EPA). Along with Pruitt, the expected confirmation of former Texas Governor Rick Perry to lead the Department of Energy (DOE) and the installation of former ExxonMobil CEO Rex Tillerson at the State Department collectively represents, to many clean energy advocates, a planned assault on the federal government's progress to reduce carbon dioxide emissions from the U.S. economy.

Clean energy proponents expect to see the Trump administration reject the Paris Agreement, dismantle the Clean Power Plan (CPP), and roll back new CAFE and appliance standards, all while enabling oil infrastructure construction and somehow resurrecting the coal industry. (Snider, 2017). At DOE, analysts predict that research into renewable energy, energy efficiency and clean coal technologies will be defunded. (Temple, 2017).

Coupled with the possibility of stripping out many key aspects of existing federal research and regulatory policies, the Trump administration claims that it will shift more environmental authority to states. This potential decentralization may lead to a patchwork of environmental regulations, which, ironically, was the dynamic that industry leaders were trying to remedy in promoting the establishment of a federal environmental agency in the first place during the Nixon administration. (Rudich, 2016).

States were the original instigators of the policies that established the clean energy transition that is now underway. State renewable portfolio standards and energy efficiency resource standards came into vogue starting in the late 1990s and state and local governments began adopting energy efficient building codes and appliance standards.

When President Obama was elected into office with a democratically-controlled Congress in 2009, national environmental organizations and their progressive funders aggressively sought to establish the American Clean Energy and Security Act to create a shift toward federal action on climate and clean energy partly to force laggard states into action. The bill ultimately failed in the Senate and the groups and their funders moved again back to advocating at the state level for expanded clean energy programs in lieu of federal policy.

After 2009, while working with the states, the companion federal strategy was to use Section 111D of the Clean Air Act to regulate carbon dioxide emissions at the federal level, which resulted in the Clean Power Plan. It appears that this regulation's future is uncertain, although overturning it will not happen quickly or easily. And with EPA's 2009 endangerment determination, Scott Pruitt will likely be forced to move in some way to reduce carbon dioxide emissions at the federal level.

In the meantime, it's back again to the states.

Conventional wisdom points to progressive states on the West Coast and in the Northeast as models for how to move clean energy forward in the anti-regulatory Trump era. However, this very rejection of federal environmental regulations indicates that conservatively-skewed state models may be more relevant to this new administration.

Take the state of Texas, for example. The "accidental clean energy state" could serve as a case study of how a suite of deregulated energy markets, timely investments, and smart policies can set a dynamic clean energy economy into motion. As the emphasis of environmental regulation shifts away from the federal government, there's no reason why Texas couldn't serve as the new clean energy bellwether state. In fact, Texas could be to the Trump administration what California and other mandate-focused states were to the Obama administration. (Hastings, October 19, 2016).

One of the first and most fundamental actions Texas took that helped enable the current clean energy transition was to deregulate the Electric Reliability Council of Texas (ERCOT), the regional transmission organization that manages most of the Texas electricity system. Former Governor George W. Bush signed the deregulation legislation in 1999 with the intent to increase competition in ERCOT and drive down electric rates. (Dyer, 2016). An unintended consequence of the ERCOT transition was to allow more "green energy" choices to ERCOT customers thus providing market signals to renewable energy developers that there was demand for their product in Texas.

Deregulation also helped, over time, to increase the sophistication of retail energy customers **who**

now respond more quickly to the transparent price signals than under the old regulated system. The combination of new customer choice and better prices helped lay the foundation for what was to evolve in the ERCOT market.

In 1999 Governor Bush also signed legislation establishing one of the nation's first Renewable Portfolio Standards (RPS). Being from the blustery plains of West Texas, Bush understood the significant wind resource the state enjoys and the rural economic growth potential of its development. The initial RPS required that utilities provide 2,000 MW of electricity from renewable sources.

In 2005, former Governor Rick Perry expanded the RPS to 5,000 MW from renewables by 2015 and set a target for 10,000 MW by 2025. Texas surpassed the 2025 RPS target 16 years ahead of schedule in 2009. (Cusick, 2016). Texas now has the largest wind capacity in the U.S., accounting for a quarter of all installed capacity in the country.

A 2016 study by the Brattle Group on behalf of the Texas Clean Energy Coalition shows that ERCOT's increased reliance on renewable fuels is expected to cause no increase in wholesale electricity prices through 2032, in real terms. (Shavel et al, May 17, 2016). Furthermore, a recent study by the Business Council for Sustainable Energy and Bloomberg New Energy Finance shows that ERCOT retail prices declined 10 percent between 2011 and 2016. (Business Council for Sustainable Energy, 2017).

Another important step in Texas' clean energy evolution was the timely and significant investment it made in its transmission infrastructure. In 2005, Rick Perry led the development of Texas' competitive renewable energy zones (CREZ) program, a $7 billion transmission complex that included 3,600 miles of lines and completed in 2014. (Cusick, 2016). This project carries wind power from West Texas to urban centers to the eastern part of the state where demand is expected to continue growing. (Hastings, 2017).

Another recent Brattle Group study shows that the increased integration of renewable energy into the ERCOT system is not expected to have significant impact on its grid reliability. Perry's investment in transmission over a decade ago helped ensure that reliability concerns are negligible. (Shavel et al, December 7, 2016).

Governor Bush again was responsible for the Texas energy efficiency resource standard (EERS) that he signed into law in 1999. Texas was the first state to adopt utility energy efficiency requirements – reducing electricity bills more than $1 billion. The original EERS mandated that at least 10 percent of an investor-owned utility's annual growth in electricity demand be met through energy efficiency programs each year, a goal that was met and exceeded.

In 2007, the American Center for an Energy Efficient Economy (ACEEE) rated Texas 11th in the United States for energy efficiency attainment. Later the legislature increased the goal to at least 20 percent of growth in demand, and the state's Public Utility Commission again increased the efficiency goals to 30 percent of growth in demand in 2010. (SPEER staff, 2014).

Despite the success of the program in reducing consumer costs, Texas' initial leadership in efficiency has all but completely eroded. While Texas started out ahead, efficiency investments have leveled off, and are now decreasing. (SPEER staff, 2014). While recent progress is disappointing, the early adoption of efficiency standards and related building codes indicates that a conservative state like Texas, against all conventional thinking, has the capacity for leadership in this area. With some adjustments to the structure of the EERS program, the state could regain a leadership position on energy efficiency.

The state continues to lead in the adoption of building energy codes, with Governor Greg Abbott signing legislation in 2015 moving the single-family residential code from 2009 to the 2015 International Residential Code (IRC) by September 1, 2016. (Department of Energy, 2016).

In the midst of progress made on deregulation, transmission infrastructure, renewables growth and energy efficiency, Texas was also leading the way in applying existing oil and gas drilling technologies to shale formations and unlocking significant new supplies of natural gas for power production.

Together with research expertise at the DOE, in 2005, George P. Mitchell was the first to deploy hydraulic fracturing and horizontal drilling as an economic means of extracting shale gas. Ample supplies of natural gas drove prices down in ERCOT and, together with falling prices for renewables, have halted any new construction of coal-fired generation for the foreseeable future. (Shavel et al, May 17, 2016).

With half the carbon emissions of coal plants, increased reliance on natural gas plus renewables will cut the state's emissions by 28 percent below 2005 levels. At these levels, it will be market forces that driving Texas to beat and exceed the emission reduction requirements of the Clean Power Plan, rendering the Plan all but irrelevant. (Shavel et al, May 17, 2016).

The tension between the CPP's future and the role of markets in driving Texas toward clean energy without federal regulation encapsulates many of the differences in environmental protection between

progressives and conservatives. While Northeast and West Coast environmental funders and their grantees look primarily to regulatory frameworks to push results, the so-called "flyover states" generally reject this approach but not necessarily the associated environmental protection goals.

The Trump administration appears to be particularly aggressive in its anti-regulatory stance.

This is deeply depressing for many advocates and funders who have invested heavily in regulatory regimes: first the cap-and-trade system in the American Clean Energy and Security Act, and then the federal regulatory strategy of the CPP. Even with a democrat as president and a democratically –controlled Congress, the Act could not pass. And the CPP's future is clearly uncertain.

Now, with a republican-skewed Congress, a republican president, and the majority of states decidedly republican, it's time to revisit the overall approach to clean energy and climate protection.

With the exception of possibly designing an equitable and effective carbon tax and dividend, clean energy strategies going forward must rely on state-focused, market-driven shifts to clean energy alternatives and away from overarching federal regulations. Lessons from Texas' progress in cutting carbon emissions, driving down electricity prices and preserving reliability can appeal to conservative leaders and be translated to the national level. (Hastings, December 9, 2016).

The Trump Administration could take several steps to move forward a clean energy economy without promulgating new environmental regulations.

Based on the ERCOT model the administration could require that all regional transmission organizations put the systems in place to deregulate their wholesale electric markets if they have not already done so. While the ERCOT system is not without its challenges, a deregulated market like ERCOT allows consumers to read the price signals that drive down prices and allow renewables to flourish.

Trump could include new transmission lines that bring renewables from the center of the country to loads on the East Coast in his infrastructure package. He could also include upgraded transportation systems that enable greater market penetration of electric vehicles on the country's highways. These improvements could be paid for with the carbon dividend recommended on February 8, 2017 by the Climate Leadership Council, led in part by James Baker and George Schultz. (Baker et al, 2017).

This policy would allow the administration to claim credit globally for addressing climate change when a fully Democratic administration and Congress could not in 2009, all the while dismantling current and pending climate regulations.

New markets for and jobs in natural gas and renewables, which would benefit rural and agricultural constituents, would be created. Also, as the presumptive new DOE Secretary, Rick Perry could continue the research and development arm of the department and double-down on technologies that enable carbon emissions to be captured economically from existing coal-fired generation domestically. These proven technologies could then be exported to areas of the world where coal is still the dominant fuel for electricity generation, such as India and China.

As a clean energy "arms race" escalates with China over the coming years, it is essential that clean energy technology innovation be developed in the U.S. rather than ceded to our global competitors. American government and corporate leaders do not need to accept the science of human-caused climate change to see that the country stands to economically and politically benefit from gaining global leadership in advanced energy technology markets.

It remains to be seen if the country's new leadership has an appetite for considering such innovative yet pragmatic measures. Although these steps are not simple and their adoption represents a long-term proposition, the basis is a market-driven, conservative model that could demonstrate how clean energy progress can continue without federal regulatory burden while creating new jobs, lowering prices, preserving reliability and continuing energy technology innovation. Although imperfect, the Texas accidental clean energy story is a model that can help inform our path forward.

See References on page 16

CONFERENCE OVERVIEW

Over the last decade, energy markets have experienced a period of extreme volatility. The growth in unconventional oil production in the United States, and the retreat of OPEC from stabilizing the market, have both contributed to the recent sharp decline in oil prices. World events, including Nigerian militant attacks and the return of Iranian crude to the world market, will continue to create uncertainty about world oil supply. Events arising in the US, from first LNG export cargos to the prerogatives of a new presidential administration will also have far-reaching effects for oil & gas markets. At the same time, the US economy's reliance upon electricity continues to grow as demand for the nation's number one fuel for dispatchable generation, coal, is dwindling. The 35th USAEE/IAEE Conference will provide a forum for informed and collegial discussion of how the highs and lows of the current and future energy markets will impact all stakeholders—from populations to companies to governments—in North America and around the world.

What better location to discuss the past and possible future of the energy industry than Houston? It has been known as the "Energy Capital of the World" since Spindletop erupted in 1901, and has remained the home for global oil and gas companies since the early 20th century. Today it is home to offices of most major oil and gas companies.

Houston has seen many oil market booms and busts, but, partly in response to these cycles, it has also developed diverse energy sector industries beyond oil and gas. In particular, Houston serves as the renewable energy innovation headquarters for the state of Texas, which is home to more than 12,000 MW of wind capacity with several thousand more megawatts still under development. Houston also hosts engineering firms focused on energy construction projects, major banks operating in energy trading and energy project finance, major law firms specializing in energy issues, a vibrant software industry focused on energy applications, and a large diplomatic community with analysts focused on energy industry developments.

As the world looks to smooth the ride in oil & gas prices, resolve the dilemmas of energy affordability and environmental responsibility, and cultivate disruptive leaps forward in technology, this conference can provide the perfect setting for discussions around policy approaches, economic indicators and technological drivers. The 35th USAEE/IAEE Conference is sure to contribute to the analysis of these critical issues. Speakers will include key figures from industry, academia and government. The conference also will provide networking opportunities for participants through informal receptions, breaks between sessions, public outreach, and student recruitment. There also will be offsite tours to provide closer insight into why Houston will continue its role as *the* global energy hub in the years and decades to come.

TOPICS TO BE ADDRESSED INCLUDE:

The general topics below are indicative of the types of subject matter to be considered at the conference. A more detailed listing of topics and subtopics can be found by clicking here: www.usaee.org/usaee2017/topics.html

- How to Survive, Adapt & Evolve in Oil & Gas
- Energy Finance and Commerce
- Lifecycle Costs of Energy Technologies
- LNG Markets
- Community Impacts of the Energy Industry
- Energy Risk & Uncertainty
- Electricity Market Outlook: Supply & Demand
- Midstream/Downstream Oil & Gas Trends
- Electricity Grids
- The Future of the Energy Sector & Geopolitical Impact
- Energy in The Age of Volatility
- Other topics of interest including new hydrocarbon projects, transportation innovation, generation, transmission and distribution issues in electricity markets, etc.

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PLENARY SESSIONS

The 35th USAEE/IAEE North American Conference will attract noteworthy energy professionals who will address a wide variety of energy topics. Plenary sessions will include the following:

- Major Developments and Implications for the Energy Industry
- Innovation in Energy Finance and Investment – Accelerating a Transition
- Future of the Refining Sector - Trumponomics and Low Oil Prices
- Changing Ties With Mexico
- Electricity Markets
- Entrepreneurship in the Energy World
- Renewable Energy – Integration Challenges and Emerging Solutions
- Strategies to Adapt, Survive and Evolve in the Upstream Oil and Gas Markets
- Intelligent Energy Systems

SPEAKERS INCLUDE

Guillermo Garcia Alcocer
President Commissioner,
Energy Regulatory Commission

Kemal Anbarci
Managing Executive, Chevron Energy Ventures

Caldwell Bailey
Senior Consultant, IHS Energy

Brad Burke
Managing Director, Rice Alliance for Technology and Entrepreneurship

Jason Blumberg
CEO and Managing Director, Energy Foundry

Melanie Craxton
PhD Candidate, Stanford University

Carol A Dahl
Senior Fellow, Colorado School of Mines

John Daniel
Senior Research Analyst,
Oilfield Services, Simmons

Carlos De Regules
Executive Director, National Agency for Safety, Energy and Environment (ASEA)

Alejandra Elizondo
Research Fellow, CIDE

Martha Goodell
Managing Partner, Enigami Partners LLC

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President, Liberty Oilfield Services

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William W Hogan
Professor of Global Energy Policy, Harvard University

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Chief Energy Economist,
Energy Intelligence Group

Alberto J Lamadrid
Assistant Professor, Lehigh University

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Assistant Professor Energy Economics, The Pennsylvania State University

David Madero
General Director, National Center for the Control of Natural Gas (CENAGAS)

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Will Renegotiating NAFTA Threaten U.S. Natural Gas Exports to Mexico?

By Thomas N. Russo

Thomas Russo is President of Russo on Energy LLC. He may be reached at tnrusso@gmail.com

See footnote at end of text.

Trade between the U.S. and Mexico is one of the great success stories of the world economy. More than $1.25 billion of goods and services cross the border each day per Export.gov. Mexico is second only to Canada in energy trade with the United States. Based on the latest annual data from the U.S. Census Bureau, energy accounted for about 9% of all U.S. exports to Mexico and 3% of all U.S. imports from Mexico in 2016. However, U.S. natural gas exports are a late comer. That all started to change in 2013, when Mexico announced significant energy reforms. Today, the U.S is exporting about 4.1 Bcf/d of natural gas to Mexico valued at $11.7 million per day.[1] U.S. exports to Mexico are expected to double by 2030, driven by rising industrial and power generation demand, and a 50% decline in domestic gas production in Mexico.

With the new Trump Administration threatening to either renegotiate or tear up NAFTA, severe economic and environmental consequences may be in store for both Mexico and the U.S. Without NAFTA, there is a possibility that both the U.S. and Mexico will institute tariffs on cross border natural gas sales and purchases with some as high as 25%. The effect would be a significant reduction of U.S. natural gas exports to Mexico and disrupt what is fast becoming a significant energy supply chain.

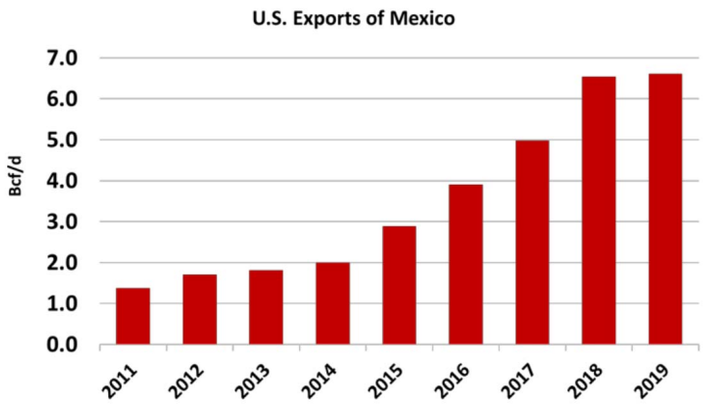

Figure 1. U.S Natural Gas Pipeline Exports to Mexico
Source: U.S. Energy Information Administration

Energy reform in Mexico is already a politically divisive policy. Increasing tariffs on natural gas or a trade war could threaten the reduction of electricity prices and greening of the Mexican power sector promised by the energy reforms. Although nothing has been done so far, the rhetoric of the Trump Administration, which focuses on job losses, U.S. companies moving operations to Mexico, and immigration issues has caused the Mexican government to rethink its dependence on U.S. trade. Mexico has already begun to explore new partners, notably China and India.

Given the uncertainty of what Mexico and the U.S. will do with respect to NAFTA, I speculate on several scenarios that policy makers, investors and energy companies should be considering. I also describe the economic and environmental risks for both governments and companies trying to take advantage of the U.S. Shale Revolution and Natural Gas and Electricity Reforms in Mexico.

WHAT'S AT STAKE

It took 19 years after the North American Free Trade Agreement (NAFTA) took effect on January 1,1994 for Mexico to pass legislation to reform its energy sector in 2013. Much earlier energy deregulation in both the U.S. and Canada had taken place. Thus, NAFTA only served to facilitate and encourage greater trade in natural gas, petroleum, and electricity between the U.S. and Canada, resulting in a well interconnected energy supply chain.

U.S. Natural Gas Infrastructure Investments

With plentiful and relatively inexpensive natural gas from the U.S., Mexico has committed to restructuring its natural gas and power sectors, reducing its electricity costs and greening its power sector. Growing U.S. exports to Mexico by cross border pipelines now average 4.0 Bcf/d (billion cubic feet per day) on February 15, 2017 and may double in the next few years assuming nothing changes. In contrast, U.S. LNG (liquefied natural gas) exports are currently 1.2 Bcf/d, but expected to grow to 3.2 Bcf/d in less than three years.

Natural gas pipeline companies in the U.S. with the support of producers are replumbing the existing natural gas pipeline system to meet Mexican demand for natural gas. The replumbing amounts

to reversing pipeline flows on existing pipelines that have traditionally flowed south from the Gulf of Mexico to markets in the Northeast and Midwest and in some cases the pipelines may be bi-directional. The costs of four of the largest reversal pipeline projects in Figure 2 is about $1 billion.

Now with abundant and inexpensive natural gas from the Marcellus and Utica shales in Pennsylvania, Ohio and West Virginia, the priority is to move Appalachian gas south to Louisiana and Texas and then to Mexico or abroad via LNG vessels. In less than three years, five new interstate natural gas pipeline projects in the U.S. are being developed to deliver up to 8.0 Bcf/d to Mexico. In addition, pipeline companies in Texas are implementing five intrastate and LNG header projects and 6 projects to bring gas to and across the Mexican border. During the same timeframe, 3.2 Bcf/d of new LNG export capacity will be online from the Sabine Pass, Freeport, Corpus Christi in Texas and Cameron, Louisiana by 2018. In addition, five intrastate and LNG header projects, and 6 projects to bring gas to and across the Mexico border are also being developed.

Mexican Natural Gas Infrastructure Investments

Mexico hopes to attain the success and transformation of its natural gas and electric power sectors and the environmental benefits that were realized by the U.S. Abundant and inexpensive natural gas and a restructured U.S. natural gas pipeline system were instrumental in achieving that goal and continue to provide benefits currently. The U.S. Energy Information Administration database showed that inexpensive natural gas displaced 200 million tons of coal annually in U.S. power plants. Largely due to natural gas power burn, U.S. annual carbon dioxide emissions fell by 725 billion tons from 2007 to 2012 according to the Global Carbon Database. The decline was equivalent to total emissions from Germany.

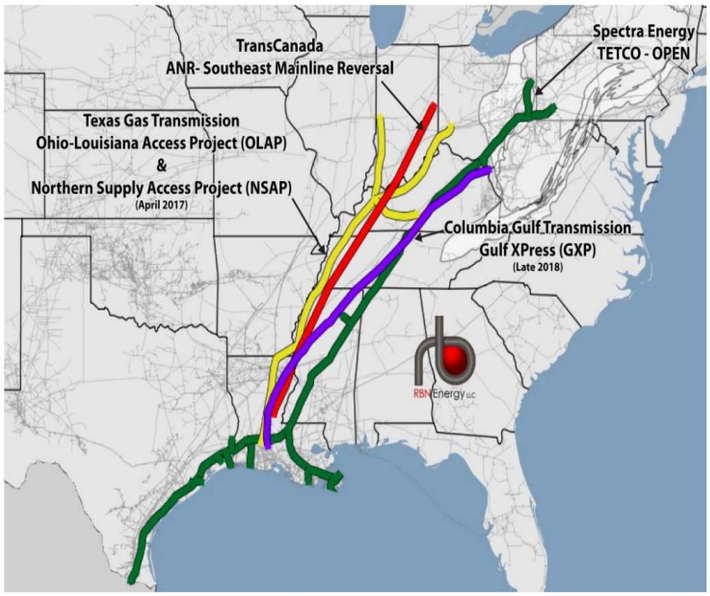

Figure 2. Major Pipeline Reversals bring Marcellus Gas to U.S. Gulf Coast for Export
Source: RBN Energy

Cenagas (Centro Nacional de Control del Gas Natural), Mexico's new and independent natural gas pipeline operator is expanding the natural gas pipeline infrastructure and making improvements to existing gas pipelines to take advantage of the U.S. Shale Revolution. Created in 2014, Cenagas' dual role reflects the restructure U.S. natural gas pipeline industry that occurred in the U.S. in the 1980s under the Federal Energy Regulatory Commission. However, Cenagas not only operates the pipeline and storage systems, but is also a shipper of natural gas.

Cenagas' existing pipeline system is nearly 5,592-miles long and formerly operated by PEMEX (Petróleos Mexicanos). Cenagas' 5-year plan calls for spending $4.6 billion on 12 additional natural gas pipelines and a compressor station. The projects would be operational in 2018 and add 1,926 miles to its pipeline system. By the end of 2017, Mexico's energy ministry expects pipeline supply to account for all natural gas imports as a series of new pipelines start operations and the Los Ramones Phase 2 South reaches full capacity following maintenance work.

Figure 3. Existing and Proposed Natural Gas Pipelines and LNG facilities in Mexico
Source: U.S. Energy Information Administration

Mexican Electricity Investments

Cenagas' natural gas pipeline investments are modest when compared to those planned to modernize Mexico's electric sector. On August 11, 2014, Mexico's current President Enrique Peña Nieto signed additional legislation opening both the oil, gas and

electricity sectors to private investment. Mexico's demand for gas has been rising primarily, because of an ongoing effort by the state-owned Comisión Federal de Electricidad (CFE) to expand and modernize its power generation fleet by building thousands of MW of new, gas-fired combined-cycle power plants. Virtually these new power plants need new gas supply, with most of it planned to come from the U.S. via new natural gas pipelines.

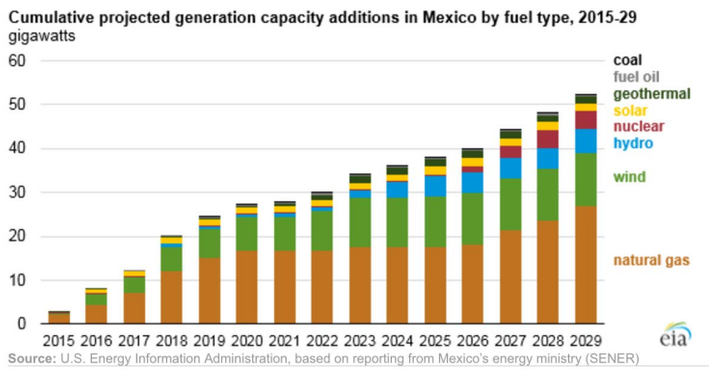

Figure 4. Natural gas-fired power plants lead electric capacity additions in Mexico

Source: U.S. Energy Information Administration and SENER (Secretaría de Energía de México)

Mexico wants to increase its electric capacity from 68,044 MW (megawatt) in 2015 to 109,367 MW in 2030 or by buy 61%. This will require an investment of over $131.6 billion. The 41,323 MW needed to reach the total capacity of 109,367 MW means that more than 40 power plants with 900 MW capacity will need to be built. Many of these the power plants will be gas-fired combined cycle plants and which will be heavily dependent o Parag.Nathaney@icf.com n a well-integrated natural gas pipeline system that can reliably deliver natural gas at a competitive price.

Current Mexican electric power generation is high cost, with large concentration of fuel oil- and diesel-fired power plants, followed by coal, nuclear and offset by low-cost hydropower. Gas fired power generation made up 54% of Mexico's power generating portfolio in 2015. SENER (Secretaría de Energía de México) estimates that more than 60% of Mexico's electric capacity additions will come from combined-cycle gas turbine (CCGT) generation between 2016 and 2020. Plans to gradually retire inefficient oil and diesel-fired power plants should provide downward pressure on electricity rates and improve air quality as well.

SCENARIO AND OUTCOMES

This section looks at a few scenarios that could affect the U.S. natural gas exports to Mexico:

1. NAFTA renegotiations fail,
2. The U.S. withdraws from NAFTA,
3. Imposition of tariffs by Mexico and the U.S.
4. U.S. immigration bans result in increased deportation of Mexican citizens,
5. Inflammatory rhetoric by the Administration increases (Mexico will pay for the Wall),
6. Growing populist sentiment in Mexico and the election of [name the guy] in Mexico's 2018 presidential election

Outcome 1- The big winner here could be Canada

NAFTA's Article 2205 states that a party may withdraw from the agreement six months after it provides written notice. Article 2205 also states that withdrawal of one [party] *does not affect the remaining two countries*. Hence, if the U.S. withdrew from NAFTA then Mexico and Canada would be free to carry on trade without the U.S.

Canada has abundant natural gas production and it may find itself in an enviable position if it could export natural gas into Mexico. Fortunately, the interconnected 305,000+-mile natural gas pipeline system in North American may enable Canadian producers to reach Mexican markets via flowing the gas and/or by displacement (backhaul). The latter is due to the fungibility of natural gas, since Canadian molecules are indistinguishable from U.S. molecules and meet natural gas industry standards of 1,032 Btu per cubic feet. How the U.S. Customs and Border Patrol would view such trade is another matter. The U.S. may impose a tariff on such natural gas entering Mexico if they don't recognize the transaction as originating in Canada and transporting Canadian natural gas.

Some free trade analysts believe also that if the U.S. withdraws from NAFTA then the former Fair Trade Agreement (FTB) between the U.S. and Canada would automatically be resurrected. That is debatable but a possibility, because the FTB fell into disuse when NAFTA was signed.

Other beneficiaries of the failure to successfully renegotiate NAFTA or a break down in trade between the U.S. and Mexico could be LNG exporters from Peru, Nigeria and Trinidad and Tobago. Mexico has two LNG Import Terminals that have received major cargos in the last two years—Manzanillo on the Pacific coast and Altamira on the Gulf coast. Manzanillo is Mexico's most active LNG terminal, receiving cargoes

from Peru under a long-term contract with Mexican state-owned utility CFE. Although LNG imports into Mexico have declined in the last two years as cross border pipeline projects like NET Mexico could source gas from South Texas, a decline in pipeline imports from the U.S. or Canada could be bullish for LNG exports to Mexico from other countries, even though LNG is more expensive.

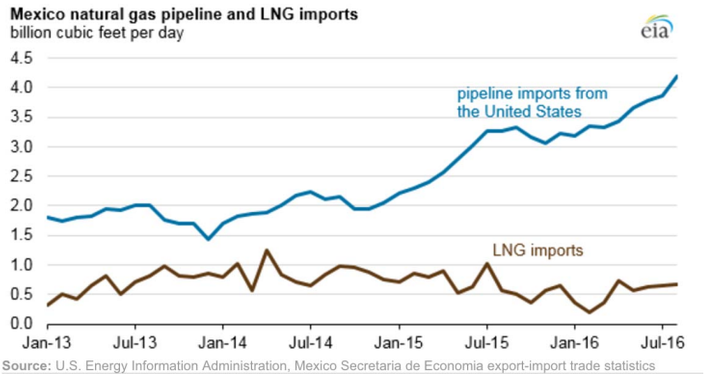

Figure 5. Pipeline Imports from the U.S. displacing LNG imports to Mexico

Outcome 2- Mexico decides to develop its own shale gas resources

Mexico's growing dependence on the U.S. for natural gas is tied in part to challenges that Petróleos Mexicanos (Pemex), Mexico's state-owned oil and gas company, has faced in maintaining its own production levels. Mexico has vast potential gas production in the Burgos shale region in northeastern Mexico (just south of Texas' Eagle Ford). Any development of these shales would require Mexico to invest in natural gas processing plants and natural gas liquids (NGL) facilities and pipeline take away capacity. The government could also emphasize foreign investment in shale gas production, and downstream gas processing and NGL facilities.

This outcome is even more likely if populist Andres Manuel Lopez Obrador is elected president in the 2018 Mexican elections. Often referred to as AMLO, he has twice run for Mexico's presidency, losing narrowly in 2006 and again by 6 points to Peña Nieto in 2012 — and he's set to run again in 2018. AMLO has railed against Mexican energy reforms, the most polarizing of which opened the country's oil industry to private investment. Even if a pro energy reform President is elected, populist feelings in Mexico and national honor, may force Mexican leaders to look closely at becoming self-sufficient in natural gas production rather than relying on less expensive U.S. natural gas.

Outcome 3- Mexican Electricity Reform Efforts could be much more expensive.

Mexico's plan to build gas-fired power generating plants would be faced with the prospect of higher cost natural gas. In the absence of U.S. natural gas transported via pipeline, the make-up gas would have to come from Canada via the U.S. natural gas pipeline system and/or LNG imports. Fortunately, Mexico has two LNG Import Terminals that have received major cargos in the last two years—Manzanillo on the Pacific coast and Altamira on the Gulf coast. However, landing prices of LNG at Altamira LNG Import Terminal in December 2016 were nearly three times the average South Texas Regional Daily Price Index Price of $2.79/MMBtu (see footnote 2 and Figure 3 and comparable at Manzanilla.)

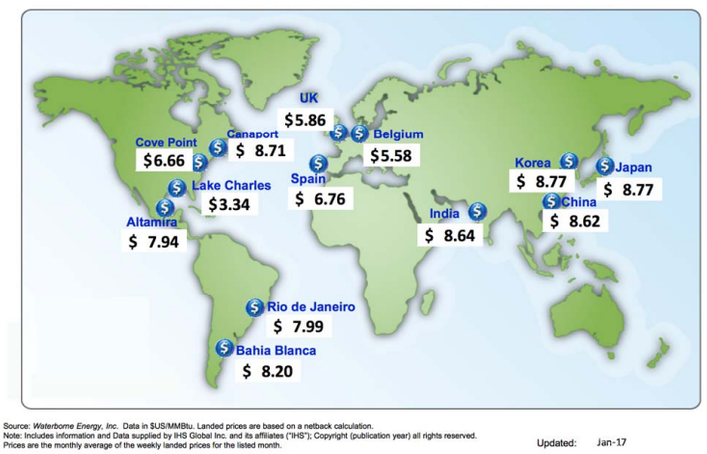

Figure 6. Selected World Liquefied Natural Gas Landed Prices for December 2016
Source: FERC and Waterborne Energy Inc.

Mexico's energy reforms are considered by many to be too expensive and have suffered recent setbacks when the price of gasoline increased. If Mexico and the U.S. exempt natural gas trade from any renegotiation, then the electricity reforms will in time reflect decreased electricity costs. However, Mexico may decide not to go forward with some gas-fired power generation if renegotiation of the NAFTA does not result in abundant U.S. natural gas supplies at prices comparable to South Texas regional prices. As we mentioned in Outcome 1, if Canada can successfully flow gas through the U.S. pipeline system at lower prices than LNG, then this could mitigate the higher LNG prices at Altamira and Manzanilla.

Outcome 4- The Environment may be the biggest loser.

In response to higher natural gas prices, Mexico will continue and most likely extend the economic life of the existing oil-fired and coal-fired power generation fleet. This will result in increased use of fuel oil and coal, at the expense of clean air quality afforded by burning natural gas. Hence, Mexico's

electric power sector not attain the air quality benefits realized by the U.S. Shale Gas Revolution nor use natural gas as a "bridge fuel." Even if Mexico installs more renewable energy, it will have to rely on some gas-fired power generation to follow electric load and any installed wind and solar power generation. However, gas-fired power generation may not be needed it utility-scale electric storage projects gain traction and become a mainstream technology in areas like California.

Outcome 5- The success of natural gas pipeline investments will depend largely on LNG exports to recoup costs.

If U.S. natural gas pipeline flows into Mexico are reduced, because of tariffs imposed by either Mexico or the U.S., then those investments will have to rely solely on increased LNG exports to balance natural gas supply. Failing that, U.S. natural gas producers may constrain production to balance the market. Most of the interstate pipeline reversals can probably whether the storm, however, if gas does not flow to Mexico through the numerous cross border pipelines and intrastate pipelines, those investments may be unprofitable and stranded.

Footnote

[1] 4.2 Bcf/d of natural gas valued at $2.79/MMBtu at Natural Gas Intelligence South Texas Regional Daily Price Index Price on February 15, 2017.

Hastings (continued from page 9)

References

Baker III, James, Martin Feldstein, Ted Halstead, N. Gregory Mankiw, Henry M. Paulson, Jr., George P. Schultz, Thomas Stephenson, and Rob Walton. 2017. The Conservative Case for Carbon Dividends.

Business Council for Sustainable Energy. 2017. 2017 Sustainable Energy in America Factbook.

Cusick, Daniel. 2016. "Perry oversaw a Texas wind miracle – but did he lead it?" Climatewire, December 14.

Department of Energy. 2016. "Building Codes Energy Program." Last modified November 16, 2016. https://www.energycodes.gov/adoption/states/texas.

Dyer, R.A. 2016. Deregulated Electricity in Texas. http://tcaptx.com/wp-content/uploads/2015/02/TCP-793-Deregulation2014-A-1.18.pdf

Hastings, Marilu. 2016. "Clean Energy and the Irony of the Red State of Texas." Houston Chronicle, October 19.

Hastings, Marilu. 2016. "Where could Trump find an example of a GOP-led clean energy plan? Texas." Dallas Morning News, December 9.

Hastings, Marilu. 2017. "Rick Perry's DOE Could Lead on Clean Power." U.S. News & World Report, January 19.

Rudich, Ryan, Phil Comella and Ann Zwick. 2016. "How President-Elect Trump's Environmental Policy Might Shift to Environmental Protection Responsibility to States and Citizens." Environmental Law Next, November 17.

Shavel, Ira, Yingxia Yang, Roger Lueken, Andrew O'Brien, and Colin McIntyre. 2016. Exploring Natural Gas and Renewbles in ERCOT, Part IV, May 17.

Shavel, Ira, Yingxia Yang, Roger Lueken, and Colin McIntyre. 2016. Reliability Risks Due to Coal Retirement at ERCOT, December 7.

Snider, Annie. 2017. "Five Things Pruitt Can Do to Cripple EPA." Politico, February 17. Accessed February 17, 2017. http://www.politico.com/story/2017/02/scott-pruitt-epa-reshape-235156.

SPEER staff. August 2014. Energy Efficiency as a Resource in Texas.

Temple, James. 2017. What's at Stake as Trump Takes Aim at Energy Research." MIT Technology Review, January 31.

Real Time Pricing and Market Power: A New Zealand Case Study

By Stephen Poletti

INTRODUCTION

There are a number of features of electricity markets which make them quite different to most other markets. Electricity cannot be stored, or at least it is uneconomic to store significant amounts of electricity. Thus supply must equal demand instantaneously. Too much or too little supply may lead to rolling blackouts or even system collapse. Many customers cannot be billed for time of use consumption (meter reads monthly or more). As a result there is very little demand response. Wholesale prices typically vary over the course of a day by 100% or more, with price spikes of 10 or even 100 times the average price not uncommon.

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Many economists have argued that electricity markets would work better if customers were charged the real time price for electricity. The advantages of real time pricing cited include more elastic demand which may lead to a reduction in market power. It is also argued that customers will reduce consumption, when demand is high and electricity expensive to produce, and consume more during the off peak. This in turn should lead to higher effective capacity utilisation and a more efficient market.

As well as inelastic demand electricity markets have a hard constraint on supply once all generations are producing at full capacity. This means that supply is inelastic above total generation capacity. The combination of inelastic supply and demand can cause market porker issues for electricity markets. For example Borenstein (2002) concludes his analysis of California's power crisis failure:

> "....Electricity Markets have proven to be more difficult to restructure than many other markets that served as models for deregulation --- including airlines, trucking, natural gas and oil --- due to the unusual combination of extremely inelastic supply and extremely inelastic demand. Real-time pricing and long-term contracting can help to control the soaring wholesale prices recently seen in California (p210)."

Whilst there is general agreement that more customers on real time pricing contracts is desirable there has been surprising little theoretical work investigating the quantitative gains that might be expected. A key paper that does do this is Borenstein and Holland (2005). They model the electricity market as competitive and argue that "increasing the share of customers on RTP is likely to improve efficiency, although surprisingly it does not necessarily reduce capacity investment, and is likely to harm customers already on RTP...Efficiency gains from RTP are potentially quite significant".

Our intention here is to extend the work of Borenstein and Holland (2005) to a setting with market power. As will be seen we make quite different assumptions about the retail market and the shape of the demand functions in our quantitative analysis which leads to quite different results even in a setting with perfectly competitive markets.

MARKET MODEL

We consider here an Energy Only market with wholesale firms offering capacity into the spot market at a specified price with retail companies buying from the spot market and on-selling to their customers.

A fraction β of customers are on RTP contracts with their retail company and face a time varying price p_t, with the rest paying a fixed price p which doesn't vary with their time of consumption. We will assume there are T time periods with different demand realisations specified from lowest to highest demand. Demand in each period is $D_t(p,p_t) = \beta D_t(p_t) + (1-\beta) D_t(p)$. Power companies have access to different types of technologies and will build and run new capacity according to the merit order. Retail competition is modelled as perfectly competitive, however the retail companies can charge a fixed fee to customers. In equilibrium they charge a fixed fee to their customers paying the fixed price only. For customers on RTP contracts the retail firm just passes through the spot-market price.

The wholesale market is modelled using a Cournot approach. There are N firms which have access to different types of technologies – they will build and run new capacity according to the merit order. For linear demand functions Poletti and Wright (2016) solve for the prices and find that as the fraction of customers on RTP plans increases off-peak prices tend to increase and peak prices decrease.

NEW ZEALAND MARKET SIMULATION

We will consider a simple stylised version of the NZ electricity market with three types of plants baseload, mid merit and peakers. Capital and running costs for both hydro and geothermal are similar and hydro does play a significant role as baseload generation, however, here we choose geothermal plants as the baseload technology as capacity factors are over 90%. Although much of New Zealand's generation is hydro it plays a complex role in the market. A significant amount of hydro always bids into the spot market at a price of zero due to run of river generation or minimum flow rates below the hydro dams, however it also plays a role as mid merit and peaker plants due to its flexible ramp rates and limited storage capacity of the storage lakes. Table 1 shows the data for overnight costs, capacity factors, variable costs and calculated fixed costs assuming a 35 year payback and a real interest rate of 5%. The break-even prices p_t^* are also listed in the table. These are the prices which would allow all the generators to just cover their fixed and variable costs.

In our stylised model we make the assumption that there are only three periods with the marginal technology as demand increases from period one being geothermal, CCGT and peakers. Under these assumptions f_1=0.32, f_2=0.48 and f_3=0.2. Demand is ranked for each period between 2004-2014, from highest to lowest and we specify that the demand in period one is the average demand for the lowest 32 per cent of demand periods and so on for the other periods.

Technologyy	OC($/kw)	FC($/MWh)	VC($/MWh)	cf	pt*
Geothermal	5200	35	10	0.9	-1
CCGT	1800	12	50	0.68	50
Peaker	1250	12	70	0.2	114

Table 1: Generator information

To make further progress for our quantitative analysis we need to estimate the linear demand parameters. We will use empirical elasticity estimates and the known demand for the recent study of the South Australian electricity market Fan and Hyndman (2011) estimates the demand elasticity ε (that is the elasticity of demand with respect to the average price) to be approximately -0.3. Our reading of the literature is that most empirical estimates lie between --0.2>ε >-0.4 so a choice of ε=-0.3 seems reasonable.

The other parameter that we need to estimate is β. There is little information on this except that nearly all commercial and household customers pay a fixed price. Accurate information for the New Zealand market is not available -indeed the Wolak report which investigated the extent of market power had the relevant data reduced in the publicly available version of the report. Our reading of the literature is that β =0.2 is a reasonable value to assume which is what we use in the analysis.

Average net demand for period 1 is 2807 MW, for period 2 it is 3887 MW and for period 3 it is 4659MW with average demand of 3696MW. Using the estimates for the elasticity and the fraction of customers paying the spot price gives the following demand functions.

$$D_3=6000-16$$
$$D_2=5000-16p$$
$$D_1=3800-16p$$

Figure 1 shows the estimated prices and how they change as β increases. The peak price computed for our estimated value of β is about $50 higher than the observed price of $154, the mid-period price estimate is about $35 too high, with the off-peak price estimate about $25 too low. The Cournot model here in, common with many Cournot models of electricity markets tends to predict more market power than actually observed. This due a couple of factors. The first is that firms in general bid in supply functions in the market due to demand uncertainty which increases the effective residual supply elasticity faced by each firm and hence its ability to exercise market power. The other factor is that, in the New Zealand context, the big firms are all vertically integrated which reduces their incentive to exercise market power even though biggest firms are net sellers on the spot market}

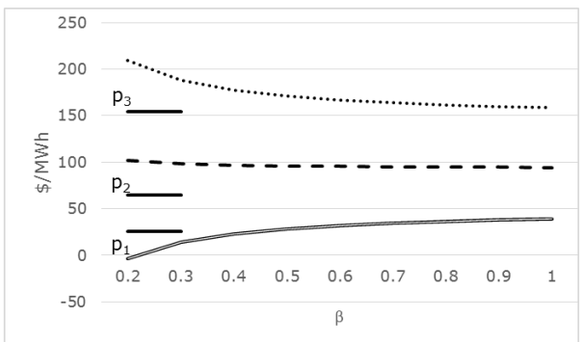

Figure 1. Estimated prices as a function of β. The solid lines are the observed prices.

One interesting feature is the way that the mark-ups differ as β increases. The peak price decreases and the off-peak price increases, with p_2 decreasing slowly. The fixed price stays the same and is approximately $90/MWh. As β increases the capacity mix changes with less need for mid merit and peak capacity and much more baseload which is one of the key reasons why real

time pricing is advocated. Overall less capacity is needed which contributes to the efficiency gains as customers switch to RTP.

Table 2 shows how revenue, profits, consumer surplus (CS), social welfare (SW), total costs (TC) and social welfare for a competitive market (SW*) change as β increases The increase in social welfare, as β increases from 0.2 to 1, in a setting with market power is about 20% higher than the increase in social welfare for a competitive market. However, the increase in social welfare looks to be less than that reported by Borenstein and Holland (2005). They do not report increases in social welfare directly, instead reporting on change in total surplus (social welfare) as a fraction of revenue. By this measure our calculations (not reported in the table) show, for the competitive market, an increase in the change in total surplus (social welfare) as a fraction of revenue of 4.1 per cent going from β=0 to β=1which compares to the figure of 8.8 per cent reported by Borenstein and Holland (2005) for constant elasticity demand functions with ε=-0.3.

β	% Change Revenue	% Change Profits	% Change in CS	% Change in SW	% Change in TC	% Change SW*	% Change in TC
0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.4	-4.9	-8.7	5.1	0.8	-2.4	0.5	-2.4
0.6	-7.2	-11.6	7.2	1.4	-4.7	1.0	-4.7
0.8	-8.9	-12.9	8.5	1.9	-7.1	1.5	-7.1
1.0	-10.3	-13.4	9.5	2.4	-9.5	2.0	-9.5

Table 2: Simulated market outcomes of customers switching to RTP

There are a two possible reasons for the different results. The first is that Borenstein and Holland use linear pricing whereas we assume that traditional customers are on a two-part tariff. The second is that the demand functions assumed here are linear. The constant elasticity demand functions used by Borenstein and Holland do not seem realistic for high prices as the consumer surplus is infinite, which is why they report only changes in consumer surplus. It may well be that the unrealistic shape of the demand function for extremely high prices may lead to an over estimate of the consumer surplus and in turn an over estimate of the change in consumer surplus as β increases.

Turning to table 2 it can be seen that the percentage change in profits and consumer surplus are significantly higher than the overall change in social welfare as β increases. Profits decrease by -13.4 per cent with consumer surplus increasing by 9.5 per cent. Whilst the overall increase in social welfare is relatively modest the gain to customers is considerable. Hence one of the key findings of our investigation is that encouraging or mandating a movement from traditional flat rates to real time pricing may have a significant role to play as a policy to increase competition. The large drop in profits seen also suggests that firms may not encourage such a shift. The other noteworthy finding which can be seen in the table is the large decrease of almost 10 per cent in system costs (which includes equilibrium investment and running costs). As β increases the demand profile over the day is flatter which leads to higher average capacity factors and lower system costs. Overall market revenue also falls significantly. The other pattern that emerges from the table is that the increases in consumer surplus, system efficiency and social welfare are relatively higher for initial increases in β which agrees with the results presented in Borenstein and Holland (2005).

References

Borenstein, S. (2002). The trouble with electricity markets: understanding California's restructuring disaster. The Journal of Economic Perspectives, 16(1), 191-211.

Borenstein, S. and S. Holland (2005) `On the efficiency of competitive electricity markets with time-invariant retail prices,' RAND Journal of Economics, 36(3), pp. 469-494.

Fan, S. and R.J. Hyndman (2011) ``The price elasticity of electricity demand in South Australia," Energy Policy, 39(6), pp.3709-3719.

Joskow, Paul, and Jean Tirole. "Reliability and competitive electricity markets." The Rand Journal of Economics 38.1 (2007): 60-84.

Poletti, S. and Wright, J. (2016) Real Time Pricing and Imperfect Competition in Electricity Markets, University of Auckland working paper

Summary 6 ELAEE Conference in Rio de Janeiro

After almost 10 years and 5 editions, the Latin American Association of Energy Economics conference returned to Brazil, the country that gave rise to this successful initiative of the International Association of Energy Economics, and allowed the integration of this region into the international discussion of strategic energy issues.

From the first conference in the magical city of San Salvador de Bahia (Brazil), passing through Santiago (Chile), Buenos Aires (Argentina), Montevideo (Uruguay), and Medellin (Colombia), the wonderful city of Rio de Janeiro received delegates with the challenge of addressing the issue of "New Energy Landscapes: the Challenges for Latin America."

During almost three full days, 11 plenary sessions, 36 parallel sessions, almost 150 papers presented, more than 300 abstracts and an attendance of approximately 250 delegates, the Conference was a demonstration of the great dynamic that the energy economy has acquired in Latin America, with high-level exhibitions and an outstanding participation of professors and specialists from around the world.

From the opening session, the topics related to the transition the energy sector is going through. The discussions and analysis of the participants, showed the challenge of the times. Something new is emerging in the energy markets and we are forced to change the methods of classical thinking.

Regulation must find new ways that include emerging technologies and changes in the business models of energy companies, in an unstoppable and inevitable process. This creates new opportunities for the countries of Latin America, which is a region where natural resources abound and the level of development of new technologies is incipient. The challenge is to find specific answers to the new problems that arise to meet the commitments made at the Paris Conference of the Parties in 2015 (NDC) in which the energy sector plays the leading role.

Two plenary sessions following the opening were dedicated to analyzing the new scenarios in the oil and electric sectors, respectively. In the session dedicated to the oil industry Clarissa Lins, a consultant of the Brazilian Petroleum Institute (IBP), said: "This century's energy landscape will inevitably be a patchwork of renewables and hydrocarbons. Such realism is crucial to achieving an effective and efficient energy transition". Ben van Beurden, CEO Shell, atated "our industry's response to those challenges relies on the understanding of the long term energy transition that has already started." "More than ever, our industry needs to adapt to meet those changing energy needs." was the statement from Bob Dudley, BP CEO.

The commitments assumed by Brazil consist of reducing GHG emissions 37% by 2025; subsequently reducing GHG emissions 43% by 2030, both in comparison to 2005. It should reach a) a share of 45% renewable energy in the energy matrix by 2030; b) increase the participation of bioenergy to 18%; c) Expand the use of non hydro renewables to 28%-33%; d) obtain at least 66% of hydroelectricity in the electric matrix in 2030; e) increase the use of non hydro renewables in the electricity matrix by 23% through the growth of wind, biomass and solar, and f) achieve 10% efficiency gains in the electric sector by 2030.

The oil industry has become aware of the need to achieve sustainable growth and fulfill the commitments of economic development with low CO_2 emissions. This was clearly stated in the presentations by the speakers of BP and Shell in Brazil. Their projections of penetration of electricity from non-renewable resources into end-uses may be surprising. For example, Shell, in its 2100s outlook, is seeing penetration of nearly 75% of electric vehicles, almost 100% in railways, leaving the air transport and ship market still reserved to oil products. It is very clear that the major concern of the oil industry in the new energy scenario is the speed and depth of the penetration of electricity produced by renewable resources and reduced CO2 emissions in markets that are currently captive to their products' tankers, in particular the transport and the production of thermal electricity.

The new energy scenario seen from the electrical industry presents less doubts about the progress of low-carbon electrification because it is already dealing with the imperfections that this produces in the markets, In particular the European Union already finds very clear limits that were exposed in brilliant form by three scholars recognized by the clarity of their thoughts. Jean Michel Glachant, Director Florence School of Regulation, European University Institute (Florence, Italy), asks the following questions for which there is currently no single answer: 1) How to get coherent rules for seamless power operation when both markets and systems cross borders of countries having separate national authorities (either regulators NRAs; or system operators TSOs)?; 2) How to get a multi-country energy transition path followed when all key policy makers are national?; and 3) What happens when new technologies (as PV & batteries) enable consumers to exit grid regulation?.

Renewable energies, storage technology and their impact on the new energy scenario were also mentioned by Professor Richard Green of Imperial College London, raising very strong warnings as market developments pose challenges to generators with renewable energies, analyzed in the United Kingdom because: a) "Thermal-Renewable" market will have volatile prices from hour to hour, and renewable generators will tend to receive prices below the time-weighted average; b) "Hydro-Renewable" market will have stable prices from hour to hour, but volatile prices from year to year; c) Renewable generators will still receive prices below the long-term time-weighted average.

In his keynote address closing the Conference, Professor Jacques Percebois, Director of the Center de Recherche de

l'Economie, Droite de l'Energie et des Ressources Naturels (CREDEN), University of Montpellier, indicated that there are increasing disparities in energy and electricity balances throughout the world and even in Europe, because factor endowments are different (countries with large reserves of fossil fuels, others without natural resources) and because the choices are divergent, (maintaining coal for some, leaving nuclear for others); there is a relative convergence of gas prices within EU countries (including at the level of the final consumer) as the supply conditions in the international market are close. On the other hand, there is no convergence in prices for the end-user of electricity (even though we observe a relative convergence of wholesale prices); there is a consensus in Europe to give priority to "low carbon" energy (renewable and/or nuclear, including gas, the least carbon fossil energy), but the CO_2 market price is too low (5 to 8 euros, a high carbon price is a necessity). Some operators like Total or Engie have already introduced a "notional price" (shadow price) for carbon (20 to 30 euros/tCO_2?) when they have to select investments, anticipating high prices in the near future. In the long term the coexistence of large interconnected transnational networks and small local networks for electricity should be corrdinated (the difficulty is the coordination of the two types of networks and the reform of the access pricing of these networks).

With this the lessons for Latin America are the following: on the wholesale electricity market, public intervention engenders distortions that often have perverse effects (as in the case of guaranteed prices on the wholesale price of electricity); in the carbon market, it is better to have an objective in the form of a "price corridor" rather than a "quota target". Interventions of the "open market type" must be made as soon as the price falls below a threshold price (floor price) or exceeds a certain threshold (ceiling price). The social optimum is a high "carbon tax". Marginal cost pricing no longer works in the wholesale electricity market when the share of renewables with zero variable cost exceeds a certain threshold and the pricing of electricity networks must be reviewed if self-generation of solar energy is developed because otherwise fixed costs can no longer be financed.

The regional impacts of the energy transition at the international level were deeply discussed during the Conference. José Gutman, Director of the National Petroleum Agency of Brazil (ANP), raised the country's vision regarding the changes that are occurring in E & P activities of the oil industry, indicating that Brazil is in a good position to continue receiving investments in its deepwater reservoirs. The changes that have occurred in the last two years contribute to making investments more attractive, which should be reflected in the exploration tenders in progress this year and in 2019, resuming the development of Pre Salt, which is becoming more and more prominent on the Brazilian scenario.

On the other hand, the Undersecretary of Strategic Planning of Argentina, Mauricio Roitman, presented the country's Energy Scenarios projected to 2025, indicating that it is strategic for his country to develop the non-conventional gas fields in the basin of Vaca Muerta and in that way reduce the country's vulnerability to LNG imports, as well as achieve electricity production equivalent to 20% of consumption in 2025 with non-conventional renewable energy sources (ERNC).

The next few years will require much intellectual input to solve the problems of the energy transition, which in Uruguay acquired a fast pace with the incorporation of more than 1,000 MW of wind energy, and an important contribution of biomass and hydraulics, enabling this country to produce fully renewable electricity for many days in the year. The president of the electricity company of Uruguay (UTE), Gonzalo Casaravilla, highlighted the imperfection of markets and the difficulties in adapting to the new paradigms: incorporation of ERNC and smart grids; planning, guaranteeing investments and controlling them. Avoiding the abuse of dominant positions is a responsibility that cannot be left exclusively to the market.

We should think about this in two stages: a) the transition and b) the mid to long term; nobody can tell what the future wll look like 35 years ahead. Scenario planning is a good tool for thinking about possible futures, incumbents. Most likely a combination of utility models, initially much more competition and smaller sized (utilities will lose market). The industry will look different from what it looks like today, according to Isaac Dyner of the Universidad Jorge Tadeo Lozano de Colombia.

The trends related with the power markets evolution are the rising of flexibility and complexity, the next big thing in the power market will be driven by a massive introduction of new technologies in a traditional, regulated and conservative sector. Those changes will deeply impact the value chain of the industry and its supply chain. Pedro de Oliveira Jatoba of Eletrobras asks: Who will be the tech leaders of this revolutions? Are the Latin American Countries prepared for this? These questions take on their full dimension when coming from Eletrobras: the largest company of the electric power sector in Latin America, the cleanest in the electricity generation business. It operates in generation, distribution, transmission and commercialization through fifteen subsidiaries. The largest shareholder of the company is the federal government of Brazil, has shares traded in the stock exchanges of São Paulo, Madrid and New York and is the holder of 50% of the capital stock of Itaipu Binacional, the second largest hydropower plant in the world.

The plenary sessions dealing with the issue of energy transition and climate change focused on a specific feature in Latin America, which has an abundant supply of natural water, wind and solar resources that would enable the energy sector to reduce its GHG emissions, and at the same time promote the development of sectors of industry hitherto with very little relative weight in the regional economic structure. Professor Emilio Lebre La Rovere explained the task developed by The Research and Modeling Team, coordinated by CentroClima at the Institute of Post-graduate Studies and Research in Engineering (COPPE) at the Federal University of Rio de Janeiro (UFRJ). It was responsible for processing the selected mitigation measures and input data in mathematical models and analyzing the implications for the Brazilian economy,

and found that even in a scenario of high economic growth it is possible to reduce emissions considerably by 2030, thanks to the reduction witnessed in the emissions/GDP ratio.

The penetration of new forms of non-conventional renewable energy is a key development factor in all the countries of the region, which generates employment and at the same time allows taking advantage of the availability of important sources of natural resources. The key factor for its full use is the possibility of financing production facilities and transport infrastructure, in this sense the action of national development banks has been decisive. The Brazilian National Development Bank (BNDES) has granted credits on the order of US $ 60 trillion, especially for the construction of hydroelectric and wind power plants, in projects with total investments of US $ 100 trillion between 2003 and 2016. it has decided not to continue financing projects related to coal and diesel oil, and focus its actions in the auctions for the production of electricity with renewable sources, and in the associated transmission and distribution systems.

The Latin American Development Bank (CAF, by its old name: Corporación Andina de Fomento), confirmed what was mentioned throughout the Conference, that the main challenge today is that over 30 million people in Latin American lack access to electrical services. A clear link exists between poverty and energy and a direct relationship, not incorporated in public policy vision, is that energy poverty is a rural issue: for the most part, Latin Americans who lack access to electricity live in rural (isolated) areas. But urban poverty does not get a hall pass. Issues related to illegal land occupation and clandestine connections endanger people as well as the sustainability of the service.

LAC s has a big investment potential: some countries such as Peru, Chile and Brazil have promoted new legal frameworks to improve investment conditions, including Public-Private Partnerships (PPPs) Today in PPPs, both the private and public sectors are involved in all stages of a project. As governments take more risk in developments with high investment costs and low economic returns, the private sector feels more enticed to participate.

So far LAC has performed well in satisfying its population's energy needs. Nonetheless, investments are needed and must be intensified, especially in electricity, natural gas and oil refineries. Energy demand has grown and thus the requirements to reduce the impact of resource usage. The constant search for new sources and an increase in energy efficiency are key elements for the sustainable development of LAC's energy sector. Cooperation amongst different actors and institutions is fundamental to overcome the new challenges that lie ahead.

The Conference was closed by IAEE authorities, current President Ricardo Raineri, and the last President Gurkan Komburoglu. Both were gratified by the success of the conference and celebrated the 40th anniversary of IAEE. Ricardo Raineri remarked on the way ahead in the following subjects: energy security remains at the center of the energy agenda: Now and in the future we are going to be in the presence of increasing competition to secure the control on key energy sources.

Renewables are and will continue toplay an increasing role in the energy matrix, they are becoming increasingly competitive with traditional energy sources which might be forced into being a stranded asset. The main challenges will be the path of institutions and business environments, the response of the civil society and the environment and the threat of climate change.

At the end of the conference, the ALADEE authorities thanked IAEE for the permanent support and the effort it makes to maintain the flame of knowledge in the field of energy economy in this part of the planet, and announced the accomplishment of 7ELAEE in 2019, in one of the following cities to be selected in the course of this year: Buenos Aires, Montevideo,Santiago de Chile.

Gerardo Rabinovich

What Lies Beneath the Shifting Politics: Implications of U.S. Energy Policy on Global Energy Markets

By Julie Carey and Maggie Shober

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See footnotes at end of text.

The domestic and global energy industry is inextricably linked to political and regulatory systems that collectively implement government objectives for the energy industry, including economic incentives for investment and regulatory oversight. The recent U.S. election highlighted the importance of energy policy and now there is an anticipated shift away from the Obama Administration's clean energy policy agenda toward a pro-fossil fuel policy focus under the Trump Administration. This article investigates the influence of energy policies on the U.S. and global energy industry.

Important considerations for the impact of shifting policies include the various levers of policy and regulatory oversight that exist on the federal and state levels that direct the energy industry. While the Federal government regulators implement Presidential Administrative policies, state policy makers and regulators have a substantial role as a considerable amount of energy regulatory activity occurs at the state level. State goals vary widely, and can be in conflict with Federal goals.

In addition, market forces are at work in both the shale oil and gas revolution and the development of renewable energy that factor into the overall impact of any shifts in energy policies. The U.S. is flush with economic oil and gas resources that have observed substantial growth and development over nearly a decade. These resources provide strong contributions to the economy during their development and for ongoing operational jobs. U.S. oil and gas is increasingly important to global energy markets.

On the renewable side, the heightened focus on clean energy initiatives over the past 10 years has been spurred by a combination of Federal and State regulations. These policies have combined with technological advances to drive substantial cost reductions in renewable energy products that now put renewable energy in a more advantageous economic position than ever before.

Importantly, considerations of the market impacts from oil and gas and renewables is required to evaluate the impact of a policy shift by the new administration and Congress. Additionally, the benefits from a diversified portfolio of energy resources to meet our nation's energy needs, economic (i.e., jobs), environmental, and other policy goals should all be considered in concert when developing and advancing energy policy measures.

RENEWABLE ENERGY

Recent compounding forces have led to strong growth in both solar and wind energy. Chief among these are technological improvements and steep declines in equipment costs, in addition to cost assistance provided by state and federal policies. The average cost of a utility-scale solar power plant dropped by 12% in 2015 alone.[1] Wind has seen similar trends of declining costs and improving capacity factors.[2] Future improvements are generally expected. In addition to dropping costs, advances in the technologies and design of systems have increased the performance of solar projects. Solar capacity factors of projects installed in 2014 increased from 21% to 26.7% from new projects installed in 2010.[3] Demand for renewables can arise from state policies, most commonly Renewable Portfolio Standards (RPS) that require utilities to obtain an increasing proportion of electricity from renewable sources, as well as customer demands including corporate renewable or sustainability policies leading to purchasing renewable power as well as residential roof top solar demand. Energy efficiency (i.e., targeted goals to reduce energy consumption) has seen similar trends and policies as well. The U.S. increased reliance on renewable energy is not unique. Developed and developing countries across the globe are seeing surges in renewable installations.

Despite growing interest and reliance on renewable energy in the U.S. and abroad, the new Presidential Administration and Congress are expected to shift federal policies away from additional support to the renewable energy industry towards support for fossil fuel. While the energy industry generally believes existing tax credits for wind and solar will not be repealed by the new Congress, most of the energy industry anticipates they will not be extended beyond their current sunset date. The Clean Power Plan (CPP), a regulation on CO_2 from power plants promulgated by the Obama EPA, would have created an advantage for renewable sources over those that emit CO_2 when it began in 2022. The 2016 election ensures that the CPP will not move forward.

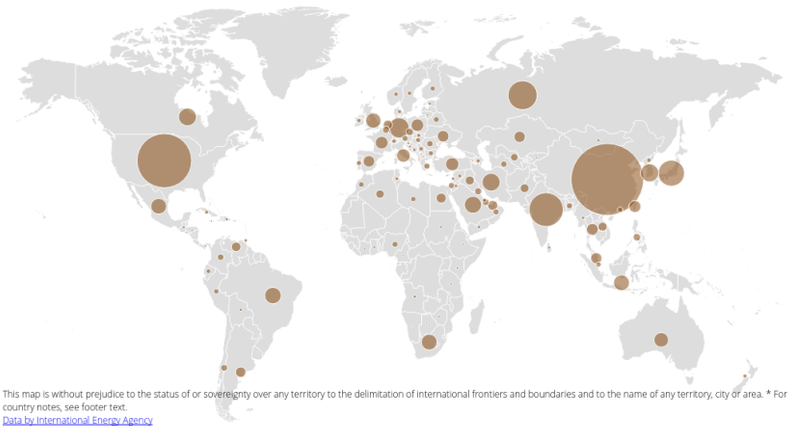
The combination of continuing state policies and incentives and declining costs suggests that even after the tax credits are allowed to expire renewable energy is likely to remain a key piece in our power grid. In addition, states have the ability to step in where the federal government is reducing or eliminating fiscal incentives and can offset the lost federal incentives with state policies. While the renewable sector has a more tempered outlook than it would have if the election results had been different, its future remains bright in spite of anticipated federal policy changes.

CLIMATE CHANGE

The Paris Agreement went into effect in November of 2016, just before election day in the U.S. The Paris Agreement is an international agreement under the United Nations Framework Convention on Climate Change in which countries affirm the importance of limiting global temperature changes to below 2° C and pledge to reduce global greenhouse gas emissions by meeting binding commitments determined by each signatory nation. The following map provides a visual depiction of the global nature of energy-related CO_2 emission, a common reference greenhouse gas.[4] The Paris Agreement covers additional greenhouse gases such as methane from land use change. As seen below, China and the U.S. had the first and second highest emissions of CO_2 from fuel combustion in 2014, respectively. Other large emitters include the European Union and India.

New Presidential leadership has vowed to pull the U.S. out of the Paris Agreement. While the impact of the U.S. not participating is unclear, international climate negotiations have evolved over the past few decades, other countries could step into the fold and offer to lead the path forward, and the market forces described above have not been limited to the U.S. In fact, some of the advancements that have enabled the U.S. to rapidly install renewables can be attributed to markets built in countries that have had climate policies in place for some time. In reaction to the possible U.S. exit, China expressed its continued interest as a Chinese official stated "China's influence and voice are likely to increase in global climate governance, which will then spill over into other areas of global governance and increase China's global standing, power and leadership."[5] , China has recently showed increased commitments to additional renewables in its long term energy plan (including , nearly doubling the country's installed solar capacity in 2016 with 34 GW solar installation additions), completion of over 30 GW of nuclear capacity installations and, effectively cancelling or delaying over 150 GW in new coal capacity, and capping total coal capacity at 1,100 GW by 2020.[6] Other nations (including Mexico and Canada) have contemplated a possible carbon tariff on the U.S. if the Paris agreement pledge is not upheld.[7]

CO_2 Emissions from Fuel Combustion (Mt CO_2) (2014)



This map is without prejudice to the status of or sovereignty over any territory to the delimitation of international frontiers and boundaries and to the name of any territory, city or area. * For country notes, see footer text.
Data by International Energy Agency

For all of these reasons, if the U.S. chooses not to follow through with the ratified Paris Agreement, it will not likely be viewed as a leader in the international climate political regime and could lose its seat at the table. In addition, the U.S. would likely have a hard time meeting its target of 26-28% emission reductions in 2025 compared to 2005 levels without the CPP.[8] However, trends not dependent on federal regulations have contributed to significant declines in U.S. greenhouse gas emissions in recent years. The growth in natural gas and renewable power generation and a heightened focus to curb energy consumption through high energy efficiency capabilities.

OIL AND GAS

The emergence of unconventional oil and gas in the U.S. over nearly the past decade has and will continue to have a tremendous impact on both the energy industry and the economy. In a paradigm shift, the oil and gas resources which were thought to be rapidly depleting, are now made possible by the shale revolution and economically efficient horizontal drilling combined with hydraulic fracturing of oil and gas resources from shale rocks located deep under the earth's surface. The net effect of our abundant resources and cost effective extraction has led to high production levels of unconventional

oil and gas, as shown in Table 1 below.

The outlook for U.S. unconventional oil and gas is exceptionally bright—with expectations of enough supply to substantially meet domestic needs, and surplus enough to export to other countries. The U.S. became a net exporter of natural gas in November 2016. Importantly, oil and gas resources comprise the majority of energy consumed in the U.S. and global economy, comprising 65% of domestic energy use (and 16% for coal) and 57% of global energy consumption (29% for coal).[10]

Notably, our country's increased reliance on natural gas from abundant and low cost unconventional resources (by displacing coal) has reduced CO_2 emissions, and will continue to do so in the future. Carbon emissions hit a 20-year low (in the first quarter 2012 according to EIA) and the U.S. has made substantial and unexpected progress toward meeting the Kyoto Protocol even though we did not commit to it.[11]

The U.S. abundant unconventional oil and gas resources create substantial energy security benefits, increasing our economic bargaining power or leverage in the global geopolitical arena. The bargaining tool can lead to better negotiations for global diplomacy and other goals as the U.S. has the ability to walk away from international negotiations which increases our likelihood to achieve our goals. We also have the ability to bring parties to the negotiating table that we previous were not able to. Importantly, this increased bargaining power could be used to effectuate many changes including. if the U.S. desired. global CO_2 emissions reductions or other goals that would increase sales of the U.S. abundant oil and gas resources contingent upon certain requirements.[12] A few illustrations of potential requirements could include greater reliance on natural gas power plants, commitments to CO_2 abatement power generation technology development, and other ways to reduce carbon. Assuming the U.S. energy policy targeted such goals.

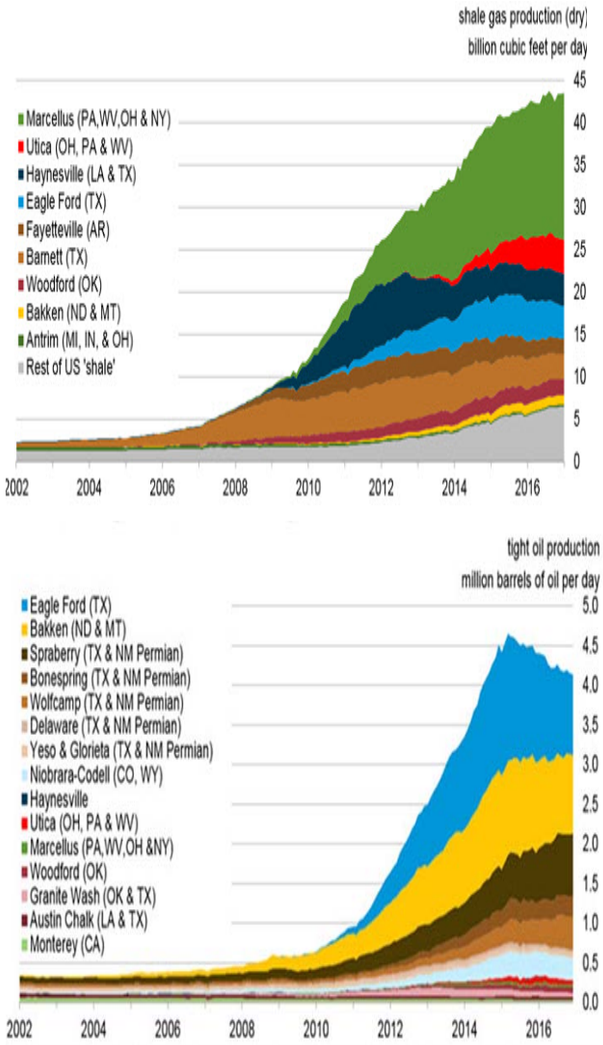


Table 1: U.S. Shale Gas and Tight Oil Production Selected Plays[9]

In addition, increased oil and gas production from the additional sales to international counterparts in the global energy market strongly contribute to the U.S. economy by expanded energy output that creates additional jobs, increases tax revenues, improves our balance of trade payments and consequently expands Gross Domestic Product (i.e., GDP). The economic benefits extend beyond the energy industry as the expanded oil and gas production is like throwing a rock into water, which has a ripple effect. The increased demand for oil and gas has an indirect impact on related industries and services that serves as an extra benefit to the economy in an indirect benefit. There is also a further induced impact to the economy from additional spending due to higher labor income in these industries. Energy policies that expand U.S. energy exports contribute to the U.S. economy.

CONCLUSION

While what lies beneath the shifting politics is challenging to forecast, it is clear that we need a better path forward to find ways to meet in the middle for the benefit of our collective goals surrounding the economy, the energy industry, and the environment. More thoughtful comprehensive energy polices could be made to achieve substantial improvements for the U.S. to maximize the benefits to the energy industry, the economy and the environment which recognize the substantial economic benefits from a *diversified energy portfolio*, inclusive of oil, gas, and renewables.

Footnotes

[1] Lawrence Berkeley National Laboratory, "Median Installed Price of Solar in the United States Fell by 5-12% in 2015" August 24, 2016: http://newscenter.lbl.gov/2016/08/24/median-installed-price-solar-united-states-fell-5-12-2015/

[2] See DOE's 2015 Wind Technologies Market Report for details: https://emp.lbl.gov/sites/all/files/2015-windtechreport.final_.pdf

[3] Ibid

[4] International Energy Agency. http://www.iea.org/statistics/ieaenergyatlas/

[5] Reuters, "Trump win opens way for China to take climate leadership role," November 11, 2016: http://www.reuters.com/article/us-usa-election-climatechange-idUSKBN1360DK

[6] Chinese Energy Storage Alliance, "Power Sector Reforms Announced in China's 13th Five Year Plan," November 22, 2016: http://en.cnesa.org/latest-news/2016/11/22/power-sector-reforms-announced-in-chinas-13th-five-year-plan.

[7] New York Times, "Diplomats confront new threat to Paris Climate Pact: Donald Trump," November 19, 2016: https://www.nytimes.com/2016/11/19/us/politics/trump-climate-change.html

[8] Nature World News, "US to Fall Short on Paris Agreement Without the Clean Power Plan, Study Suggests," September 27, 2016: http://www.natureworldnews.com/articles/29296/20160927/u-s-fall-short-paris-agreement-without-clean-power-plan.htm

[9] Energy Information Administration https://www.eia.gov/energy_in_brief/article/shale_in_the_united_states.cfm

[10] https://www.eia.gov/energyexplained/index.cfm?page=us_energy_home; Also notably the U.S. has an abundance of coal resources, including low-sulfur coal from the Powder River Basin. BP Energy Outlook 2016. http://www.bp.com/en/global/corporate/energy-economics/energy-outlook.html

[11] Surprise Side Effect Of Shale Gas Boom: A Plunge In U.S. Greenhouse Gas Emissions, Forbes, Julie Carey, December 7, 2012. https://www.forbes.com/sites/energysource/2012/12/07/surprise-side-effect-of-shale-gas-boom-a-plunge-in-u-s-greenhouse-gas-emissions/#8f5f5e2068fe

[12] The same bargaining leverage could be used with our U.S. coal resources.

The Trump Effect on Foreign Direct Investment (FDI): Alternative Scenarios Involving the Mexican and U.S. Oil and Gas Industries

By Roy Boyd, Alejandra Elizondo and María Eugenia Ibarrarán

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Mexico's Energy Reform of December 2013 was designed to completely revamp its fossil fuel sector. Under this action several constitutional amendments were enacted in order to open up the hydrocarbon and power sectors to private and, most importantly, foreign investment (Alpizar-Castro and Rodriguez Monroy, 2017). This historic breakthrough is significant given that since the late 1930's (in the case of oil) and the 1950's (in the case of power), only Mexican public capital was allowed into these industries. Now, new arrangements such as profit and production sharing contracts may be enacted, as well as joint licenses for exploration and production.

These reforms were passed, among other things, under the expectation that there would be a robust trading relationship between the U.S. and Mexico, and the ultimate success of this energy reform relies strongly on the unimpeded flow of foreign capital into the oil and gas sector. In 2016 energy accounted for 9% U.S. exports to Mexico, and 3% U.S. imports from Mexico (EIA, 2017). U.S. natural gas exports doubled between 2009 and 2016, mostly due to increasing exports to Mexico (EIA, 2016). As part of the Reform, there are plans to further develop the natural gas pipeline network, including an underwater pipeline through the Gulf of Mexico. The expansion of the network may double the pipeline natural gas exporting capacity of the U.S. to Mexico (EIA, 2017).

Recent political changes in the U.S., however, have cast considerable uncertainty on this whole enterprise. In the wake of pressure from the new U.S. administration in the form of punitive threats, Ford, Carrier, and General Motors have all decided to shift their new investments to the U.S. The automotive industry would seem to be the initial target of the administration's new trade policy, but a report from the Institute of Finance International (2017) indicates that overall U.S. investment in Mexico in 2017 may be trimmed by over 40% to $13 billion this year, the lowest in five years and the highest drop in percentage terms. While such cutbacks would most certainly affect thousands of manufacturing jobs, its implications for the fossil fuel industry remain clouded in uncertainty, both in the short and the long run.

At the present time it would seem that the Trump Administration is not inclined to curb foreign investments by U.S. oil and gas corporations. The public perception of foreign activities by fossil fuel interests is quite different than those of manufacturing firms, especially when they involve cutbacks in domestic manufacturing jobs. Indeed the fossil fuel industry has been given virtual "carte blanch" with respect to its activities, and during the first month in office Trump repealed a Securities and Exchange (SEC) rule (under the 2010 Dodd-Frank financial reform) that required energy companies to disclose their payments to foreign governments.

That being said, however, fossil fuels themselves could still be subject to tariffs or quotas as part of an overarching U.S. protectionist policy directed towards Mexico. If such policies were to be implemented, there could be a significant downside for Mexican energy production. In exploration and production, for instance, 39 contracts have been or will soon be signed between the Mexican Government and private companies, both national and international. Potential investments for the next 10 years are estimated in more than 41 billion U.S. dollars. A significant fraction of these investments will come from 6 U.S. oil and gas companies that were awarded contracts in the first round of tendering processes. The results of a simulation we conducted using a computable general equilibrium (CGE) model of Mexico indicates that under a U.S. protectionist policy Mexican petroleum production could be seriously curtailed, leading to lower investment, a decline in economic growth, and a loss in consumer welfare.

Over the longer term, other factors may also conspire to negatively impact FDI in the Mexican petroleum sector. The positive signals that the Trump Administration has given to resume controversial Canadian pipeline construction and accelerated exploration and drilling on the U.S. public lands may seriously dampen the interest that American oil and gas companies have in future joint ventures in Mexico. If this were to happen, then Mexico would be forced to seek FDI from other sources such as companies in Europe and Asia. While joint ventures with such companies would certainly be viable, they may not prove to be as efficient as partnering with U.S. firms since (1) they lack the geographical

proximity of U.S.-based firms, and (2) they may not have ready access to the vast physical and financial capital reserves that large corporations in the U.S. typically enjoy. Finally, since most of the natural gas fields in question are located in the north of Mexico, much of the appeal for their development lies in the possibility of a pipeline linkup with the United States. Thus, uncertainty about the ongoing economic relationship between the U.S. and Mexico may have a chilling impact on long run FDI in Mexico's fossil fuel sector, regardless of the source of foreign capital.

References:

Alpizar-Castro, I. and Rodríguez-Monroy, C. (2016), Review of Mexico´s energy reform in 2013; Background, analysis of the reform and reactions, Renewable and Sustainable Energy Reviews, 28, 725-736.

Institute of International Finance (2017), Weekly Insights: Place Your Bets. January 19, 2017.

EIA (2016), U.S. natural gas exports to Mexico continue to grow. November 29, 2016.

EIA (2017), U.S. energy trade with Mexico: U.S. export value more than twice import value in 2016. February 9, 2017.

IAEE/Affiliate Master Calendar of Events

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

Date	Event, Event Title and Language	Location	Supporting Organization(s)	Contact
2017				
June 18-21	40th IAEE International Conference *Meeting the Energy Demands of Emerging Economic Powers: Implications for Energy And Environmental Markets*	Singapore	OAEE/IAEE	Tony Owen esiadow@nus.edu.sg
September 3-6	15th IAEE European Conference *Heading Towards Sustainability Energy Systems: by Evolution or Revolution?*	Vienna, Austria	AAEE/IAEE	Reinhard Haas haas@eeg.tuwien.ac.at
November 12-16	35th USAEE/IAEE North American Conference *Riding the Energy Cycles*	Houston, TX, USA	USAEE	David Williams usaee@usaee.org
2018				
June 10-13	41st IAEE International Conference *Security of Supply, Sustainability and Affordability: Assessing the Trade-offs Of Energy Policy*	Groningen, The Netherlands	BAEE/IAEE	Machiel Mulder machiel.mulder@rug.nl
September 19-21	12th BIEE Academic Conference *Theme to be Announced*	Oxford, UK	BIEE	BIEE Administration *conference @biee.org*
2019				
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: The Way Ahead Towards a Competitive, Secure and Sustainable Energy System*	Ljubljana, Slovenia	SAEE/IAEE	Nevenka Hrovatin *nevenka.hrovatin@ef.uni-lj.si*
2020				
June 21-24	43rd IAEE International Conference *Energy Challenges at a Turning Point*	Paris, France	FAEE/IAEE	Christophe Bonnery *Christophe.bonnery@faee.fr*

Electricity Market Design in a Decarbonised Energy System

By Tim Nelson

INTRODUCTION

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See footnotes at end of text.

It is arguable that Australia's 'energy-only' National Electricity Market (NEM) is at the vanguard of considering how best to design energy markets to achieve multiple policy objectives. Australia has some of the highest rates of embedded solar PV installations in the world. Furthermore, the South Australian region of the NEM has some of the highest penetrations of non-hydro renewables of any electricity market. The region has a peak demand of around 3,500 MW and installed wind capacity is approximately 1,500 MW. South Australia is connected to other regions of the NEM through the Heywood transmission interconnector that is rated to around 500 MW. The Australian Energy Market Operator (AEMO) estimates that only 10% of wind capacity and 31% of solar capacity in South Australia can be relied upon at times of peak summer electricity demand. Therefore, there is a need for other 'firm' capacity to be available to meet demand when wind and solar PV are unavailable. This capacity is only remunerated when it is needed via the energy it produces. A confluence of factors in South Australia has led to the Australian Government initiating an inquiry into energy policy, led by Australia's Chief Scientist (the 'Finkel' review). South Australia has stagnant underlying electricity demand, high rates of renewables penetration, an ageing thermal generation fleet and reliability issues.[1]

The purpose of this article is to assess whether an 'energy-only' wholesale electricity market design can coexist with a largely decarbonised/renewable energy system, with a particular focus on Australia's NEM. The article is structured as follows: Section 2 outlines a theoretical investigation of how 'energy-only' markets respond when other policy instruments are used to drive investment in new generation capacity; empirical observations of Australia's electricity system are presented in Section 3; with policy recommendations and concluding remarks provided in Section 4.

A THEORETICAL INVESTIGATION OF 'ENERGY-ONLY' MARKETS

Inter-period pricing

Figure 1 shows a stylised longer-term shift in pricing trends associated with the introduction of renewables and other policies that drive investment in new generation capacity, irrespective of whether demand requires it. The chart on the left shows an 'energy-only' market without the overlay of other policy interventions. Prices rise and fall based upon tightening reserve margins due to increasing demand driving up prices or excess capacity driving up reserve margins respectively. The chart on the right shows how price trends shift in an 'energy-only' market with subsidised renewables. Prices fall to very low levels due to oversupply and low-SRMC renewable generation. Firm thermal generators cannot recover FOM and eventually are removed in a 'disorderly' way, potentially resulting in sustained periods of above LRMC pricing.

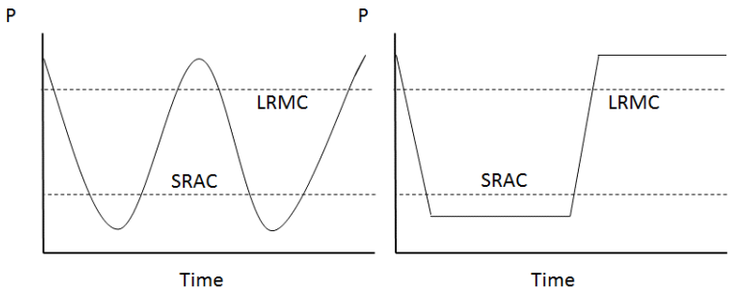

Figure 1: Change in nature of inter-period pricing events

Intra-period pricing

Figure 2 shows the stylised impacts of increased renewable penetration on intra-period pricing.[2] As renewables enter the market, they occupy the bottom of the merit-order bid stack and are able to 'bid' into the market at their short-run marginal cost (i.e., effectively zero). For other generators to recover their heavy fixed costs over the business

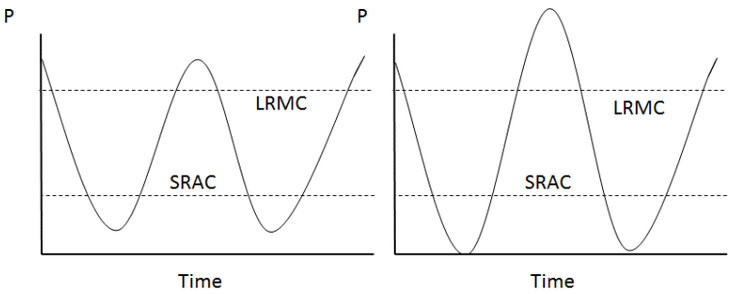

Figure 2: Change in nature of intra-period pricing events

cycle, prices at other times must increase significantly. Capital and other fixed costs are recovered over reduced periods of time/demand. Within Australia, estimates have been made in relation to how high the market price cap would need to be for generators to recover their long-run costs in a high-penetration renewable scenario. Riesz et al (2016) concluded an increase from $13,100 per MWh to between $60,000 and $80,000 per MWh would be necessary. In itself, this is not necessarily an issue but it is important to think through how a restructured retail market would function in this environment given the reduced availability of traditional financial derivative products.

EMPIRICAL OBSERVATIONS OF THE AUSTRALIAN NEM

Australia is arguably one of the best markets to assess the impact of renewables and climate change policy on energy-market design. As noted earlier in this article, South Australia has one of the highest penetrations of renewable energy of any region in the world. Furthermore, Australia is currently unable to secure abatement opportunities from the substitution of coal with gas-fired power generation due to chronic domestic gas supply unavailability.[3] Unsurprisingly, government policy is skewed towards supporting renewable investment as a method of reducing emissions. The Victorian and Queensland governments have established policies to achieve 40% and 50% renewable energy penetration by 2025 and 2030 respectively. These targets are likely to drive abatement towards partially achieving Australia's COP21 commitment to reduce emissions by 26-28% on 2005 levels by 2030.

Figure 3 shows historical pricing within the NEM since its creation in the late 1990s. It is clear that the NEM has produced wholesale pricing that is reflective of relatively efficient dispatch. In most years since its creation, the market has produced pricing outcomes well below that of a new entrant coal or gas-fired plant. It is arguable that this is a reflection of oversupply created by unanticipated declining energy demand, the 'sweating' of existing aged assets and the adding of supply through adjacent climate change policies.

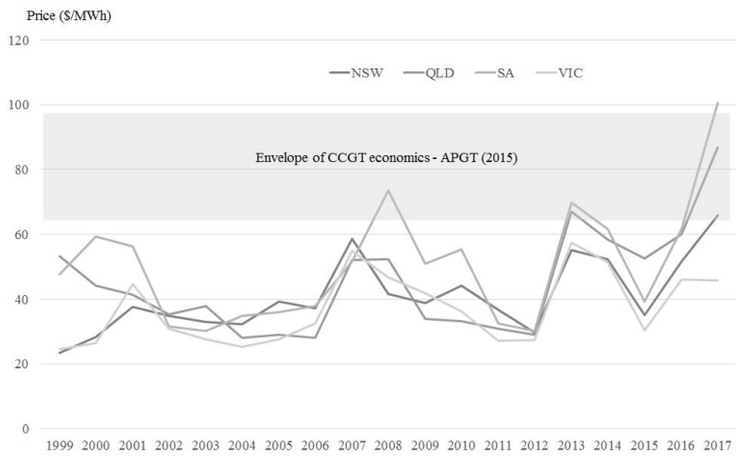

Figure 3: Historical average wholesale prices in the NEM
Source: AEMO market data

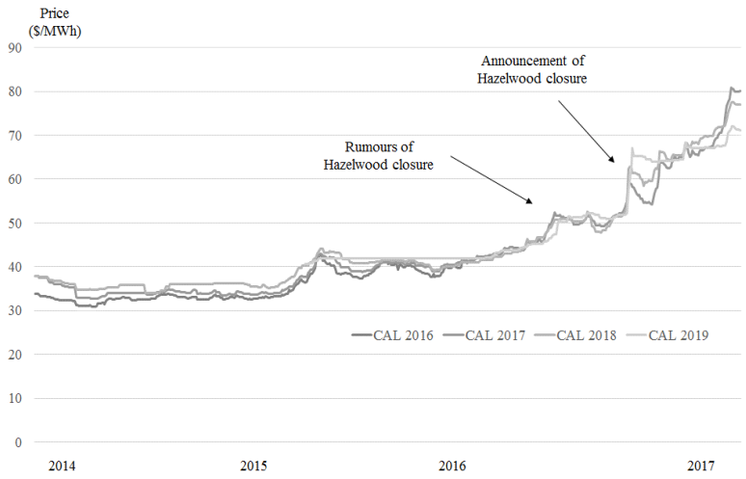

Figure 4: Victorian forward electricity pricing
Source: Market data

The NEM has not produced pricing outcomes sufficient to incentivise new investment. However, pricing has increased substantially since 2015. Significant withdrawals of aged thermal plant has led to tightening reserve margins. The average prices in 2017 reflect both a resurgence in peak demand and a tighter demand/supply balance. Figure 4 shows forward pricing in Victoria and the increases attributable to the permanent retirement of the 1,600 MW coal-fired baseload Hazelwood power station in March 2017.[4]

Figure 4 effectively demonstrates the inter-period pricing phenomenon established in Section 2. Prices were significantly below LRAC for many years due to oversupply created by flat underlying energy demand and additional supply driven by climate change policies. This resulted in economic pressure being placed upon remaining generators which eventually led to the disorderly withdrawal of the Hazelwood power station. Only six months' notice was provided, well below the notice required to invest in the requisite new firm capacity.[5] Forward pricing has resulted in significant discussion within Australia about prices being 'too high', evidence that realistic political economy of energy prices is perhaps inconsistent with 'energy-only' market design.

The same scenario described above occurred in South Australia in 2015/16. In October 2015,

the owners of the Northern (546 MW) and Playford (240 MW) power stations announced their permanent closure in May 2016.[6] Again, with less than a year of notice, there was no time for new generation to be built (see Nelson and Orton, 2016). Capacity is required to complement the significant penetration of wind generation within the South Australian region. However, 'baseload' coal-fired generation is unsuited to these duties. Figures 5 and 6 provide evidence that lower capacity factor 'firm' plant would be better suited than existing less flexible plant to complement wind generation. The peak/average factor in the South Australian region is 1.89 but if wind is excluded it increases to 2.94. Capacity is required but for much fewer hours of the year. Much of the remaining plant in the South Australian market is unsuited for providing this type of 'flex'.

Wind generation is increasingly reliant upon climate change policy subsidies (Large-scale Generation Certificate: LGC revenue) as it suffers from a 'price penalty' due to its nature as a 'price taker' and coincident generation profile. Figure 7 shows the weighted average spot price in South Australia received by technology type. In every year, wind receives much less revenue due to its inability to generate at times when energy is most valuable (e.g., peak demand times). It is also unable to forward contract by selling forward derivative products. In our view, these issues will become even more evident as more renewable energy enters the market in coming years to achieve the 26-28% emissions reduction target established by the Commonwealth Government.

POLICY RECOMMENDATIONS AND CONCLUDING REMARKS

Addressing inter-period pricing

Inter-period pricing in 'energy-only' markets is likely to continue to be at odds with the criterion of realistic political economy of energy pricing. Retailers and industrial users of energy cannot forward plan when prices are subdued for a period of time but then rapidly increase due to the 'lumpy' withdrawal of thermal plant. However, an 'orderly' transition to a higher-penetration renewables system can be facilitated within an 'energy-only' market if generators provide sufficient notice of impending closures to allow new complementary capacity to be built. As noted in the subsequent sub-section below, this new investment will likely be lower capacity factor thermal plant in the short-term (e.g., OCGT) or perhaps advanced batteries or pumped hydro style technologies in the long-term. There are a plethora of ways this 'sufficient notice of closure' could be achieved through either plan-

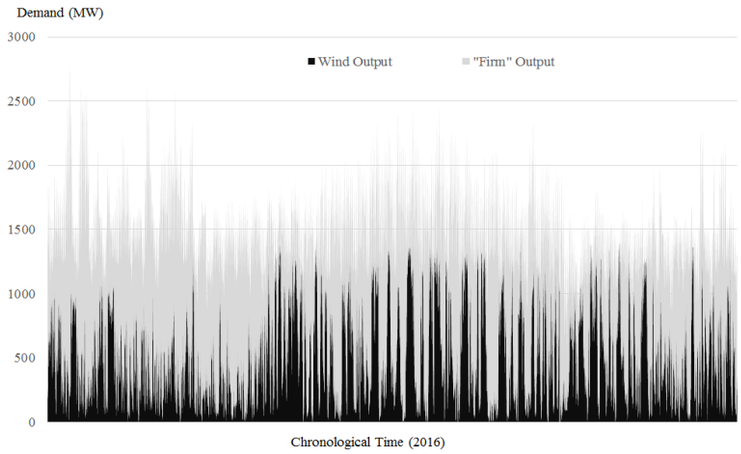

Figure 5: Output of generation in South Australia chronologically ordered in 2016
Source: AEMO market data

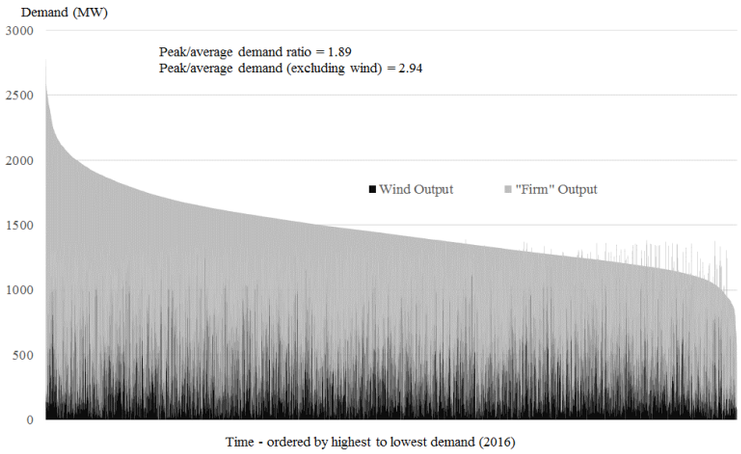

Figure 6: Output of generation in South Australia ordered by demand points (2016)
Source: AEMO market data

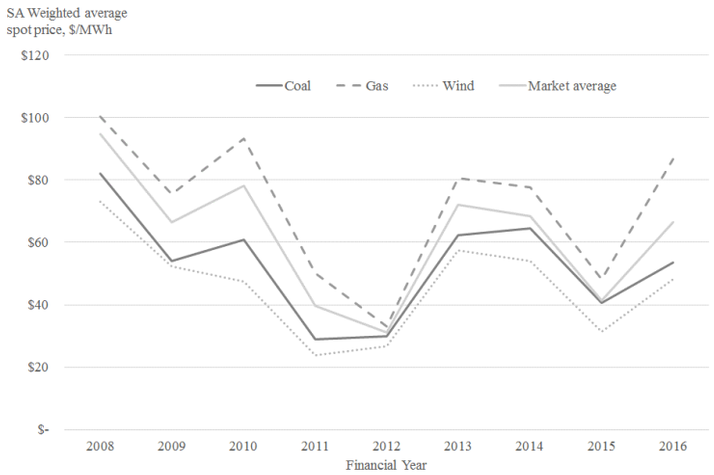

Figure 7: Weighted average pricing for South Australian generation
Source: AEMO market data

ning laws or amendments to AEMO generation registration rules. It could also be facilitated through market-based or age-based emission reduction style 'closure' policies (see Jotzo and Mazouz, 2015, for further information).

Addressing intra-period pricing and facilitating new investment

In our view, new investment in capacity is likely to be driven by climate change policies that encourage fuel substitution.[7,8] However, it is important that this new investment is 'dispatchable' and can actively participate in the market. Active participation facilitates the forward contracting of generation and the operation of a competitive downstream restructured retail market (allowing intra-period pricing volatility to be managed).

Rather than creating further distortions on the operation of the electricity market (by implementing capacity markets and the like), it may be preferential for policy makers to alter the design of climate change policies or renewable energy obligations to ensure unintended consequences of climate change policies for 'energy-only' markets are avoided. Intermittent, non-contractible generation (i.e., wind, solar, etc.) could be required to contract with complementary plant such as OCGT, advanced batteries or pumped hydro to create a 'synthetic financial generator', capable of bidding into the spot market and participating in forward derivative markets. This could be achieved through a market mechanism (e.g., 'firm capacity right' certificate which would be required to be stapled to renewable generation facilitating some proportion of the capacity being 'firm') or a generator registration mechanism.[9]

This development is necessary for at least two reasons: it would facilitate retail market innovation and competition by ensuring that sufficient price mitigation hedging tools are available; and it would allow the 'synthetic financial generator' to optimise investment to ensure the right lower capacity factor plant is forthcoming to complement renewables (rather than the sub-optimal use of higher duty incumbent plant that is not suited to such operation). Renewable generators would be better able to participate in the market and be less reliant upon subsidies. There would also potentially be a more transparent 'transfer payment' from non-firm renewable generators to 'firm generators' that provide integration services that are not currently explicitly valued.

Footnotes

[1] In fact, it was a state-wide blackout on 28 September 2016 that led to the creation of the Finkel review. The blackout was largely caused by an extreme weather event but prompted discussions about whether a different market design or energy mix would have prevented the loss of power.

[2] Intra-period pricing would also be impacted by the choice of climate change policy. For example, in a system with most generators benefiting from Contracts for Difference (CfDs), generators with the highest CfDs will be able to produce at lower prices than those with a lower CfDs. Effectively, the bias is towards the more expensive plants. The impacts of specific climate policy design on energy-markets is therefore worthy of further research.

[3] While east-coast Australia has significant gas reserves, the vast majority of 2P reserves are now allocated for export through a new LNG export industry in Gladstone, Queensland. Simshauser and Nelson (2015) provide a detailed explanation of the events that led to this situation.

[4] See http://www.gdfsuezau.com/media/UploadedDocuments/News/Hazelwood%20Clousure/Hazelwood%20closure%20-%20Media%20release.pdf for further information, Accessed online on 17 February 2017.

[5] Note the specific use of the term capacity rather than energy. The market will continue to need capacity to meet peak demand but less energy due to the introduction of intermittent renewables.

[6] See https://alintaenergy.com.au/about-us/power-generation/flinders-operations for further information. Accessed online on 17 February 2017.

[7] This is irrespective of whether a carbon price (e.g. emissions intensity scheme), direct renewable portfolio obligations or contract for difference policies are pursued.

[8] This effectively solves (albeit temporarily) the limitations of 'energy-only' markets for incentivising new investment.

[9] The market price cap (MCP) will still need to be increased, or more controversially removed, to ensure costs can be recovered and market participants are incentivised to hedge pricing risk.

References

Australian Power Generation Technology Group: APGT. (2015), *Australian Power Generation Technology Report,* CSIRO Publication.

Jotzo, F. and Mazouz, S. (2015), 'Brown coal exit: a market mechanism for regulated closure of highly emissions intensive power stations', *Economic Analysis and Policy*, Vol. 48, pp. 71-81.

Nelson, T. and Orton, F. (2016), 'Climate and electricity policy integration: Is the South Australian electricity market the canary in the coalmine', *The Electricity Journal,* Vol. 29, No. 4, pp. 1-7.

Riesz, J. Gilmore, J. and MacGill, I. (2016), 'Assessing the viability of Energy-Only Markets with 100% Renewables', *Economics of Energy & Environmental Policy*, Vol. 5, No. 1.

Simshauser, P. and Nelson, T. (2015), 'Australia's coal seam gas boom and the liquefied natural gas entry result', *Australian Journal of Resource and Agricultural Economics*, Vol. 59, No. 4, pp. 1-22.

Report of the Windsor Energy Group

Meeting of 3-5 March 2017

Recent Surprises in Global Energy – Finding a New Balance with Black Swans

Editor's Note: The Windsor Energy Group (WEG) was founded in London in 2000 under the chairmanship of the late Sir David Gore-Booth and Paul Tempest as the Executive Director until 2009 with the full and continuing support of HE Khaled Al-Duwaisan, Dean of the London Diplomatic Corps and Ambassador of Kuwai. Ian Walker has been Office Manager from the start and Executive Director from 2009. Throughout WEG has enjoyed strong support from the leading energy multinationals, key governments and international institutions.

WEG aims to provide a high level forum to address global, regional and national energy issues and problems arranging briefings, meetings, seminars, private lunches and dinners through the year at the request of the London Ambassadors and their Governments. All discussions are conducted on a strictly non-attributable basis to ensure a full and frank exchange of views.

We're grateful to Paul Tempest, IAEE past president, for this report.

KEY POINTS

The theme for this year's annual residential weekend in Windsor Castle was finding a new balance – political, financial and technological. This international expert gathering addressed this theme in separate sessions looking at the flocks of black swans now on the energy horizon. We covered:

- Energy policy consequences of the election of President Trump
- Implications of Brexit for Britain, the EU and the wider world
- The powerful resurgence of U.S. tight oil and shale gas production
- Growing political insecurity in the Middle East and North Africa
- Uncertainty over continuing high economic growth in China and South East Asia
- The significance of Russia's interventions in Syria
- Fears over military confrontation in the South China Sea
- COP – or cop out - the changing global green agenda

Re-setting Global Economic, Financial and Political Assumptions

- New barriers are emerging to long-term investments in energy, infrastructure and international trade.
- Meanwhile financial markets are again facing turmoil under flimsy global supervision
- OPEC has demonstrated some success in persuading Russia to join in oil production cuts, at least temporarily. The compact is not expected to last.
- Saudi leadership in OPEC is driven by their 2030 vision of a rapid transition to a diversified economy which is less energy dependent.
- Many energy-related jobs in energy-producing states are being axed as budgets are tightened with low energy prices.

Increased Turbulence in Global Markets

- Low energy prices (oil at $45-55 pb) are forcing energy companies and energy-rich countries to undertake a radical rethink of how they operate and which alliances still have long-term value.
- Many energy-exporting governments need $85 pb prices to break even as they continue with large domestic subsidies and wrestle with high unemployment. Political insecurity as seen in Venezuela is a real threat to several others.
- The direction of U.S. leadership under the new administration is unclear. "Show me my nuclear launch button" has sent tremors through Washington DC, Israel, Iran, North Korea while several Arab leaders have welcomed what is seen as a tough decision-taker in the White House

President Trump and U.S. and Global Energy

- President Trump was supported by voters in energy producing states and this will colour his administration's priorities in areas such as coal.
- The administration's pro-energy policies are, however, likely to face delays due to the twelve district courts that can determine local developments. The picture varies enormously across the States.
- Equally 24 states are opposed to setting a reduction of greenhouse gases by a third by 2030.
- Claims that U.S. shale gas and tight-oil production and exploration have made the U.S. a global swing producer is regarded as an exaggeration. However as energy prices have risen so has U.S. production acting as a damper on global prices.
- U.S. shale's ability to respond to rapid changes in market prices has been slower as the industry has scaled back and re-scaling takes time.
- Not all U.S. new energy is low cost. Some of the heavy sour crude in the U.S. will need a $65 pb

oil price to cover costs.
- Exploration access to U.S. Federal lands fell from 36 per cent in 2010 to 21 per cent in 2015. It is estimated there could be 1.5 trillion barrels over 20 years if more land was opened up which at $35 pb would add $50 tr to the US economy.
- The proposed boost in U.S. military budgets offers an enhanced ability of the U.S. to intervene rapidly in any trouble-spot worldwide while some U.S. partners in NATO are being told they will have to pay their share of the NATO defence budget.
- Targeting of Mexico makes little economic sense given the close commercial ties that have developed under NAFTA and plans to open PEMEX up to international partnership. Canada is likely to benefit from these tensions with the new administration green-lighting controversial pipelines.
- Future U.S.-China relations remain unclear. China's militarisation of three areas of the South China Sea is seen as a provocation with the U.S. having bilateral defence ties with many of the countries affected. Some see this as a forward defence of the maritime energy silk road while others feel the Chinese occupation allows it to claim access to large tracts of potentially energy-rich seabed.
- The widely held expectation that the global debt/GDP growth ratio and key interest rates are about to rise significantly has also unsettled financial and energy markets. While equity markets have so far recovered, energy multinationals are cutting their risk exposure by continuing to dispose of high energy-cost, high labour-cost assets as well as those now carrying heightened political risk.
- The Trump denigration of the media, tax evasion and globalisation is also making industry hesitant and cautious.
- Cheap U.S. natural gas and the development of alternative energy seem to be following non-regulatory paths probably presenting a dilemma at some point in the future.
- Finally the evidence of any pre-election U.S.-Russia consultation awaits definitive examination and confirmation.

Another Middle East Implosion on the Horizon?

A detailed double-session analysis of the current situation focused on the wars in Yemen, Syria, Iraq and tensions between Iran and all other Gulf states except Oman. Foremost was what was happening in Saudi Arabia with questions about leadership, the succession, the restructuring of Saudi Aramco and internal dissent fuelled by inflation and unemployment. Any curtailment of Saudi or other major Gulf oil or gas production or exports would have instant impacts on oil and gas prices (see below). Under particular review were:

- Jordan with 70% share of its population now immigrants and refugees who are expected to remain in-country for at least fifteen years.
- Egypt desperately poor with failing agriculture and fears that Ethiopia's new dam will reduce Egypt's water supply
- Syria, Libya and Yemen – all failed states in dire need of rescue and massive aid
- Libya – a new source of weapons, flowing now into Egypt, Yemen and elsewhere
- Algeria has depleted much of its national budget due to its massive dependence on energy exports.
- Morocco is a leader in the Arab world for sustainable energy – currently chairing the COP process. However a large energy find in Northern Morocco by a UK company could change the country's energy profile.
- Emboldened by President Trump's promises of help and abandonment of the U.S. backing of a two-state solution, Israel has launched its new wave of settlements on the West Bank and warnings that further provocation and protest by Palestinians will be met with overwhelming force and retaliation.

Within the oil and gas industry, contingency plans are under review for scaling down, evacuation of personnel and families as well as cutting external costs if necessary in countries at risk.

Iran – Apparent Opportunity is not without Risk

Iran has the largest gas reserves and some of the largest oil reserves in the world with some of the lowest costs of production. It is not easy to operate in Iran. Massive investment in energy infrastructure is required. China has been on the ground for many years but there is an Iranian wish to bring in other players.

Some Other Insights

Japan – Energy market liberalisation looks too slow. The nuclear component cannot be replaced quickly. A strong burst of activity and success in energy-use technology - hydrogen, nitrogen, synthetics/chemical innovation, etc. Plans for an Asian Super-Grid may provide more reliable and cheaper electricity over a triangle from Pakistan/India, Singapore, Japan and points within or nearby. Soft Bank has

joined the China Electricity Grid, KEPCO and Russian Grid as organisations interested in a super grid.

Turkey – A review of Turkish-Russian rapprochement prompted a powerful response on NATO's need to re-engage with Turkey. Issues covered included the recent battle of increased presidential powers; the present bleakness of the Turkish economy; and new offers of more Russian gas.

The North Sea – Signs of an upturn in both UK and Norwegian sectors are strengthening with evidence of cheaper drilling costs, exploration with super-computers, submarine drones for routine maintenance and new solutions for de-commissioning. Costs have come down as companies have reviewed their procedures. As large players withdraw smaller companies are willing to develop smaller fields. Debate taking place over the speed and extent of decommissioning with some environmentalists arguing that keeping obsolete plant in situ may support marine life. Cost of decommissioning to be shared by industry and UK tax-payers.

Nuclear – Mixed signs ranging from green light for EDF-led Hinkley Point in UK while Westinghouse has gone bankrupt. The cost of big nuclear is too much for many countries. Where China and Russia are funding projects there are concerns that this will lead to long-term bilateral arrangements and undue influence. Likely therefore that small nuclear will be the way ahead. Nuclear is manageable. Hitachi's Horizon project with two UK nuclear projects potentially servicing ten million homes is both on time and budget with 350 employees.

Latin America – Argentina's giant Dead Cow shale field has attracted 19 companies and is powering the country's growth. Venezuela's political situation remains unstable while most Venezuelan exports are going to US refineries. Brazil is still making money on its offshore exploration with green energy being a major part of the energy mix with wind, biomass and solar. China is investing tens of billions in Latin America while Petrobras has massive debt and is embroiled in a national political cash cow scandal.

SHORT-TERM PROSPECTS

Our conclusions for the short-term are based on a rough and ready marking system to indicate what is getting better and what is getting more dangerous. Our impressions attempt to indicate the broad consensus of the discussions. Despite much misery as noted above in the various sectors the overall mood of the international petroleum and coal industries appears to have been encouraged by President Trump's promises and actions. After several years of defensive cutting of high-cost and high-risk investment, a turning point seems to have been reached. This seems to us to promise a sustained upward trend in global demand, production volume, investment and the current price of hydrocarbons. For the petroleum and coal industry today, this marks, we think, a most notable change of direction and a most welcome recovery of nerve. .

THE LONG-TERM VIEW

IMF and other leading global energy institutions see no diminution of global energy demand, indeed a steady expansion. The energy mix will evolve slowly with gas the fastest growing and oil demand probably reaching its peak in 20 to 30 years time. Gone therefore are the green hopes of blocking and eliminating the use of oil and gas and coal much sooner.

- The power sector currently absorbs two-thirds of the steady rise in energy demand. It looks likely to maintain and maybe increase this share. Two key questions are whether cheap coal can play a stronger role without adverse environmental effects and whether nuclear might again safely close the gap.
- An alternative worst-case scenario foresees severe economic dislocation with acute anxiety among parts of the market and industry. The overall mood covering the next three years would change if international energy shipping and pipeline trade are blocked by political and/or military intervention. A steep rise in energy prices would then be inevitable and impose a sharp brake on global economic growth.

Participants, 2017

LEAD-SPEAKERS: Lord Howell (WEG Chair); Sir Mark Moody-Stuart (ex-Chairman of Shell); Spencer Dale (Chief Economist of BP); Dr Herman Franssen (ex Chief Economist of the IEA); Prof. William Arnold (Jones Business School, Houston); Paul Murphy (MD, Gowlings, Washington DC); Dr Kent Moors (Exec Chair, Energy Capital Research Group); Prof. Paul Sullivan (National Defense University, Washington DC); Ghayth Armanazi (ex-Arab League Ambassador); Richard Burchill (Director, TRENDS, Abu Dhabi); Prof Tatsuo Masuda (Tokyo, ex VP JNOC); Mehmet Ogutcu (Bosphorus Energy, Istanbul); Dr Carole Nakhle (Director, Women in Energy, Abu Dhabi); Dr Ahmed Badr (Exec Director, RCREE, Cairo); Daniel Morler (CEO RJFleming); Arne Walther (Oslo, ex Norway Ambassador to India and Japan); Ieda Gomes (Brazil); Lady Barbara Judge (Chair Emeritus of UK Atomic Energy Authority); Gavin Graham (ex-Shell and ex-Petrofac); Niels van Berlaer (GM, Eversea, Belgium); Yasunori Sota (Hitachi Europe); Bip Rakshi (Atomic Acquisitions); Greg Pytel (Sobieski Institute, Warsaw); Steve Whyte (Chair, Sound Energy). Concluding Remarks: Paul Tempest .

Paul Tempest and Ian Walker

Second Greek Affiliate Conference a Success!!

Saturday May 20th, 2017 marked the very successful completion of the second international conference of the Hellenic Association for Energy Economics think tank "THE LANDSCAPE IN THE NEW ERA OF ENERGY TRANSITION: Challenges, investment opportunities and technological innovations" held at the Metropolitan Hotel in Athens.

The three day event surpassed every expectation as more than 250 experts from all over the world attended, representing more than 25 nationalities from Greece, United States of America, Germany, Belgium, the United Kingdom, France, Spain, Italy, Russia, Japan, China, India, Canada, Chile among others.

During the conference over 80 presentations from academics and analysts were presented which contain information needed by any investor, businessman and policy maker operating in the energy domain. Furthermore over 50 top experts from the energy sector, business executives from private firms and government organizations, academics, policy makers and representatives from sectoral media, from Greece and abroad, analyzed the landscape and offered solutions for the development of the country's energy potential, in over 10 round table plenary discussions.

The results and conclusions of the conference are at any given time at the disposal of the global energy community confirming HAEE as the most effective source of information for the international energy world about the developments in Greece.

Already a team of expert associates is working on systematically recording, sorting and prioritizing the positions and proposals set forth in the conference concerning Greece's energy policy, the role of Greek government and private firms and the possible cooperation of domestic and foreign firms. A second team will compare these results with the situation in Greek energy policy and corporate reality and will highlight the common interests and the possible joint ventures of Greek and foreign firms.

Their findings and recommendations will be shared with all the affiliates of the International Association for Energy Economics worldwide to foster possible cooperation in the Greek energy market, facilitating foreign investors in their strategic planning, in benefit of Greece's economy. Finally, special care is given to the promotion of the conference's economic and media supporters as they represent the most suitable Greek organizations for international cooperation, not only in the energy sector, but in the foreign investments' market as well.

The Economics of Distributed Solar PV: California in International Comparison

By Maximilian Eissler, Clemens Gerbaulet, Ralf Ott, Charlotte Rochell and Philipp Zorn

INTRODUCTION

This article gives an overview of the current business case and regulation as well as relevant developments for distributed generation focusing on California as the biggest market for solar installations in the U.S. We then compare these developments with those ongoing in four other distinct legislations and energy systems: Australia, Germany, India, and South Africa. These five locations were chosen because of their diversity to cover a spectrum of geographic, infrastructural and political conditions for residential rooftop PV. We model households for each location in exemplary spots close to main population centers to, as close as possible, represent each location in installation cost and interest rate, insolation and climate profile; San José, Brisbane, Berlin, Kanpur and Melkbosstrand. The simulation then iterates through all possible scenarios to optimize the profitability for each combination of solar and battery capacities. As we aim to analyze the viability of prosumage for an individual investor, we do not consider system effects, i.e. the role of prosumage for total system costs (see Green, 2016; Schill et al., 2017), nor distributional implications.

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See footnotes at end of text.

FUNDAMENTALS

When analyzing the economics of distributed solar, the most influential factors for the economic performance of a rooftop PV system have to be identified first. Lang et al. (2015) clustered the driving factors into three categories: geographic, technological and economic. For geographical influencing factors irradiation is found to be the most significant one. The module type, capacity, orientation, and inclination directly affect the output of the system: Since solar power is the energy source for a PV system, the local irradiation is the key element for a good performance. But it also increases the temperature of the module and hence leads to efficiency losses. Among the technological factors are the design of the building and attributes of the installed module. The size and type of the roof constraints the installed capacity and the possible orientation of the PV system. When modeling the economic performance in times of prosumage, energy demand of the household is a driving technological effect on the achievable rates of self-consumption. If the installed system contains demand side management devices like a battery for storage, up to 24 % higher self-consumption rates and therefore higher returns can be reached (see Luthander et al., 2015). The economic factors cover the investment (module price, battery price, capital costs) and installation costs and the operation and maintenance costs. They also include retail prices that are avoided while self-consuming, and the remuneration when feeding in production surpluses; the higher both factors, the better the overall performance of the system.

SOLAR IN THE U.S. AND CALIFORNIA

Several U.S. states have seen rising installation rates of solar capacity for the past ten years. In general, this is due to favorable regulation, great solar potential because of high insulation and plummeting costs for modules and BOS (balance of system). Figure 2 shows the biggest U.S. solar markets by the absolute rate of installed capacity. While California is by far the biggest market with over three gigawatts of capacity installed in 2015 (this includes residential, commercial and utility scale), several smaller markets with a larger per capita installation also exist. The solar boom was started by regulatory incentives which first made investments in PV systems profitable: In California and many other states these incentives where implemented in the form of “net metering”. In this scheme, investors can connect their PV systems to the grid and can either sell the generated electricity or consume it directly. By feeding it in, they roll back their meter and thereby reduce their electricity bill. Self consumption is exempted from taxes and fees. Prosumers can choose to pay their monthly or annual net electricity consumption, users with larger solar systems and small storage can benefit more from yearly net metering because of greater feed in during the summer months. Additionally they receive a tax credit of 30 % of their PV systems cost. This framework resulted in 580,000 solar projects in California since 2006 (see California Energy Commission & California Public Utilities Commission, 2016). Research has shown that a doubling in cumulative installed solar capacity drops the price of modules on average by 23 %. Through massive installation

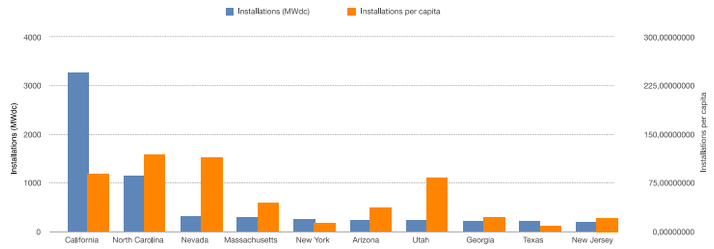

Figure 1: Solar Installations absolute and per Capita in Biggest US Markets 2015

Source: own illustration after SEIA (2016).

because of investment incentives in many jurisdictions world market prices of PV modules have fallen from 3.3 $/kWp to around 0.6 $/kWp of capacity between 2007 and 2017 (see Fraunhofer, 2017). While residential installations in California have slightly dropped after 2015 because of the anticipated end of the net metering program in 2019, installations of commercial systems up to one megawatt under net metering are not affected by this trend and are rising (see Figure 2). This could indicate an increasing independence of the prosumage business case from net metering due to steadily sinking module costs, which should eventually cause further increase in residential installations. The Californian utilities already offer Time-of-Use (TOU) pricing schemes. A TOU pricing reflects the current price of electricity and reflects the balance between supply and demand. Hence, prosumers are incentivized under this scheme to feed in when supply is low and demand is high (high electricity prices). New incentive policies will likely aim in a similar direction (see PG&E, 2016a). PV systems with storage capabilities for load shifting could become the most profitable investment under these new policies.

THE CURRENT BUSINESS CASE IN CALIFORNIA

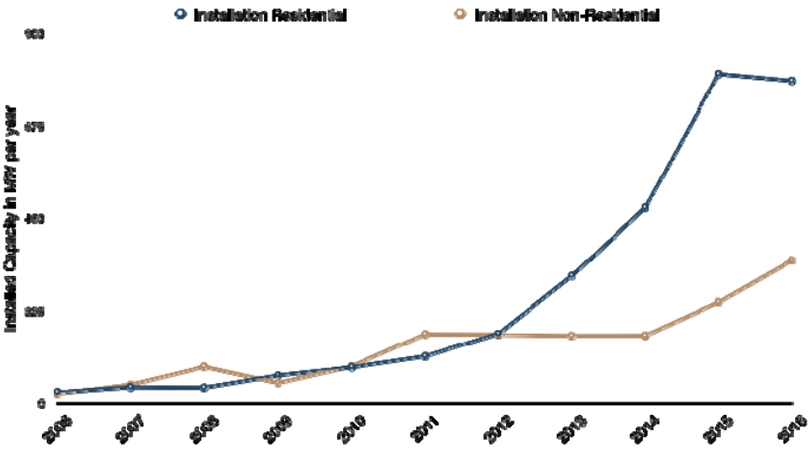

Figure 2: Yearly Residential and Non-Residential Solar Installations under Net Metering in California

Source: own illustration after Public Utilities Commission (2016).

When looking at a simplified investment decision example in rooftop PV the potential investor determines if the expected income per unit of electricity will exceed the levelised cost of electricity (LCOE)[1] of the PV system. The returns can be either selling the generated electricity or avoiding the electricity retail price when consuming it directly. Hence, an investor in California under the net metering policy would compare the LCOE of a PV system with the expected retail price which would be earned when feeding in or avoid by self consumption. If the retail price is expected to be higher until the costs are amortized, the investment is profitable.

The time of day or market demand currently does not affect the electricity retail price; additionally, most electricity retailers in California have multiple (PG&E has 3) pricing brackets for electricity to promote energy efficiency: Energy used above the baseline allowance is in tier 2 and billed at a higher price, even higher consumption is in tier 3 and billed accordingly. The tiers are not fixed but need to be calculated for each household based on their baseline territory (see California Energy Commission & California Public Utilities Commission, 2016). Especially smaller PV systems without storage are incentivized by this situation, because the avoided electricity price when self-consuming or feeding in is invariable over time, equal to the retail price and decreases when reaching lower pricing brackets. Ony the netto consumption is relevant. The highest rates of return can therefore be achieved by shaving the upper brackets with a small PV system without storage.

For a representative Californian household in San Jose, the consumption allowance for tier one pricing would be 9.3 kWh per day in summer and 16.7 kWh in winter (see PG&E, 2016b). These allowances are determined by region and multiplied by the amount of days in the current monthly billing period. San Jose is located in region "X" (the 12 grid regions in California are historical legacy and are labeled alphabetically) which covers the area of PG&E's operational territory (see PG&E, 1990). The tier prices for this household would be 18.35 $ct/kWh, 24.28 $ct/kWh and 40.31 $ct/kWh for tier 1, 2 and 3 respectively (see PG&E, 2016b) and the therefrom calculated PV LCOE is at around 22,85 $ct/kWh (for the values used, please see appendix). Given the household consumes enough electricity to reach the higher tiers of this rate structure the real return could be maximized by only shaving of the highest tier consumption with net metering. In practice, the LCOE drops for bigger installations due to static

costs for installation and electronics, which makes it more profitable to shave both of the top tiers. The average plant size in California between 2014 and 2016 of 5,48 kWp reflects that calculation (see Public Utilities Commission, 2016). Currently, home owners in California are deterred by the uncertain future of the net metering program after 2019 (see California Energy Commission & California Public Utilities Commission, 2016), which means that the retail prices are only known for a fraction of the lifetime of the PV system, which are usually assumed to be twenty years for the LCOE calculation. This uncertainty decreases the potential profitability for small plants and is most likely the reason for the stagnating installation count. For commercial and utility scale plants with far lower LCOE this apparently does not apply, since installations continously increase for this segment (see appendix for details).

INTERNATIONAL COMPARISON

Method

We now compare the LCOE of residential PV in California with four other locations, using production data generated by the website "www.renewables.njna" by Pfenninger and Staffell (see Pfenninger, Staffell, 2016; Staffell, Pfenninger, 2016) for each location. To generate comparable data that can be scaled to each of the observed system sizes we generate the data for a system of 1 kWp, without any tracking capabilities, and oriented optimally i.e. to the south on the northern hemisphere, and to the north in the southern hemisphere, as well as optimal tilt. An internal system loss of 10 % is assumed. The calculation takes into account PV-inverters as well as installation costs for each examined location. PV panels are assumed to cost 46 €ct/kWp after tariffs for each country which is the price of European panels in Europe as well as Chinese panels after import and penal tariffs (see pvxchange, 2017). The prices are then multiplied by the sales tax rate at each location.

To have a representative grasp on inverter costs for different sizes of PV and storage systems the products examine of world market leader for inverters and similar equipment "SMA Technologies" (see Munsell, 2016) are examined. The PV inverter required was determined for PV capacities from 1.5 kWp to 10 kWp in steps of 0.5 kWp. It is assumed that the maximum capacity of the PV inverter needs to be greater or equal to the capacity of the solar installation.

Installation costs in Germany, California and Australia were sourced from the Rocky Mountain Institute Paper (see Calhoun et al., 2014). Installation Costs for India and South Africa were approximated by sourcing hourly labor costs for all five countries (see Labour Organization, 2017).[2] Then the factor between mean hourly labor costs in Germany, Australia and California and the mean hourly installation costs in these three countries was calculated to account for differences in pay for this kind of specialized labor. This factor was then applied to Indian and South African hourly labor costs. They were then multiplied by the median installation time per kWp of the other three countries, which is Australia's 6.1 h/kWp to arrive at installation costs per kWp, same as for the other three countries. To take taxes for labor into account, the costs were multiplied with the sales tax rate. Also, costs for cable and other installation material have to be considered. We assumed 10 % of the total costs to reflect those.

The interest rates in each location except Germany were derived by calculating the mean interest rates on home loans of the four largest banks in each country. For Germany the interest rate of the government owned KfW bank, which offers low interest rates specifically for solar installations, are taken as input.

RESULTS

Figure 3 shows the results of the LCOE calculation of residential PV (exchange rate euro to usd 1:1.1). The LCOE might not differ much on first sight, but the conditions for investments into own generation differ significantly between the countries, and thus can't be generalized. The cost of capital can outweigh efficiency gains and per unit cost reductions (such as in India), whereas a stable institutional environment is worth a lot (case of Germany so far).

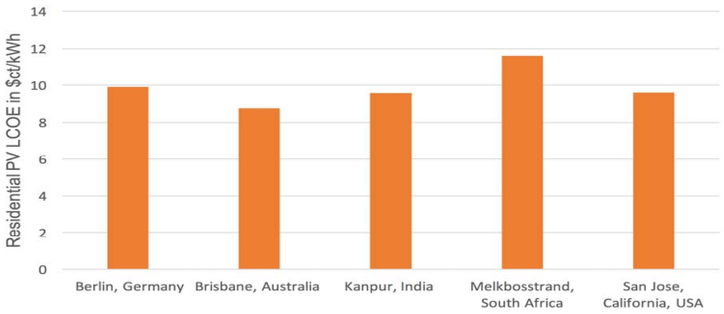

Figure 3: LCOE of PV in Selected Places
Source: Own calculation (see appendix).

Just like California, Germany represents a large-scale, highly interconnected energy system, with high penetration of solar PV and increasing privately owned storage. Both have set similar renewables standards (~ 50 % share by 2030), but Cali-

fornia has a significantly higher solar intensity (see EEI, 2016; Fraunhofer, 2016). Australia is probably the most interesting developed country for prosumage due to its low population density and favorable insolation profiles across the country. India's government has set 100 GW and 40 GW of grid-connected and rooftop solar PV respectively as a goal for 2022 (see IEA, 2015) as it needs both grid-connected and off-grid electricity. Thus, India might see the fastest increase of prosumage. South Africa too, has ambitious plans for PV development and excellent natural conditions, although the economic case for prosumage is not yet evident, given highly subsidized retail prices and ongoing investments into coal and nuclear power. The sharp decline in prices for PV components and the simultaneous rise of retail prices lead to grid parity in an increasing number of places (see IEA, 2014).

OUTLOOK

Besides a rapid price drop of PV module prices, smarter generation and storage will shape the future of prosumage. Ongoing innovation of solar modules is reforming solar generation, exemplary the company SolarCity introduced solar cells integrated into roof shingles. The so called Solar Roof is marketed with costing equally or even less than a conventional roof (see Elon Musk Solar City, 2016).

Storage has great potential to expand. Battery storage might surpass hydro in the coming years. In the past, battery innovation was largely focused on making batteries lighter and smaller for electric vehicles (EV), less on making them cheaper and more powerful. The rise of EV and the advent of so called "gigafactories", very large factory-plants which are designed to minimize the production cost of cells via economies of scale, yield improvements in battery production.

Net Metering has impacted the energy landscape in California and other parts of the world. Although the immense growth of solar in these places in the past five years can mostly be attributed to support schemes and residential installation currently stagnating as the end of the program approaches, the trend will most likely continue with different or without such regulation, as technological advances and economies of scale further decrease prices for PV and storage. The growing affordability of EV and the market entry of new products such as the Solar Roof and similar products will enable prosumers to leverage synergistic effects between electric transportation, heating, cooling, home improvement or renovation, and prosumage. This will result in a further increase in rates of return and a higher degree of independence from the grid and therefore regulation. As a result of these developments we believe that prosumage will grow in California, other U.S. states, and the considered jurisdictions to become an increasingly important factor in the energy systems of those countries.

Footnotes

[1] The LCOE is a method to measure the total production costs of one unit of electricity a certain power generating asset provides. This implies that the investment will exactly break-even at the end of its lifetime if the generated electricity is always sold for the LCOE (including the risk-adjusted interest rates of an investor).

[2] Indian data had to be substituted with values from Sri Lanka, due to data being not up to date.

Bibliography

Calhoun, K., Crofton, K., Goodman, J. & McIntosh, R. (2014). Lessons from Australia - Reducing Solar PV Costs Through Installation Labor Efficiency. last accessed April 26, 2017 at http://www.rmi.org/PDF_reducing_solar_pv_soft_costs_australia.

California Energy Commission & California Public Utilities Commission (2016). Net Energy Metering in California. Go Solar California, last accessed November 20, 2016 at http://www.gosolarcalifornia.ca.gov/solar_basics/net_metering.php.

Elon Musk Solar City (2016). Elon Musk unveils Solar Roof (2016.10.28).

Fraunhofer (2017). Recent facts about photovoltaics in Germany. Fraunhofer ISE, p. 92.

Green, R. (2016). "Prosumage" in the electricity market. Presented at IAEE Pre-Conference Workshop on June 2016.

International Labour Organization (2017). ILOSTAT-the world's leading source on labour statistics. International Labour Organization, last accessed April 22, 2017 at http://www.ilo.org/ilostat/faces/ilostat-home/home?_adf.ctrl-state=mv5vb3fzq_441&_afrLoop=102538451462419#!

Lang, T., Gloerfeld, E. & Girod, B. (2015). Don't just follow the sun – A global assessment of economic performance for residential building photovoltaics. Renewable and Sustainable Energy Reviews, 42, pp. 932–951.

Luthander, R., Widén, J., Nilsson, D. & Palm, J. (2015). Photovoltaic self-consumption in buildings: A review. Applied Energy, 142, pp. 80–94.

Munsell, M. (2016). Top 10 Players Control 80% of Global PV Inverter Market in First Half of 2016.

Greentech Media, last accessed May 02, 2017 at https://www.greentechmedia.com/articles/read/top-10-players-control-80-of-global-pv-inverter-market-in-first-half-of-201.

Pfenninger, S. & Staffell, I. (2016). Long-term patterns of European PV output using 30 years of validated hourly reanalysis and satellite data. Energy, 114, pp. 1251–1265.

PG&E (1990). Map of Baseline Territories - Pacific Gas and Electric Company.

PG&E (2016a). Explore the PG&E Time-of-Use plans. PG&E, last accessed November 20, 2016 at https://www.pge.com/en_US/residential/rate-plans/rate-plan-options/time-of-use-base-plan/time-of-use-plan.page.

PG&E (2016b). Current Electricity Rates - PG&E OCT 2016.

Public Utilities Commission (2016). NEM Currently Interconnected Data Set.

pvxchange (2017). Preisindex. pvxchange, last accessed May 02, 2017 at http://pvxchange.com/priceindex/Default.aspx?template_id=1&langTag=de-DE.

Schill, W.-P., Zerrahn, A. & Kunz, F. (2017). Prosumage of solar electricity: pros, cons, and the system perspective. Economics of Energy & Environmental Policy, 6(1).

SEIA (2016). Solar Market Insight 2015 Q4. SEIA, last accessed February 11, 2017 at http://www.seia.org/research-resources/solar-market-insight-2015-q4.

Staffell, I. & Pfenninger, S. (2016). Using bias-corrected reanalysis to simulate current and future wind power output. Energy, 114, pp. 1224–1239.

APPENDIX

Location	Germany Berlin	California San Jose	India Kanpur	South Africa Cape Town/ Melkbosstrand	Australia Brisbane
Capacity Ftr.	0.13	0.185	0.176	0.23	0.21
Discount Rate	1.5 %	5.22 %	9.15%	15%	3.32%
Labor Cost per Hour in €	38.4	47.8	0.37	9.85	54.13
Hours per KWp	4.3	9.4	6.1	6.1	6.1
Panel Price in € per Wp	0.60	0.548	0.579	0.576	0.556
Inverter Price per KwP (5 kWp Inastallation) in €	279.8	279.8	279.8	279.8	279.8
Wiring, Mounting Etc.	10% of Total Costs	10% of Total Costs	10% of Total Costs	10% of Total Costs	10% of Total Costs
Conversion Rate Eur/Usd	1.1	1.1	1.1	1.1	1.1
Total Initial Costs per kWP in USD	$1.304,90	$1.589,86	$1.042,72	$1.119,40	$1.451,53

LCOE Calculation

The ERCOT Experience with Integrating Renewables

By Chen-Hao Tsai and Gürcan Gülen

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See footnotes at end of text.

In a mild evening around 9 p.m. on March 31, 2017, instantaneous wind generation set a new record in the Electric Reliability Council of Texas (ERCOT): 16,141 megawatts (about 85% of installed wind capacity), accounting for 39.5% of total electricity demand at that moment. One week earlier on March 23rd, wind penetration had reached 50% market share at 3:50 a.m., but only with 14,391 megawatts (MW) of wind generation as load was much lower at that time. These record-high generation and penetration numbers are impressive. However, it is important to emphasize that high wind generation/penetration often happen in shoulder (non-peak demand) seasons, and non-peak hours of the day. Average annual capacity factor for wind has been swinging between 31% and 35% between 2011 and 2016. It is also worth noting that these high wind penetration numbers benefit from the state's Competitive Renewable Energy Zone (CREZ) initiative that induced the investment of $6.8 billion in nearly 3,600-miles of new transmission lines with roughly 18,000-MW of capacity to accommodate abundant wind resources of West Texas. The cost of CREZ lines is socialized across all customers in ERCOT footprint.[1]

Although wind has been the dominant story in Texas, ERCOT, in its latest long-term system assessment, has forecasted a range of 14.5 gigawatts (GW) to 28.1 GW of solar generation capacity to be added by 2031 depending on the scenario, mostly at the expense of coal and natural gas retirements. These forecasted numbers are quite large but current solar capacity, including those in the pipeline to be built over the next 4 to 5 years, is only about 2.5 GW.

INCREASING RENEWABLES AND EVOLVING OPERATIONAL ADJUSTMENTS

As the share of renewables in the system continues to increase, the grid operator needs to address new operational challenges. ERCOT recently added a new "Reliability Risk Desk" in its control room (which went live in January 2017) to address these evolving risks to grid operation, including renewable energy forecast errors, net load ramps, low inertia, and need for variable ancillary services.

Wind generation predictability is important for least-cost reliable system operations. Short-term wind forecasts have been improving but there are still noticeable errors, particularly in shoulder months when wind penetration is higher. Between 2012 and 2015, average day-ahead wind forecast errors have improved from 8.8% to 6.8% for the off-peak season (October to May) and from 8% to 5% for the peak season (June to September). Hourly forecasts errors have been lower historically but have also improved from 6.1% to 4.3% for the off-peak season, and from 5.2% to 3.4% for the peak season.[2]

Nonetheless, these forecast errors translate into several hundred MWs of discrepancy. Given that total installed wind capacity in ERCOT will reach 25.5 GW by 2019, the errors in thousands of megawatts are likely to become more routine unless forecasts continue to improve. Other generators (often gas or coal-fired) have to be available to either ramp up (when the wind generation is less than forecasted) or ramp down (when the wind generation is more than forecasted). Such ancillary services have a cost; but, the average cost per MWh of load has been in the range of $1 to $1.50 between 2012 and 2016 as compared to $2.4 in 2011, an extreme weather year. These costs are small relative to energy prices that averaged $25-30/MWh between 2012 and 2016 versus $48 in 2011. Hence, we will not focus on the drivers of ancillary costs in this brief note.

IMPACTS OF INCREASING RENEWABLES GENERATION ON THE ERCOT MARKET

One would expect increasing share of wind generation to put downward pressure on financial viability of thermal generators because wind displaces MWhs supplied by these generators, suppresses wholesale energy prices, or, often both. In both competitive and regulated markets, system operators accommodate intermittent wind when it is available subject to reliability constraints. Even without any requirements, wind would displace thermal generators in the dispatch merit order since it has low operating and no fuel cost. This change in merit order could result in lower market prices. Furthermore, wind generators sometimes bid negative prices in order to get dispatched and to collect federal production tax credits (PTC), which lowers market clearing prices further. Such price distortions can be observed more frequently in nodal markets at various nodes but could also impact average system prices. Indeed, average wholesale prices in ERCOT have decreased from $45/MWh in 2011 to $22/MWh in 2016 as wind penetration has increased from 9% to 16% (Figure 1). The low energy prices and threat

of market share loss raised concerns of revenue adequacy among existing thermal generators.

However, there are other factors to consider. First, during the same period (2011-2016), the price of natural gas, which has fueled consistently more than 40% of generation in ERCOT and has been the marginal fuel setting the market clearing prices at many nodes most of the time, has been very low (Figure 1). Except for 2014, the annual average natural gas Henry Hub spot price was below $4 per million Btu (MMBtu) and was below $3/MMBtu in 2012, 2015 and 2016. Second, unlike many parts of the country, load growth in ERCOT has been robust. Electricity consumption in ERCOT grew almost 28 million MWh between 2012 and 2016.[3] Wind generation grew more than 23 million MWh over the same period. As such, thermal generators did not have to reduce generation to accommodate wind. Indeed, between 2012 and 2016, coal and natural gas plants consistently generated about 255 to 265 million MWhs of energy every year. Still, it is possible for individual units to have experienced a drop in generation depending on their location on the grid relative to high load growth areas and wind farms. In other markets where load growth is stagnant or even negative, increasing wind penetration would displace MWhs from existing thermal generators.

Overall, differentiating the effects of subsidized, low-operating-cost wind, cheap natural gas, and load growth on ERCOT wholesale energy prices is a non-trivial exercise; but we offer some statistics that support the expectations discussed above with some important qualifications.[4]

First, in Figure 2 and Figure 3, we illustrate the level of wind penetration in percentage of total load at different hours of the day during the peak season (June to September) and the off-peak, or shoulder, season (October to May) between 2011 and 2016. In general, we observe a similar pattern: wind penetration is low (below 10%) during peak hours (between 12 p.m. and 6 p.m.) and higher during off-peak hours, in both peak and shoulder seasons. However, as the installed wind capacity doubled from 9 GW in 2011 to 18.9 GW in 2016, and CREZ lines are completed, we observe that the number of higher wind penetration hours (above 20%) began to increase, and also to migrate, albeit in a limited fashion, from off-peak to peak hours in a day, and from shoulder to peak months in a year.

Second, we are interested in how market clearing energy prices change at different levels of wind penetration. For illustrative purposes, we graph the distribution of ERCOT-average hourly prices at peak hours during the peak season (Figure 4), and the price distribution at off-peak hours during the shoulder season (Figure 5). Increasing wind penetration has limited impact on market prices during peak hours and peak months (Figure 4) when wind penetration is usually below 20%. There was noticeable difference between the median of the two price distribution curves in early years (from 2011 to 2013). However the completion of CREZ lines helped to mitigate negative prices and helped nodal price convergence. In each year from 2014 to 2016, the two price distribution curves do not differ significantly. On the other

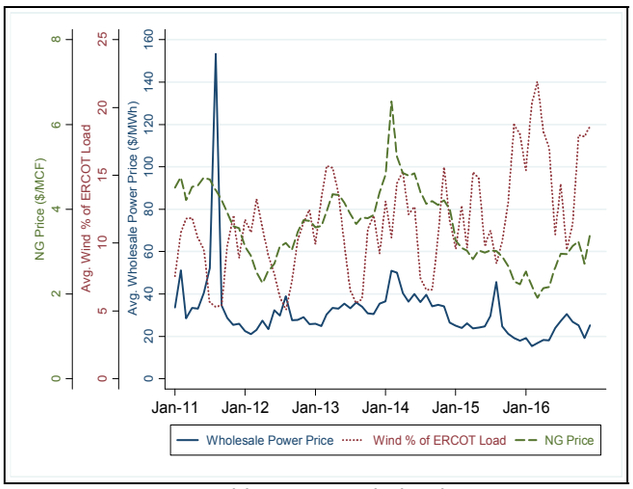

Figure 1: ERCOT Monthly Average Wholesale Energy Price, Wind Penetration and Henry Hub Natural Gas Price (2011 to 2016)

Data sources: ERCOT for hourly Day-Ahead energy price, hourly load, and wind generation output; U.S. EIA for daily natural gas Henry Hub spot price.

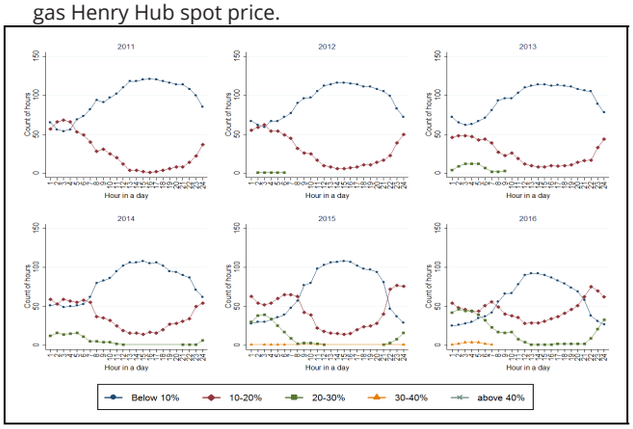

Figure 2: ERCOT wind penetration at different hours in a day (Peak season, June to September)

Data sources: ERCOT

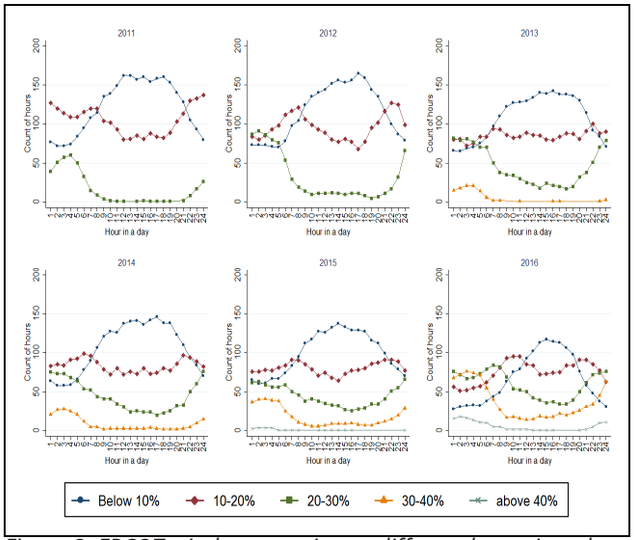

Figure 3: ERCOT wind penetration at different hours in a day (Shoulder season, October to May).

Data sources: ERCOT

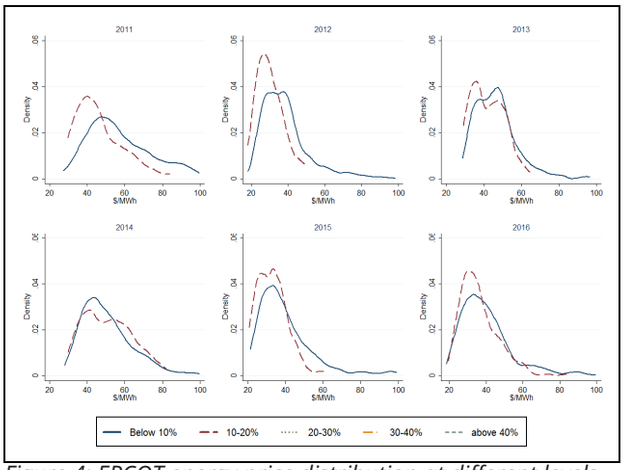

Figure 4: ERCOT energy price distribution at different levels of wind penetration - Peak hours (12 p.m. – 6 p.m.) during the peak season (June to September).

Data sources: ERCOT

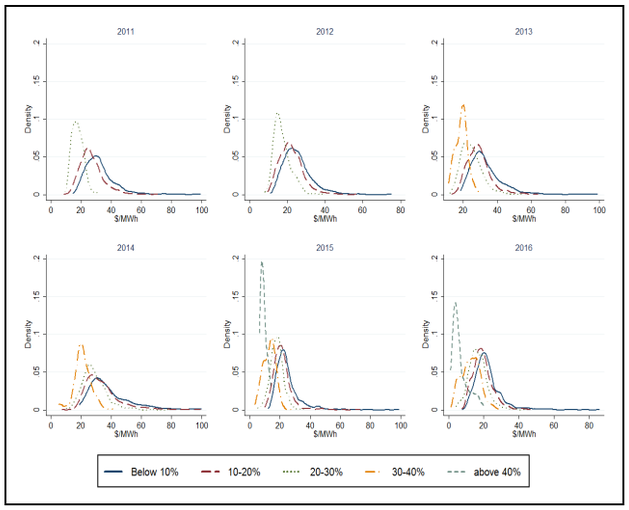

Figure 5: ERCOT energy price distribution at different level of wind penetration – Off-Peak hours (7 p.m. – 11 a.m.) during the shoulder season (October to May)

Data sources: ERCOT

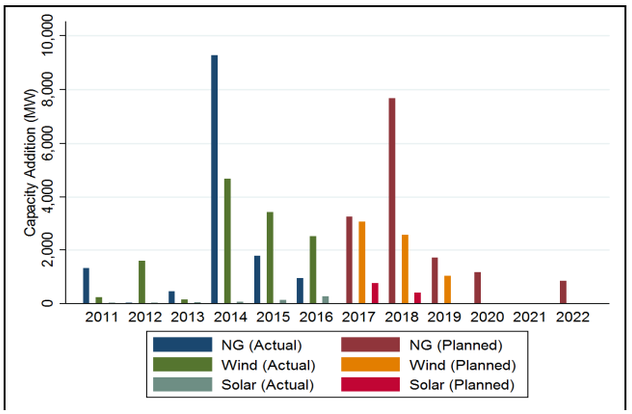

Figure 6: Actual and planned natural gas, wind and solar generation capacity additions in ERCOT (2011 to 2022)

Data source: U.S. EIA Form 860

hand, increasing wind penetration has a larger impact on suppressing market prices during off-peak hours in shoulder seasons (Figure 5), particularly when wind penetration begins to exceed 30%. For example, the median price in 2016 is $20.9/MWh, $18.8/MWh, $16.3/MWh, $12.7/MWh, and $4.9/MWh when wind penetration is below 10%, 10-20%, 20-30%, 30-40%, and above 40%, respectively.

Finally, an interesting counterfactual question is: would we have seen higher wholesale energy prices if there was less wind generation? We utilize AURORAxmp, a commercial power market economic dispatch model, to test hypothetical scenarios of having less wind and investigate its impact on energy prices and conventional fossil plants. We first obtain results for a baseline scenario by running hourly economic dispatch of the ERCOT market in 2015 and 2016, without limiting wind generation output. The model yields aggregate wind generation that is within 2% of the actual wind generation reported by ERCOT, and within 0.1% of the actual ERCOT native load, suggesting the model serves as a good representation of the ERCOT wholesale market. We test five scenarios, in which annual wind generation (MWh) is curtailed at 5% increments, starting at 95% of the baseline and finishing with 75% (Table 1).

Reducing wind generation enhances average wholesale price but only slightly (less than $0.3 per MWh). The effect is smaller in 2016 with lower natural gas price ($2.39/MMBtu versus $2.59 in 2015 in real terms). Second, although gas-fired generation increases in all scenarios in both years significantly, coal generation's response is relatively small and can even be negative. In 2015, limiting wind output to 95% or 90% of the baseline generation encourages natural gas to displace coal, while a deeper reduction (85% to 75%) would help both coal and gas generators. In 2016, changes in coal-fired generation fluctuates across scenarios but remains low. Third, additional generation indeed brings significant additional revenue, particularly to natural gas plants. Revenue enhancement is smaller in 2016 owing to lower electricity prices in 2016 although change in gas-fired generation is larger in most scenarios.[5]

BUILDING MORE GAS AND WIND WHEN SOLAR IS READY TO TAKE OFF IN TEXAS?

Looking at the suppressed electricity prices of the ERCOT market in recent years and expectations of very large solar builds in Texas, the total capacity of planned new builds in the near future and those units under construction is surprisingly high (Figure 6). The federal PTC is the main driver for wind as it has been for a long time although some local tax benefits have probably played a role.[6] Wind developers are eager to get their projects qualified for PTC before it declines over the next few years and is eliminated in 2020.

However it is rather puzzling that more than 14 GW gas-fired generation capacity are also in the pipeline, with 7.6 GW scheduled to come online in 2018. Given the project development cycles, final investment decisions for these facilities were probably taken several years ago. Several ex-

pectations are among the likely drivers of gas plant investments: coal retirements, higher (but not too high) natural gas prices, and load growth. Environmental regulations that threatened coal units might be less of a concern today. Natural gas prices might be climbing somewhat higher than what they were but the forward curve is fairly flat at around $3 for the next few years. The rapid expansion of utility-scale solar on the basis of declining costs have probably surprised many. Still, we may yet see coal retirements, somewhat higher natural gas prices, and less bullish solar expansion. As it stands today, though, sustained low natural gas prices, rapid expansion of solar capacity, which could lower peak prices, and additional wind will continue to stress the long-term functioning of the competitive, energy-only market in ERCOT. Calpine and NRG, two of the largest merchant generators in the country, filed a report on May 10, 2017 with the Public Utility Commission of Texas to recommend "policy and price formation improvements" including scarcity pricing and replacement of "socialized transmission planning" (see footnote 1) in order to address shifts resulting from low natural gas prices and subsidized renewables. This problem is faced by all organized wholesale markets around the country with peculiarities of individual markets and state policies.

	Change in Average Price ($/MWh)		Coal Plants Generation (Thousands MWh)		Coal Plants Revenue (Million$)		Natural Gas Plants Generation (Thousands MWh)		Natural Gas Plants Revenue (Millions$)	
Scenarios	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
95% Wind	0.07	-0.02	-472	-104	-8.5	-5.8	2,473	2,508	64.0	32.8
90% Wind	0.12	0.00	-453	476	-7.6	6.9	4,466	4,254	106.5	49. 6
85% Wind	0.18	0.03	80	-278	4.8	-6.5	5,933	7,371	149.9	128.3
80% Wind	0.23	0.02	125	-4	11.7	-6.9	7,892	9,441	203.5	135.4
75% Wind	0.26	0.18	701	698	27.3	18.2	9,308	11,087	244.3	201.5

Note: (1) In this table we report changes in price, generation and revenue from the baseline scenario, in which we did not constraint wind output. (2) All prices and revenues are in real $2014.

Table 1: Hypothetical Wind Constraint Scenarios – Changes from the Baseline Scenario

Footnotes

[1] A report filed with the Public Utility Commission of Texas in May 2017 recommends that "market-reflective policies for transmission investment should be considered as a replacement for Texas socialized transmission planning, which, by building new transmission in advance of scarcity developing, fails to provide the opportunity for markets to respond." http://interchange.puc.state.tx.us/WebApp/Interchange/Documents/40000_669_939373.PDF.

[2] For example, see "Wind Forecasting at ERCOT" at http://www.sewind.org/images/fact_sheets/ERCOT_Wind_Forecasting_and_Integration.pdf

[3] We exclude 2011 because load was exceptionally high in that extreme weather year.

[4] We are investigating ERCOT 15-minute data to gain better understanding of wind impacts throughout the seasons and across the grid.

[5] It is important to note that we use the zonal version of AURORAxmp with eight zones. ERCOT is a nodal market with real time price cleared every 15 minutes at various settlement points. Our hourly, zonal modeling runs capture low and negative prices with regional aggregation. It is reasonable to expect that a sub-hourly, nodal analysis would capture more of the low/negative pricing. However, it is also worth noting that the number of 15-minute negative prices has been declining as CREZ lines reduced wind curtailment. On the other hand, increasing wind capacity in the future could potentially surpass the transmission capacity and lead to an increase in negative bidding again as long as PTC remains active.

[6] Texas renewable portfolio standard has not been relevant since mid-2000s when the mandated installed renewable capacity was surpassed.

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Calendar

03-05 July 2017, 9th Asia-Pacific Global Summit & Expo on Healthcare at Kualampur,Malaysia. Contact: Phone: 7025085200, Email: healthcareasiapacific@conferenceseries.net, URL: http://healthcare.global-summit.com/asia-pacific/venue-hospitality.php

06-07 July 2017, Mining On Top: Africa- Summit (MOTA) at The superior Intercontinental Frankfurt Hotel, Wilhelm-Leuschner-Strasse 43, 60329, Frankfurt, Germany. Contact: Phone: +44 207 700 4949, Email: barbora@ametrade.org, URL: https://go.evvnt.com/78871-0

10-12 July 2017, Geol. Society - Managing Risks across the Mining and Oil & Gas Lifecycle at Imperial College London, South Kensington, London, SW7 2AZ, United Kingdom. Contact: Phone: +44 (0)207 434 9944, Email: registrations@geolsoc.org.uk, URL: https://go.evvnt.com/86947-0

24-27 July 2017, Power Purchase Agreement - Kuala Lumpur at Kuala Lumpur, Malaysia. Contact: Phone: +6563250351, Email: vincs@infocusinternational.com, URL: http://www.infocusinternational.com/ppa/index.html

26-28 July 2017, Conference on Sustainable Energy, Engineering, Materials and Environment at Northumbria University (conference venue), Newcastle City Campus, 2 Ellison Pl, Newcastle upon Tyne, NE1 8ST, United Kingdom. Contact: Phone: 7467043350, Email: info@ircseeme.com, URL: https://go.evvnt.com/115310-0

01-05 August 2017, 22nd International Conference on Environmental Indicators at Crowne Plaza Hotel Helsinki, Mannerheimintie 50, Helsinki, 00260, Finland. Contact: Phone: +902122999984, Email: eertan@kenes.com, URL: https://go.evvnt.com/84935-0

15-17 August 2017, Argus Petrochemical Asia 2017 at TBC, Singapore, Singapore. Contact: Phone: 64969899, Email: josephine.pulvera@argusmedia.com, URL: http://go.evvnt.com/129451-0

21-22 August 2017, 19th Nano Congress for Next Generation at Finland. Contact: Email: nanocongress@nanotechconferences.org, URL: http://nanocongress.conferenceseries.com/

21-25 August 2017, Gas / LNG Contracts: Structures, Pricing & Negotiation - Johannesburg at Johannesburg, South Africa. Contact: Email: vincs.kong@infocusinternational.com, URL: http://www.infocusinternational.com/gascontracts/index.html

05-07 September 2017, The Green Expo at World Trade Center, Montecito 38 Napoles, Benito Juarez, Mexico City 03810, Mexico. Contact: Phone: +52 55 1087 1650, Email: csanchez@ejkrause.com, URL: https://go.evvnt.com/63085-0

11-15 September 2017, Gas / LNG Contracts: Structures, Pricing & Negotiation - Port of Spain at Port of Spain, Trinidad & Tobago. Contact: Email: vincs.kong@infocusinternational.com, URL: http://www.infocusinternational.com/gascontracts/index.html

12-15 September 2017, Power Purchase Agreement - Johannesburg at Johannesburg, South Africa. Contact: Phone: +6563250351, Email: vincs@infocusinternational.com, URL: http://www.infocusinternational.com/ppa/index.html

13-15 September 2017, Argus Americas Petroleum Coke Summit at Marriott Woodlands Waterway Resort, 1601 Lake Robbins Dr, The Woodlands, TX 77380, United States. Contact: Phone: 7134007846, Email: sarah.mireles@argusmedia.com, URL: https://go.evvnt.com/106768-0

21-21 September 2017, Is There a Plan ? UK Energy Policy for the 2020s at London, UK. Contact: Phone: 07876477449, Email: conference@biee.org , URL: http://www.biee.org/conference-list/plan-uk-energy-policy-2020s/

27-29 September 2017, Coal Association of Canada 2017 National Conference at Westin Bayshore Vancouver, 1601 Bayshore Drive, Vancouver, V6G 2V4, Canada. Contact: Phone: (780) 757-9488, Email: info@coal.ca, URL: https://go.evvnt.com/115962-0

28-29 September 2017, 2nd World Congress on Wind & Renewable Energy at United Kingdom. Contact: Phone: 6502689744, Email: windenergy@conferenceseries.net, URL: http://windenergy.conferenceseries.com/

02-03 October 2017, The 4th Annual Nuclear Decommissioning and Used Fuel Strategy Summit at The Ritz Carlton, 201 East Trade Street, Charlotte, 28202, United States. Contact: Phone: +44 0207 375 7537, Email: bmoss@nuclearenergyinsider.com, URL: https://go.evvnt.com/128421-1

18-20 October 2017, The Green Expo 2017 at World Trade Center, Montecito 38 Napoles, Benito Juarez, Mexico City, 03810, Mexico. Contact: Phone: +52 55 1087 1650, Email: csanchez@ejkrause.com, URL: https://go.evvnt.com/63085-0

22-24 October 2017, 37th Argus Fuel Oil and Feedstock Summit at The Ritz Carlton, 1 Lincoln Road, Miami Beach, 33139, United States. Contact: Phone: 7139680000, Email: usconfmarketing@argusmedia.com, URL: https://go.evvnt.com/113883-0

23-24 October 2017, International Summit on Sustainable Energies at United States. Contact: Phone: 8888438169, Email: sustainableenergies@protonmail.com, URL: http://sustainableenergies.conferenceseries.com/

25-26 October 2017, 2nd Ethiopia International Mining Conference and Exhibition at Addis Ababa, Ethiopia. Contact: Phone: +44 (0) 207 700 4949, Email: barbora@ametrade.org, URL: https://go.evvnt.com/77887-0

25-26 October 2017, 10th Asian Downstream Summit 2017 at Sands Expo and Convention Centre, 10 Bayfront Avenue, Singapore, 018956, Singapore. Contact: Phone: +65 6590 3970, Email: infoasia@clarionevents.com, URL: https://go.evvnt.com/77392

26-27 October 2017, Geological Society - Ground Related Risk to Transportation Infrastructure at London, United Kingdom. Contact: Phone: +44 (0)207 434 9944, Email: registrations@geolsoc.org.uk, URL: ttps://go.evvnt.com/79634-0

07-10 November 2017, Power Purchase Agreement - Singapore at Singapore. Contact: Phone: +6563250351, Email: vincs@infocusinternational.com, URL: http://www.infocusinternational.com/ppa/index.html

13-17 November 2017, POWER WEEK 2017 at Singapore. Contact: Phone: +6563250351, Email: vincs@power-week.com, URL: http://www.power-week.com/index.html

16-17 November 2017, International Meeting on Petroleum Engineering at Holiday Inn Atrium 317 Outram Rd Singapore 169075. Contact: Phone: 800-101-2526, Email: petroleum@meetingseries.org, URL: http://www.meetingsint.com/chemical-engineering-conferences/**petroleum**

IAEE ENERGY FORUM *Vol. 26, Third Quarter 2017*

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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