IAEE Energy Forum

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CELEBRATING 40 YEARS ANNIVERSARY

CONTENTS

contents continued on page 4

Editor: David L. Williams

President's Message

Dear Fellow Members:

In early September the 15th IAEE European Conference 2017 took place in Vienna with the theme "Heading towards sustainable energy systems: evolution of revolution?". We enjoyed 5 days with a great program to exchange ideas on energy issues and the challenges ahead. I thank all those who were involved in the organization of the event, the host institutions (Technische Universität Wien, its Energy Economics Group, and the Austrian Association for Energy Economics), our sponsors, Austria and the City of Vienna and its authorities, and all our members that participated and gave life to this successful event. The themes discussed were diverse as are the interests of our community that come from more than 90 countries and we enjoyed the participation of a large number of enthusiastic students who made great contributions in the poster and concurrent sessions, giving us fantastic prospects for the future of IAEE.

For the coming years there is a lot more to come, and I invite you to navigate through and to contribute with your scientific and policy-oriented research to our three leading publications, The Energy Journal, Economics of Energy & Environmental Policy, and the Energy Forum. Also, I encourage you to save the date for upcoming events, including the following:

- 35th USAEE/IAEE North American Conference "Riding the Energy Cycles", November 12-16, 2017, USAEE, Houston – Texas - USA.
- 41st IAEE International Conference "Transforming Energy Markets", June 10-13, 2018, BAEE/IAEE, Groningen - The Netherlands.
- 2019 16th IAEE European Meeting Ljubljana, Slovenia August 25-28
- 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.

40 years have passed since this wonderful organization was founded by a group of visionaries in Washington, Boston, and Cambridge (UK). When we look back in time at the beginning of our association, the issue of energy security was at the heart of the energy agenda and discussion, and was a cornerstone theme in IAEE that received a lot of attention from governments, industry, civil society, academia, and the inter-

(continued on page 2)

President's Message (continued from page 1)

national community. It was no coincidence that IAEE was born after the oil embargo in the early 1970s, and just before the Iranian revolution, where Iran cut production and exports and cancelled contracts with some foreign companies, and where energy was one of the key drivers of the economic and geopolitical agenda. From the late 1970`s up to today, world population has grown by 80%, the world economy by 200%, and energy consumption by more than 200%. We expect them to increase even further in the decades to come. In these 40 years, there have been big changes in technology and civil society attitudes. We live in a more integrated and connected world, with a different geopolitical landscape, and with increasing social and environmental constraints. Through all these years, during periods of higher or lower stress, the issue of energy security has remained as a central theme given the relevance that energy has as a key pillar for development and economic growth in the modern economy. Commemorating the times when IAEE was founded, main theme for this current issue of the Energy Forum is on energy security.

There is more than one interpretation of energy security, IEA defines energy security as the uninterrupted availability of energy sources at an affordable price; while NATO refers to it in a more holistic manner, in talking about energy security it says that "there's much more at stake than cheap, reliable sources of energy. It's about independence. Energy security is about politics, sovereignty, political stability, democracy and development". This highlights the importance that energy security has for economic and social development, as well as for national security. Beyond the more or less holistic interpretation of energy security we take, energy security challenges are diverse and depend on a diverse set of factors and particular conditions of each economy: as an energy importer or exporter, on the availability of native energy sources, its degree of integration with regional and global energy markets, and the degree of development and commoditization of the different energy sources at the regional and global level, among others.

On the topic of the risks faced by an energy importing country, one that integrates its energy markets and/or infrastructure to regional or world energy markets, a key is the understanding of the risk grade that is embedded in its energy imports, an imported risk that comes from outside economies and energy markets. The impacts of risky conditions and the decisions and/or strategic decisions made abroad can be carried to the country through the energy markets when there are no reliable and competitive alternative sources of energy supply. The solution to improving energy security is not one of self-sufficiency but is one of setting the proper safeguards that guarantee a safe supply of energy. As practicable, the chance

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

to take advantage and rely upon native energy sources and/or global but competitive energy markets is an enabler for a more secure supply of energy. Some risks that can be faced by an energy importing country are:

- Opportunistic behavior from undiversified sources of supply
  - price instability
  - energy disruptions with deep economic and political effects
  - changes in tax regimes, royalties, contractual schemes in the export country
  - the use of energy as a geopolitical weapon
  - the use of energy and prices to punish/rewards particular behaviors, as a mean of extortion/manipulation
- Changes in foreign regulatory framework, environmental/social safeguards
- Exposure to political decisions, such as energy subsidies, and conditions of turmoil and social unrest in neighborhood or supplier countries
- Exposure to weak Rule of Law and changes in the business environment in neighborhood countries
- Supply disruption that leaves large stranded assets/investments and imposes huge switching costs
- Supply disruption that leaves a dislocated/disrupted energy system with deep economic, social, environmental, and political consequences

These threats, in general, highlight the debate on energy dependency, which advocates diversifying energy sources with access to competitive and secure regional and/or global markets, and for the development of native energy resources/sources.

As importing countries are exposed to risk from global and regional energy markets, energy resource-rich and exporting countries face a different set of risks such as:

- The need to secure a market and a stream of revenues, where government revenues often depend heavily on energy rents, and the loss of those rents can pose severe impacts on social and political stability.
- One of feeding substantial energy subsidies, with a heavy burden on the state and distorted energy prices.
- One of being left with stranded assets due to large swings in energy demand and markets
- Being exposed to opportunistic behavior because of a undiversified target market
  - Risk of price instability or price extortion/manipulation
  - Risk of changes in tax regimes, royalties, contractual schemes in an import country which might affect price and demand
- Changes in foreign regulatory framework, environmental/social safeguards that affect price and demand
- Potential conflicts with communities and civil society that seeks a share from energy rents.

At the risk of being simplistic, and as a rule of thumb, in an exporting country an effort should be placed in the diversification of the target markets, with a broader access to regional and/or the global market, as well as the promotion of sound economic and fiscal policies to bring a proper management of energy rents.

When we look up the different feelings about energy security, we see that there is a consensus that the integration of energy markets/infrastructure creates wealth and improves peoples' wellbeing. However, from a security/geopolitical perspective, some clouds loom over the belief that the integration of energy markets/infrastructure necessarily enhances energy security. There is a wide diversity of views, of development models, and on the role of the private and public sectors within each region, and on how to distribute the rents from energy resources, as well as twisted models of competition to capture them. In recent years, we have observed unilateral changes on energy contracts, price and supply manipulation, and on the use of energy as a political weapon. All these have happened beside the great business opportunities that exist for the greater integration of regional and global energy markets, creating wealth and improving citizens' living conditions. We are confident that the articles that we bring in this issue of the *Energy Forum*, written by our distinguished fellow members, will convey some answers and solutions to the many questions that come up when we talk about the challenges that an economy faces when confronted with complex issues regarding its energy security.

We thank you for your commitment to IAEE and look forward to having you at our upcoming local and regional conferences, as well as the upcoming 41st IAEE International Conference "Transforming Energy Markets", that will take place on June 10-13, 2018, in Groningen, The Netherlands.

Ricardo Raineri Bernain

Editor's Notes

In this issue we continue our discussion of *Renewables and Conventional Energy Resources: Challenges, Opportunities, Complementarities, Rivalries and Game Changers* and open the discussion of *Energy Security.* The response to our call for articles on the latter has been most gratifying. If you don't see your paper in this issue, the chances are it will be in the next. And our next issue, the first in 2018, will carry the final papers on renewables. Both subjects have been well received.

Before we get to these articles, however, we have a special article on *How to Give a Good Presentation* by **Richard Green**. This should be of particular interest to those planning presentations at coming IAEE conferences. The European meeting in Vienna was a great success and we're fortunate to have an overview of the plenary sessions of the conference put together by **Jaroslav Knapek**. Now on to the balance of this issue.

Mamdouh Salameh argues that the newly-imposed U.S. sanctions on Russia will have very limited impact on the Russian economy. Since the 2014 oil crash, the Russian economy has adjusted to lower oil prices and sanctions.

Travis Roach writes substitution between coal and renewable energy has been a hot topic for some time now, but has received even more attention under the Trump administration. However, this trade-off was made much prior to today's conversations, and may have been influenced by cognitive biases.

Mark A. Andor and **Manuel Frondel** draw on two stated-preference surveys conducted in 2013 and 2015 to elicit household's willingness-to-pay for green electricity. They present evidence that the accumulating cost of Germany's ambitious plan to transform its system of energy provision is butting up against consumers' willingness-to-pay for it.

Sophie Gabriel, Antoine Monnet and **Jacques Percebois** examine the long-term availability of uranium resources. They have modeled the ultimate uranium resources and uranium market mechanisms, and have thus been able to conduct prospective studies with, in particular, changes for technical or political reasons of production in a given region.

Kazutomo Irie notes that a bipolar system created by OPEC and the IEA for world energy governance was established in the 1970s. But, entering the 21st century, various international entities proliferated for international cooperation and dialogue on energy issues. He discusses the result; a multilayered intergovernmental system has been formed for world energy governance.

Joseph Cavicchi and **Maheen Bajwa** use real-time pricing data from U.S. wholesale electricity markets to examine the increasing frequency and incidence of negative electricity prices corresponding to the increasing supply of renewable resources. Increased reliance on State renewable resource production-based subsidies will likely lead to more frequent negative prices.

Hongbo Duan and **Shouyang Wang** develop a one-sector energy-economy-environmental integrated framework of China, combining with a series of well-proposed energy security metrics to explore the unidirectional consistency between climate policy and energy security from the national perspective. They considered the potential impacts of emission budgets on China's energy security.

Silvia Andrea Cupertino, Marcia Konrad, Hirdan Katarina de Medeiros Costa, and **Edmilson Moutinho dos Santos** discuss the diversification of the Brazilian electric matrix as a tool to promote environmental sustainability, security of supply in the country, and national energy policy guidelines. Brazil implemented a federal policy that grants incentive to renewables, but still has a long way to reach an optimum diverse matrix.

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International Association for Energy Economics

Contents continued from page 1

U.S. Sanctions on Russia: Geopolitics, Pipelines& U.S. Self-interest

By Mamdouh G. Salameh

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See footnotes at end of text.

In imposing new sanctions on Russia, the U.S. Congress aimed to punish Russia for its alleged meddling in the U.S. elections in 2016. Still, these sanctions were mostly motivated by U.S. self-interest and geopolitics.

There are indications that these sanctions will have very limited impact on Russia but could cause some collateral damage to others. They are virtually a restatement of the ones imposed by Barack Obama in 2014 after Russia annexed the Crimea. The biggest change, however, is that these sanctions are now codified into a law specifying that any move by U.S. President Trump (or a future president) to loosen the sanctions could be blocked by Congress.

The target of these sanctions as in the previous ones is Russian banks and companies as well as Russian oil and gas projects. The new law tightens some of those limits a bit – for instance, U.S. companies can't participate in any energy project in which Russian entities have a stake of 33% or more.[1] This certainly applies to the U.S. oil giant Exxon Mobil's involvement in the Russian Arctic with its Russian counterpart Rosneft.[2]

These sanctions have already been discounted by the markets as evidenced by the strengthening of Russian bonds, stocks and the ruble after Trump signed the sanctions legislation.

COLLATERAL DAMAGE

However, the European Union (EU) could suffer some collateral damage. The sanctions ban improvements including repair of Russian-owned pipelines into Europe. That provision could curb investment in the jointly European and Russian-financed Nord Stream II gas pipeline that would enable the Russian gas Giant Gazprom to divert gas supplies to the EU via Ukraine into a less controversial route under the Baltic Sea, to Germany (see Map 1).

Map 1. Nord Stream II Gas Pipeline

The U.S. sanctions will also place additional restrictions on international companies participating in oil projects with Russian companies or facilitating or investing in Russian export pipelines.[3]

However, the most contentious issue could well be the sanctions on pipelines. Key projects such as Nord Stream II and the TurkStream pipeline which will carry gas from Russia to Turkey under the Black Sea, are threatened if investor companies or contractors could come under sanctions.

Two other European energy projects could be undermined by the sanctions. They are the Caspian Pipeline Consortium to carry Kazakh oil to the Black Sea via Russia and a prospective Baltic liquefied natural gas (LNG) plant.

Nord Stream II construction will start in 2018 and will be finished by the end of 2019. The first pipes for the Nord Stream II were delivered in October 2016 to the German Logistics hub Mukran on the Island of Rugen.[4] The two "Nord Stream II" threads will transfer 27.5 billion cubic meters a year (bcm/y) of gas, doubling the capacity of the Nord Stream I.

The newly enacted sanctions are almost certain to create tension between the U.S. and Europe. "The U.S. bill could have unintended unilateral effects that impact the EU's energy security interests", Jean-Claude Juncker, the European Commission president, said in a statement." This is why the Commission concluded that if our concerns are not taken into account sufficiently, "we stand ready to act appropriately ".

The Financial times reported that the EU was drafting possible countermeasures against the U.S. including challenging the pipeline project sanctions through the World Trade Organization (WTO) should the U.S. start to enforce them.[5]

Some in the EU are claiming that the U.S. wants to displace Russia as a gas supplier to Europe. While there is some truth in this, U.S. LNG can't compete with Russian gas supplies to Europe. Russia has a fully integrated gas industry underpinned by the world's largest proven reserves of natural gas, the cheapest production costs , doesn't have to convert its gas to LNG to ship it to Europe and already has a network of export pipelines, even without Nord Stream II.

Moreover, Gazprom says it has other means of financing infrastructure if interest from Europe dries up.

GEOPOLITICS & U.S. SELF-INTEREST

The U.S. has always been opposed to Nord Stream II, which it views as Russia's attempt to solidify its hold on Europe's energy supplies.

In fact, U.S. misgivings about the geopolitical implication of Nord Stream II are shared by eight European countries (perhaps instigated by the U.S.) – Poland, Hungary, Lithuania, Latvia, Estonia, the Czech Republic, Slovakia and Romania. They sent a letter dated the 7th of March 2016 to European Commission President Jean-Claude Juncker warning that Nord Stream II would have potentially destabilizing geopolitical consequences, undermine the energy security of Central and Eastern Europe, and detrimentally impact Ukraine.

On March 21, 2016 the prospective shareholders in the Nord Stream II consortium (Gazprom 50%; E.ON 10%; BASF/Wintershall 10%; Royal Dutch Shell 10%; OMV 10% and Engie 10%) issued a rebuttal. They argued that Nord Stream II would enhance Europe's long-term energy security by providing an alternative gas supply route that avoids the unreliable transit state of Ukraine. The rebuttal further asserted that the project will improve internal market competition by increasing liquidity in North-West European gas hubs with the delivery of additional gas supplies at a time when North Sea gas production is declining and European gas demand is rising.

Nord Stream II, with dual lines totaling 55 bcm/y capacity, would traverse the Baltic Sea along a route parallel to the existing Nord Stream I (also 55 bcm/y capacity) making landfall at the Lubminer Heide gas hub near Greifswald, Germany. It would provide up to 110 bcm/y of Russian gas supplies to the North-West European gas market.

PUTIN'S ENERGY MASTER PLAN

Map 2. The TurkStream Gas Pipeline

Putin's plan is to turn Russia into the world's energy superpower and it is working.

In the beginning of 2017, Gazprom projected that the demand for Russian natural gas in 2017 will increase by 2.7% to 430 bcm/y.

Russia has been building many pipelines to deliver its natural gas to every corner of Eurasia. Prominent among these pipelines is the Nord Stream II and TurkStream. By 2019 Turkish and European consumers will receive a new and reliable route for the import of the Russian natural gas (see Map 2).

TurkStream will have two parallel pipeline threads: one with the natural gas for Turkey and another one for European countries. Each thread will carry 15.75 bcm/y of Russian gas. The commissioning of both threads is planned for December 30, 2019.

There is also the Power of Siberia gas pipeline which will deliver Russian gas to China (see Map 3). It will start operation by 2019 with the delivery of 38 bcm/y of Russian natural gas, which can be increased to 61bcm/y if Putin decides to cut the shipment of natural gas to Europe in favor of China.

Then, there is India. The delivery of 2.5 million tons of LNG to India by Gazprom (the equivalent of 3.4 bcm of natural gas) will start in 2018. The plans to build a pipeline to India as an extension to Power of Siberia are also under consideration.

And it does not stop there. Russia and Japan are actively discussing construction of a natural gas supply pipeline from Sakhalin (a Russian island in the Pacific Ocean) to Japan. The 1,500 km underwater pipeline will be able to provide Japan with 20 bcm/y of natural gas, which is 18% of Japan's LNG imports.[6]

European appetite for Russian natural gas has been growing despite political frictions. Since the beginning of 2017, deliveries to the European market have grown by 15% compared to the same period of the last year, or 8.6 bcm/y.

Map 3. The Power of Siberia Gas Pipeline. Selected natural gas infrastructure in eastern Russia.

Collectively, the EU imports 53% of the energy it consumes. This includes 90% of its crude oil and 66% of its natural gas—a higher percentage than most other regions of the world, including North America, East Asia (but not Japan), and South Asia. All told, energy accounts for 20% of all EU imports.

Most European countries import more than 30% of the energy they consume. Russia provides roughly 40%.[7] Germany, which boasts the largest economy in the EU, imports more than 60% of the energy it consumes, and France, which boasts the second-largest economy, imports about 45%. Currently, one-third of the natural gas consumed by Europe comes from Russia (see Table 1).

France and Germany illustrate how Russian energy can shape foreign policy. France may rely heavily on foreign energy, but most of its oil and natural gas comes from Algeria, Qatar, Saudi Arabia, and Libya—not Russia. France can, therefore, afford to be more aggressive and supportive of sanctions against Russia.

Not so with Germany, which receives 57% of its natural gas and 35% of its crude oil from Russia. Berlin must, therefore, tread lightly between its primary security benefactor, the U.S., and its primary source of energy, Russia.

This is one reason Germany has been an outspoken critic of the recent U.S. sanctions, which penalize businesses in any country that collaborate or participate in joint ventures with Russian energy firms. Germany supports the construction of Nord Stream II. The pipeline would help safeguard German energy security and needs.

Of course, Germany may try to diversify its energy sources from other countries like Libya, Nigeria, Kazakhstan and Norway, but it would struggle to do so. It relies heavily on pipelines for its energy, particularly Russian natural gas. But Germany has fewer options for natural gas and no major LNG facilities. Simply put, Germany is beholden to the countries with which its pipelines have a connection—something that makes it vulnerable to retaliation (see Map 4).

Country	Dependency on Russia
Lithuania	75%
Hungary, Austria & Slovakia	60%-65%
Czech Republic	62%
Germany	57%
Poland	53%
France	45%
Latvia	45%
Bulgaria	37%
Romania	17%
Estonia	9%
The EU as a whole	**33%**

Source: BP Statistical Review of World Energy, June 2017 / OPEC Annual Statistical Bulletin 2017 / OilPrice.com accessed on the 9th of August, 2017.

Table 1.Europe's Dependency on Russian Gas Exports

Cultivating this dependency is a conscious move by Russia. Russia has developed economic leverage that enables it to exert pressure over countries that could pose a danger to it by threatening their energy security. Is this just business for Putin? Of course not; geopolitical interests are intertwined.

First, China, Turkey and Russia are discussing ways to conduct their mutual trades using national currencies only, which will exclude the U.S. dollar from these deals.

Second, Turkey will become a European energy hub, which will increase the country's political weight on the continent. But this will happen as a result of energy cooperation with Russia.

Third, the ambitious plans to ship American LNG to Europe could be either delayed or put to rest for a long while.

The reality of the 21st century—as Putin sees it—is that energy is a political instrument. Political

Map 4. Major Gas Pipelines between Russia & Germany

alliances and the rise and fall of the international importance of particular countries will change in accordance with the energy supply routes.

Still, there is only so much Russia can do. Its geopolitical interests in Ukraine, for example, align with Germany's energy needs. Germany would benefit from Nord Stream II by getting a new and secure natural gas route, and Russia would benefit by gaining more leverage over Ukraine. But Washington wouldn't want Moscow to halt energy flows through Ukraine at its leisure. The U.S. needs to try to manage the Ukraine situation in a way that prevents a greater general German-Russian alignment.

U.S. Senator John McCain once called Russia a gas station masquerading as a country. While you can insult your gas station as you like, one still has to pay the bill.

GEOPOLITICAL FALLOUT FROM THE SANCTIONS

Russian Foreign Minister Sergei Lavrov was quoted saying after the sanctions were announced that while Russia has been doing everything possible to improve relations with the United States, recent events showed that U.S. policy was in the hands of Russophobic forces, pushing Washington to the path of confrontation.[8]

Many experts have warned that there are visible parallels between the current sanctions pressure over Russia and the situation in the 1980s when Washington also used sanctions and manipulated oil prices, resulting in the collapse of the Soviet economy and the subsequent political turmoil.[9]

"By imposing new sanctions, the U.S. risks losing global influence and uniting non-Western countries against it," according to Vladimir Lepekhin, a Russian political expert and director of the Eurasian Economic Institute (EEU) think tank.[10]

If the United States continues to up the ante with measures such as arming the Ukrainian government, then the Russians are likely to make life difficult for Washington in other parts of the world. For example, Russia could provide arms to Iran, North Korea or potentially other regimes.[11]

Energy sales are an important source of revenue, of course, but for Russia they are more than that: they are an instrument of geopolitical power. They give Moscow considerable influence over the countries whose energy needs are met by Russian exports. If Russia intends to retaliate further against the U.S., its energy supplies, especially those it sends to Europe, may be its best option. A policy of dividing the U.S. and Europe could be Putin's best bet.[12]

WINNERS & LOSERS

The Ukraine and ExxonMobil could be the biggest losers in the sanctions' saga.

The new pipelines will make the Ukrainian pipelines' role in the European economy and politics null and void. The contract between Gazprom and the Ukrainian pipeline company, Naftogaz, will expire at the end of 2019.

Last year, Gazprom sent about 82 bcm of natural gas through Ukrainian territory for its European customers. The construction of Nord Steam II and TurkStream pipelines would deprive Ukraine of $2 bn a year of transit fees that Ukraine collects from Russia. It will also lower the market capitalization of Ukrainian pipelines by 5 times—down from $30 bn to $5 bn.

Signs of despair in Kiev are obvious. Right after the start of the work on the TurkStream, Naftogaz "unofficially" let it be known that, starting 2020, it was ready to decrease the 10% transportation fee that Russia pays for the flow of natural gas through Ukrainian territory.

Gazprom says that it does not rule out sending gas through Ukrainian territory after 2019 to its customer countries that border Ukraine—but it will be a much smaller amount of probably 15 bcm/y and only if it makes economic sense.

Chart 1. Russia GDP Annual Growth Rate

The other potential loser could be ExxonMobil. In the run-up to 2014 sanctions, ExxonMobil and Russia's oil giant Rosneft invested $3.2 billion in a project for drilling for oil in the Russian sector of the Arctic — a region that Rosneft estimated could have more oil than the entire Gulf of Mexico. But the sanctions forced Exxon Mobil to halt drilling.[13]

ExxonMobil applied in 2015 and in June 2017 for a waiver from U.S. sanctions on Russia but the U.S. Department of the Treasury rejected both applications.[14]

Russia's economy could in the long term be the winner in the sanctions war. Since the oil price crash in 2014, the Russian economy has been diversifying away from reliance on oil and gas exports. As a result, growth reached an annual rate of 2.5% in the second quarter of 2017, the fastest in almost five years (see Chart 1).

The recovery is definitely taking place amid clear signs that economy has adjusted to lower oil prices and the sanctions imposed in 2014.[15]

Russia is now saying that its economy can now live forever with an oil price of $40 or less.[16] It is also signaling that neither low oil prices nor sanctions will deter it from Arctic drilling. Rosneft is getting its drilling activities underway in the Russian Arctic. By so doing, Putin's Russia is demonstrating that sanctions did not succeed in putting a crimp in Russia's oil sector.

The recent U.S. sanctions demonstrate how remote, difficult and protracted the process of normalizing U.S.-Russia relations is.

Footnotes

1 Joel Parshall, "U.S. Sanctions Hit New Russian Projects, Add Uncertainty" Journal of Petroleum Technology (JPT), 8 August, 2017.
2 Mamdouh G Salameh, "Is U.S. Oil Giant ExxonMobil Trying to Evade U.S. Sanctions on Russia" (An article posted by the Research Centre for Energy Management (RCEM) on the 11th of May, 2017).
3 Joel Parshall, "U.S. Sanctions Hit New Russian Projects, Add Uncertainty".
4 Ibid.,
5 A Report by Jim Brunsden & Courtney Weaver published in the Financial times on the 23rd of July 2017.
6 BP Statistical Review of World Energy, June 2017, p.29.
7 "How U.S. Sanctions against Russia Could Backfire", a report by OilPrice.com posted on the 7th of August, 2017 and accessed on the 12th of August.
8 Nicole Gaouette & Jeremy Herb, "White House: Trump Sign Russia Sanctions Bill" (A CNN Report on July 29, 2017).
9 Vladimir Lepekhin, "Window of Opportunities: Why U.S. Sanctions Likely to Boost Russian Economy", a report published by Sputnik International on the 11th of August, 2017.
10 Ibid.,
11 Dave Majumdar, "America & Russia Will Square Off Over New Sanctions", the National Interest, August 15, 2017.
12 Meghan O'Sullivan, "The One Big Problem with New Russia Sanctions", published by Bloomberg View on the 10th of August, 2017.
13 Mamdouh G Salameh, "Is U.S. Oil Giant ExxonMobil Trying to Evade U.S. Sanctions on Russia".
14 Ibid.,
15 Kathrin Hille, "Russia's Recovering Economy Fears from U.S. Sanctions Chill", The Financial Times, the 11th of August 2017.
16 A Bloomberg interview with the Russian economy minister, Maksim Oreshkin at the Petersburg International Economic Forum (SPIEF2017) as reported by Reuters on the 2nd of June 2017.

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.

HOSTED BY

35TH USAEE/IAEE NORTH AMERICAN CONFERENCE

CONFERENCE SESSIONS & SPEAKERS

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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
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Behavioral Economics and the Tradeoff between Coal and Renewable Energy Capacity Additions

By Travis Roach

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See footnotes at end of text.

The introduction and evolution of renewable energy technologies, along with policies intended to support them, have disrupted the traditional electricity generation mix which has historically relied on coal as the primary baseload generating source. Since 1999 renewable energy (RE) generating capacity has grown by 3,303%[1] with a robust 40.2%[2] being added in the last five years despite lapses in one of the main policies that drive RE capacity additions, the Production Tax Credit. The growth in RE capacity can be attributed to an array of Federal, state and local tax credits and subsidies as well as state renewable portfolio requirements. To a lesser extent some states have even passed legislation limiting carbon dioxide emissions which incentivizes RE generation at the margin.[3] Along with these policies, RE technologies have broadly witnessed decreasing average costs that can be attributed to economies of scale and "learning by doing" (among other factors). Indeed, Rhodes, et al. (2017) show that even without carbon pricing wind and natural gas have the lowest LCOE for large swathes of the United States. This, then, leads to a natural question: as the capacity of RE grows nationwide, and as natural gas prices stay low due to an abundance of supply, what will happen to the share of coal as a baseload supplier? The answer may have been decided *much* before the present day discussion of substitutability between renewable energy and fossil-fuel technologies. This brief Dialogue delves into one possible cause for the decline in coal generating facilities that has nothing to do with renewable energy and coal competing to supply baseload demand, but rather internal decision making and lessons from the field of behavioral economics.

One of the main, and most robust, findings from behavioral economics is that humans are more deeply affected by losses than by equivalent gains. In short, we are loss averse. In their seminal work on prospect theory and loss aversion, Kahneman and Tversky (1979), show that losses weigh heavily on decision making and in fact sway consumer choices in such a way that sub-optimal decisions are made. Their findings are consistent even when pairs of options with the exact same risk and reward probabilities are presented in the same questionnaire, but framed differently to reflect a possible gain or loss. Lessons from Kahneman and Tversky's prospect theory have been proven time and time again in a number of contexts, and are a mainstay of the behavioral finance literature.

Applied to the topic at hand, consider a simple example of the tradeoff between choosing to invest in a coal generating facility or a wind farm. Although wind production is intermittent by the hour, to the project facilitator electrical output over a year can be estimated with accuracy because yearly wind speeds and net capacity factors are less stochastic. Further, the vast majority of wind projects sell their electrical output at a fixed PPA[4] price that is agreed upon in advance of construction. Without any marginal fuel costs, wind projects can yield a near constant cash flow to the wind farm developer. Let's assume for this example, then, that the wind project will yield an expected net present value of $50 million dollars with little to no expected volatility. Coal projects on the other hand may appear riskier at the outset given uncertainty in market conditions and future policy decisions. For example, perhaps a coal project is profitable given current coal prices and the lack of a carbon tax or permit system, but if marginal coal prices were to rise, or if a tax on carbon dioxide emissions was passed, or both, then it is possible that the coal facility will become too expensive to be tapped for baseload demand and losses would be equal to the costs of installing the plant. For simplicity, then, let's assume that there is an 80% chance that the coal project will yield a net present value of $100 million, and a 20% chance that the net present value of the project is negative $20 million. What is your gut reaction to this investment decision?

Guaranteed $50 million from wind facility
Coal facility with:
80% chance of $100 million
20% chance of losing $20 million

According to prospect theory we would expect most to choose the 'guaranteed' $50 million from a new wind farm rather than take the risk of losing $20 million on a new coal plant. This is despite the fact that (at least in this example) the coal plant has a higher expected profitability of $76 million; $26 million more than the expected profit from the wind farm.

$$80\% \cdot \$100M + 20\% \cdot -\$20M = \$76M$$

Although this is certainly a simplification, this tradeoff decision making may already be seen in the growing age of existing coal plants and the dearth of new coal plant facilities that have been brought online. According to the EIA the capacity-weighted average age of existing coal facilities is 39 with 88% of the existing coal fleet having been installed between 1950 and 1990 (EIA, 2017) Figure 1, below, shows this downward trend in coal capacity additions by showing the amount of new coal plants by year since 1930. It is clear that new additions have been in a broad decline since at least 1978, eight years after the first "Earth Day". Further, since 1992 there has not been a single year in which there were 10 new coal fired plants installed. Figure 1 also includes any combined cycle gasification plant installations. Even when including combined cycle gasification plants it is clear that the amount of new coal facilities is waning.

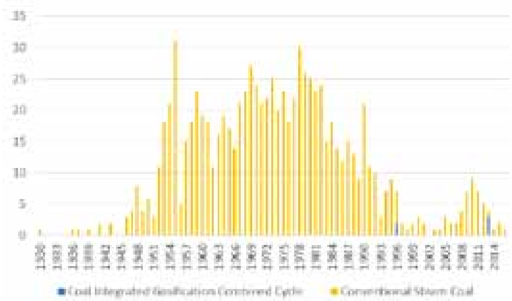

Figure 1

Of course project profitability and cost benefit decisions are much more complex than the simple example presented here. However, the mounting evidence (and acceptance) of global climate change due to the burning of fossil fuels should not be discounted in effecting large-scale capital decisions. That is to say, to the decision maker the probability that a new carbon tax or permit system is instantiated is most likely non-zero. If a new coal project is to have a 50-year life span, and this decision maker assigns any non-zero probability to future climate action that would inhibit profitability, then it is entirely possible that loss aversion may impact the decision making process. Returning to Kahneman and Tversky (1979), the authors show that even when there is only a 1% risk of earning $0, respondents tend to pick the option with a guaranteed payout of $2400 instead of an option with a higher expected payout.[5] Thus, even an incredibly low amount of risk could affect capital decision making and shift investment away from coal and toward RE and natural gas facilities.

As baseload capacity markets continue to evolve and adapt to the presence of cheap natural gas and a continually declining LCOE for wind and solar, it is interesting to note that tradeoff decisions between coal and renewable energy have already taken place, and that these decisions may have been unduly influenced by cognitive biases. Lessons from prospect theory and loss aversion in particular, suggest that investors may have hedged uncertainty with potentially lower profit RE projects in the past, and may continue to do so in the future.

Footnotes

[1] 1999 capacity = 2,472 MW; 2017 Q1 capacity = 84,143 MW
[2] 2012 capacity = 60,005 MW
[3] States in the Regional Greenhouse Gas Initiative, and California which has a carbon trading program.
[4] Power Purchase Agreement
[5] They choose $2400 rather than 33% chance of $2500, 66% chance of 2400 and 1% chance of $0.

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Germany's Energiewende: A Tale of Increasing Costs and Decreasing Willingness-To-Pay

By Mark A. Andor, Manuel Frondel and Colin Vance

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In recent years, the political economy of electricity provision in Germany has been strongly influenced by two factors. The first is the country's ongoing commitment to increase the share of renewable energy technologies, with green electricity production amounting to almost 33% of gross consumption by the end of 2015 (BDEW, 2016:11). The second factor is the nuclear catastrophe at Japan's Fukushima in 2011. This event had a profound impact in exacerbating a longstanding skepticism in Germany on the merits of nuclear power, and led to the legal stipulation of its phase-out in the same year. Both factors are the most salient pillars of Germany's so-called Energiewende (energy transition), which advances the most ambitious subsidization program in the nation's history, with costs that may approach those of German re-unification.

Summarizing the paper of Andor, Frondel, Vance (2017), which will be published in a forthcoming Special Issue of The Energy Journal, we present evidence that the accumulating costs of Germany's Energiewende are butting up against consumers' willingness-to-pay (WTP) for it. We begin with a descriptive overview of the growth of renewable energy technologies in Germany since the introduction of the Renewable Energy Act in 2000, focusing on increases in both capacity and the associated costs. Thereafter, we turn attention to the public's acceptance of these costs, which have to be born by electricity consumers via a surcharge on their bill.

IMMENSE COSTS OF RENEWABLE CAPACITY EXPANSION

In Germany, electricity generated from renewable energy sources (RES) has preferential access to the grid and is promoted via a feed-in-tariff (FIT) system that guarantees technology-specific, above-market rates, commonly over a 20-year time period. This promotion scheme has established itself as a global role model and has been adopted by a wide range of countries (CEER, 2013). In fact, FIT systems have been established in more than 100 countries throughout the world (REN21, 2015).

Since the implementation of Germany's FIT system in 2000, installed capacities of renewable energy technologies have increased remarkably, by more than eightfold between 2000 and 2016 (Table 1). Photovoltaics (PV), until recently the most expensive renewable energy technology in Germany (Frondel, Ritter, Schmidt, 2008), and onshore windmills have experienced the largest increase, with PV capacities sky-rocketing: In 2010 alone, more than 7,000 Megawatt (MW) were installed, an amount that exceeded the cumulated capacities installed by 2008. According to estimations of Frondel, Schmidt, Vance (2014: 9), the real net cost for all those modules installed between 2000 and 2015 amounts to more than 110 billion Euros.

In 2016, total RES capacities reached about 104 Gigawatts (GW), equaling those of conventional power plants (last column Table 1), while the share of green electricity in gross electricity consumption was about 32% (BMWi, 2017: 5). This relatively modest share owes to the fact that wind and solar power are not permanently available 24 hours a day. Consequently, to reach Germany's renewable goals of a 50% share in gross electricity consumption set for 2030 and 80% in 2050, a multiple of today's capacities have to be installed, an endeavor that will inevitably lead to higher costs of electricity generation.

These costs were already substantial in the past: Between 2000 and 2015, consumers paid about 125 billion Euros in the form of higher electricity bills for Germany's RES promotion (Table 2), with the cost shares of industrial and household consumers estimated at 31.5% and 34.5% in 2016,

Year	Hydro Power	Wind Onshore	Wind Offshore	Photo-Voltaics	Biomass	Total RES Capacities	Conventional Capacities
2000	4.83	6.10	–	0.11	0.70	11.75	109.9
2001	4.83	8.74	–	0.18	0.83	14.57	107.9
2002	4.94	11.98	–	0.30	1.03	18.24	106.5
2003	4.95	14.59	–	0.44	1.43	21.41	105.6
2004	5.19	16.61	–	1,11	1.69	24.59	106.0
2005	5.21	18.38	–	2.06	2.35	27.99	107.0
2006	5.19	20.57	–	2.90	3.01	31.67	107.6
2007	5.14	22.18	–	4.17	3.50	34.99	110.2
2008	5.16	23.82	–	6.12	3.92	39.02	110.4
2009	5.34	25.63	0.06	10.57	4.55	46.14	111.4
2010	5.41	27.01	0.17	17.94	5.09	55.61	111.6
2011	5.63	28.86	0.20	25.43	5.77	65.87	103.2
2012	5.61	31.00	0.31	33.03	6.18	76.10	102.1
2013	5.59	33.76	0.51	36.34	6.52	82.71	103.9
2014	5.61	38.16	1.04	38.24	6.87	89.91	104.3
2015	5.90	41.24	3.30	39.80	6.90	96.83	104.1
2016	5.60	45.38	4.15	41.28	7.11	103,52	103.2

Table 1: Germany's Conventional and Renewable Electricity Generation Capacities in Gigawatt (GW).

Sources: BMWi (2016: 12, 2017: 7), BDEW (2016: 13). With an installed capacity of less than 0.05 GW in 2014, geothermic systems are of negligible relevance and not included in the table.

Year	Hydro Power (Bn. €)	Wind Onshore (Bn. €)	Wind Offshore (Bn. €)	Photo-Voltaics (Bn. €)	Biomass (Bn. €)	Total RES Net Costs (Bn. €)	Average Net Costs per kWh (Cents/kWh)
2000	0.213	0.397	–	0.014	0.042	0.667	6.4
2001	0.295	0.703	–	0.037	0.105	1.139	6.3
2002	0.329	1.080	–	0.078	0.177	1.664	6.7
2003	0.253	1.144	–	0.145	0.224	1.765	6.2
2004	0.195	1.520	–	0.266	0.347	2.430	6.3
2005	0.193	1.518	–	0.636	0.540	2.997	6.8
2006	0.168	1.529	–	1.090	0.896	3.765	7.3
2007	0.121	1.428	–	1.436	1.307	4.338	6.5
2008	0.081	1.186	–	1.960	1.565	4.818	6.8
2009	0.025	1.608	0.003	2.676	1.991	5.301	7.0
2010	0.192	1.647	0.019	4.465	3.000	9.525	11.6
2011	0.263	2.145	0.057	6.638	3.522	12.774	12.4
2012	0.223	2.944	0.092	7.939	4.576	16.008	13.5
2013	0.303	3.165	0.122	8.276	5.172	17.340	13.8
2014	0.301	3.669	0.208	9.166	5.675	19.222	14.1
2015	0.306	4.136	1.717	9.402	5.552	21.066	13.1
Total Costs	3.460	28.818	2.218	54.221	34.689	124.821	–
Cost Shares	2.8%	23.1%	1.8%	43.4%	27.8%	100 %	–

Table 2: Net Costs of Germany's Promotion of Renewable Energy Technologies in Billions of Euros.

Source: BMWi (2015). Figures for 2015 are unconsolidated forecasts.

respectively (BDEW, 2016:60). The remaining 34% are contributed by commerce, trade, services (18.8%), the public sector (12.2%), transport (2.1%) and agriculture (0.9%).

The strong increase in alternative electricity generation capacities in Germany and the resulting rise in the share of green electricity in consumption led to a surge in the surcharge that appears on German electricity bills (Figure 1). In 2015, the surcharge of 6.17 cents per kWh comprised roughly 20% of the average per-kWh price of electricity of about 28 cents (Table 3). The increase of this surcharge is particularly pronounced in the years between 2009 and 2014, a period that largely coincides with the stark extension of PV capacities. In fact, the exploding PV capacity increases in the years 2009-2012 (Table 1) were responsible for the near doubling of average subsidies per kWh between 2009 and 2013 (last column in Table 2). As a consequence, while comprising about 6% of Germany's annual electricity production (BDEW, 2016:12), PV accounts for 43.4% of total net promotion costs (Table 2), by far the largest cost share among all alternative technologies. The prognosis of 'dark clouds on the horizon' in the subtitle of an earlier analysis by Frondel, Ritter and Schmidt (2008) has thereby materialized, with the subsidies for PV having increased more than 300% since their warning was issued.

Presuming that the annual subsidy level of more than 20 billion Euros in 2015 (Table 2) is extended for the next two decades, a crude back-of-the-envelope calculation yields an estimate of 400 billion Euros for the continued promotion of renewable energy. Several considerations render this estimate conservative. First, the annual subsidies are likely to far exceed 20 billion Euros in light of their inexorable increase to date. According to a recent forecast, they will approach 30 billion in 2020 (BDEW, 2016:83), in large part owing to the expansion of offshore-wind capacities, currently the most expensive green technology in Germany.

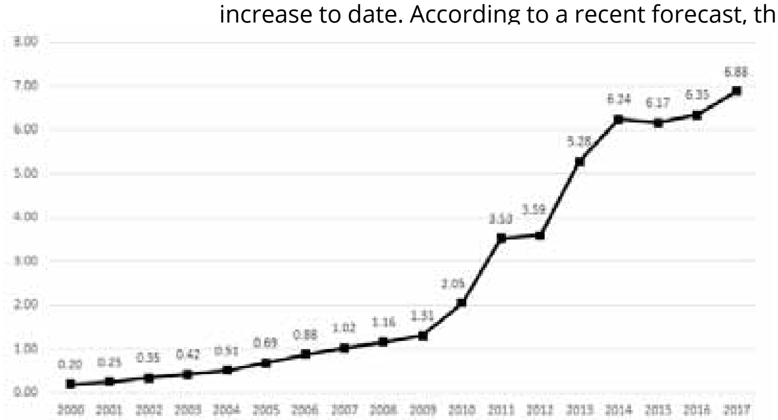

Figure 1: Surcharge on Electricity Prices (in Cents per kWh) to Support Green Electricity (BDEW 2016:60)

Additional costs arise due to the fact that a large portion of today's conventional power plants has to be sustained to compensate for the intermittency of wind and solar power, since storing volatile green electricity is likely to remain unprofitable for the next decades (Frondel, Sommer, Vance 2015). Not least, substantial costs of several tens of billions of Euros accrue to consumers from the indispensable expansion of power grids, in particular as the electricity produced by wind power installations in the north and east of Germany must be transported to the highly industrialized west and south of the country. In short, it is most likely that future electricity prices will rise further if Germany actually reaches its renewable goals.

Some sense for the extent of the likely rise can be gleaned from past developments. Between 2000 and 2015, electricity prices more than doubled, from 13.94 to 28.68 ct/kWh (BDEW, 2016:56). For typical households with an electricity consumption of 3,500 kWh per annum, this implies an additional burden of about 520 Euro per year. In terms of purchasing power parities (Table 3), German households now incur the highest power prices in the European Union (EU). In a similar vein, prices for industrial customers are also among the highest in the EU.

BENEFITS OF RENEWABLE CAPACITY EXPANSION

	Household Prices	Industrial Consumption in Gigawatthours				
		< 500	< 2,000	< 20,000	< 70,000	< 150,000
Denmark	22.8	26.73	25.90	25.87	24.37	24.18
Germany	28.3	22.76	19.79	17.49	15.05	13.88
Italy	24.4	22.64	18.79	16.65	13.64	11.14
Austria	18.2	14.95	12.47	10.77	9.17	8.32
United Kingdom	16.6	20.05	17.88	16.44	16.03	15.65
Netherlands	17.9	18.06	11.06	9.89	8.51	8.49
France	14.8	14.42	12.08	10.53	9.22	7.71
EU 28	20.8	16.00	13.24	11.74	10.41	13.04

Table 3: Electricity Prices in Euro Cents per kWh for European Household and Industrial Consumers in 2015

Source: Eurostat (2016). Average Prices including Taxes and Levies in Purchasing Power Standards.

Of course, whether these high costs are justified from a social-welfare perspective depends on the size of the benefits associated with the promotion of renewable energy technologies, a quantity that is considerably more difficult to calculate than the costs and one that is beyond the scope of the analysis by Andor, Frondel, Vance (2017). The majority of studies that have tackled this issue have focused on quantifying specific benefit categories, such as carbon dioxide (CO_2) emissions reductions and innovation effects, or have investigated economic impacts, such as job creation. In addition, in the absence of appropriate policy instruments, an important co-benefit of the use of renewable energy technologies is the reduction of local air pollution and associated health impacts due to the avoidance of local emissions of particulate matter and nitrous oxides from burning fossil fuels.

Perhaps the most important economic benefit relates to climate change mitigation. The record here is inauspicious. Germany's CO_2 emissions have been relatively stagnant in recent years, even rising somewhat in 2016, and an expert commission appointed by the country's minister of economy and energy has cast skepticism on reaching the target set for 2020 of a 40 percent reduction in CO_2 relative to 1990 (Löschel et al., 2016).

One reason is the country's continued reliance on fossil sources to bridge the intermittency of renewables. Mainly due to the nuclear phase-out, coal use has maintained a relatively stable share in Germany's electricity generation, amounting to about 42% in 2015 (AGEB, 2016). By contrast, the use of natural gas, which is much less emissions-intensive than coal, is on the decline, with its share in electricity production decreasing from 14.1% to 9.4% between 2010 and 2015.

Equally important is Germany's membership in the European Trading System (ETS), which sets a binding cap on the emissions of participating countries and consequently renders the feed-in tariff system redundant. Germany's success in unilaterally reducing its emissions through feed-in tariffs releases tradable emissions certificates, thereby reducing their price and resulting in higher emissions elsewhere in Europe.

SHRINKING WILLINGNESS TO PAY FOR GREEN ELECTRICITY

The foregoing analysis has documented the substantial costs of Germany's support scheme for renewable energy technologies, which are likely to exceed 400 billion Euros over the next 20 years. Given the now decade-plus history of unabated cost increases, coupled with the prospect that this trend will continue into the foreseeable future, the question arises as to the public's tolerance for continued support of Germany's Energiewende.

Drawing on two stated-preference surveys conducted in 2013 and 2015 that elicit households' willingness-to-pay for green electricity, the results presented by Andor, Frondel, Vance (2017) suggest tepid support for financing renewable energy technologies. In fact, the open-ended responses reveal a marked decrease of about 17% in the average willingness-to-pay between the 2013 and 2015 waves of the survey, a period during which the surcharge paid by households for green electricity rose commensurately, by 17%.

The shrinking willingness-to-pay for green electricity and the cost burden notwithstanding, the data analyzed by Andor, Frondel, Vance (2017) suggests that the German public, at least in principle, is highly supportive of RES technologies. Based on the 2015 wave of the survey, some 88% of respondents stated that RES should generally be supported, a finding that is buttressed by other polling (e. g., Statista, 2016). Overall, the survey results highlight a strong contrast between the households' general acceptance of supporting renewable energy technologies and their own willingness-to-pay for green electricity: On the one hand, the share of respondents who agreed with the statement that, in principle, renewable energy technologies should be supported increased from 84.4% in 2013 to 88.0% in 2015. On the other hand, almost 60% of those household heads who participated in both surveys reduced their willingness-to-pay for 100% green electricity relative to 2013.

CONCLUSION: MORE COST-EFFECTIVENESS

Presuming that subsequent surveys reveal a continued decrease in the willingness-to-pay for green electricity, the public's resistance to increasing electricity prices may force a discussion that leads to a restructuring of Germany's energy transition and climate protection policy, which is currently costing the country more than 0.8% of its GDP per year. Resistance may be further exacerbated as recognition grows of the marginal environmental benefits of the Energiewende coupled with absence of positive economic impacts, such as employment creation. In this regard, the longstanding narrative surrounding 'green jobs' has instead been contradicted by a series of bankruptcies in the photovoltaics sector, the most recent being the insolvency of Germany's largest PV-manufacturer Solarworld, announced in May of this year.

In short, high costs of the promotion of renewables of about 25 billion Euros per annum together with minor environmental benefits render Germany's feed-in tariff system highly cost-ineffective, a point that has been recognized by several expert commissions, such as the German Council of Economic Experts (GCEE, 2011: 219) and the International Energy Agency (IEA, 2007:76). To improve cost-effectiveness and dampen future electricity price increases, the German government has recently introduced an auctioning system for the renewable energy technology promotion, where capacities are auctioned separately by technology to foster competition among providers. As these auctions are technology-specific, though, there is still no competition across technologies. Cost-effectiveness could be further improved if future capacities were to be increased by technology-neutral auctions.

More desirable, from the perspective of consumers, would be a fundamental reform of the support scheme that involves a switch to a technology-neutral quota system (GCEE, 2011) or the subsidization of capacities, rather than electricity generation (Andor, Voss 2016), both of which would make the suppliers of green electricity more responsive to the demand side. An additional increase in cost-effectiveness would be achieved if support schemes for renewable energy technologies were to be coordinated at the European level, as is called for by the European Commission, thereby recognizing that green electricity production may be cheaper in Europe's southern periphery, where the sun intensity is high.

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Uranium Resources and Security of Supply

By Sophie Gabriel, Antoine Monnet and Jacques Percebois

INTRODUCTION

In order to study the possibilities for the future deployment of nuclear power plants, we have examined the long-term availability of uranium resources. We first defined a model to estimate the ultimate uranium resources (discovered and undiscovered resources and those already mined) (§ 2) and then studied the dynamics of the uranium market (§ 3). This allowed us to define a market model (§ 4). The modelling carried out allowed us to conduct prospective studies, with particular attention given to supply security issues (§ 5), introduced by changes of production in a particular region, for technical or political reasons. Our analysis was not based on modelling demand scenarios as this involved too many underlying assumptions, hence we adopted a literature review based approach [3]. Two demand scenarios were subsequently selected: scenario A3, representing high global demand for nuclear power (5,400 GWe installed capacity in 2100) with a consequently high-growth demand for natural uranium (810 ktU/year); and scenario C2, representing moderate-growth demand (2,100 GWe in 2100 and 340 ktU/year) (Figure 1).

The description of our study is given in [5] (in English) or with much more detail in [4] (in French).

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MODELLING ULTIMATE RESOURCES

Several bivariate and multivariate statistical models can be found in the literature to estimate the abundance and production costs associated with a non-ferrous metal such as uranium. These models are essentially used to estimate potential reserves within a specific region of the world.

Our methodology allows for an estimation of ultimate uranium resources based on a lognormal distribution of the grade and tonnage of deposits, on the use of an economic filter and on cost functions which take account of economies of scale and the type of mining involved.

The regional breakdown used to estimate ultimate resources (including both identified and undiscovered resources) consists of 6 subregions: **USA, Canada, Africa, Australia, Kazakhstan** and the **rest of the world.** These regions were selected on the basis of the following criteria:

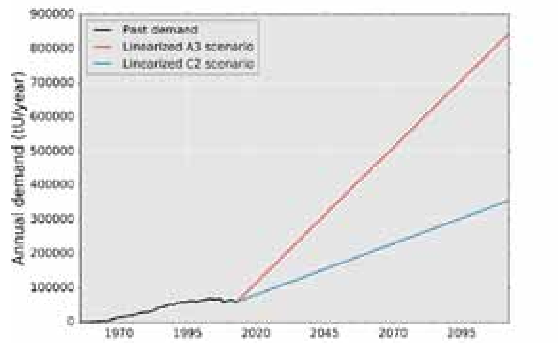

Figure 1 – Cumulative global uranium consumption scenarios [1]

- Representativeness: the top 5 subregions account for almost 85% of world production and close to 80% of reasonably assured resources (RAR) at <USD 130/kgU in 2013 [6].
- Availability of data on known deposits and recent mining projects.
- Minimal variability in the types of deposit encountered and a certain degree of standardisation of mining regulations within the regions to ensure relative consistency when estimating the costs of ultimate resources.

Our cost calculation method (cost-capacity relationship) was used for each subregion, taking account of the specific regional characteristics in terms of mining techniques.

Application of our model gave the ultimate resource estimates for each region illustrated in Figure 2. (The cumulative ultimate resources estimated is about 72 MtU at <USD 260/kgU). The results obtained in each region were compared with estimates from the NEA-IAEA published in the "Red Book" [6]. This comparison does have its limitations, however, bearing in mind that the resources (reasonably assured and inferred resources (RAR+IR)) identified in the Red Book do not, by definition, include any undiscovered or already-mined resources, whereas these are included in our estimate of ultimate resources.

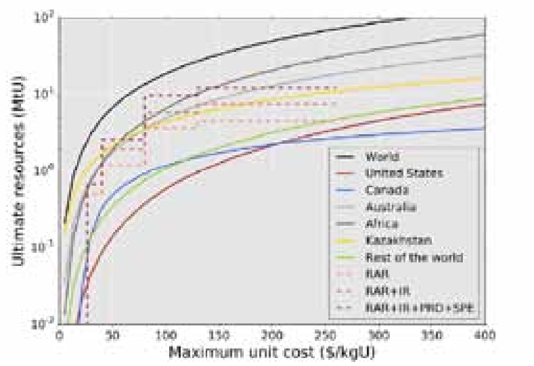

Figure 2 - Cumulative ultimate resources

It is important to note that the model developed only considers resources from the earth's continental crust and that uranium is considered to be a primary product. Hence, uranium resources dissolved in seawater are not taken into account.

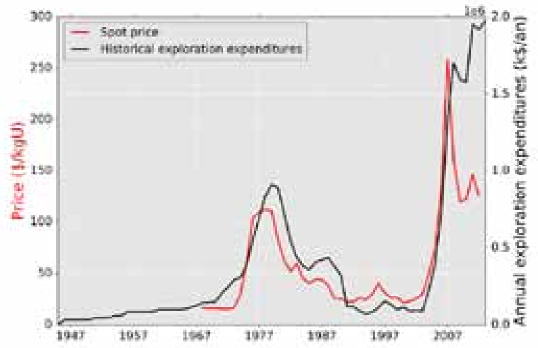

Figure 3 – Uranium spot price (yearly average of month-end prices) and exploration expenditure (1940-2013)

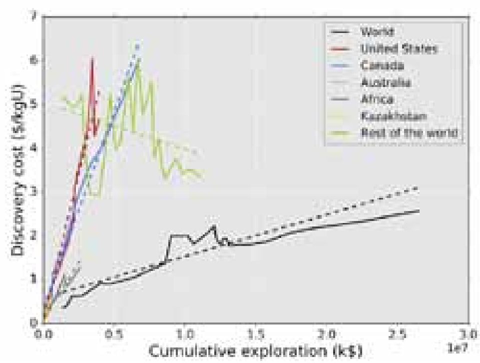

Figure 4 - Correlation between discovery cost and cumulative exploration expenditure

Moreover, sensitivity analysis showed significant uncertainties on the ultimate resource estimate. The most sensitive parameters include the discount rate, the depth of the earth's crust considered and the price of uranium representative of current economic conditions. (In order to take into account this high level of uncertainty, we will also consider an estimate of 36 MtU at <USD 260/kgU.)

It can now be noted that a very limited number of regions gather a large part of current resources and production which raises questions about security of supply. We will see later how the variation of production of a single region can influence the market.

DYNAMIC CONSTRAINTS ON URANIUM SUPPLIES

Analysis of exploration activity and associated discovery costs allow the introduction of two key relationships.

- Market prices and exploration expenditure

Like many other mineral raw materials, uranium shows a clear correlation between its spot price and exploration expenditure (see Figure 3).

- Discovery cost and cumulative exploration expenditure

As a territory is explored, more and more difficulties in identifying new resources are encountered, which results in an increase in the discovery cost. We have estimated the correlation between discovery cost and cumulative exploration expenditure per region.

Besides, the reserves-to-production ratio (R/P) is an indicator of availability of a non-renewable resource used primarily in the oil and gas industry [2]. We propose two original interpretations of the R/P ratio. On a global level, R/P is a simple indicator of scarcity, which can represent a constraint associated with the anticipation of global demand. On a regional level, this ratio can be interpreted further as the result of the producers' technical, budgetary and financial constraints or a regional strategy. If the perceived scarcity of the resource exceeds a critical value, a retroactive increase of the price is applied until the additional exploration expenditure is sufficient to satisfy this constraint. This type of modelling introduces the notion of **scarcity rent**.

MODELS OF THE URANIUM MARKET

Based on the supply constraints described earlier, which may be short-term (such as the causal link between price and exploration expenditure) or longer term (such as the anticipation of demand), we study the long-term availability of uranium using a succession of short or medium-term economic balances.

Figure 5 - Price trends (A3 and C2 72 MtU)

The market is modelled as an oligopoly of 6 regions with exploration and anticipation constraints (the market players are combined and modelled together in these regions), but no rent other than the scarcity rent or the differential rents is included in the market price to represent a possible dominant position of any player.

Figure 5 and Figure 6 show the price and resource rent trends for demand scenarios A3 and C2.

Two marked trends can be seen in prices for scenario A3: the price remains fairly stable in the short and medium term (around the 2013 levels), then increases significantly after 2035 (Figure 5). In fact, this change occurs when the global R/P ratio reaches its 60-year threshold. In this situation, the market mechanism introduces an increasing scarcity rent to keep the R/P ratio at its minimum level (Figure 6).

For scenario C2, the R/P ratio reaches its threshold later and the price increase is lower.

The sensitivity analysis has shown that anticipation of demand and the need for visibility for consumers, represented by the constraint on the global R/P ratio, directly affect price trends, by influencing the scarcity rent (Figure 7). Maintaining a minimum R/P ratio is necessary to avoid a shortage. It can also be seen that the higher the anticipation constraint, the sooner and the stronger the price increase.

Some parameters introduced in our model tend to increase production costs as resources are depleted and new resources discovered. Yet, these trends are secondary compared with the long-term uranium price trends since the scarcity rent is the first determining factor when demand rises according to scenarios A3 or C2.

These results show that in the case of increasing demand for uranium, low market prices that do not favor exploration threaten long-term security of supply, whether by a shortage of identified resources if there is no anticipation of the risk, or if not, by a very large price increase linked to the appearance of a scarcity rent.

PROSPECTIVE STUDIES OF SUPPLY VARIATIONS

In order to test the robustness of our model and to go further in the analysis of security of supply over the long term, we considered three cases of variation in supply. First of all, we study the effect of the uncertain estimation of the ultimate resources on price trends and then situations in which production is suddenly stopped or doubled in one region.

Effect of the ultimate resources

Figure 8 shows the price trends with two supply scenarios, 72 MtU and 36 MtU at <USD 260/kgU, for the two demand scenarios A3 and C2. The following observations can be made:

- Uranium demand is the first-order variable which influences uranium price trends.
- The estimation of the ultimate resources affects price trends more in the medium terms than in the long-term (the characteristic medium and long-term timescales depend on the growth of demand).
- Increasing the ultimate resources, in the medium term, delays the price increase associated with the differential rents, which limits exploration and, in the longer term, brings forward the date when a scarcity rent appears, and therefore the significant price increase.

Thus, at the first order and over the long term, the uncertainties about the quantities of ultimate resources are not responsible for the rise in prices. The rise in prices is linked to the anticipation of demand (R/P ratio), that is to say the quantities of identified resources (R) since in our model production (P) corresponds to demand and is exogenous.

Effect of stopping production in one region

We simulate stopping Australia's production in 2050 and analyse its effect on price trends. Australia was chosen because this region plays an important role in global production and past political choices have already restricted or suspended its production for several years. In a context where some countries decide to stop exploration and production of hydrocarbons, it is conceivable that a country decides to stop its exports of nuclear fuel only for political reasons.

The results obtained (Figure 9) show that stopping production in a country such as Australia would result in a period of price fluctuation followed by a residual price variation in relation to the reference situation. This variation continues in the long-term. Furthermore we have shown that the earlier production is stopped, the greater the variation.

These results suggest that the political decision to stop uranium production in a region like Australia may threaten the global security of supply and have long-term consequences.

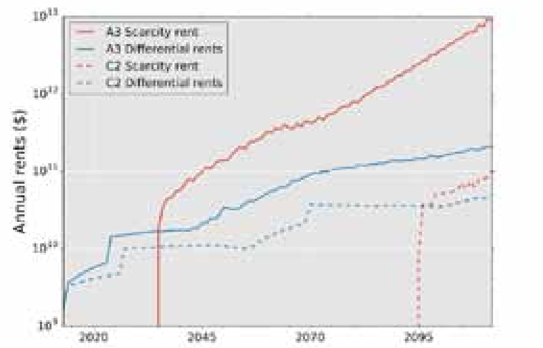

Figure 6 - Resource rent trends (A3 and C2 72 MtU)

Figure 7 - Effect of the anticipation of demand constraint (A3 72 MtU)

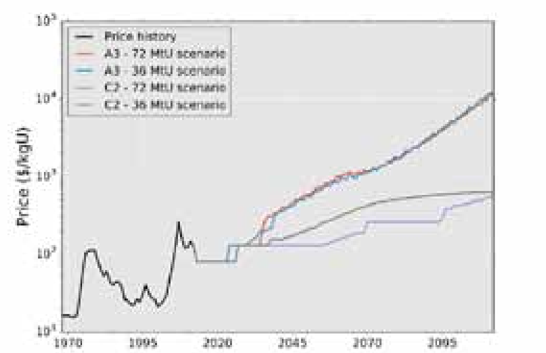

Figure 8 - Effect of the supply and demand scenarios

Figure 9 - Effect of stopping Australia's production in 2050

Effect of doubling the production in one region

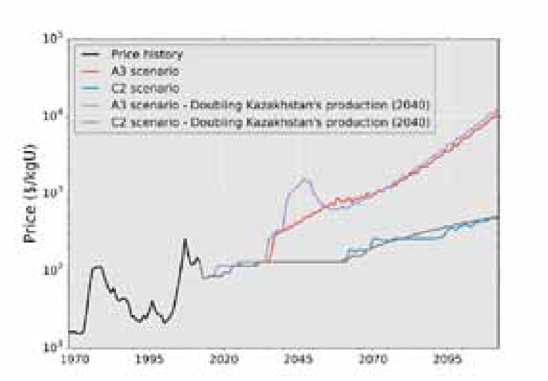

Figure 10 - Effect of doubling Kazakhstan's production in 2040

We now look at the effect on price trends of doubling Kazakhstan's production in 2040. Kazakhstan was chosen because this region has already proved, at the start of the 21st century, that it is capable of rapidly increasing its production.

According to the results (Figure 10), doubling the production of a country such as Kazakhstan would introduce price fluctuations in the short and medium term, but would have little long-term effect.

CONCLUSION

This analysis of uranium resources and security of supply is based on modelling the ultimate uranium resources (discovered and undiscovered resources and those already mined) and modelling the market.

A new methodology for estimating the ultimate resources and their associated production costs has been developed using available data on known uranium deposits. The model incorporates the specific economic and geological characteristics of each region in the best possible way by calibrating the deposit distributions and cost functions differently.

Despite significant uncertainties, the results obtained have shown that, due to some regions' specialisation in particular mining techniques and/or their specific economic and geological characteristics, the ultimate resources of uranium are distributed unevenly throughout the world. The discount rate, the depth of the earth's crust taken into account or the price of uranium representative of current economic conditions are all particularly decisive parameters in the estimation carried out. However it has also been shown that the estimation of ultimate resources only has a second-order influence on long-term uranium price trends and security of supply.

The analysis of the structure of the market and its dynamic constraints has enabled us to define a new model to investigate market mechanisms. This is a deterministic model which calculates a series of short-term economic balances in order to carry out a long-term prospective study. This model takes into account the causal link between price and exploration expenditure. It also accounts for increases in discovery costs and anticipation of demand. The regionalisation of the market players (modelled by an oligopoly with no collusion) introduces differential rents which have a limited short and medium-term effect in the increasing demand scenarios that have been studied. At the same time, the demand anticipation constraint introduces a scarcity rent. This contributes to maintain security-of-supply margins, but also leads to a significant increase in the price of uranium in the long-term.

A sensitivity study has revealed the particular importance of the demand scenarios, the demand anticipation constraint and even the regionalisation of the discovery costs: they all have a significant effect on price trends by influencing the scarcity rent.

Our results have shown that, without anticipating demand, prices are not high enough to encourage exploration and the discovery of new resources needed to offset production and rising demand. This leads more or less rapidly to a shortage.

Only an anticipation of demand ensures security of supply over the long term. This anticipation is made via a scarcity rent and translates into a sharp rise in prices.

Further analysis of security of supply should take account of the limited number of producing regions. Geopolitical analyzes of the producing countries, but also of the uranium-consuming countries, would be very relevant, but the time horizon to be considered is a major difficulty for these analyzes.

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How to Give a Good Presentation

By Richard Green

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I don't think anyone wants to give a bad presentation at a conference (or anywhere else), but it is sadly true that many people do. In most cases, I'm sure that this is not due to a lack of thought or preparation, but it may be due to not thinking about the presentation in the right way. I believe the key questions are "what am I aiming to achieve?" and "how can I get information across to give myself the best chance of achieving this aim?"

A typical conference presentation may only last for 15 minutes, followed by a couple of minutes for questions. This means that you cannot expect to tell the audience every detail of your research, or hope for in-depth discussion of (say) econometric techniques. Instead, you want the audience to hear your key messages – what have you discovered, how do you know it, and why is it important and/or interesting?

I suggest you start by saying what you are looking at, and why it is important. Many of the people coming to a parallel session at an IAEE conference will have a good background in the area of your paper, but some may not, particularly if the papers in your session are not very close to each other. In my most recent presentation (of a paper with Joachim Geske, at the Singapore international conference), we set the scene by pointing out that both energy storage and demand response are potential solutions to the variability of renewable electricity generation, and that our aim was to ask whether demand response could also be seen as a kind of storage – storing consumption rather than energy. You don't need to go back to the real fundamentals – we didn't spend time on why renewables are being adopted as a response to climate change.

This gets me back to the second question I posed at the start of this article, but perhaps in a different form: "what is the right amount of information to give my audience?" If I give them too little information, they won't be able to properly understand my research. If I try to give them too much, they won't be able to absorb it all, and this will also make it less likely that I achieve my aim. Everything I put in a presentation has an opportunity cost – either I have to take something else out, or I have to put the information across faster, which may be too fast for easy understanding. A long introduction to set the scene gives me less time to talk about my own contribution. For this reason, I rarely include a formal "outline" slide.

I probably spend too little time putting things in the context of existing research. As well as giving credit to those who have gone before, this can help reassure your audience that your techniques (if previously used by others) are sensible, and that others also felt your topic deserved attention. When I do have a "literature slide", however, I try not to use a reference like "Newbery (1995)". Some people will immediately recognise the article, but if you don't, the Harvard style doesn't give much help for finding it – and what if the author has a common name? Give slightly more information: "Newbery (Energy Journal, 1995)" – that's enough to quickly note down and easily find after the conference. But do not put the full reference – the paper's title and page numbers – on a slide appearing in the middle of your presentation.

The point that this illustrates may be my most important advice. Whenever something new appears on the screen, your audience will start to look at it, and won't be paying full attention to what you are saying until they have processed the new information. If you give them lots of words to read, or several equations, or a complex diagram, you will distract them for quite a long time. It will be even worse if the font sizes are small enough to make things hard to read. The conference venue may give you a relatively small screen in a large room – don't choose font sizes that would only work with a large screen in a small room. And please don't argue that you didn't choose your font size, but took the one that came with your institution's template. Imperial College Business School has a template that looks very nice, but uses relatively small fonts as its default option, and draws lines on graphs in similar colours that are hard to tell apart. Since I want my audience to see what I've done, I make the fonts big enough to read easily, change the colours and make the lines thicker until the differences are clear.

I can give my audience more information, and they will absorb more of it, if I break it up and present it in small pieces. If I have "bullet points" with lots of text (which can be helpful for people who have less experience of listening to spoken English) I may get them to "appear" one at a time. (I would never use the trick, sometimes seen in pdf presentations, of distracting the audience by putting everything on the screen in a hard-but-just-possible to read light colour.) I put "appear" in quotations to show the

PowerPoint command that does exactly that; fancy entrances are available, but I don't want to distract my audience.

If a diagram is made up of many separate PowerPoint items, I may get them to appear at different times, starting with something simple. If I have imported it as a single picture, I may cover parts of it with shapes in my background colour, and make them "disappear" as I discuss those things. I don't think it is possible to make part of a PowerPoint chart "appear", and so I copy the slide with the final version of a graph, change one (or more) series to "no line" and cover its legend entry with a box in the background colour. As I move from this altered slide to the next, my series and its legend appear, focusing the audience's attention on the thing I want them to look at, while nothing else should move. I might want a slide to end with two graphs side by side, but that doesn't mean they both have to be there as soon as the slide is shown.

Equations can be difficult – will the audience understand your notation? It may be standard – but every electrical engineer "knows" that p indicates the amount of (real) power, and π is its price, as opposed to the economists who "know" that I've just written the symbols for price and profits. In many presentations, I use words to describe what I am optimising, but don't actually give the equation – remember that I am using the presentation to tell the audience what my research is about and why it is worth their while to follow up by reading the paper. I can't communicate all of the information that a referee would need, or someone trying to replicate my results, and the audience would probably remember less of my presentation if I tried to do so. If it is a more theoretical paper, where the results depend on the equations, I will naturally show and explain them, but can make the presentation easier to follow by highlighting particular parts in turn.

For numbers, remember again that "less can be more". Please don't try to persuade me that the difference between 123456789 and 123456788 is important in the context of most energy research. Writing the number as 123.4 million will usually be accurate enough, and the shorter number takes less time to process. I could quickly see that 123.2 million is (slightly) different in a way that long strings of digits hide. Axis labels on a chart should probably have between two and four digits – it can be a good idea to multiply or divide the numbers in your data source by 1,000 (or more) to get to units that allow this. It is much better to show that annual electricity consumption in Great Britain is around 300 TWh than to present it as 300,000 GWh. Make sure your tables are aligned on the decimal point (or last digit if you don't have one), especially if the numbers differ by an order of magnitude or more.

After you have told the audience what you believe you have discovered, and why, conclude by reminding them of why it is important. If your paper has a specific setting, can you draw out themes or lessons that apply more generally? This will make your paper more interesting to the non-specialists in the room, but don't go overboard – people will know if you are over-claiming.

When it comes to the presentation itself, try to look at the audience as much as possible, as eye contact helps engage them. It can be better to use the computer's mouse arrow to highlight things on screen (which you can do while basically facing forward) than to turn your back and use a laser pointer. This is especially important if you are giving a talk in a room with two screens and an audience scattered in front of both of them.

A good session chair will be sitting somewhere you can easily see them, and will be holding a card or piece of paper to show when you have five minutes left, and when you have two minutes. Do practice your presentation to check that you can finish within the time allowed, and if you are behind schedule at the five minute warning, that is the time to speed up – rushing just the last two minutes, or overrunning by more than a few seconds, won't give a good impression. If you do finish on time, there will be a chance for a couple of questions or suggestions, which I hope you find useful. Don't allow your answers to get bogged down in detail – the next presenter will be anxious to start – but feel free to ask the questioner if you can carry on the discussion at the end of the session.

After the session, the organisers may want to post your slides. I often create a new pdf for this – it allows me to "tidy up" slides that had boxes covering up things I didn't want to show at first, or to show only the final version of a chart that grew over several slides. I can also add extra notes to make it clear what I am using a graph to show, or explain short bullet points at greater length. If I am using a lot of these, I write them in the PowerPoint "notes" screen, and print the document to pdf in this format.

May I offer one final piece of advice? Please don't read your slides out loud. Your audience can read them faster than you can speak, and so they will quickly get bored – you are giving them too little information. It's even worse if you turn your back on the audience to do so. I realise that one reason many people read their slides is that they find it difficult to present in a foreign language – this is something that I myself would find impossible. In the early years of my career, however, after a couple of very poor presentations, I realised that I (then) needed to write out what I wanted to say, read it through a few times, and have a copy ready for use in the presentation. The key thing, though, is that I never wrote out just the words on the slides, but something different, so that the audience had a reason to listen to me. So my advice would be that if having a piece of paper with the words you might use gives you confidence, bring it with you – but make (most of) those words different from the ones on your slides.

I have an unfair advantage, for English is my first language, but this brings risks. I may speak too quickly, or use obscure words, or put in jokes that only work for people who have seen my favourite TV programme. If I have done so in your presence, please accept my apologies.

IAEE/Affiliate Master Calendar of Events

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

Date	Event, Event Title	Location	Supporting Organization(s)	Contact
2017				
October 12-14	2nd IAEE Eurasian Conference *Energy in Eurasia: Economic Perspectives On Challenges, Risks and Opportunities*	Zagreb, Croatia	IAEE	Gurkan Kumbaroglu gurkank@boun.edu.tr
November 12-16	35th USAEE/IAEE North American Conference *Riding the Energy Cycles*	Houston, TX, USA	USAEE	David Williams usaee@usaee.org
2018				
April 22-24	11th NAEE/IAEE Conference Theme to be Announced	Abuja, Nigeria	NAEE/IAEE	Wumi Iledare wumi.iledare@yahoo.com
June 10-13	41st IAEE International Conference *Transforming Energy Markets*	Groningen, The Netherlands	BAEE/IAEE	Machiel Mulder machiel.mulder@rug.nl
September 23-26	36th USAEE/IAEE North American Conference *Evolving Energy Realities: Adapting to What's Next*	Washington, DC, USA	USAEE	David Williams *usaee@usaee.org*
November 2-4	6th IAEE Asian Conference Energy Exploitation and Cooperation in Asia	Wuhan, China		Xiao Jianzhong xjianzhong@cug.edu.cn
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*
2021				
July 25-28	44th IAEE International Conference *Mapping the Global Energy Future: Voyage in Unchartered Territory*	Tokyo, Japan	IEEJ/IAEE	Yukari Yamashita *yamashita@edmc.ieej.or.jp*

Vienna Conference Overview

The 15th IAEE European Conference was organized by TU Vienna, Energy Economics Group in cooperation with Austrian Association for Energy Economics from 3rd to 6th September 2017.

Held at Hofburg Congress Center, Vienna, Austria.

The conference title "Heading Towards Sustainable Energy Systems: Evolution or Revolution?" and topics discussed during the conference reflected the changes and challenges currently under way in the energy systems of many countries. The conference focused 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. Speakers also discussed which new technologies are required and which role they may play in a future supply system consisting of decentralised and central supply units (power plants, refineries, pipelines ...). The main question of this conference was: In heading towards sustainability - is an evolutionary continuous development possible or is a revolution necessary?

The conference was well attended with more than 400 participants. The Conference's opening address was given by Fatih Birol from IEA and was aimed at global energy markets in transition and the implications for the economy, environment and geopolitics.

Conference presentations were scheduled within the eight plenary sessions (including opening and closing plenary sessions), 64 concurrent sessions and two poster sessions. Conference also included special activities for young researchers, such as a PhD Day/Presentation Workshop and Student Happy Hour at Café "Das Möbel" which created the opportunity not only to presents their research, but also to exchange opinions, and last but not least to do networking as the basis for potential future cooperation. Another special activity targeted at young researchers was a special concurrent session "Best Student Paper Award" where four qualified finalists presented results of their research and competed for the award.

The conference program also included various activities and social events which offered many possibilities for participants to exchange opinions, to discuss hot topics, to build new contacts. These special events and especially the Flying Dinner organized in Museumsquartier, and Award Dinner held in Heuriger Wolff, gave conference participants an unique chance to enjoy the spirit of Vienna, the city on "Blue Donau" which combines with numerous historical buildings, museums, cathedrals and churches and modern buildings including UNO city, headquarters of IAEA, etc. history and the modern era.

Two technical tours were organized succeeding conference events: to Nuclear Power Plant Zwentendorf (which was never been under operation and is the symbol of the alternative way of energy system development) and to Waste Incineration Plant Spittelau which is not only unique by its architectural design by well-known architect Hundertwasser but also as the successful example of trigeneration.

SUMMARY OF PLENARY SESSIONS

Special Address: Global Energy Markets in Transition: Implications for the Economy, Environment and Geopolitics

Opening Plenary Session: The Way to Paris: Climate Targets and Decarbonization Strategies

These opening parts of the conference were chaired by Hans Auer from the Viennese host. Fatih Birol, IEA; Pantelis Capros, Technical University of Athens, Greece; Michael Strebl, WIENENERGIE, Austria

After introductory speech and the invitation to all participants by Hans Auer, plenaries were opened with a special address by the director of the IEA, *Fatih Biro*l. Fatih started his presentation by focusing on the basics of research in Energy Economics, referring to his own PhD studies at Technical University of Vienna. His key message was that despite the worldwide stagnation in CO_2 emissions over the last three years urgent further action is needed.

The following presentation by *Pantelis Capros* focussed on the European efforts to meet the 2050 Greenhouse gas emission reduction targets with special emphasis on the 2017 ECs winter package. He presented the scenarios for energy and GHG emissions up to 2050 and the major necessary policy measures. Capros' main conclusions were that the role of electricity is central in the transition, and that the main two pillars are energy efficiency and renewables. In addition he stated that the energy efficiency improvement is ambitious and demands strong policies affecting consumers.

The final contribution in the first plenary was presented by *Michael Strebl.* He showed the point-of-view of an "energy service company of the future" with the major asset "Customer" respectively "Prosumer". He ended his presentation with the citation: "If the winds of change blow, some build walls, other set sails. It is WIENENERGIE's strong intention to be among the latter."

Dual Plenary Session I: Long-term Scenarios: New Challenges, New Approaches, New Results

The dual plenary session on long term scenarios of energy systems development was chaired by Christian von Hirschhausen, Berlin University of Technology and German Institute for Economic Research /DIW Berlin, Germany. He was joined by Klaus Mohn, University of Stavanger, Norway; Volker Krey, International Institute for Applied System Analysis; Claudia Kemfert, German Institute for Economic Research /DIW Berlin and Hertie School of Governance, Germany; Paula Ferreira, University of Minho, Portugal.

The objective of the dual plenary was to contribute to the debate with a discussion of both, political economy aspects of scenario making, but also on concrete scenarios on the longer-term energy and environmental future.

The first presentation by *Klaus Mohn* included a critical survey of long-term scenarios, in particular with respect to the macroeconomic assumptions. Mohn took as an example the World Energy Model which, in spite of presenting several scenarios, always maintains the same assumptions about economic growth. In addition, Mohn referred to very conservative assumptions about the development of low-carbon technologies. Mohn suggested to balance the policy advice emanating from the modeling and to improve the transparency of the process.

Volker Krey insisted on the link between two agendas, i.e., the Paris Climate Agreement and the Sustainable Development Goals (SDG). At first, Krey provided insights in the synergy between climate policy and air pollution actions, which results in less black carbon and sulfur emissions, when fulfilling the 1.5° or 2° targets. Furthermore, Krey elaborates the link between climate policy and the SDG for affordable and clean energy. Additionally, he emphasized on the impacts of climate change mitigation policies on food security and thermal water pollution.

The contribution of *Claudia Kemfert* and *Pao-Yu Oei* focused on a new approach in energy system modeling, i.e. "100% renewable" scenarios. They presented developed scenarios for a global decarbonization (1.5° - 2° targets), based on the Open Source Energy Modeling System (OSeMOSYS). The results presented by Kemfert and Oei suggest that in order to achieve the 1.5° or 2° targets, a combination of renewable energy sources provides the lowest-cost solution and is technically feasible.

How to implement the scenarios? *Paula Ferreira* presented how to model electricity supply and demand under new market designs. She elaborated the new market design and the resulting challenges for the power sector, e.g. rising energy demand due to increasing electrification of the economy and higher shares of distributed and variable renewables. She highlighted that modeling of electricity scenarios has to consider dynamics across the electricity value chain, as well as planning across time scales and including energy-related behavior and consumer participation.

Dual Plenary Session II: New Designs in Electricity Markets

The dual plenary session on new design in electricity market was chaired by Christophe Bonnery, French Association for Energy Economics, France. He was joined by Dominik Möst, TU Dresden; Audun Botterud, Massachusetts Institute of Technology, USA; Isabel Soares, University of Porto, Portugal; Markus Graebig, 50Hertz, Germany.

Speakers *Dominik Möst, Audun Botterud* and *Isabel Soares* aimed their presentations at new market design which would reflect quickly growing share of RES in power generation, long term target on decarbonisation and both changes in power generation structure and on side of power consumption. The issue of integrating renewable energy sources (RES) on power grids goes on par with the one of storage and of its rampant growth as a mechanism to create flexibility and contribute to adequate demand-side management. Mid and long-term perspectives to integrate RES and reduce network congestion ought to include interdependencies between grid extension, stronger market integration, and decentralized storage systems.

This is particularly true in the U.S., where low natural gas prices have triggered baseload retirements, and where windpower has sustained a surge in installed capacity over the past decade, thus generating oversupply and market distortions. Beyond storage systems, extra flexibility solutions for such power markets with high shares of intermittent RES may include dynamic operating reserves, in order to generate demand curves that would better reflect the uncertainty in electricity forecast prices, flexi-ramp capacities (adjustment of active power output), and trade-offs with other energy generation sources such as nuclear power.

Energy planning in a long-term perspective must not only be compatible with existing markets, but also ensure consistency between regulation, investments, and infrastructure goals. The new market design should include innovative solutions that such as: flexibility activation, sector coupling, trade-offs between regionalization and transmission, new market roles and business models for power grids through the use of intelligent infrastructures, effective use of data, as well as the involvement of all end users as fully-fledged stakeholders of these markets.

As highlighted by *Markus Graebig*, this may be well-observed in Europe, and most specifically in North Eastern Germany, where the energy transition has transitioned from integrating RES and de-carbonating the national economy, to now ensuring compliance between power and heat/transportation sectors at regional level.

Dual Plenary Session III: Geopolitics of Oil and Natural Gas in Europe

The dual plenary session on geopolitics aspects was chaired by Georg Erdmann, Berlin University of Technology, Germany. He was joined by Kostas Andriosopoulos, ESCP Europe, Paris; Manfred Hafner, Enerdata, France, Jim Smith, Southern Methodist University, USA

Kostas Andriosopoulos presented an interesting overview on new infrastructure projects, in particular in the Eastern Mediterranean. In spite of their often weak economic attractiveness no lack of financial resources seems to exist today.

Manfred Hafner showed that the traditional view of European dependency on Russia and the Middle East has shifted: The new view is bilateral dependency between exporters and importers. As a consequence a key motivation of the many weakly profitable infrastructure projects is securing the access to the European gas and oil markets.

Jim Smith underlined this view by the expectation of sustainable low oil and gas prices, due to the impact of technical progress on the supply side (shale oil, ...) and the demand side (de-carbonization, ...). To wrap up the session, the geopolitical focus has shifted from securing access to fossil resources to securing access to markets, but the fossil fuel suppliers are likely to miss the intentions of their investment efforts on the long run.

Dual Plenary Session IV: The Future of Transport and Electricity Systems

The dual plenary session on the future of transport and electricity systems was chaired by Amela Ajanovic, Vienna University of Technology, Austria. She was joined by Ben Schlesinger, University of Maryland, USA; Reinhard Haas, Vienna University of Technology, Austria, and Richard Green, Imperial Collage Business School, London, UK.

Ben Schlesinger presented an interesting overview on the developments in the gas industry in the U.S. focusing on the competitive aspects of natural gas and electric vehicles. He also discussed cost and value of electricity storage.

Reinhard Haas discussed how to integrate large shares of variable renewables into electricity systems as well as corresponding impact on prices in electricity markets. He analyzed the role of flexibility and sector coupling and provided ideas for the future market design.

Richard Green continued discussion on the future of electricity with the special focus on the renewables in a power market. He underlined that markets based on power will have volatile prices in a high-renewable world, and that storage can smooth these prices, creating markets based on energy.

During the discussion the role of electric vehicles and storage and its potential impact on the market was emphasized.

Dual Plenary Session V: Will Market Forces or Planned Economies Determine the Future Energy System?

The dual plenary session on the future of energy systems was chaired by Anne Neumann, University of Potsdam, Germany. She was joined by Nektaria Karakatsani, Greek energy regulator/RAE, Greece; Karsten Neuhoff, German Institute for Economic Research /DIW Berlin, Germany, Jean-Michel Glachant, European University Institute, Italy

During this session *Nektaria Karakatsani, Karsten Neuhoff* and *Jean-Michel Glachant* investigated the role of policies and market mechanisms for the transformation of the European energy system.

Nektaria first provided a view of the Greek regulator and CEER of the European Winter package in the light of stimulation competition and innovation in the short-term, while coordinating investments in the long-run. Although it contains several positive aspects there are still shortcomings in the proposed future design in particular increasing consumers' benefits. One of the main concerns voiced is the lack of the retail market to react to drops in wholesale prices. There will be a proposal of European regulators with according amendments to the current debate whilst avoiding over-regulation of the market.

Karsten Neuhoff then argued that the most important tool of the European energy system is the EU Emissions trading scheme. Strengthening this tool by including a consumption charge that should be levied to consumers will provide enough incentives for all players to dynamically adjust to the system.

Jean-Michel Glachant highlighted the new environment of the deregulated electricity market in which double unbundling and incentive regulation are the challenges. The pronounced role of institutions is the major obstacle of creating a truly European market. His vision entails strong decentralization forces and modularity which could make any future regulations on a European level redundant. These new "communities" of production and consumption in turn would become the new governance issue.

During the discussion the role of distribution companies was scrutinized and the role of storage was also highlighted.

Dual Plenary Session VI: Smart Energy Future ... Whatever that Means?

The dual plenary session on the smart energy systems was chaired by Johannes Mayer, E-Control Austria. He was joined by Peter Lund, Aalto University, Finland; Michel Derdevet, Enedis, France; Michael Merz, Ponton, Germany, Franz Strempfl, Energienetze Steiermark, Austria

Plenary session VI dealt with the vision of a smart energy future. The background of this session is the increasing intermittency of electricity production in Europe and elsewhere and as a consequence the need to better co-ordinate activities of market participants.

Peter Lund presented flexibility options and diverse aspects of these options. Starting with the typical “duck curve” the net load of the Californian ISO exhibits, he presented technical options for increasing the flexibility in the system. In addition to curtailing intermittent generation he advocated the use of power-to-heat sector coupling as thermal heat dominates the energy used in cities. Under such circumstances the marginal value of power may be lower than the marginal value of heat, especially in an electricity system of high intermittent RES shares.

Michel Derdevet presented the challenges distribution network companies are facing nowadays. It is mainly the large number of small scale production units connected to their grid, the fact that more consumers become producers and the need for more data, which have to be generated, transmitted and consequently processed, which describes the new landscape of a DSO. He presented almost 20 examples of innovative demonstration projects. In terms of new major projects the roll-out of 35 mio. smart meters and a total cost of some 5 bln € over the next 6 years constitutes a veritable challenge to the company.

Michael Merz presented their blockchain platform “enerchain” and its use for peer-to-peer trading. In a vision for 2030 regionally hierarchical markets exist. In a more functional ordering of markets separate blockchains may serve these markets from P2P trading and local as well as wholesale markets, to flexibility and markets for ancillary services. Mr. Merz concluded, at present blockchain technology is still looking for potential applications, reversing the traditional development cycle for software.

Franz Strempfl presented the changing energy flows in the electricity grid, which is more and more reversed from former times. The future production will mainly be connected to the DSOs, necessitating increased co-operation between DSOs and TSOs. He presented the Austrian data hub “EDA”, a platform which exchanges commercial and metering data in the retail market in Austria, as a case in that respect. Projects using blockchain technology such as Gridchain (a solution for real time grid management) and LEAFS (a solution which allows customers to use central storage devices for private purposes) were presented. Finally he discussed regulatory challenges such as grid tariffs for storage and the question of ownership of storage by DSOs.

All four presentations have drawn a picture of revolution in the electricity system. Not minor adaptations but a major reversal of the functioning of the electricity system was presented.

Closing Plenary Session: Innovation in the Energy Sector: Which Technologies do we Need after 2030 and which Policies do we Need Now?

The Closing plenary session was chaired by Reinhard Haas, Energy Economics Group, Vienna University of Technology, Austria. He was joined by Pierre de Champs, European Commission, Nebojsa Nakicenovic, International Institute for System Applied Analysis, Austria, Georg Erdmann, Berlin University of Technology, Germany, Ricardo Raineri Bernain, Pontificia Universidad Católica de Chile.

The major focus of the Closing Plenary was to analyze the need for innovations to finally meet the Paris targets. In addition, proper policies should be identified to bring about these innovations.

Four different views were provided: the European standpoint vs. the view of developing countries, the technological and the energy economic views.

Pierre de Champs presented the of the European Commission’s perspective. He showed the major features of the “Clean energy package“ as well as the specific targets of the EC with respect to CO_2 reduction, renewables and energy efficiency.

Nebojsa Nakicenivic’s contribution was focused on the technological aspects with respect to climate issues. He stressed that the achievement of technological learning effects is of high relevance for new technologies to enter the markets and dissemination.

Georg Erdmann added the economic view of learning rates, especially for the German case. He showed impressingly how the PV prices fell mainly due to the subsidies financed by German households.

Finally *Ricardo Rainieri* argued from the developing world’s point-of-view. His major statement was that the rich countries have to be role models and conduct the investments in the new technologies.

The session concluded that the current actions are mainly focussing on short-term achievements. Yet, for meeting the long climate-targets up to 2050 long-term views and corresponding strategies are required. This has to be underlined by accompanying long-term policies.

Jaroslav Knapek

Scenes from the 15th IAEE European Conference September 3-6, 2017





HOFBURG


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IAEE staff and Council members met with key organizers of the 6th IAEE Asian Conference recently. The conference will take place in Wuhan, China, November 2-4, 2018. The theme of the conference is: *Energy Exploitation and Cooperation in Asia*. Pictured from left to right are: Xiaolin Wang, Xing Gao, Haixiang Guo, Jianzhong Xiao (conference chair), Ron Ripple, David Williams and Ying Fan.

The Transformation of World Energy Governance: A Brief Overview Focusing on Energy Security

By Kazutomo Irie

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INTRODUCTION

During the last half century, we witnessed a rapid change in world energy governance. The bipolar system, created by OPEC and the IEA in the 1970s, only lasted until the 1990s. Entering the 21st century, various international entities proliferated for international cooperation and dialogue on energy issues. As a result, a multilayered intergovernmental system has been formed for world energy governance. However, partly due to the lack of a comprehensive intergovernmental organisation/forum for energy governance, existing energy-related organisations/fora are focusing on the decarbonisation of energy systems rather than energy security, which remains an important criterion for energy policy.

This paper traces the history of world energy governance since the 1970s by observing the construction and function of various energy-related organisations.

'COLD WAR' TYPE BIPOLAR SYSTEM OF OPEC AND IEA AFTER THE 1970S

Up until the 1970s, energy supply and demand was dictated by market forces in most countries. Though the oil supply instability in Europe during the Suez Crisis (or the 2nd Arab–Israeli conflict) in 1956 led to the origin of the energy security concept, only a limited number of countries articulated concern over a stable supply of energy.

Two oil crises in the 1970s dramatically changed this state of affairs. Energy security became a major national interest for energy importing countries. International governance for energy issues first emerged after these geopolitical crises, establishing a Cold-war type bipolar system. Oil exporting countries, united in the Organization of the Petroleum Exporting Countries (OPEC), gained the right of price determination in international oil markets through an international cartel for oil supply restriction [1].

In response, developed countries in the Western Bloc, which were major customers of exported oil, formed the International Energy Agency (IEA) in 1974 under the framework of the Organisation for Economic Co-operation and Development (OECD) and pledged to build oil stockpiles in order to countervail oil supply restrictions by petroleum exporting countries [2]. As both OPEC and IEA were 'collective defence organisations' for major energy exporters and importers, the conflict of OPEC and IEA in the 1970s and 1980s can be described as a Cold-war type system.

However, this bipolar system could not endure for long. In the early 1990s, both OPEC and IEA waned in influence due to the changing international energy supply and demand dynamics. OPEC's power had been reduced as a collective defence organisation because oil was no longer the overwhelmingly dominant energy source. Partly due to oil importers' efforts to reduce dependence on oil, oil-substituting energy sources such as coal, natural gas and nuclear energy increased their share in the energy mix of oil importing countries. In addition, oil production outside OPEC members, for example in the North Sea, was promoted and further decreased OPEC's influence.

The decline of OPEC was a laudable success by the IEA and its member countries, but the IEA itself had also experienced a decline of prominence. Because of the globalization of the world economy, industrial activities in developing countries increased rapidly and their demand for energy grew in tandem. The most notable example was China after its 'reform and opening-up' in 1978. India followed China. In 1973, IEA members' share in world energy consumption (total primary energy supply) was just over 60%, but according to the latest IEA statistics, in 2014, it has fallen to less than 37%. Non-IEA countries' share has risen from 40% to 63% over the same period [3].

THE MULTILAYERED INTERGOVERNMENTAL SYSTEM SINCE THE 21ST CENTURY

Entering the 21st century, in addition to OPEC and the IEA, various international entities have proliferated for international cooperation and dialogue on energy issues. Similar to oil exporting countries, gas-exporting countries formed the Gas Exporting Countries Forum (GECF) in 2001, as natural gas had become increasingly important in international energy trade [4].

The IEA has been expanding its scope from primarily focusing on oil to covering other energy resources as well as energy efficiency. However, as for membership, its OECD framework hinders the IEA in fully involving developing countries. Though the IEA is making an effort to establish closer cooperation with major developing countries, such as China and India, and has introduced an Association country system, it is unlikely these Association countries will ever join the IEA as full members, even in the future.

Thus, specialised international organisations/fora have appeared for various energy issues, inviting major developing countries as their members. On the energy demand side, the International Partnership for Energy Efficiency Cooperation (IPEEC) was formed in 2008 [5].

On the energy supply side, the International Atomic Energy Agency (IAEA), whose major task was originally 'a watch dog' for nonproliferation of nuclear weapons, has expanded its role in promoting the peaceful use of nuclear energy in both a regulatory and policy context [6]. Since most countries possess renewable energy resources, such as solar, wind and sometimes geothermal and bio-energy, international cooperation for renewable energy is sought among many countries that are both a producer and a consumer of renewable energy. However, except for bio-energy, renewable energy resources are not suitable for international trade. Therefore, each country has to develop its domestic renewable energy resources and international cooperation is generally undertaken with the goal of increasing information sharing and technology transfer. The Renewable Energy Policy Network for the 21st Century (REN21) was launched in 2004 as a global multi-stakeholder policy network [7] and the International Renewable Energy Agency (IRENA) was established in 2009 as a formal international organisation [8].

Furthermore, a proposal by France and Venezuela to begin a dialogue between OPEC and the IEA resulted in the establishment of the International Energy Forum (IEF) in 1991 [9]. In 2002, the IEF decided to have a permanent secretariat to facilitate dialogue between energy producers and consumers. Though the IEF was established to create a channel between energy producers and consumers, it currently plays a relatively small role in world energy governance.

The end of the Cold War also influenced the governance of international energy issues. In 1991, western countries signed the European Energy Charter (EEC) with Russia and western European countries in order to protect and promote their investment in the energy sector in the former Eastern Bloc. The EEC was later expanded to the International Energy Charter (IEC) with a small-scale permanent secretariat [10]. Thus, until recently, a multilayered intergovernmental system was used for world energy governance.

It should be noted that coal, the most traditional and abundant fossil energy resource, has no well-established international organisation/forum. This fact may result in the underrepresentation of coal in policy discussions on energy supply in individual countries, as well as globally. Although coal is the 'dirtiest' energy resource in terms of carbon-dioxides (CO_2) emitted through its consumption, it is still important for many developing countries in achieving their energy security due to its low cost and supply reliability.

"Cold War" Type Bipolar System (IEA vs OPEC) after the 1970s

Energy	Consumer		Supplier
	Developing	Developed	
Oil	-	IEA	OPEC
others	-	-	-

Multilayered Intergovernmental System since the 21st Century

Energy	Consumer		Supplier
	Developing	Developed	
Oil	-	IEA	OPEC
Gas	-	(IEA)	GECF
Coal	-	-	-
Nuclear	IAEA		
Renewable	IRENA		
(Crosscutting)	IPEEC, IFC, IEC		

Figure1: The Transformation of World Energy Governance

GLOBAL WARMING AND ENERGY SECURITY

As the challenges posed by global warming have surfaced as a pressing issue in international fora, the energy security concept has declined in prominence. For climate change, an international governance has been pursued since the 1990s and was adopted through the Paris Agreement, under the United Nations Framework Convention on Climate Change (UNFCCC) dealing with greenhouse gases emissions mitigation, adaptation and finance, on 12 December 2015. As global warming is closely related to CO_2 emissions from energy consumption, existing energy-related organisations/fora are switching focus from energy security to decarbonizing energy systems.

As there is no single intergovernmental organisation/forum that comprehensively covers energy issues and widely involves both developed and developing countries, regional cooperation has become complementary to world energy governance. For example, the European Union (EU) in Western and Central Europe, Asia-Pacific Economic Cooperation (APEC) in the Asia Pacific region and the Association of South East Asian Nations (ASEAN) in Southeast Asia, among others. In these regional organisations/fora, energy issues are discussed more from an environmental viewpoint rather than a security viewpoint.

For example, because energy security has been one of the top policy imperatives for most countries in the Asia Pacific region since the oil crises in 1970s, APEC, as a regional forum, has been particularly concerned with energy security. In September 2000, APEC Senior Officials considered what action APEC could take to respond to oil price volatility and directed its Energy Working Group (EWG) to analyse the issue in order to make recommendations on ways to strengthen regional energy security. The EWG developed the APEC Energy Security Initiative (ESI), which was endorsed by the EWG in September 2001, and by APEC Economic Leaders in October 2001 [11].

ESI is quite broad. Almost all energy issues are linked with energy security, including energy data, energy efficiency and renewable energy. While energy efficiency and renewable energy have become hotly debated issues in the EWG, they have gradually become discussed separately, in the context of global warming, rather than that of energy security, even though ESI continues to exist. APEC renewed its concern over energy security as recently as 2012. This time APEC focused on emergency preparedness. APEC started Oil and Gas Security Exercise (OGSE) in 2012 [12] and expanded to Oil and Gas Security Initiative (OGSI) in 2014, which includes OGS Network (OGSN) with bi-monthly newsletters and annual meetings and OGS Studies (OGSS) for research themes related to energy security [13].

Unlike environmental issues, the United Nations (UN) has not wielded strong influence over energy issues. Because climate change is now perceived as a common challenge to almost all countries, it is natural for the UN to fulfill the role of a global coordinator. In contrast, because there are competing interests between energy producer countries and consumer countries, or energy exporters and importers, it would be difficult for the UN to intervene in energy security situations. Since a world energy governance led by the UN is not yet foreseeable, the current multilayered intergovernmental system is expected to continue for the time being.

CONCLUSIONS

Currently, a multilayered intergovernmental system exists for world energy governance. In this system, three issues should be stressed in relation to energy security.

Firstly, coal, the most traditional and abundant fossil energy resource, has no well-established international organisation/forum. This fact may result in underrepresentation of coal in policy discussions related to energy supply in each country, as well as globally.

Secondly, in any case, there is no single intergovernmental organisation/forum that comprehensively covers energy issues and widely involves both developed and developing countries. As such, regional cooperation can be complementary to world energy governance, especially for energy security issues. Such regional cooperation includes, for example, the European Union (EU) in Western and Central Europe, Asia-Pacific Economic Cooperation (APEC) in the Asia Pacific region, the Association of South East Asian Nations (ASEAN) in Southeast Asia, among others.

Thirdly, in order to fill the gap created by the lack of a comprehensive intergovernmental organisation/forum, worldwide cross-sectional discussion and dialogue by non-governmental entities has become increasingly important. The World Energy Council (WEC) and the International Association of Energy Economics (IAEE) are fulfilling such a role in business circles and academia, respectively. In addition, collaboration between WEC and IAEE would be useful in order to bridge practitioners and intellectuals as they cope with the difficult task of world energy governance.

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Growing Evidence of Increased Frequency of Negative Electricity Prices in U.S. Wholesale Electricity Markets

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See footnotes at end of text.

SUMMARY

The significant increase in the supply of renewable resources in California and Texas is contributing to notable growth in the incidence of negatively-priced hourly energy in these states' wholesale electricity markets.[1] Although the incidence of negative prices is less pronounced in other geographic regions of U.S., it has also grown in specific geographic regions of the PJM Interconnection and the New York Independent System Operator (NYISO). As renewable portfolio standard requirements continue to increase, negative pricing frequency can be expected to occur more often, and similarly impact New England and the Midwest and southwestern regions of the U.S.

The increased incidence of negative pricing can be linked to two characteristics associated with U.S. renewable energy resource development. First, renewable resources receive production-based subsidy payments from the U.S. federal government, and from most states where renewable portfolio standards are used to encourage these resources' development.[2] Because these subsidies are paid only when the renewable resource produces energy, resource owners that are required to make offers into wholesale electric energy markets are willing to pay the system operator to accept their production (i.e., make negatively-priced offers). These resource owners are willing to pay the system operator up to the total of their subsidy payments given that they will realize revenue based on the difference of their subsidy payment and what they pay the system operator to take their production.

Second, most renewable resource production is maximized when the wind blows and the sun shines. The periods when renewable resource production is maximized are at night and mid-day, which do not correspond to when consumer demand from electricity is highest. Thus, as renewable resource supply has increased, it can outpace demand, leading to a potential oversupply of electric generation. During these periods of oversupply, generation resources that prefer to, or must, continue to supply electricity even as prices decline will make negatively-priced offers to the system operator in order to continue producing. When excess supply is large enough, sellers will compete to remain operational using negatively-priced offers. Although accommodating negatively-priced offers is important for system operators to efficiently back down generation resources, subsidized resource production driven by production subsidy payments will contribute to more aggressive negatively-priced offers than would otherwise occur.

Negative prices resulting from the subsidization of zero pollutant emission resources artificially lowers electric energy prices. If the unpriced externalities associated with the production of electricity from fossil fuel resources were internalized in electric energy prices, the energy prices would increase, signaling the estimated cost to society of the associated pollutants. Increasing prices through appropriate internalization of the external costs not captured in the marketplace would benefit producers by increasing the value of resources that are low, or zero, emission and signal to consumers the increased societal costs of consuming electric energy. By artificially lowering energy prices, renewable resource subsidization policies are distorting market prices away from more efficient outcomes.

Moreover, over the long-term, the dynamic efficiency of the power market will be affected as forward market prices incorporate expectations of artificially lower spot market prices. This can be expected to affect the resource mixture as energy market prices that otherwise internalize the unpriced external cost of pollutants would result in higher-emitting resources being supplanted by lower-emitting resources, and these higher-emitting resources become those most likely to retire and be replaced by new, higher-efficiency, lower-emitting resources. In contrast, renewable production subsidies create financial challenges for the least competitive resources, not necessarily the highest emitting resources.

Absent a change in renewable subsidization policies, or actions taken by Independent System Operators (ISOs) to diminish the frequency of negative prices, the incidence of negative prices is poised to continue to grow. Renewable resources are already zero marginal cost resources and the impact of subsidization policies that incentivize negatively-priced offers should be minimized or eliminated.

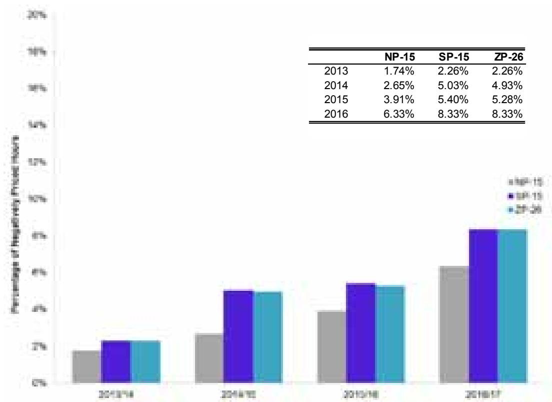


Figure 1A. Percentage of Negatively-Priced Hours at CAISO Hubs, Hourly Real-time Average Prices, 2013 - 2016
Source: Ventyx.

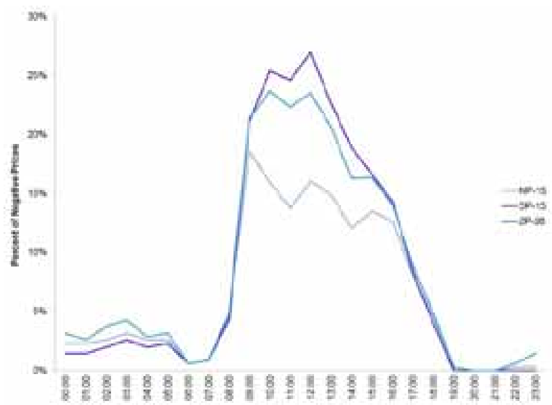


Figure 1B. Frequency of Negative Prices at CAISO Hubs in Each Hour, Hourly Real-time Average Prices, 2016
Source: Ventyx.

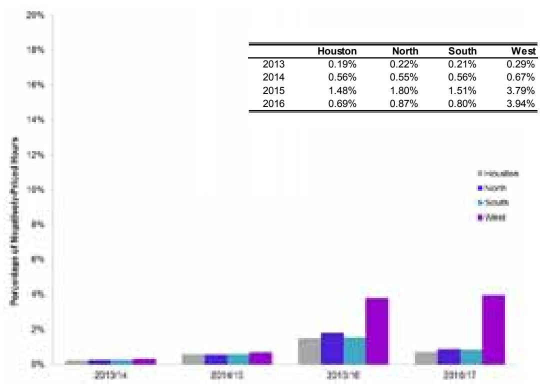


Figure 2A. Percentage of Negatively-Priced Hours at ERCOT Hubs, Hourly Real-time Average Prices, 2013 - 2016
Source: ERCOT

SELECTED U.S. ISO NEGATIVE ELECTRIC ENERGY MARKET PRICING FREQUENCY AND DIURNAL INCIDENCE

The following sections present analyses of the frequency and incidence of negative pricing in select U.S. ISOs. These results are derived by analyzing the reported hourly average real-time locational marginal prices at various ISO hubs (or the average of four fifteen-minute settlement point prices at Electric Reliability Council of Texas (ERCOT) hubs). The frequency of negatively-priced hours is reported as a percentage of total hours in each year (defined as June 1 – May 31) from June 1, 2013 to May 17, 2017. The diurnal incidence of negative prices during the hours of the day are presented by calculating the percentage of reported prices that were negative in each hourly interval (0:00 to 23:00) for 2016/17. These hourly percentages show the pattern of when negative prices are most prominent.

California Independent System Operator (CAISO)

The proportion of negatively-priced hours in California has grown in each year and in each of CAISO's zones over the period 2013/14-2016/17 (Figure 1A). In 2013/14, between 1.7% and 2.3% of all hours were priced negative. By 2016/17, between 6.3% and 8.3% of hours were priced negative, with the incidence of negative pricing higher in the Southern California zones when compared to California's Northern zone. The higher frequency of negative prices in Southern California is likely driven by the much greater proportion of renewable resources located in the Southern part of the state.

Examining the data from a diurnal perspective reveals that the percentage of negative prices is concentrated into those hours of the days in which renewable resource production is greatest. Figure 1B shows that negative prices in 2016/17 occurred more frequently in the middle of the day when solar powered resources are most productive (between 8:00 a.m. and 6:00 p.m.), and that the percentage of negative prices in some of these daytime hours is greater than 20%. For example, in CAISO's SP-15 zone, approximately 27% of hours ending 12:00 p.m. were priced negative in 2016. The effects of the substantial growth in solar powered resources in California is clearly resulting in negative pricing exasperating financial difficulties of natural gas generation resources that serve as back-up supply when unexpected variations in renewable resources occur. Note also that the majority of negative prices (more than 97%) in CAISO's three pricing zones were in the -$50 to $0/MWh range, likely driven by production subsidies.

ERCOT

Negative pricing has also been growing at ERCOT's pricing hubs from 2013/14-2016/17 (Figure 2A). At the Houston, North, and South hubs, the highest proportion of negative pricing occurred in 2015 with between 1.5% and 1.8% of hours priced negative. The incidence of negative pricing at the West hub has grown in each year over 2013/14-2016/17, and over the last two years has been more than double the proportion at the other three hubs (3.9% of hours were priced negative at the West hub in 2016/17). This corresponds to the substantial growth in wind resources in Texas over the last several years.

Figure 2B also shows that the negative prices tend to concentrate in the early morning (between midnight and 7:00 a.m.) hours at ERCOT hubs consistent with greater production from wind resources during the overnight time period. The most frequently negatively-priced hour in 2016/17 was the hour ending 3:00 a.m. at all hubs, priced negative close to 4% of the time at the Houston, North, and South hubs and over 11% of the time at the West hub. All but one instance of negative pricing fell in the -$50 to $0/MWh range at ERCOT's pricing hubs.

NYISO

Figure 3A shows that in the NYISO negative pricing frequency has grown in the upstate Western, Genesee, Central, Northern, and Mohawk Valley zones, with the highest proportion of negative prices observed in 2015/16. The percentage of negatively-priced hours in the Western, Genesee, Central, and Mohawk Valley zones grew from approximately 0.4% in 2013/14 to between 2.2% and 3.5% in 2015 (down to between 1.2% and 1.8% in 2016). NYISO's Northern zone has a significantly higher proportion of negative prices than the rest, similar to that seen in the CAISO. Over 8.5% of hours were priced negative in the Northern zone in 2015/16 and over 6.5% in 2016/17.

Figure 3B shows that negative prices occurred more often in the hours between midnight and 7:00 a.m. during 2016/17 consistent with the production profile of wind resources. However, negative prices occur throughout the day. The most frequently negative hour in the Western, Genesee, Central, and Mohawk Valley zones was the hour ending 6:00 a.m., priced negative approximately 5% of the time. In the Northern Zone, the most frequently negative hour was the hour ending 2:00 a.m., priced negative nearly 11% of the time. Almost 94% of negative prices across all NYISO hubs fell in the -$50 to $0/MWh range.

PJM

Negative prices have only been prevalent at PJM hubs and pricing nodes located in Illinois over the last four years (see Figure 4A). While the pricing hubs have had limited incidence of negatively priced hours in any year between 2013/14 and 2016/17, nuclear generation hubs located in Western Illinois have faced negative prices as much as 10-11% of the hours during the year in 2015/16. In addition, during this time period PJM's independent market monitor has reported rising, falling, and most recently increased frequency of wind power resources being a marginal source of generation supply in PJM's markets.

Although negative prices do not appear to be an issue across PJM's region in total, they are far more prevalent in certain areas in the western part of PJM where wind resources are concentrated and where the nuclear generation facilities Quad Cities and Byron are located in Illinois. Figure 4B shows that the proportion of hours that are priced negative is significantly higher at the Quad Cities and Byron nodes than any of PJM's hubs over the period 2013/14-2016/17. The incidence of negative pricing was particularly high in 2015/16, with nearly 11% of hours priced negative at the Byron node and just over 10% at the Quad Cities node. These areas in particular saw negative prices occur in each hourly interval of 2016/17. The hour ending 6:00 a.m. was priced negative between 6.8-8.5% of the time in Byron, and the hour ending 7:00 a.m. was priced negative over 9% of the time in Quad Cities. 80% of negative prices at these nodes were in the -$50 - $0/MWh range, with a further 16% in the -$150 to -$50/MWh range.

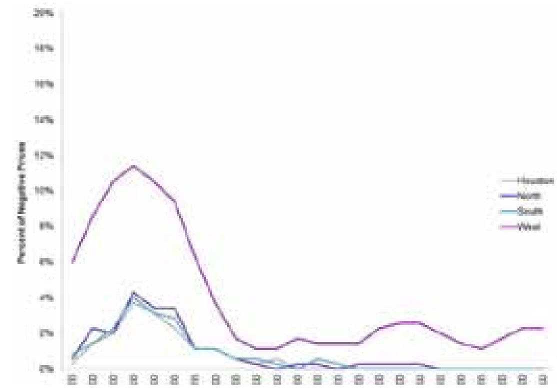


Figure 2B. Frequency of Negative Prices at ERCOT Hubs in Each Hour, Hourly Real-time Average Prices, 2016

Source: ERCOT.

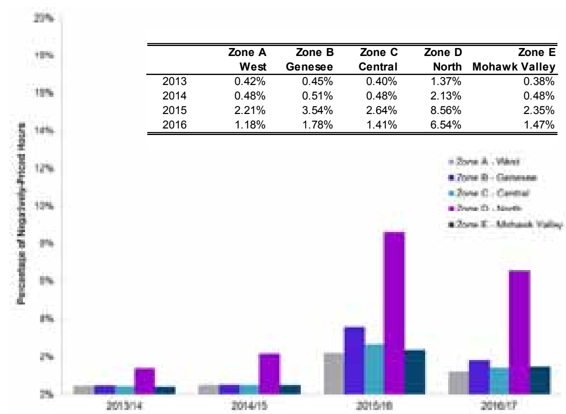


Figure 3A. Percentage of Negatively-Priced Hours at NYISO Hubs, Hourly Real-time Average Prices, 2013 - 2016

Source: Ventyx.

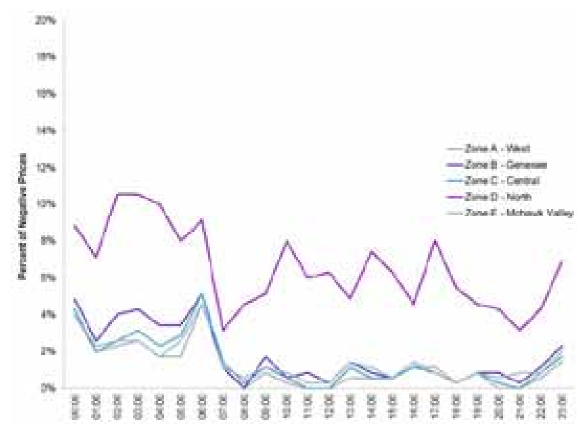
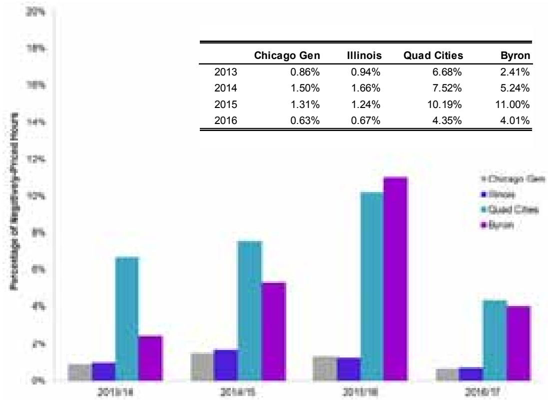


Figure 3B. Frequency of Negative Prices at NYISO Hubs in Each Hour, Hourly Real-time Average Prices, 2016

Source: Ventyx

ISO-NE

In 2013, there were practically no incidences of negatively-priced hours in ISO-NE. That has changed in the following years, growing to between 1.8% and 2.8% across ISO-NE's hubs in 2016 (Figure 5A). Maine saw the highest percentage of hours priced negative with 2.8%, followed by New Hampshire and Vermont with 2.5% and 2% respectively. As with ERCOT, NYISO, and PJM, negative prices tended to



	Chicago Gen	Illinois	Quad Cities	Byron
2013	0.86%	0.94%	6.68%	2.41%
2014	1.50%	1.66%	7.52%	5.24%
2015	1.31%	1.24%	10.19%	11.00%
2016	0.63%	0.67%	4.35%	4.01%

Figure 4A. Percentage of Negatively-Priced Hours at PJM Hubs, Hourly Real-time Average Prices, 2013 - 2016
Source: Ventyx

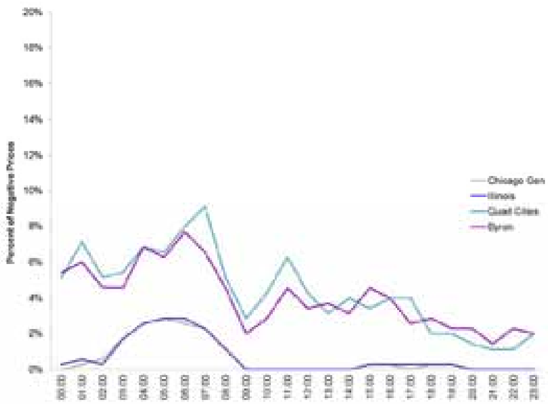
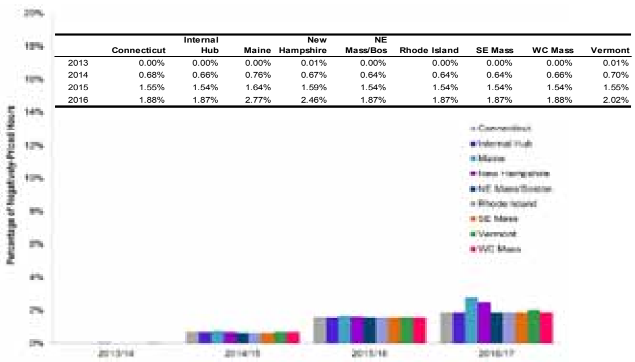


Figure 4B. Frequency of Negative Prices at PJM Hubs in Each Hour, Hourly Real-time Average Prices, 2016
Source: Ventyx



	Connecticut	Internal Hub	Maine	New Hampshire	NE Mass/Bos	Rhode Island	SE Mass	WC Mass	Vermont
2013	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.01%
2014	0.68%	0.66%	0.76%	0.67%	0.64%	0.64%	0.64%	0.66%	0.70%
2015	1.55%	1.54%	1.64%	1.59%	1.54%	1.54%	1.54%	1.54%	1.55%
2016	1.88%	1.87%	2.77%	2.46%	1.87%	1.87%	1.87%	1.88%	2.02%

Figure 5A. Percentage of Negatively-Priced Hours at ISO-NE Hubs, Hourly Real-time Average Prices, 2013 - 2016
Source: Ventyx

occur more frequently in the early morning hours between midnight and 7:00 a.m. when wind resource production is most prevalent, with some hours priced negative around 7% of the time in 2016 (Figure 5B). Maine in particular saw negative prices occur in each hourly interval. 82% of negative price occurrences at ISO-NE hubs were in the -$50 to -$0/MWh range, with a further 16% in the -$150 to -$50/MWh range.

The data presented in Figures 1-5 clearly show that the frequency and incidence of negatively-priced electric energy corresponds to the production profiles of renewable resources. The penetration of renewable resources increased substantially in recent years in both California and Texas, and the impact on electric energy market pricing coincides with the growth in supply of these resources. Absent specific contractual terms or ISO rules that minimize or reduce the impact of negative priced offers, U.S. States that are planning to significantly increase reliance on renewable resources through production-based subsidization programs will increase incidence of negatively-priced electric energy as we have seen in California in Texas.

Footnotes

[1] See, for example, California ISO Department of Market Monitoring, 2016 Annual Report on Market Issues and Performance, May 2017 at 98-101 and Potomac Economics, Independent Market Monitor for ERCOT, 2016 State of the Market Report for the ERCOT Electricity Markets, May 2017 at 11.

[2] See U.S. Department of Energy, "Renewable Electricity Production Tax Credit (PTC)," at https://energy.gov/savings/renewable-electricity-production-tax-credit-ptc and NC Clean Energy Technology Center, Database of State Incentives for Renewables & Efficiency, at http://www.dsireusa.org/

[3] Generation resource data reported by the CAISO show that 75-80% of solar and wind power resources are located in Southern California. See Master Control Area Generating Capability List at https://www.caiso.com/participate/Pages/Generation/Default.aspx, accessed August 3, 2017.

[4] La Paloma, a 1,200 MW combined cycle plant, cited a rise in renewable generation in California as one of its main reasons for filing for bankruptcy. See "California gas power plant La Paloma files for bankruptcy," Reuters, December 6, 2016 at http://www.reuters.com/article/us-la-paloma-bankruptcy-idUSKBN13V2PY. Calpine has also been facing financial trouble to the point of considering a sale of its assets – the company took one of its natural gas plants, the Sutter Energy Center, offline due to poor economics resulting from increased renewable penetration and saw another one of its combined cycle plants operating at 14% capacity. See Nichola Groom, "Unlikely casualty in California's renewable energy boom: natural gas," Reuters, June 9, 2016 at http://www.reuters.com/article/us-california-energy-analysis-idUSKCN0YV0BX and John Dizard, "The private equity arms race is hotting up," Financial Times, July 8, 2017 at https://www.ft.com/content/2e61b5ec-625a-11e7-91a7-502f7ee26895.

[5] Between the end of 2010 and Q2 2017, installed wind capacity in Texas more than doubled from 10,085 MW to 21,044 MW. See American Wind Energy Association, AWEA U.S. Wind Industry Annual Market Report, 2010, at 11 and American Wind Energy Association, U.S. Wind Industry Second Quarter 2017 Market Report, 2017, at 6.

[6] Note that nuclear units are typically scheduled and paid based on day-ahead market prices and do not realize negative real-time prices. However, suppressed real-time prices will put downward pressure on forward market prices as the market place adjusts to a greater incidence of negative prices.

[7] Monitoring Analytics, Q2 2017 State of the Market Report for PJM at 104.

[8] See U.S. Department of Energy, Staff Report on Electricity Markets and Reliability, August 2017, at 77, which shows a large concentration of wind resources in Northern Illinois and Iowa. Byron and Quad Cities are located in northwestern Illinois with Quad Cities located right at the border of Iowa.

[9] For example, Massachusetts and Connecticut each have recently passed legislation that calls for long-term contracts to support a substantial increase in renewable resource development effectively bringing forward compliance with future RPS obligations (Mass. Acts 188, 2016 and Connecticut Public Act No. 13-303, 2013).

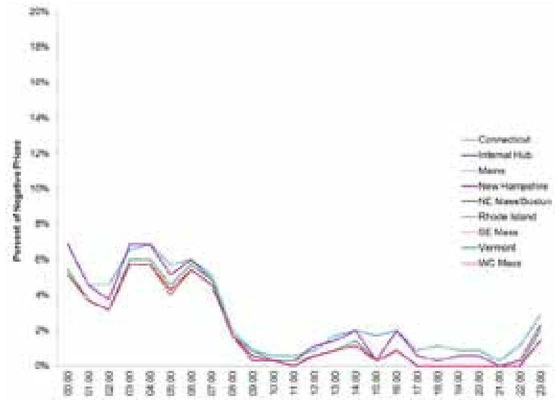


Figure 5B. Frequency of Negative Prices at ISO-NE Hubs in Each Hour, Hourly Real-time Average Prices, 2016

Source: Ventyx

Irie (*references continued from page 35*)

[4] Gas Exporting Countries Forum (GECF) (2017). The GECF History, https://www.gecf.org/_resources/files/pages/history/gecf-history-file.pdf

[5] International Partnership for Energy Efficiency Cooperation (IPEEC) (2017). Introduction, https://ipeec.org/cms/1-introduction-.html

[6] International Atomic Energy Agency (IAEA) (2017). History, https://www.iaea.org/about/overview/history

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MEMBER GET A MEMBER CAMPAIGN A SUCCESS

Jacek Kaminski Wins Complimentary Registration to attend the

Vienna European Conference

IAEE's *Member Get a Member* campaign was another smashing success in the May 1 to July 31 period.

Members had their membership expiration date advanced three months for each new member referred.

With seven referrals, Jacek Kaminski of the Polish Academy of Sciences referred the most new members. He won a complimentary registration to the European Conference in Vienna this September.

Impacts of Climate Policies on Energy Security in Carbon-restrained China

By Hongbo Duan, Shouyang Wang

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The authors acknowledge the financial support of the National Natural Science Foundation of China (Grant No. 71503242).

Energy security, as a conventional and indispensable constituent of economic security, has long been a top research priority, and the dynamics of energy security become particularly complicated with the involvement of climate change, especially for the security of 'vital vulnerability of vital energy systems.' Climate change may worsen the spatial imbalance of energy supply and demand, and cause the conventional energy market to fluctuate more frequently and extensively, which would heavily increase the cost risks of the entire economic system. In contrast, climate change affects the resilience of the energy system itself and energy-related infrastructures, which, in turn, makes the energy system more vulnerable (Farrell et al., 2006; Jewell et al., 2016). As a result, energy security further features its added acceptability, given the increasingly stringent situation of global warming (Sovacool & Brown, 2010).

As the largest greenhouse gas (GHG) emitter and energy consumer, China is facing more overwhelming and pressing challenges in climate change and energy security than any other country, which enhances the high importance of studying the possible relations between China's climate policy and energy security. Theoretically, we first incorporated the possible emission budgets across various emission allocation principles under the 2-degree warming-limit target into a 3E-integrated model. Then, we developed a systematic simulation and analysis framework by examining a series of energy security metrics. Empirically, our emphasis is primarily on exploring the potential unidirectional consistency between climate change and energy security that has been found at the global level, i.e., investigating the dynamic long-term impacts of climate policies on energy safety. Additionally, analyzing the macroeconomic costs and energy security co-benefits of climate policies is also one of our research centers.

The implementation of the entire empirical simulation, which includes the outputs of energy, economy and emissions, and the consideration of climate policies, primarily depended on the Chinese single-sector 3E-integrated assessment model, CE3METL. This model is a Chinese version of the global E3METL (Energy-Economy-Environmental Model with Endogenous Technological change by employing Logistic curves), which is lead-developed in 2013 by H. Duan (Duan et al., 2013; 2015). With the simulation outputs of CE3METL, we further build an effective metric system to evaluate China's long-term energy safety. The most representative indicators were well considered, covering energy and oil intensity, per capita energy and oil consumption, energy and oil expenditures, and energy diversity (Shannon-Weiner Index, SWDI).

The 2C warming-limit target (above pre-industrial levels) has been established as one of core tasks of the Paris agreement, which implies that the future emission budget is limited and we are striding into the times of emission control. As the most recent study reveals, if we want to prevent the global temperatures from exceeding the 2-degree threshold with a probability higher than 50%, then the cumulative carbon space from 2011 to 2100 ranges from 990 to 1,450 giga tons of carbon dioxide ($GtCO_2$). We could theoretically obtain the corresponding cumulative emission space for any specific country given the global emission budget under the 2C warming-stabilizing goal (Raupach et al., 2014), and the national-level budgets of GHG emissions play a significant role in guiding short-term emission control activities and the long-term design of emission reduction targets, particularly for China. Based on the existing estimations on regional emission constrains, we designed 6 scenarios in total, including a reference scenario and 5 emission control policy scenarios, i.e.,

- **BAU** — **B**usiness-**A**s-**U**sual: keeping the current trends of economic growth, energy consumption and technological change, no special climate policies are incorporated.
- **INDC** — **I**ntended Nationally **D**etermined **C**ontributions: taking emission constrains into account, and carbon tax policy is endogenously introduced for achieving China's committed carbon-peaking goal in 2030.
- **Inertia** — Emissions **Inertia** (Grandfathering): considering endogenous carbon tax policy, and the available emission budget is estimated by so-called inertia principle under the 2-degree warming threshold.
- **In&Eq** — Blend of **In**ertia **& Eq**uality: a emission-control case, with the available emission budget estimated in terms of the blended principle of both inertia and equality.
- **Equal** — **Equal**ity: a emission-control case, with China's cumulative available emission space al-

located and determined by the equality principle, given the 2C warming-limit goal.

Mincost **Min**imizing **Cost** Distribution: a emission-control case, with the cumulative available emission budget allocated by the principle of minimizing distribution of relative mitigation costs.

The analyses that assess the energy (oil) intensity and energy (oil) expenditures support the finding that implementation of emission control policies yields the prominent co-benefits of energy safety, regardless of whether looking at the short-, medium- or long-term. As observed from the perspective of per capita energy (oil) consumption, the introduction of emission budgets promotes the decrease in both per capita energy and oil consumption. These outcomes translate to an increase in the energy system security to a large extent. However, this effect is sensitive to the time scale of climate policies when compared to the long-term, the short- and medium-term influences of the climate policies on per capita energy and oil consumption seem more remarkable. For the metric of energy diversity, the co-benefits of energy safety that result from emission budgets are also closely related to the considered time scales. Specifically, the implementation of emission control policies significantly increases China's energy diversity in the short- and medium-term before 2050. Afterward, energy diversity will decrease until it is lower than the BAU level, at which point, the energy system may become more vulnerable than in the no emission budget cases (Figure. 1).

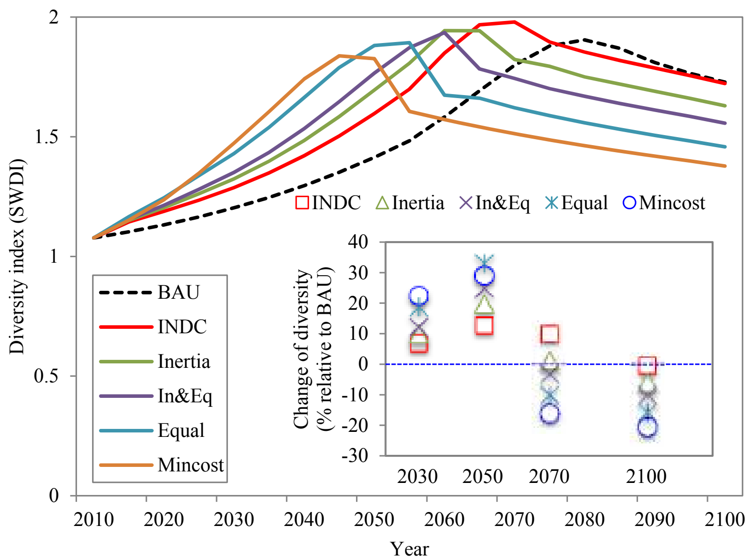

Figure 1. Changes of SWDI-based energy system diversity across various policy scenarios

Note: the embedded subfigure provides the relative changes of SWDI (relative to BAU)

Consequently, there is a unidirectional consistency between China's climate policies and energy security; in effect, climate policies in China contribute to avoiding potential climate damages, and bring the numerous co-benefits of energy security, particularly in the short- and medium-term. This finding provides new reasonable support for introducing climate policies at the national level. Further, the macroeconomic costs required to reach China's committed carbon-peaking target might be far lower than the costs required fulfilling the emission budgets under the global 2-degree warming rise threshold (Figure 2), which implies that the economics of climate policy is expected to significantly improve, if the co-benefits of energy security are considered.

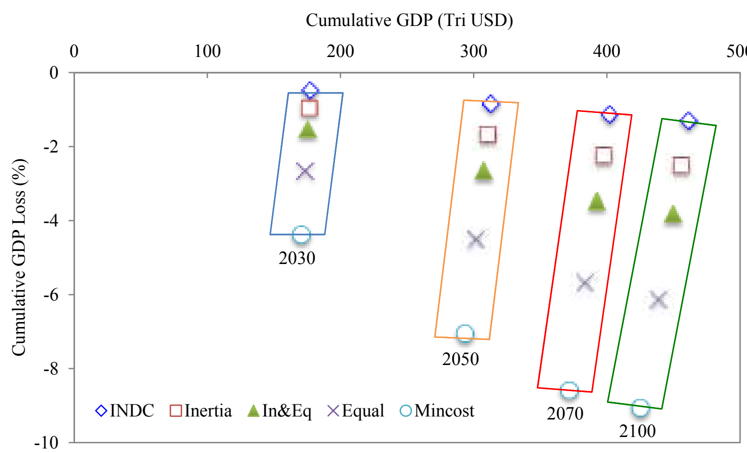

Figure 2. Distribution of cumulative policy costs given different emission budgets (with a 5% discount rate)

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TRANSFORMING ENERGY MARKETS

The Benelux Association for Energy Economics (BAEE), the International Association for Energy Economics (IAEE), the University of Groningen and the Energy Academy Europe have the pleasure to invite you to attend the 41st IAEE international conference that will be held in **Groningen, the Netherlands on 10-13 June 2018**.

Energy markets are rapidly changing. Renewable sources of energy are replacing conventional ones. Markets become more internationally integrated, but also more locally oriented. Market players are reinventing their roles: incumbent producers are looking for new strategies, while energy consumers are becoming producers as well. Market rules need to be reconsidered, just as the energy policies of governments at local, national and international level. Energy markets need to be conducive to innovation and flexible solutions, but also to provide incentives for investments, while performing the usual balancing act between security, environment and affordability.

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Authors whose abstracts are accepted will have until April 9, 2018, to submit their final papers or posters for publication in the online conference proceedings. While multiple submissions by individuals or groups of authors are welcome, the abstract selection process will seek to ensure as broad participation as possible: each author may present only one paper or one poster in the conference. No author should submit more than one abstract as its single author. If multiple submissions are accepted, then a different author will be required to pay the registration fee and present each paper or poster. Otherwise, authors will be contacted and asked to drop one or more paper(s) or poster(s) for presentation

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- Game-theoretical methods
- Simulations (e.g. agent based models)
- Interdisciplinary research (e.g. law and economics, political economy)
- Business cases / case studies / benchmarking

Those interested in organizing a concurrent session should propose a topic and 4 possible speakers to info@iaee2018.com. The abstracts proposed for the special session should be submitted, following the general submission rules within the deadline 8 January 2018.

AND ALSO...

- Pre-conference doctoral seminar with top lecturers on 8 and 9 June
- Master classes on publishing, presenting and solving an energy business case on 10 June
- Technical tours to Groningen gas fields and Groningen Seaports
- Social programme including an excursion to the World Heritage Wadden Sea
- Gala dinner at the 16th century Martini Church

Deadline abstracts:	**8 January 2018**
Notification of acceptance:	**23 February 2018**
Doctoral Seminar:	**8 and 9 June 2018**
Conference dates:	**10-13 June 2018**

Location: **Groningen, the Netherlands**
Contact: **http://info@iaee2018.com**

For more information: www.iaee2018.com

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How Brazil is Addressing the Challenges Associated with Incorporating Renewables into the Energy Supply System

By Silvia Andrea Cupertino, Marcia Konrad, Hirdan Katarina de Medeiros Costa, and Edmilson Moutinho dos Santos

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Brazilian energy policy aims at a rational use of energy sources, environmental awareness and implementation of energy conservation strategies. Despite the fact that the Brazilian electricity matrix is predominantly renewable, Brazil signed the Paris Agreement in 2015, committing itself to reach the target of 33% of renewable energy in the electricity matrix, excluding the hydroelectric source, by 2030.

The Brazilian electric energy sources expansion model has been based on large generating parks of hydroelectric and thermoelectric origin. Alternative sources - wind, solar and biomass - have been introduced in the National Electric System in a centralized approach, requiring the construction of long power transmission networks for generation to reach distant centers of consumption.

The reduction of pollutant gases is a recurrent theme and the investment in alternative sources for the generation of energy have reached a record in annual growth. The electric sector is strategic, but as world economies are facing continued change, the world's electric sector has undergone a vast process of organizational restructuring. In the current model, electrical systems are typically divided into segments such as generation, transmission, distribution and commercialization (LEÃO, 2012).

The increase in energy consumption is due to the increase in generation, which is limited by the capacity of its system, so the excess of demand served by the capacity of the system must be followed by the construction of new generation units, which may increase transportation and distribution of its commercialized energy (Barbosa e Azevedo, 2014).

The increase in the demand for electricity generates the need to optimize the use of the available resources, since, in a world in which losses become less and less acceptable, there must be an effort employed by energy companies in the search for improvement of their systems, as well as an effort by Society to obtain adequate planning of its restructuring and networks.

The availability of an efficient connective electrical infrastructure in Brazil depends on the combination of three factors: (i) competitiveness, (ii) security of supply; and (iii) economic and environmental sustainability. In this sense, the insertion of new sources must aim at safe and expanded generation, with a consequent reduction of tariffs for the final consumer.

Despite the preponderance of alternative sources, the diversification of the electric matrix is important because it promotes environmental sustainability, reinforces the security of supply in the country, and is in compliance with national energy policy guidelines.

From the environmental point of view, they contribute decisively to Brazil's compliance with the agreed targets under the climate agreement., the aforementioned target of 33% of renewable energy (excluding hydraulics) in the electricity matrix by 2030.

The Brazilian generation electricity matrix is composed of the following renewable sources (excluding hydraulics): bagasse, 5.6%; Wind, 3.5%; Solar, 0.06%; other renewables, 2.4%, totaling 11.5%. In 2024, it's expected to be biomass, 11.8%; Wind, 8.0%; and solar, 0.6%, totaling 20.4% of the electric generation (MME, 2016).

Development in public policy was driven by Law n. º 9.427, of 1996, since it granted discounts of at least 50% in the tariffs to users of transmission systems (TUST) and distribution (TUSD) for hydropower plants in a small size, known as PCH and producing energy between 1MW and 30MW.

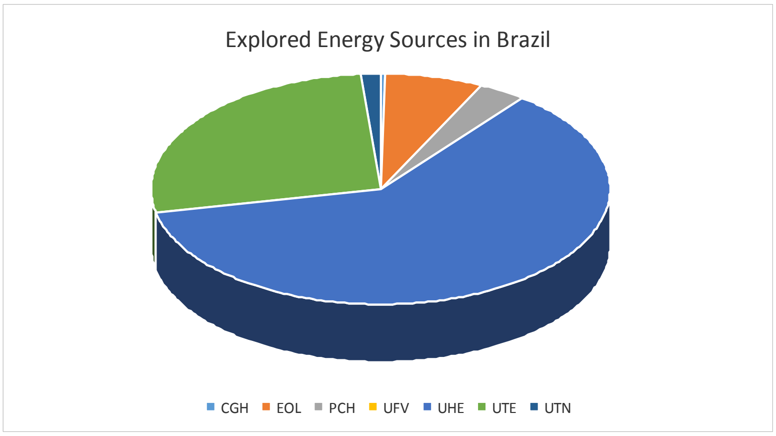

Figure 1 – Explored Energy Source
Source: BEN 2016

CGH - Central hydroelectric power plant with reduced capacity
EOL - Eollectric generating plant
PCH - Small hydroelectric plants
UFV - Solar photovoltaic plant
UTE - Thermoelectric plant
UTN - Thermonuclear plant

This measure allowed the reduction of costs when accessing the network and, consequently the cost of this energy. In 1997, Law n.º 9,478 promoted the inclusion of the use of alternative sources of energy among the goals of national energy policy. The discount on TUSD and TUST has been progressively extended to other non-hydro renewable sources, such as wind, biomass, qualified cogeneration. Currently, the discount on these services is 100% for almost all sources. In the case of biomass composed of solid waste and / or landfill biogas or biodigestors of vegetable or animal waste, as well as sludge from sewage treatment plants, the discount is 50%. In the first ten years, a discount of 80% will apply to solar energy in commercial operation until December 31, 2017, and after this date, the discount will be reduced to 50%.

In 2003, consumers were granted the TUST and TUSD rebates, and in 2015, Law n.º 13.203,of 2015, granted this discount to auto producers, limiting the injected power from 30,000 kW to 300,000 kW, and Law nº 13.299, of 2016, extended the benefit for biomass and PCHs with injected power between 30,000 and 50,000 kW (with a discount limited to 30,000 kW), in order to encourage repowering (replacement of part or components of a material for the purpose of improving performance by altering the characteristics of the design). Another important aspect to highlight is the granting process for renewable sources. It simplifies the authorization so the generators are not necessarily required to participate in an auction. These entrepreneurs are exempt from allocating 1% of net operating revenue for investment in research and development in the sector.

In 2016, the 'PCHs' were granted exemption from paying financial compensation for the use of water resources (Law nº 13.360). This will be applied until the extension of their grants end, and will be calculated at 50% of the charge of the other hydroelectric plants and calculated as established in Law n.º 9.648, of 1998.

In the commercialization field, consumers with power equal to or greater than 500kW can negotiate directly, and contract, as a distributed generator, directly with the energy distributor. There is permission to share the transmission facilities of restricted interest, the generation central for shared connection (ICG), reducing costs of connecting to the network.

Brazil still has a long way to go in order to make better use of these renewable sources, and existing incentives should be evaluated, bottlenecks identified, durable and efficient measures proposed to promote the adequate use of available infrastructure, and meet the needs of society. The firmness of the supply to the diversification of its matrix, the transmission system, the adaptation to the environmental parameters and the tariff modicity. The biggest challenge is the lack of a more agile and adequate legislation that encourages a policy of implantation of an electrical matrix with a new profile.

The incentives granted by the electric policy are paid by the Energy Development Account (CDE), representing an additional burden for Brazilian society. In 2016, CDE's budget reserved R $ 1.2 billion to cover the discounts at TUST and TUSD. The grant of 1.5 billion in benefits represents an average increase of 1% in the final consumers' tariff. Therefore, the cost of the account is one of the challenges for the sector. The projection of 45 GW in sources encouraged for the year 2024 (Ten Year Plan) will generate an account of R $ 4 billion. The analysis of the incentives against the tariff resources should be considered.

Brazil has also implemented mechanisms to systematically purchase wind energy, providing investments and consolidating the national component and wind turbine industry. As part of a public policy to stimulate the country's production chain, the public banks that granted the financing required increasing nationalization rates. The law instituted nationalization of equipment and services of at least sixty percent.

The National Bank for Development (BNDES) created the 'Progressive Nationalization Plan' for wind turbines, which forced the industries to invest about R $ 500 million in order to meet this requirement of BNDES and its customers. The requirement of 60% nationalization generated delays at first, but encouraged manufacturers to install wind turbine production and assembly plants.

Experimenting with new technologies and production at scale have led to lower costs. Even so, the costs for consumers are still significant. The Annual Proinfa Plan for 2016 indicates that the total of 131 enterprises were benefited and received annual subsidies of $ 2.78 billion (ANEEL, 2016)

Currently, wind power accounts for about 30% of the system load in the Brazilian Northeast and arrives, in peak situations, to meet 10% of the load of the national interconnected system. In percentage terms, the share of wind energy reaches around 7% of installed capacity. With the implementation of more than 14 GW contracted in auctions, the forecast is that, in 2020, the share of wind power will be around 10% to 12%, which will correspond to the second source of energy of the national electricity matrix. Brazil ranked 15th in terms of installed capacity in 2012 and reached tenth position in 2015.

In 2015, 21.4 TWh of wind energy were generated, 11 million houses were supplied monthly with this energy, 10 million tons of CO_2 ceased to be emitted and about R $ 645 million were no longer spent on fuel for the thermals. We were, in 2015, the fourth most invested country in the world and the eighth country in wind power generation.

The adjacent figure shows the rapid growth of wind generation.

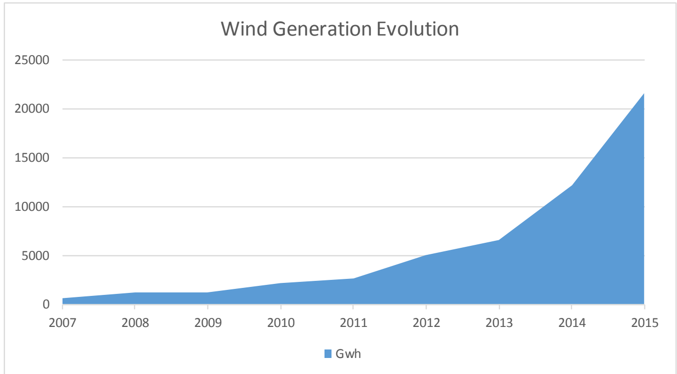

Figure 2- Evolution of Wind generation -2007 to 2015.
Source: BEN 2016

Biomass is important due to its predictability and stability, despite its seasonality, and should be considered because it is not intermittent. Bioelectricity has its generation carried out predominantly between April and November, the dry period of the year, and there is a possibility of generation until the off-season. Its stability facilitates the planning of its use, and the fact that there may be generation even in the off-season means that bioelectricity can compensate with the intermittent nature of other renewable sources.

The energy generated by biomass in the country's consumer center greatly reduces transportation and logistics costs. About 90% of processed cane is in the Midwest and Southeast regions, which account for 60% of the consumption load. Each ton of sugar cane produces 250kg of bagasse and 280kg of straw, and the straw has twice the calorific value of bagasse. In 2010, biomass added 1,750 MW to the grid, which is equivalent to 12% of an Itaipu. This was the result of Proinfa, regulated auctions and a policy more dedicated to this source. In 2015, sugarcane biomass generated 20,169 GWh for the grid. This meant serving more than 10 million households and reducing CO_2 emissions by 8.6 million tons. This type of generation saved 14% of the water in the hydroelectric reservoirs of the Southeast/Center-West sub-market.

The installed capacity of biomass plants on the National Interconnected System (SIN) reached 11.6 GW in June 2016 (CCEE, 2016). The expansion was 7.4% over the same period last year, when capacity was 10.8 GW. In the first half of 2016, biomass-based thermal plants produced 1,942 average MW, an increase of 6.1% over the average generation of 1,831 MW in the same period of 2015. The sector believes that potential could be better utilized and calls for a clearer public policy that defines the role of ethanol and biomass in the energy matrix, seeking greater use of energy cogeneration and its inclusion in auctions for reserve energy.

In percentage terms, the share of renewable energy in the electric power matrix is around 7%. (source and month) with the insertion of more than 14 GW already contracted in auctions, this percentage is expected to reach 10% to 12% by 2020. This represents the goal established in the second stage of Proinfa: 10% of the annual consumption of electricity in the country, in 20 years, that is, 2022. With these measures, renewable energy will be the second source of energy in the National power matrix.

Therefore, it is necessary to consider a long-term horizon in planning for electric power security for Brazilian society. It is, therefore, necessary to try to identify bottlenecks, and propose durable measures that, in addition to efficiently using the facilities that will be built, should consider other alternatives to remedy the problem. The security of supply is not only linked to the capacity to supply the energy, but also to its adequate transportation.

There are many challenges encountered by those who seek participation in the supply of energy to the network, from lack of information to deficiencies of regulation, and more specifically, the differences of interpretation among power distributors in the distributed generation connection process. There are some initiatives in the tax field, such as the exemption of ICMS for consumers who implant an energy system for their own consumption. However, the cost still remains high.

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27-30 November 2017, Mines and Money London at Business Design Centre, 52 Upper Street, London, N1 0QH, United Kingdom. Contact: Phone: +44 (0) 20 7216 6080, Email: bilal.azmat@resourcefulevents.com, URL: https://go.evvnt.com/110122-0

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