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IAEE ENERGY FORUM

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Editor: David L. Williams

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PRESIDENT'S MESSAGE

This year's 41st IAEE international meeting was a success on all counts. The first fundamental goal of all our conferences -- to provide a high-level forum for exchange of information and opinions on critical issues -- was more than accomplished over four days in Groningen and surrounding areas. Appropriately, Groningen's massive gas deposits and associated energy support industry that has supported the region for decades is now, like the rest of the world, transitioning from a fossil fuel dominated world to a less carbon intensive local economy with innovation at the forefront. Groningen province leads the country in start-up businesses.

The conference theme of Security of Supply, Sustainability and Affordability: Assessing the Trade-offs of Energy Policy couldn't have been more topical. Energy markets were preparing for an uncertain Opec meeting, while aggressive US policies on trade in general -- and sanctions in particular -- compounded uncertainties. Critical climate policy issues are actively under debate in various countries and international organizations.

Needless to say, from the opening plenary on "Energy in Emerging and Developing Countries" to an excellent closing panel on "Climate Policy" audiences were strongly engaged. In between, three plenaries and four "dual plenaries" were interspersed with seven sets of concurrent sessions with 13 tracks across fuels and electricity, with both supply and demand issues as well as policy aspects. Climate, technology and transport were given special attention. Each set of session also offered a round table discussion as an option.

The secondary goal of creating an effective environment for professional and personal networking among members of an extended energy economics community with geographically and generationally diverse backgrounds was equally successful. The inherently youthful character of the Groningen area matched well with the large number of student and young professionals in attendance as well as their active participation and contributions as presenters and audience members during the plenary and especially concurrent sessions. Several outside events added to the sense of community and deepened individual and collective ties to the IAEE family.

Students and other members also benefited from three masters classes on writing for scientific journals presenting at scientific conferences and energy-related problem solving in a corporate setting and many students and young professionals also took advantage of poster sessions as presenters and observers on each day of the formal conference.

The high quality of the conference organization reflects yeoman efforts by the various committees led by Machiel Mulder and Bert Willems of the BAEE. IAEE thanks the conferences three platinum sponsors – GasTerra, GasUnie and Gemeente Groningen, gold sponsor and host Provincie Groningen, along with the Rijksuniversity of Groningen where the conference was held as well as nine silver sponsors for making such a successful conference possible.

David Knapp

EDITOR'S NOTES

Once again I have had the pleasure of organizing, for the Energy Forum Special Issue, a selection of papers presented at the 41st IAEE International Conference in Groningen, the Netherlands, 10 - 13 June 2018. And again I have to make the same reservation as before: It is impossible to make a representative selection of some 20 papers from among the 500+ papers that were presented at the conference, including posters.

For this issue of the Energy Forum we ended up with 19 articles from the presented conference papers. In the selection process I have had an eye to the IAEE Specialization Codes with regard to topics, the majority of articles selected from the Codes with the largest number of submissions. I also have put some emphasis on the geographical dispersion of topics and authors. The IAEE is becoming a truly international association and its International Conference should reflect the international composition of the portfolio of papers represented there.

Invited authors were asked to write an extended abstract version of their papers on the standard Energy Forum format, limited to approximately 1500 words, taking account of the space for tables and/or figures that might be included. I would like to thank all the authors for their willingness and extra effort to prepare an article for this Energy Forum Special Issue and for pleasant cooperation in the process. Last, but not least, I would like to thank the Energy Forum Editor and IAEE Executive Director, David Williams, for inviting me to edit this section of the EF Special Issue and for efficient handling of all matters associated with the editing of the EF and with the IAEE at large.

I hope that Energy Forum readers will find the collection of articles in this issue interesting and worthwhile to study. If this editing exercise may stimulate members of the IAEE and others to come to the international conferences of the Association (and to its regional conferences as well) to get access to the wealth, scope, breadth and depth, of knowledge and insights of the changing international energy scene represented in the large volume of papers presented there, plus in the many plenary sessions, that would indeed be an additional stimulus and incentive in itself. Next year the IAEE International Conference will be held in Montreal, May 29 – June 1, 2019.

After five years in the role as editor of the invited papers section of the EF Special Issue, I have found that it is time to pass the baton on to a new editor, to be appointed by David Williams. I very much have enjoyed to have had this task for the EF and the IAEE and wish both every success in the future.

Einar Hope.

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

Contents (continued)

Interview with Prof. Machiel Mulder, General Conference Chair, 41st IAEE International Conference

Machiel Mulder attended his first International IAEE conference in 2001 in Huston, at that time he was the Head of the Energy Department at the Netherlands Bureau for Economic Policy Analysis. After a few years of collaboration with IAEE, in 2007 the Benelux chapter was re-established, and Mr. Mulder became the president of this chapter. When he became full professor at the University of Groningen in 2013, prof. Mulder was encouraged to submit a bid for organizing the first IAEE international conference in the Netherlands and in March 2015 the IAEE Council has approved the bid. Mr. Mulder and his team were very proud and grateful for being chosen to organize this conference on behalf of the IAEE. Being part of the organizing team of such a big conference was an outstanding experience for everyone involved.

"This conference is a result of three years of intense work" says Mulder. In 2015, conference team started its work with choosing the conference venue as well as the locations for the networking events. Then the entire year of 2016 was focused on work with sponsors, and in 2017 the program committee have start to work on the content of the conference program. Seeing this project to be successful makes Mr. Mulder proud and gives a feeling of achievement in leading and managing an international team. Organizing such a conference has many aspects: academic, financial, strategic, administrative and logistic. One of the learning experiences during these past three years for Mr. Mulder was to organize and lead the conference committee toward one common aim. It was very rewarding to work within a motivated and dynamic team, where people motivate each other. Additionally, Mr. Mulder says that it was very rewarding to work with so many people and to see this project coming all together as a success. However, the cost of organizing such a big event was also very high, both for himself but also for his family. Mr. Mulder is now looking forward to focusing more on research, writing articles and teaching.

Mr. Mulder advice to the future conference organizers is to have a clearly defined philosophy on what type of conference they would like to organize. "Our philosophy was to have high-quality speakers and presentations and a lot of interaction among delegates Therefore, we decided for instance, not to reserve any presentation slots to sponsors and hence to have only invited speakers and selected abstracts in our program" says Mulder. Instead sponsors were offered the opportunity of being involved in the process since the beginning. The conference committee had organized meetings and workshops with sponsors to discuss potential interesting topics which needs to be addressed during the conference. Moreover, the organizers tried to have mixed panels of speakers regarding gender and geographical background in all plenary and round table sessions. In addition, in order to foster the debate among scientists, policy makers and business, the organizers organized 6 Round Tables, which were quite a success. To define and follow this philosophy was one of the main challenges. Mr. Mulder concludes that he would not have been satisfied with the conference program if the presentations in all the various sessions would not have sufficient quality. In addition, part of the philosophy was also to realize sufficient opportunities for interaction and networking, which means that there should be not many speakers in one session and several social activities.

On behalf of the Conference Organizing Committee Mr. Mulder thanked all the delegates for making often a long journey to attend the conference.

Round Tables Sessions during the Conference

In order to foster the debate among scientists, policy makers and people from business, a number of Round Tables were organized. These sessions were scheduled as concurrent sessions. Each round table had about five speakers which are from a different background (business, policy, regulation or research). After brief pitches by the panel members, all participants could discuss on the topic of the session. There were round tables on the impact of climate policy on international competitiveness, market design in electricity market, disruptive innovation, sector coupling, the role of local governments and the alternatives for fossil fuels. The round tables were an innovation and according to the feedback of participants, they were a success. As nice small-scale follow ups of topics discussed in plenary sessions, the round tables added something extra to the conference.

Groningen Conference Overview

Pictures and Commentary

The 41st IAEE 2018 International Conference was organized by the University of Groningen and the Benelux affiliate of the IAEE – BAEE. The conference was held at Martini Plaza, Groningen, Holland on June 10 - 13, 2018. The conference reached the record number of participants with 650 attendees and included various activities and social events. Academic presentations were scheduled within the 91 Concurrent sessions and additionally seven plenary and dual plenary sessions were organized. A new concept of Round table sessions was introduced during the conference with six round table meetings scheduled over three days.

Opening Reception

On Sunday 10 June conference delegates were invited to the Academy building of the University of Groningen for the opening reception. It is the place where all university ceremonies are held. The Academy building was built in the style of the Northern Dutch Renaissance. The current building was built in 1906 after a fire destroyed the previous building built in 1850.

Gala dinner

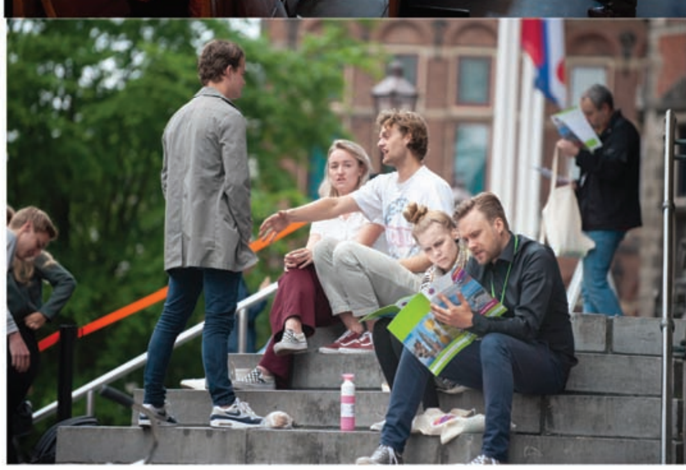
The conference gala dinner was held on Monday 11 June at the Martini Church in the city centre of Groningen. This church originates from the 13th century and is the oldest church of the city. Its organ contains stops dating back to 1450. It was a very special experience for the conference delegates to be able to enjoy the organ music during the dinner.

Gala dinner (continued)

Cultural Evening

On Tuesday 12 June delegates joined an informal evening with music, drinks and food in the Rietschans at the south border of the lake 'Paterswoldsemeer'. During the evening, it was possible to join a short boat tour around the lake.

Scenes from the 41st IAEE International Conference June 10-13, 2018

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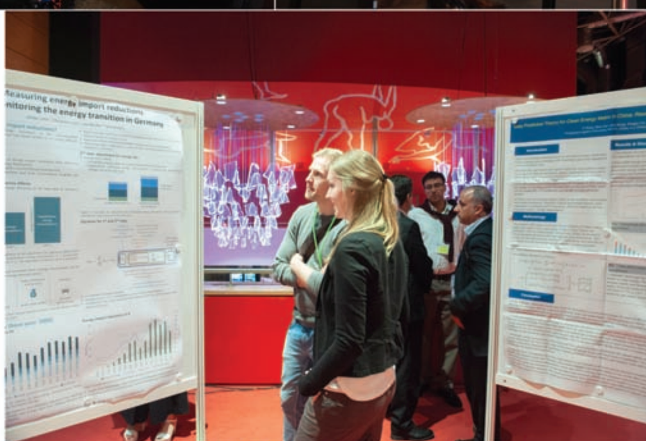
Measuring energy import reductions


World
Energy
Outlook

ALADEE | IAEE Conference

7th ELAEE - Buenos Aires 2019

Latin American Meeting on Energy Economics

Decarbonization, Efficiency and Affordability: New Energy Markets in Latin America

ALADEE ASOCIACIÓN LATINOAMERICANA de ECONOMÍA de la ENERGÍA — IAEE — INSTITUTO TORCUATO DI TELLA

The Latin American Association for Energy Economics (ALADEE), the International Association for Energy Economics (IAEE), the Instituto Torcuato Di Tella (ITDT) and the Instituto Argentino de la Energía "General Mosconi" have the pleasure to invite you to attend the 7th Latin American Conference that will be held in **Buenos Aires, Argentina on 11-12 March 2019.**

For more information about the Conference, please visit 7elaee.aladee.org

Call For Papers

Authors wishing present their papers during ELAEE's concurrent sessions must submit an abstract that briefly describes the research or case study online through the conference website 7elaee.aladee.org before **October 31, 2018**.

In case abstracts are approved by the Program Committee, authors will be notified by **November 30, 2018**. Full papers will be published on the online proceedings in the IAEE and ALADEE websites.

For more information and a description of preferred topics and methods, please visit https://7elaee.aladee.org/callforpapers or write to 7elaee@aladee.org.

The Critical Role of Economic Assumptions in Cost-effectiveness Analysis of Power Plant CO_2 Capture and Storage

BY CHUAN ZHANG, ALESSANDRO ROMAGNOLI, MARKUS KRAFT

Markus Kraft is a Professor at University of Cambridge UK. He is also the director of the Cambridge Centre for Advanced Research and Education in Singapore (CARES). **Alessandro Romagnoli** is Assistant Professor at Nanyang Technological University Singapore and **Chuan Zhang** is a PhD student at the same university. Corresponding email: mk306@cam.ac.uk.

Introduction

Decarbonization of fossil fuel power plant has been identified as a key enabler on the 2DS climate change trajectory; Carbon Capture and Storage (CCS) is an important technology for such fossil fuel power plant decarbonization. Although the technology readiness level of CCS has become mature, successful demonstration projects are quite limited. Low Cost-effectiveness has been the main reason for the low uptake of power plant CCS applications. Recently, many studies conduct cost-effectiveness evaluation of fossil fuel power plant CCS; interestingly, the results differ a lot. A closer examination would find that these studies deploy divergent assumptions, such as fuel price, CO_2 transportation cost; the following question is how these parameter uncertainties influence the power plant cost-effectiveness evaluation results and how could these analyses based on different assumptions be adapted to a consistent framework for comparison? In other words, global sensitivity of fossil fuel power plant CCS cost regarding to key economic parameters should be researched. Starting from here, we present a systematic analysis of the impact of key economic parameters on power plant CCS cost in this paper and point out how such impact should be addressed in future study.

Methods

Process flow sheet of typical Pulverized Coal (PC) and Natural Gas Combined Cycle (NGCC) power plant with CCS is simulated in the study, then surrogate model is established based on the simulation results of techno-economic model. Surrogate model is an approximation model that mimic the behavior of the simulation process as closely as possible while being computationally cheaper to evaluate. As a result, the cost of a CCS power plant under different parameter uncertainties could be quickly and accurately assessed. Through literature review, we obtain a parameter uncertainty range for the key parameters, see Table 1; seven key parameters are inspected, including fuel (i.e., coal and natural gas) price, bioenergy price, bioenergy heating value, CCS CPLEX, CCS OPLEX (CO_2 transportation and storage cost), capacity factor. Firstly, single-factor sensitivity analysis is conducted to inspect how one single factor change the overall CCS cost; then Latin hypercube sampling method is used to select representative points from the variable design space to conduct global sensitivity analysis. Finally, the CCS power plant generation cost is normalized based on global sensitivity analysis results.

	500MW subcritical PC	600MW NGCC	Uncertainty range
Fuel price	42$/ton	2.6$/MBTU	20-60$/ton for coal; 1.8-3$/MBTU for gas
Bioenergy price	0.05$/ton	0.05$/ton	0.01-1.5$/ton
Bioenergy property	16.25MJ/kg	16.25MJ/kg	5-50MJ/kg
CCS CPLEX	1200$/kW	600$/kW	700-1500$/kW for coal; 400-800$/kW for gas
CO_2 transportation cost	2.2$/ton	2.2$/ton	0.5-10$/ton
CO_2 storage cost	3$/ton	3$/ton	0.5-10$/tom
Capacity factor	75%	75%	40%-90%

Table 1. Detailed configuration of typical PC and NGCC power plant models in the paper.

Results

The generation cost of typical PC and NGCC power plants with CCS are analyzed in the study. As shown in Fig.1, the generation cost of PC plant with CCS is 82$/MWh when all parameters are at baseline levels in Table 1. When there are uncertainties for all key parameters, the generation cost varies between 72-108$/MWh, the high end of PC CCS plant generation cost happens when carbon price is at its high end (i.e.100$/ton) whereas the low end happens when coal price is at its low end (i.e.20$/ton). Similarly, the generation cost of NGCC CCS plant varies from 87 $/MWh to 75-110 $/MWh, NGCC CCS power plant generation cost is highest when carbon price is highest (i.e.100$/ton) and is lowest when natural gas price is lowest (i.e.1.8$/MBTU). In terms of percentage variation, PC CCS plant generation cost is sensitive to the change of the aforementioned seven parameters in Table1 at 22%, 9%, 8%, 14%, 9%, 12%, 18% respectively whereas NGCC CCS plant generation cost is sensitive to same parameters at 19%, 8%, 8%, 16%, 10%, 11% and 20% respectively. Such results clearly show that the cost-effectiveness of fossil fuel CCS power plant depends on various parameters and it seems that no single parameter plays dominant role. As a result, if we desire to decrease the generation cost of a CCS power plant, all mentioned parameters should be deliberately set up to favorable levels as shown in Table 1, which is a nontrivial task because the values of these parameters depend on many different factors which are not only technological, but also related to societal, political and behavioral factors.

Moreover, the impact of technology learning on the future PC and NGCC CCS plant is explored in the study. Technology learning rate could reflect the impact of technology learning on performance improvement of CCS technology. If there is carbon price at 10 $/ton, the generation cost of PC power plant with CCS would become 68 $/MWh, 65 $/MWh and 61 $/MWh when CCS learning rate is low, middle and high respectively, whereas the average fossil fuel power plant generation cost would be 64 $/MWh in 2050 (Fig.2). In such case, PC power plant with CCS would be economically feasible if the CCS technology learning rate is middle or high; however, the generation cost of NGCC power plant with CCS (e.g. 72 $/MWh at high learning rate) remains higher than the average generation cost, which means CCS integration with NGCC power plant is still economically infeasible at such carbon price.

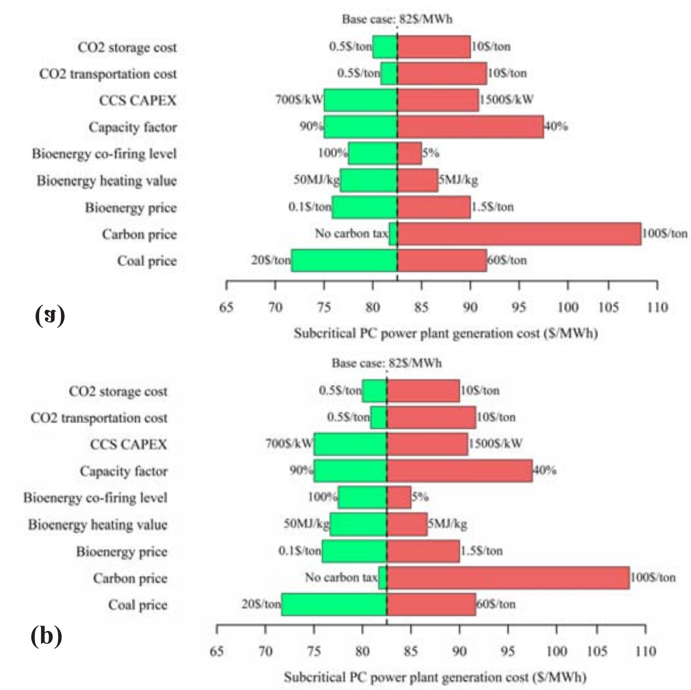

Fig.1 Effect of key parameters on power plant generation cost. Shown here are the generation cost of a typical (a) PC power plant and (b) NGCC power plant regarding to key parameter uncertainties.

Conclusion and future work

This study presents sensitivity analysis of fossil fuel CCS power plant generation cost regrading to key parameter uncertainties, including fuel price, bioenergy price, carbon tax, CCS CPLEX, CO_2 transportation and storage cost, capacity factor etc. We find that the generation cost of PC and NGCC CCS power plant could vary from 82 $/MWh to 72 $/MWh up to 108 $/MWh, from 87 $/MWh to 75 $/MWh up to 110 $/MWh respectively when key parameters change. The high end of PC and NGCC plant generation cost happens when carbon price is at its high end whereas the low end happens when fuel price is at its low end. The results show that making fossil fuel CCS power plant economic is nontrivial because it is related to various factors which are not only technological, but also related to societal, political and behavioral factors.

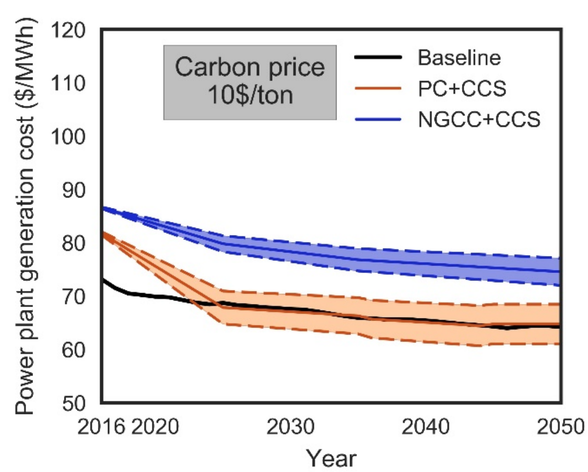

Fig.2 Impact of technology learning on the future cost of PC and NGCC CCS power plant under 10$/ton carbon tax.

Opening Session Overview

By Machiel Mulder

The conference started with a welcome and opening remarks by Machiel Mulder (general conference chairman), Nienke Homan, Executive of the Province of Groningen, Gertjan Lankhorst (chairman New Energy Coalition, Groningen) and David Knapp (president of the IAEE).

The conference was kicked off by a concise opening session in which the delegates where welcomed on behalf of the organizers, sponsors and the IAEE. Machiel Mulder, as general chairman, explained why the organizers have chosen the conference theme "transforming energy markets'. Energy systems have to change in order to reduce the emissions of carbon, but in order to do this in an efficient way, markets also need to be transformed. In the conference the transformation of energy markets is being discussed in a large number of various types of sessions. He also mentions the contribution of many people and sponsors in the organisation of this conference.

Mr. Gertjan Lankhorst, chairman of the Energy Academy Europe, stressed the fact that economists need to contribute to the field of energy as we cannot leave this to engineers.

Mrs. Nienke Homan, regional minister of energy, said that policy makers are in need of careful economic scientific analysis to underpin their decisions.

Finally, Mr. David Knapp, president of the IAEE, thanked the organizers for all the effort they have put in to make this conference to a success.

Will Russian Natural Gas Long-term Contract Prices Remain Oil Price Determined after the End of Oil-indexation?

BY PÉTER KADERJÁK, PÉTER KOTEK, ALFA DIALLO

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Until the end of the 2000s natural gas trading in continental Europe had been built on long-term gas sales and purchase contracts (LTC) between major outside gas suppliers – Norway, Russia and Algeria – and European buyers. The dominant pricing scheme of LTCs was oil price indexation. In the last couple of years however the structure and pricing of Russian LTCs have changed due to re-negotiations and recontracting. The objective of this paper is to identify the most important determinants of Russian LTC pricing strategy under the current market conditions. We investigate to what extent Russian long-term contract prices were determined by strategic considerations and Russian market position. We also assess the role of oil price in long-term gas supply contracts.

Compared to previous research our approach is novel in a sense (i) we considered long-term contract price development and price differences in multiple European countries (ii) introduced a new indicator of import dependence and showed its effect on LTC prices.

To assess the pricing of long-term contracts we formulated two hypothesis.

- First, based on the notion that European gas markets are working in a perfectly competitive manner, we argue that the Russian long-term contracts are priced to the closest competitive alternative. The rationale is that Russia's main strategy is long-term profit maximisation and market foreclosure.
- Second, we consider that LTC prices are mainly determined by the market power of the incumbent – in our analysis Russia. To grasp the market power element we formulate an indicator and assess its effect on LTC prices.

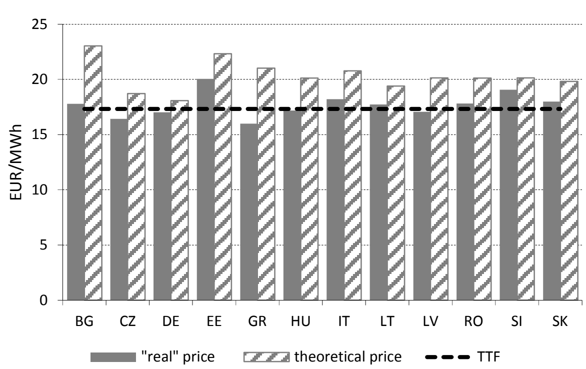

Figure 1. The relationship between real and theoretical LTC prices in 2017

Source: Authors' own calculation based on Eurostat data and REKK's data gathering.

To test the first hypothesis, we used the LTC price data of 12 countries in 2016 and 2017. The price of the closest competitive threat, referred to as "theoretical price", is estimated as the sum of the price of the relevant competitive source and the transportation cost. By looking at 2016 data we can conclude that in the Western and Central European region the presented hypothesis holds. However, these findings seem to be accidental if we compare them with the 2017 (Figure 1) numbers. We argue that Russia indeed accommodated its pricing strategy because of the increasing competitive pressure, as there is a continuous convergence between LTC prices and TTF. On the other hand, data do not support the hypothesis that LTCs are priced as the closest competitive threat plus transportation cost as in practice Russian LTC prices are significantly lower that this hypothesis would indicate, and very small cross-country differences are identifiable.

For the second hypothesis, a novel market power indictor was formulated. Our general hypothesis was that the market power of Russia in a country is determined by the competitive pressure of alternative sources of supply. Formally:

$$(1)\quad E_{i,t} = \frac{C_{i,t} - P_{i,t} - I_{max_{i,t}}}{C_{i,t}}$$

where i represent the different countries, while t the different years (2010-2017). C stands for the annual consumption level, P is the annual production, while I_{max} is the maximum import capacity per year from non-Russian source. The domestic production P affects the exposure index negatively: the higher the domestic sources of gas, lower the exposure index. Similarly, the alternative import capacity from non-Russian sources has a negative effect on the exposure index: the more alternative sources are available for a country to import, the less exposed it is to a single supplier. The effect of consumption is positive, but considerably weaker than the other two variables.

We were interested about the effect of E-index on the spread between LTC and TTF prices. Our main specification was the following:

$$(2)\ ltc_{i,t} - ttf_t = \alpha + \beta_1 * eindex_{i,t} + \beta_2 * brent_{i,t} + v_i + \rho t + u_{i,t}$$

where ltc is the long-term contract price while ttf is the average TTF price in EUR/MWh , $eindex$ is the indicator defined in equation (1), $brent$ stands for the price of a barrel of crude Brent oil in EUR/barrel, v_i is the country-fixed effect, t represents a linear time trend, while $u_{i,t}$ is the error term.

VARIABLES	(D) LTC-TTF	(E) LTC-TTF	(F) LTC-TTF
Eindex	1.030***	0.574**	-0.161
	(0.241)	(0.200)	(0.215)
Brent		0.0953***	0.0516***
		(0.0218)	(0.0159)
Time trend included	NO	NO	YES
Observations	96	96	96
R-squared	0.136	0.285	0.477

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1. Regression results with LTC-TTF spread as dependent variable

Brent crude effects turned out to be significant in all model specifications. In all of our specification its coefficient was significant, even when we tried to explain the LTC-TTF spread. The inclusion of time trend did not affect this observation. This means that even in a period, where oil indexation mechanisms are being replaced the role of oil remains important via direct channels: as in some countries at least partly oil indexations remained in place and indirect channels: the hub price itself is affected by oil price.

Additionally, we found weak evidence that dependency rate affects the LTC price of a country. Based on our regression analysis we measured a difference of 0 to 0.6 EUR/MWh between the LTC mark-up of a totally dependent (E=1) and fully independent (E=0) country. Our theoretical maximum effect (0.6 EUR/MWh) can be considered relatively high as it accounts for more than one quarter of the average deviation from the mean of LTC prices of all investigated countries in the whole 2010 to 2017 period.

Plenary Session 1: Energy in Emerging and Developing Countries

Summarised by Jan Eise Fokkema, PhD Student, University of Groningen

The plenary session on energy in emerging and developing countries was chaired by Noë van Hulst, Ambassador of the Netherlands to the OECD and Chairman of the Governing Board of the IEA. She was joined by Timur Gül, Senior Energy Analyst at the IEA; Zhang Xilian, Professor and Director of Institute for Energy, Environment and Economy, Tsinghua University, Beijing, China; and Chandra Bushan, Deputy Director General of Centre for Science and Environment, New Delhi, India.

The three speakers combined a holistic view on energy access in developing countries with a more detailed outlook on how energy policies and trends in China and India have enabled increasing the share of renewables and energy access in remote areas.

Timur Gül showed progress in worldwide energy access, even though Sub-Saharan African countries have been projected to lag behind in the future. Therefore, new policies were presented that included decentralized solar panel solutions and grid extensions.

Zhang Xilian discussed successful policies for rural electrification in China which included community and household solar panels. He attributed their success to political will, adequate public finance and coordination among decentralized government agencies.

Chandra Bushan discussed several trends which enable India to increase its share of renewable energy that included the decreasing cost of renewable energy and storage and the important role of electricity.

Innovation Policy for the Oil Industry in Brazil: an Analysis in the Light of New Technological Trends

BY HELDER PINTO JR. EDMAR DE ALMEIDA AND WILLIAM CLAVIJO

Helder Queiroz Pinto Jr. and **Edmar de Almeida** are Associate Professors of the Institute of Economics of the Federal University of Rio de Janeiro, while **William Clavijo** is a phd candidate at the same university. Corresponding author: Edmar de Almeida, edmar@ie.ufrj.br

The search for new oil and gas reserves during the cycle of high oil prices between 2005 to 2014 has led the oil industry to new and more challenging geological frontiers such as the so-called unconventional resources and the exploitation in deep and ultra-deep waters. The high oil price has allowed the world oil industry to invest in innovations to face important technological challenges linked to the new geological frontiers.

The collapse of the price of oil in 2014 has created new technological challenges to the oil industry. Companies operating in high cost areas such as the shale oil and gas in the US and the Brazilian presalt zone had no other option than to invested heavily in technological solutions related to cost reduction. More generally, the new market environment of low prices, forced the world oil industry to seek new vectors of cost reduction, both upstream and downstream.

The emergence of competitive technological solutions

Considering the challenges posed by the current context, two main trends related to the adoption of technological solutions in the oil industry deserve to be analyzed:

The first trend concerns the growing adoption of new disruptive technologies, especially those associated with the Industry 4.0 concept of so-called digital transformation in all segments of the oil industry. This trend encompasses several layers of technology such as Internet of Things (IoT), Intelligent and Connected Production (PIC), Big Data, Cloud Computing, all of which are strongly related to Artificial Intelligence systems and different Communication Networks.

The second trend includes the development of technological solutions aimed at overcoming critical bottlenecks of the industry. The main critical bottlenecks are associated with the conditions of access to the most difficult geological frontiers, combined with the need to deal with the economic characteristics of the "low price" context. As a result, the development and adoption of new technologies have significantly impacted all segments of the oil industry.

In the upstream segment, the adoption of new technologies has provoked a radical transformation in the design of E&P projects. This transformation is associated to a cluster of innovations due to:

1 Intelligent management of complex systems using dada analytics.
2 Increasing process automation by the replacement of mechanical components by electronic ones.
3 Increasing equipment sensoring of allowing the intensification of dada collection and predictive maintenance.
4 And the introduction of new materials and nanomaterials.

This cluster of innovations has allowed the companies to reduce their costs and to achieve efficiency gains in a short space of time.

Similarly, in the refining segment, the incorporation of digital technologies has allowed the reduction of operational costs by the retrofit of many existing refineries, as well as in the Greenfield refineries. The downstream segment, in addition to the implementation of digital technologies, has also undergone the incorporation of process systems engineering and the so-called "smart manufacturing", understood as the means of combining information and technology to revolutionize the industrial intelligence to gain agility, flexibility, productivity and quality gains.

Petrobras' role in innovation in the O&G sector and recent public policy efforts in Brazil

The effort to develop innovation capabilities in the Brazilian O&G sector is linked to Petrobras' trajectory and its coordinating role in the Sectorial System of Innovation, since the beginning of the second half of the 20th century. This innovation effort allowed Petrobras to play a leading role in the technological development in deep and ultradeep waters.

The end of Petrobras oil monopoly and the sector reforms in the late 1990s inaugurated a new phase for the innovation policy in the Brazilian O&G sector. This time, the National Agency for Petroleum, Natural Gas and Biofuels (ANP) and other government agencies assumed an important role in the coordination of the innovation policy. Since then, in addition to Petrobras innovation efforts, the government formulated a policy of innovation for the country. This policy was made up of a regulatory framework with obligations and incentives for the investment in R&D. The cooperation between universities and oil companies was promoted. The main tools to foster this cooperation was the innovation funds (such CT-Petro and Inova Petro) and the obligatory investment in R&D clause in the oil lease contract.

In the specific case of Brazil, efforts to develop technological skills in deepwater E&P operations were reinforced by the discovery of pre-salt reserves, prompting Petrobras and other Brazilian industry players to reformulate their technological programs to tackle this new geological frontier.

Balance and prospects

The implementation of the different policy instruments has had a positive impact on the inclusion of new actors in the Brazilian System of Innovation for the O&G industry. These policies also played a structuring role of new and more robust interactions among the agents of the system.

The R&D clause represent the main policy instrument to promote innovation in Brazilian oil sector. Oil and gas operators have invested about R$ 12 billion has been invested in R&D between 2006 to 2017, allowing the development of more than 10 thousand projects. However, about 69% of the projects and 50% of investments made between 2006 and 2017 were dedicated to the development of laboratory infrastructure.

Petrobras' own investments in R&D has also increased substantially. During the 1990s, the company disbursed an average of $ 160 million per year. In the period of 2001 to 2016, Petrobras invested more than US$ 11 billion. Because of this effort, Petrobras is today the Brazilian company with the highest number of patents registered and granted in the country. In 2014, the state oil company registered 1604 patents in Brazil and 2885 abroad (PETROBRAS, 2013, PETROBRAS, 2014).

However, the innovation policy for the national petroleum sector was projected into a context that could be called a "stable technological regime", with the search and incorporation of incremental innovations, where there were no challenges associated with the development of the Pre- Salt. In addition, the sectorial innovation policy was confounded with Petrobras' technological strategy.

Currently, the incorporation of disruptive innovations is fundamental for the competitiveness of Brazilian reserves vis-à-vis other geological frontiers. In addition, the participants in the innovation process are more numerous and diversified. However, the innovation policy instruments implemented to date do not seem to be adapted to the dynamics of the technological innovation process of the oil and natural gas industry.

The government initiatives to support innovation in the energy sector have proliferated in recent decades. It is crucial to evaluate existing programs, and to promote a greater synergy and convergence of efforts to support innovation.

Current programs of innovation support should be revised considering its effectiveness; it is important to verify if there are overlaps between programs; if there is a proper articulation and coordination between them; and whether the financing instruments and conditions are adequate to the proposed objectives (Almeida et al., 2017). After revising the programs, it is important to monitor and evaluate the them permanently, elaborating and implementing performance indicators.

With the experience already accumulated by the traditional relations of cooperation between petroleum companies, the supply chain and research institutions, the Brazilian innovation policy for O&G most advance on the improvement of existing mechanisms and their orientation seeking to integrate, more rapidly, the set of technological solutions, with more intensive use of digital tools.

As a result, the sector's innovation system should start to integrate the main companies that provide digital technologies (Google, Microsoft, IBM, GE, Siemens, among others). Given the size and specificities of the Brazilian offshore, it is natural for these companies to see in the Brazilian oil industry business opportunities and a fertile ground for the application of technological solutions and potentially disruptive technologies.

It is also important to include initiatives to include small businesses in the sectoral innovation ecosystem, both in the implementation and in the periodic review of programs to support innovation in the energy sector. Several new tools could be contemplated such as seed capital funds, venture capital and corporate venture. Those tools may insert small businesses, including startups and scale-ups, in the process of open innovation in large companies that operate in the energy sector.

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Merchant Storage Investment in a Restructured Electricity Industry

BY AFZAL S. SIDDIQUI, RAMTEEN SIOSHANSI, ANTONIO J. CONEJO

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Overview

Restructuring and liberalisation of the electricity industry creates opportunities for storage investment (Denholm et al., 2010), which could be undertaken by a profit-maximising merchant storage operator. Because such a firm is concerned solely with maximising its own profit, the resulting storage-investment decision may be socially suboptimal (or detrimental). Most of the literature on storage, however, overlooks the investment decision and does not analyse how market structure may affect installed storage capacity and social welfare. For example, the stylised equilibrium models of Sioshansi (2010, 2014) investigate the welfare implications only of storage operations, whereas the application of an equilibrium model to a network-constrained test power system focuses on the consequences of storage operations for grid congestion and generation ramping (Virasjoki et al., 2016). While Nasrolahpour et al. (2016) incorporate the storage-investment decision, they assume a perfectly competitive generation sector and do not conduct a welfare analysis. Thus, we fill an important gap in the literature by exploring the welfare implications of storage investment in an imperfectly competitive generation sector. In particular, we specify the market conditions under which a profit-maximising merchant invests in less storage capacity than the socially optimal level. The welfare and storage-capacity investment implications of imperfect generation competition are assessed. Furthermore, given the importance of ramping in electricity markets (Zhao et al., 2017), we demonstrate how a ramping charge could incentivise a merchant investor to install the socially optimal storage capacity.

Methods

We develop a bi-level programming model of an imperfectly competitive electricity market with electricity-generation and storage-operations decisions at the lower level and storage investment at the upper level (Figure 1). Proceeding via backward induction, we first solve for the lower-level Nash-Cournot equilibrium between generation (conducted by N identical firms, where higher N indicates a more competitive industry) and storage operations (handled by the storage owner) parameterised on the storage capacity. We next insert the parameterised lower-level solutions into the upper-level objective function to obtain a closed-form expression for the optimal storage capacity. The storage owner behaves as a Stackelberg leader since it anticipates market operations when making its capacity-investment decision and can be either a standalone profit-maximising merchant or a welfare-maximiser. Thus, the bi-level problem is solved as a mathematical program with equilibrium constraints (MPEC).

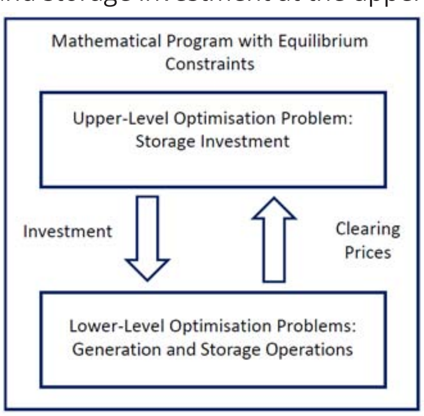

Figure 1. Market Structure

Results

Our analytical results demonstrate that a relatively high (low) amount of market power in the generation sector leads to low (high) storage-capacity investment by the profit-maximising storage operator (in blue) relative to the welfare-maximising storage owner (in green, Figure 2). Intuitively, this is because the welfare-maximiser uses a large storage capacity to subvert the generators' strategy of withholding generation by moving energy to the on-peak period. Conversely, the profit-maximising merchant is content to profit from the high price differential that results from the generators' behaviour. This can result in net social welfare losses with a profit-maximising storage operator (in blue) compared to a no-storage case (Figure 3). In fact, if the generation sector is sufficiently competitive, then the behaviour

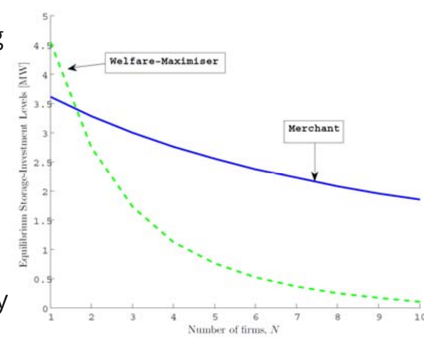

Figure 2. Equilibrium Storage-Investment Levels of Profit- and Welfare-Maximising Storage Owners

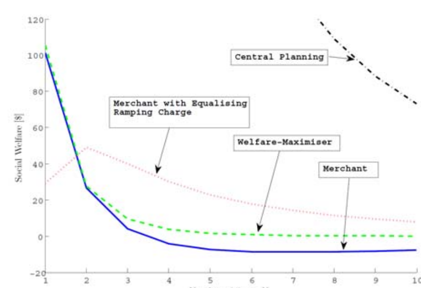

Figure 2. Equilibrium Storage-Investment Levels of Profit- and Welfare-Maximising Storage Owners

of the profit-maximising merchant is actually welfare-diminishing *vis-à-vis* having no storage at all. Using a charge on generation ramping between off- and on-peak periods, we induce the profit-maximising storage owner to invest in the same level of storage capacity as the welfare-maximiser (Figure 4). The ramping charge penalises generators and the storage operator for a large difference in the off- and on-peak load, thereby mitigating the incentives of storage and generation firms to maintain large price differences between the two periods. Increasing either the storage-investment cost or the marginal cost of generation reduces the equalising ramping charge. Such a ramping charge can increase social welfare (Figure 3, in red) above the levels attained with the welfare-maximising storage owner (Figure 3, in green) because the equalising ramping charge offers another layer of control to a hypothetical social planner. This added control allows the social planner to mitigate the potential welfare losses from inefficient storage use and withholding of capacity by generators.

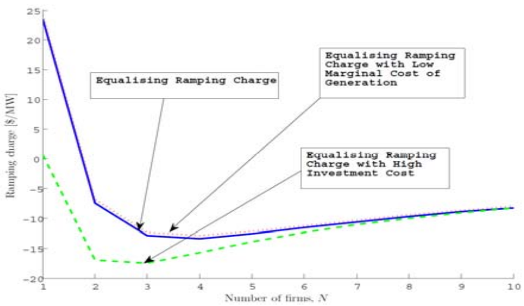

Figure 4. Ramping Charge that Induces Socially Optimal Storage Investment from Profit-Maximising Storage Owner

Conclusions

We contribute to the literature studying the welfare impacts of energy storage by examining the equilibrium level of storage investment under a variety of market structures. By taking a stylised approach, we are able to unpick methodically the countervailing incentives driving storage investment, e.g., the tradeoff between profit margin and trading volume. Hence, the policy insights stemming from our analysis can be used by regulators to align better the incentives of a profit-maximising storage owner with those of society.

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Plenary Session 2: Electricity Market Design

Summarized by Höschle Hanspeter, Researcher - Energy Markets, Unit Energy Technology, EnergyVille – VITO NV

This plenary session was chaired by Bert Willems, Tilburg University, The Netherlands. He was joined by William W. Hogan, Raymond Plank Professor of Global Energy Policy, John F. Kennedy School of Government, Harvard University, USA; Andreas Ehrenmann, Director Energy Economics, Engie Tractebel and Clara Poletti, Head of the Regulation Department, The Regulatory Authority for Electricity Gas and Water, Milan, Italy.

The second day of the conference kicked off with a insightful plenary session on electricity market designs, comparing common practice of US and European markets. In his introduction, prof. Bert Willems (Tilburg University, NL), highlights that the purpose of prices is to reflect all market information, at the same time, he raises the question how prices could possibly reflect reserve requirements in future RES-dominated electricity systems.

From the experience in US markets, prof. William Hogan (Harvard University, USA) argues that getting the market signals in real-time is key. An economic dispatch that includes an operating reserves demand could emphasize the value of scarcity, correct real-time prices and consequently ensure a proper working of all preceding markets (e.g. intraday, day-ahead, year-ahead, etc.).

In response to that, Andreas Ehrenmann (Chief Analyst at Engie, FR) emphasizes the difference to European real-time markets that are not based on an economic dispatch but balancing markets organized by the TSO. He extends the discussion by arguing that even if real-time price signals are correct, a possibility for risk-trading for risk-averse investors would be vital to support the transition.

Clara Poletti (Head of Regulation Department, ARERA, Italian NRA) sees the need for the development of a market that integrates the role of RES. She describes the benefits of the Italian design, including Reliability Options, as the combination of a long-term market signal for investment, at the same time allowing for scarcity pricing in real-time, which is crucial for a proper reaction of demand and RES.

The conclusive discussion addressed again the importance of market price signals to reflect the cost of reserve, even more so with the integration of more and more RES.

To Pool or not To Pool? A Level Playing Field for Distributed Energy Resources in European Balancing Markets

BY KSENIA POPLAVSKAYA AND LAURENS DE VRIES

Democratizing balancing markets for electricity

Stimulated by technological advances as well as EU policy objectives, distributed energy resources (DER), such as distributed generation, storage and demand response, have been transforming the power sector. DER can contribute to more efficient system balancing, a task that has been gaining more impetus with the growing shares of variable renewable energy sources (vRES). In the EU, each TSO manages a balancing market, in which they procure balancing services for maintaining system frequency similar to American real-time markets. The EU Guideline on Electricity Balancing (GL EB), adopted in late 2017, strives to create a level playing field for all potential participants in the balancing markets. However, even if new resources are formally accepted, their actual entry can still be hampered by too high transaction costs or stringent market rules.

Pooling can help to lift these restrictions and has been deemed key in enabling DER participation in the market (e.g. [1], [2]). Pooling in this context means aggregation of multiple units on the supply and/or demand side operated together with the help of an IT infrastructure and used to provide system services or to participate in electricity markets. Besides the rules for the procurement of balancing services, requirements for formal access and pooling play a significant role when it comes to DER participation. These vary from country to country and balancing service providers (BSPs) are subject to strict prequalification criteria before they even enter the market. Since balancing market integration and the harmonization of rules constitutes a major EU policy goal, these aspects should be addressed as an integral part of harmonization efforts.

To pool, but who and how?

European countries apply different criteria regarding 1. the type of units that are expected to provide balancing services, 2. how big the pool or the units in it can be or 3. who can aggregate balancing resources (e.g. [3]). This raises the question how specific design choices affect the creation of a level playing field for DER in the balancing market.

The review of different markets in the EU shows that a lack of appropriate conditions for aggregation is one of the main reasons for its still-underdeveloped status. For instance, in some countries formal access criteria may bar specific types of providers from the balancing market, as is the case with demand response in Spanish, Portuguese and, until very recently, Italian balancing markets. This also makes it impossible to include these resources in a pool. Another example is one where only large industrial loads may be allowed to participate, rather than all consumers, which can be either explicitly specified or de facto through high minimum bid sizes. If only large generators are given a chance to submit their bids in the balancing market, as until recently used to be the case with power plants with 60 MW installed capacity in the Netherlands, making providers at the distribution level unable to compete.

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Similarly, portfolio requirements should not explicitly prohibit the inclusion of different technology types in the same pool, such as storage, biomass, small hydro power plants and other vRES. Variable RES are mostly insulated from the markets, including the balancing market, due to the widely applied support mechanisms. Besides, both their individual size and variable nature make it challenging to technically qualify for participation, where a BSP has to demonstrate its ability to deliver neat supply or load curves. Operators of vRES then either need to significantly oversize the pool or combine it with other types of resources. Prohibiting this would violate the principle of non-discrimination, pursued in the GL EB [4], the principle applicable irrespective of size or type of technology.

Obliging generators to reserve capacity for potential balancing clearly foregoes price efficiency and runs contrary to the market-based procurement of balancing services (GL EB [4]). While some countries such as, Germany, Austria, the Netherlands and the Nordics are characterized by well-developed, organized balancing markets, a number of EU countries still apply mandatory provision of balancing services for a number of products, such as for example France or Hungary.

To effectively allow joint service provision from a pool, it is important to consider whether any restrictions are placed on the size of the pool, i.e. the number of technical units, it can contain. For instance, if a BSP would need 5 MW of capacity to be able to submit a minimum possible bid in the balancing market, this would mean pooling about 710 7kW-PV systems, 5000 1kW-washing machines, 2500 2kW-electic boilers, a fleet of 65 medium-sized electric vehicles or a few onshore wind turbines to provide a service. This is the ideal case, while in reality RES variability and the actual consumption patterns will significantly reduce the available capacity.

If the prequalification requirements refer to a pool, i.e. are pool-based, and not to individual units within it, i.e. unit-based, this would greatly facilitate the participation of DER. The Netherlands among others, for instance, are still applying unit-based criteria for providers of the fastest balancing service, frequency containment reserve. In contrast, recent policy developments in Germany and Austria show both extensive efforts to design flexible pooling concepts for all types of balancing services and to allow balancing services provision from vRES, specifically from wind parks, following the requirement in the GL EB [4]. In this way, vRES might get actively involved in system support instead of being the source complicating system balancing.

Finally, independent aggregators, supported by the European Commission [1], that can ensure market entry of DER on par with existing well-established market actors. According to [1], "'independent aggregator' means an aggregator that is not affiliated to a supplier or any other market participant". Some countries, like Germany and Austria, already formally recognize independent aggregators and allow them on the balancing market. Finland is looking into allowing independent aggregation and so are Denmark and the Netherlands, which so far require the intermediation of balance responsible parties. Among others it is important to ensure that independent aggregators can pool resources across balancing portfolios to create a larger and more flexible pool. Conflict situations may yet arise specifically if independent actors provide aggregation services to consumers that have different electricity suppliers. So, in most European countries such questions as balancing responsibility and the settlement of imbalances between aggregators and other market parties involved still have to be clarified.

A level playing field – a more flexible system

The principle of a level playing field, widely promoted in the EU energy policy, refers to applying the same rules and granting the same rights and obligations to all BSPs, existing and prospective. The flexibility potential is yet to be assessed and quantified based on how much more flexibility is needed to back up volatile renewable generation. What is clear is that flexible pooling options are likely to improve DER integration and vRES own contribution to system balancing, while harmonized pooling requirements are instrumental for all market actors to participate in the balancing market on the same footing. The concept of a level playing field should therefore refer not only the same rights and obligations for all BSPs in a balancing market but also across European markets to create similar opportunities. All the above shows that even if pooling is allowed and practiced, the actual requirements placed on pools vary, which may have implications especially for those market participants that intend to expand their geographical outreach.

What kind of changes to balancing market design are needed to fully exploit the value of pooling? An explicit permission to pool resources to participate in the market does not just create regulatory certainty but also prepares ground for new innovative solutions in the long term. If potential market participants have sufficient freedom in determining the size and composition of the pool, they can to accommodate technical constraints of DER, fulfill prequalification criteria unrestricted by minimum unit sizes as well as to ensure optimal service procurement through portfolio management. Other solutions include authorizing all types of resources, including demand side, to provide their services and independent aggregators to harvest flexiblity. Instead of finding fault with vRES for creating system challenges, it is crucial to allow them into the blancing market together with service delivery from a mixed-technology pool. Creating a level playing field technically does not exclude a transition period during which those technologies that were initially disadvantaged targeted support necessary as a provisional arrangement towards a "level starting point". Later on, it is the market that should be left to decide which of the balancing resources is the most economically viable since the main yardstick is not the origin of the service but the technical capabilities and economic efficiency of its provider.

This work is part of the overall comprehensive framework developed to assess the level of integration of DER in any European balancing market. Aggregation is key to enabling such integration.

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A Measure of Market Power in the German Electricity Market

BY CARLO ANDREA BOLLINO, LARS DITTMAN AND GEORG ERDMANN

After many years of liberalization of the electricity markets in Europe and a massive development of renewable energy, there are still unresolved issues that continue to stimulate research and flourishing literature. We do not even attempt here to bother the reader with a literature review. As a background example, it suffices to recall the Special Issue of the Energy Journal, entitled: "High Shares of Renewable Energy Sources and Electricity Market Reform" Vol. 37, SI 2, 2016. The main issue is quite simple, according to our view: the supply of electricity from high shares of renewable energy sources (RES) and the actual market design are conflicting. This is very easy to prove in abstract terms. Given that power supply dispatching is on a merit order basis and that RES have priority of dispatching and (virtually) zero marginal cost, in case of 100% RES the equilibrium price is zero.

However, zero price cannot provide a sufficient signal to the market for strategic future investment, let alone the issue of missing money for generation units already in use.

This background introduction motivates the analysis of the market outcomes, to investigate whether this state of the matter has some implication on the correct functioning of the market. In non-technical words, we think that the conjecture that an exposure to bacteria brings infection is a valid reason to use the thermometer to check whether there is fever.

In this context, we focus on the analysis of market power, which is an important tool of the regulator in the electricity market. Market power is the ability of the economic agent (supplier or buyer) to act as a price-setter, rather than price-taker as in competition, by enacting some pricing strategy. The existence of exercise of market power reduces welfare. It a case of market failure.

This paper contributes to the literature proposing a new methodology to measure market power in the electricity market. We apply this method to the German market. We assume that profit maximization can be described for suppliers and in the framework of the conjectural variation. We estimate the aggregate supply and demand elasticities for every hour and use it to estimate the Lerner index for the main four suppliers in every hour: RWE, EON, EnBW, Vattenfall. We find some empirical evidence of market power.

In detail, we assume profit maximization for each big supplier in an oligopolistic framework and we derive the classic Lerner Index, which is the markup over marginal cost and which can be interpreted as a measure of market power (p-MC)/p for each supplier. This expression can be written mathematically in two ways, under given assumptions. First, it can be seen as the ratio of the market share of each supplier to the elasticity of the market demand. Second, it can be expressed as the inverse of the elasticity of the residual demand, faced by each supplier.

This theoretical background allows us to construct some empirical measures of the Lerner index, which can be used to perform some econometric estimation of its structural determinants. The idea is to estimate the Lerner index as a function of some structural variables, such as the seasonality, the temperature variation, the peak and off-peak hours, the generation mix variation of the main operators. This estimation can help to test several hypotheses, which may be useful for the policy maker. For instance, is there a specific time of the day in which the increase in RES is associated with an increase of the exercise of market power? In other European markets (i.e. Italy) there has been evidence that market power is concentrated in the evening hours. This can be understood as a reaction to the massive injection of solar during the sunny hours of the day, which forces low prices. At dawn and during the evening hours, gas-fired plants become necessary and this results in some exercise of market power (i.e., higher mark up over marginal cost).

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Another hypothesis to test is whether the overall size of the market affects the exercise of market power. On the one hand, the intuition is that a larger market may be characterized by more competition; on the other hand, a larger market size may render some supplier pivotal or crucial for dispatching, thus increasing the possibility to exercise market power.

In our empirical analysis we compute the hourly market shares for the main generators, ENBW, EON, RWE, Vattenfall and an aggregate Others in the EPEX, in the period January – March 2017.

The average market shares in the period are ENBW 7.29%, EON 10.39%, RWE 33.03%, Vattenfall 21.81% and Others 27.49%. The market shares do not vary much in the hourly averages.

We also analyze the individual bid data in the market for the main generators.

Preliminary results show that Vattenfall has the highest market power but has the second highest market share. RWE has the second highest market power with the largest share. EON and ENBW have smaller market shares and also smaller market power.

In general, our preliminary results show that there is some evidence of market power in the German market. The measures of Lerner index are mildly increasing with the total equilibrium market quantity (i.e. the measure is higher in those hours when the market equilibrium quantity is higher. This seem to suggest that the intensity of the market power seems to be somehow positively correlated with market size.

Our findings may have some policy implications for the efficient functioning of the German Power Exchange. In any case, the empirical finding that there is evidence of some exercise of market power is a challenge for the policy maker, because it is a signal of failure of competition.

Further analysis of the nexus between RES injection and market functioning can be also useful to the policy maker. If market power exercised by conventional fueled plants is a sort of a survival strategy, albeit distorted, enacted by these operators in order to recover their investments in gas fired plants, this should be properly understood and addressed.

The correction of one distortion (the missing money issue) with another distortion (letting suppliers exercise market power) is not a first-best solution. In conclusion, there is need at the European level to discuss a new market design, which includes RES and conventional generation to compete for the consumer, but also to efficiently cooperate for the system security.

Doctoral Seminar Friday 8 – Saturday 9 June

Summarized by Arjan Trinks, PhD Student, University of Groningen

Two days preceding the IAEE international conference (8-9 June), 28 young professionals, from all over the world, came to Groningen for the Doctoral Seminar. The aim of the two-day Doctoral Seminar was to get an overview of and interactively discuss key economic and policy issues surrounding the energy transition.

Professor Richard Green from Imperial College Business School (London, UK) provided two days of interactive lectures, and introduced participants to the research questions, topics, and methodology of some key recent research in the area. Many topics were covered, including the fundamentals of electricity, market design, the impact of renewables on energy markets, policy instruments to support renewable generation, transmission and storage, and emissions savings. Due to the diverse backgrounds of the participants and their input in the discussions, there was something to be learned for everyone (hopefully including Prof. Green as well).

In addition to the in-depth seminar sessions, there was plenty of time for social activities, including a dinner and a boat cruise through the beautiful canals of Groningen. Most participants carried over their experience and discussions to the conference, where they presented their own work.

From this place, a big thanks to Prof. Green and all participants for the two intensive but rewarding days!

Masterclasses for Young Professionals on Sunday 10 June

By Arjan Trinks, PhD Student, University of Groningen

On Sunday afternoon (10 June), just before the welcome reception of the conference, three master classes were given at the Academy Building of the University of Groningen. About 60 young professionals and others attended. Adonis Yatchew, Editor-in-Chief of The Energy Journal, gave a master class on writing and publishing scientific articles. He addressed several important issues in this area, including “What are the key features of a well written paper?”, “What do editors consider when assessing submissions?”, ”What is the role of editorial boards?”, ”How do editors deal with conflicting referee reports?”, ”What constitutes good empirical work?”, and, ”What can be done to enhance the likelihood of getting a paper published?” The session by Prof. Yatchew was very inspiring for young academics and provided valuable new insights for their publishing and presentation activities.

Georg Erdmann, professor in Energy Systems at the Berlin University of Technology, and Markus Graebig, project leader of the WindNODE consortium and former research associate at Professor Erdmann’s department, gave a master class on presenting scientific papers on conferences. In this master class participants had the opportunity to practice the presentation of their conference paper. Erdmann and Graebig provided participants very helpful tailor-made comments and suggestions to further improve their presentation skills.

Finally, Elwin Delfgaauw and Jacqueline Giesen from ENGIE organized a novel type of master class in which students and young professionals worked together to solve a business case about the electricity industry. The master class was a unique opportunity to meet with a key player in the energy industry, to provide creative solutions to a challenging real-life case, and to showcase individual qualities. The case focused on the challenge of decentralization: For ENGIE, the urgent need to reduce environmental impacts necessitates the implementation of a more decarbonized, decentralized, digital and energy-efficient system. To make this transformation, stakeholder engagement is key to ENGIE. “How do we effectively combine our ambitions in decarbonizing the energy system in a way that local stakeholders support the projects?”, ”How to best communicate with the variety of stakeholders (local policy makers, politicians, inhabitants, local NGOs, etc.), which all have different stakes?”, and ”How to interact, encourage participation, and prevent the NIMBY-effect?”. The master class by ENGIE successfully challenged participants to interactively discuss these and other questions from their own backgrounds, to step into the shoes of different stakeholders, and to negotiate, formulate, and present solutions.

See Page 42 for more networking activities.

ElecXit: The Impact of Barriers to Electricity Trade after Brexit

BY JOACHIM GESKE, RICHARD GREEN , IAIN STAFFELL

Joachim Geske and **Richard Green** are with the Imperial College Business School. **Iain Staffell** is with the Centre for Environmental Policy, Imperial College London.

See footnotes and end of text.

The structure of global electricity supply has changed dramatically since the 1990s, especially in Europe. In this process the European Union followed its proven general principle of a cross-border internal market - the internal electricity market. For this purpose, the deregulation of national electricity markets was initiated in the 1990s, and since 2015 the vision of a cross-border market design has been largely implemented as the Electricity Target Model (ETM, ACER, 2015). In particular, market coupling implies that markets clear simultaneously and transmission capacity is automatically allocated so that electricity can flow from low- to high-priced areas until prices are equalized or the capacity is fully used. Trade between Member States is now only limited by capacity constraints of the infrastructure. To tackle this, the EU has set the goal to expand interconnector capacities to 10% of each national electricity generation capacity by 2020 and 15% by 2030.

Until recently, it seemed highly unlikely that the integration of the European electricity industry would be reversed, but the United Kingdom is in the process of leaving the EU. As part of this the EU and the United Kingdom are currently negotiating the conditions of this exit and their future relationship. The outcome of the negotiations is currently unpredictable given their breadth, depth and political circumstances.

The complexity of the negotiation is evident in the electricity sector. In addition to the institutions of electricity trading, or tariff and non-tariff trade barriers, any readjustment of the emissions trading system, Euratom regulation or the renewable energy directive might have indirect consequences for the electricity sector. Again, the result is not foreseeable. Nevertheless, Brexit scenarios have been developed to help stakeholders prepare and to underpin their bargaining positions. Two significant design principles and conclusions from them are presented as examples:

- A huge part of the Brexit scenarios builds on the UK Government's rejection of the jurisdiction by the European Court of Justice. A UKERC/Chatham House Report[1] suggests that the rejection of this institution excludes British actors from the institutions controlled by them, amongst others the single electricity market. In particular, UK electricity markets could not remain coupled with their continental counterparts.
- The resulting uncertainties about the profitability of trading and a reduction of EU funds could hinder the expansion of the trade infrastructure mentioned above from 4 to 10 GW by 2021 (UKERC, Chatham House), especially in the planning phase.
- The European Commission (Directorate-General Energy) published on 27/04/2018 a scenario for the case that negotiations would not succeed by the date of withdrawal. Then, the United Kingdom would become a 'third country' and 'EU rules in the field of energy market regulation will no longer apply to the United Kingdom'. As consequences of this, the Commission derives not only market uncoupling, but also the necessity to charge an interconnector usage fee for trade with the United Kingdom. Whether the latter equals a tariff is not yet obvious.

Although the EU approach sketches an extreme case, the fact that market uncoupling has been highlighted in both approaches and that the Chatham House Report considers a reduced expansion of the trading infrastructure possible has motivated us to focus on both as crucial Elecxit building blocks. But how do these very general Elecxit building blocks impact long-term welfare? To answer this question let's refer the background of market coupling:

As described earlier, day-ahead markets in France and the United Kingdom were not coupled in 2009, i.e. the market closing times differed by several hours. This forced traders to commit to trades only on the basis of anticipated market prices. Unavoidable anticipation errors made it impossible to have efficient trading in which either the capacity was exhausted or the price differences between the markets disappeared. This can be seen very well in the noisy trading pattern of price differences and capacity utilization in Figure 1. Not surprisingly market coupling eliminated this noise and a nearly ideal trade pattern emerged (Figure 2, 2017).

By comparing the observed noisy trade with a trade extrapolated to an ideally full capacity and by considering price adjustments, EU-wide welfare gains through market coupling on the day ahead markets have been

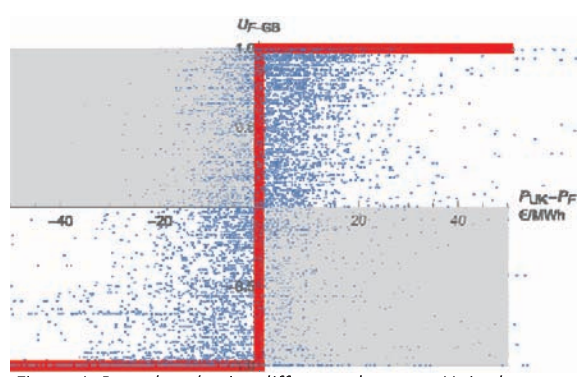

Figure 1: Day ahead price difference between United Kingdom and France [€] vs. interconnector utilization [-1,+1] in 2009. Positive utilization reflects electricity trade from France to UK; negative the reverse. The red curve indicates the efficient patttern.

estimated as 0.2-0.5% of the market value[2] (Newbery, Strbac and Viehoff, 2016).

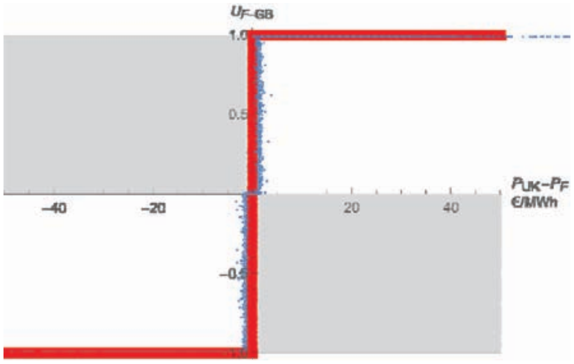

Figure 2: Day ahead price difference between United Kingdom and France [€] vs. interconnector utilization [-1,+1] in 2017. Positive utilization reflects electricity trade from France to UK; negative the reverse. The red curve indicates the efficient patttern.

To deduce long-term welfare effects of market uncoupling in the context of Elecxit one might be inclined to project this welfare gain of market coupling one-to-one into the welfare loss from market uncoupling, continuing into the future. But this would treat results from a snapshot during the transition towards a sustainable electricity system as giving long-term effects. To avoid this, we estimate the welfare effect for 2030, as representative for the long-term effect of Elecxit, because at that point in time, it can be expected that electricity systems are widely decarbonized and consolidated. However, the state of the system in 2030 renders an application of the welfare gains estimated for 2009 highly inaccurate, since:

1. Without market coupling trading decisions have frequently proved uneconomic but their impacts have been limited by small interconnector capacities (2GW between France and the UK in 2009). This would change as the UK's interconnector capacities may rise to 10 GW in 2021. This implies that the opportunity costs of market uncoupling in 2030 might exceed estimates of the benefits of market coupling in 2009.
2. The structure of electricity generation will change dramatically as more intermittent renewables will enter the market. The resulting uncertainty will make international coordination more valuable and a lack of coordination costlier.
3. Generation mixes will be adjusted to the higher share of intermittent renewable generation and a change in the load profile. These changes in national supply might also affect the sensitivity of the market price to traded electricity and thus alter the effect of reduced market coordination.

To take these changes into account we developed an equilibrium trade model with anticipation error and estimated its key parameters based on 2009 data. We could then simulate trade in 2030 with and without market coupling, considering scenarios that cover the changes in renewable and other generation, to determine the expected welfare losses of Elecxit.

For this purpose, we used load profiles from the DESSTINEE model based on the scenario ENTSOE 2030 vision 3 for the United Kingdom and France. Generation capacities and costs have been applied directly from the same scenario. As a reference, we embedded the 'Soft Elecxit' scenario, with an expansion of interconnector capacity to 10 GW (as planned today) and persisting market coupling. We compared this scenario with a 'hard Brexit' in which interconnector capacity drops to 5GW (so minimal expansion) and markets are uncoupled and determined the difference in market values of electricity.

We make the assumptions that renewables capacity will have doubled (thus increasing uncertainty) and that after the uncoupling, trade will be no more efficient than it was between France and the UK in 2009. Without the coordination of market coupling, both markets suffer from an information asymmetry so that participants have to form expectations, with the resulting anticipation errors and thereby inefficiencies.

Under these conditions, market uncoupling and limited interconnector capacity would increase the sum of generation costs in France and UK by 1.3% of the combined wholesale market value in France and Britain, compared to the case with coupled markets and an expansion to 10 GW of transmission capacity; 'soft Elecxit'. This apparently small percentage represents a loss of €500 million per year. Furthermore, expanding transmission capacity to 10 GW would only reduce costs by 0.1% of the combined market value, if de-coupled markets meant that the expanded capacity was not sensibly used. We are not suggesting that abandoning the successful system of electricity market coupling is a likely outcome of Brexit, but wish to illustrate the costs of doing so, when some people in the UK apparently still think[3] that failing to reach agreement with the EU on our exit would be a desirable outcome.

Footnotes

[1] "Following the UK's decision to leave the EU, it is still unclear whether GB will remain part of current and future market coupling arrangements. This is because these require the active collaboration of GB interconnection counterparts, and market coupling was mostly developed through European legislation (e.g., the European Network Codes on capacity allocation and congestion management (CACM), and on forward capacity allocation (FCA))."

[2] Newbery, D. M., Strbac, G., & Viehoff, I. (2016). The benefits of integrating European electricity markets. Energy Policy, 94 253-263. https://doi.org/10.1016/j.enpol.2016.03.047

[3] We use the term loosely.

Investment in Zero Carbon Technologies under Uncertainty about Future Climate Policy: Should Governments Target CCS Instead of Renewables?

BY SIMEN GAURE, ROLF GOLOMBEK, MADS GREAKER AND KNUT EINAR ROSENDAHL

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Introduction

Parties to the Paris treaty restated their commitment to the 2ºC target, and agreed to pursue efforts to limit the temperature increase to 1.5ºC. In order to keep global warming below the 2ºC target, a third of oil reserves, a half of gas reserves, and more than 80 percent of coal reserves must stay in the ground, according to McGlade and Ekins (2015). These estimates, combined with the IEA prediction of a 50% growth in total energy demand in the next 25 years, implies that production of zero carbon energy must increase radically in the coming years. Yet, it is highly uncertain whether the Paris targets will be reached. The uncertainty might reflect that future emissions goals of countries are uncertain, for example, because country-specific costs of climate change are still not known. Alternatively, current governments might announce deep emissions cuts for the future, but it is uncertain whether future governments will implement necessary policies to meet the announced targets.

In this paper, we study investments in R&D and production capacity in zero carbon technologies under uncertainty about future climate policy. Zero carbon energy technologies differ with respect to their properties. Renewables are decreasing returns to scale technologies, reflecting that locations differ with respect to wind and sun conditions. Coal and natural gas power with Carbon Capture and Storage (CCS), on the other hand, are (close to) constant returns to scale technologies. The full cost of these technologies exceeds the full cost of conventional coal and natural gas power, and hence investors will not choose CCS technologies as long as climate policy is not significantly tightened.

We pose the following research questions: I) How do the different properties of renewables and CCS electricity technology affect the investment decisions of private firms under uncertainty? and II) Does the market outcome depart from the first-best social outcome?

Uncertainty

We analyse two types of climate policy uncertainty: Either, there is uncertainty about the marginal damage cost of greenhouse gas (GHG) emissions, or there is uncertainty about the ability of the politicians to impose a stringent climate policy. For the first type (scientific uncertainty), we assume that the climate policy will be optimal, that is, if the marginal damage cost of GHG emissions turns out to be low, the future carbon tax will be low, and if the marginal damage cost of GHG turns out to be high, the future carbon tax will be high. For the second type of uncertainty (policy uncertainty), we assume that the marginal damage cost of GHG emissions is known to be high, but it is uncertain whether the future carbon tax will be equal to the true marginal damage cost of GHG emissions or lower. Hence, under both types of uncertainty the future carbon tax can take two values; it will either be high or low.

The interpretation of the high and low tax differs between the two types of uncertainty. Under scientific uncertainty, the high tax shows the social cost of carbon if this value turns out to be high, whereas under policy uncertainty, the high tax shows the true (and ex ante known) social cost of carbon. Under scientific uncertainty, the low tax shows the social cost of carbon if this value turns out to be low, whereas under policy uncertainty, the low tax is simply a tax below the true social cost of carbon and should therefore not have been imposed.

Theory model

We first set up a theory model. Here, there are two zero-carbon electricity technologies; renewable energy, for example wind power, and fossil-based electricity production with CCS and no emissions. In addition, there is a conventional fossil-fuel based technology.

Our model has three periods. In the first period, a representative innovator decides under uncertainty the level of R&D for the two types of zero-carbon technologies; more R&D will lower the cost of investment of a technology. We assume that the conventional fossil energy technology is mature, that is, R&D will not lower its cost of investment. In the second period, a representative power producer may invest in power capacities in the three electricity technologies – still under uncertainty. Finally, in the third period, the uncertainty (carbon tax) is revealed, and then production and consumption of electricity are determined, that is, the electricity market clears.

We solve the model by backward induction. In period 2, that is, when R&D expenditures are predetermined, there exists three equilibrium regimes. In all three regimes, there is investment in renewable electricity capacity as the cost of the cheapest renewable capacity is assumed to be low. The three regimes differ with respect to the competiveness of conventional fossil electricity relative to CCS electricity. Either there is investment in conventional power capacity but not in CCS electricity (regime 1), or there is investment in both conventional power and CCS electricity (regime 2), or there is investment in CCS electricity capacity but not in conventional fossil electricity (regime 3).

We then solve the complete model. We show that under scientific uncertainty, where the future carbon tax policy is assumed to be optimal, the market outcome is first best. Under policy uncertainty, the market outcome will be the same as in the case of scientific uncertainty – private actors are exposed to the same uncertain taxes – but the equilibrium is not first-best because of the non-optimal carbon tax policy. The possibility that a carbon tax below the true social cost of carbon might be imposed perverts private investments so that their equilibrium values differ from the social optimal ones.

Numerical simulations

We complement the theoretical analysis by establishing a stylized numerical model for the European electricity market in 2030 that builds on the theory model. We mainly use parameters and variables from the numerical energy market model LIBEMOD, see Aune et al. (2008; 2015) and LIBEMOD (2015), to determine the parameters in the numerical model. LIBEMOD determines simultaneously investment, extraction, production, trade, transport and consumption of eight energy goods, including electricity, in 30 European countries. In addition, the model determines prices and quantities of energy goods traded globally, and emissions of CO2 by sectors and countries.

We use the 2030 reference scenario in Aune et al. (2015) as the starting point of picking parameter values. Here, the LIBEMOD model is run for 2030 under the assumption that the following EU targets are reached: i) a 40 percent reduction in GHG emissions relative to 1990, which is split between one emissions goal for the ETS sectors and another emissions goal for the non-ETS sectors, and ii) a renewable share in final energy consumption of 27 percent. Like in the LIBEMOD model run, we assume that the ETS emissions goal is accomplished by imposing an EU-wide quota system in the ETS sector, whereas an EU-wide subsidy on renewable energy is offered in order to reach the renewable target. In the numerical simulations, we impose that the non-ETS emissions goal is reached through electrification of activities in the non-ETS sectors. Finally, in the numerical simulations we assume that the low carbon tax is 5 euro/t CO2, which is a rough estimate of the ETS price over the last 5-10 years, whereas we vary the high tax.

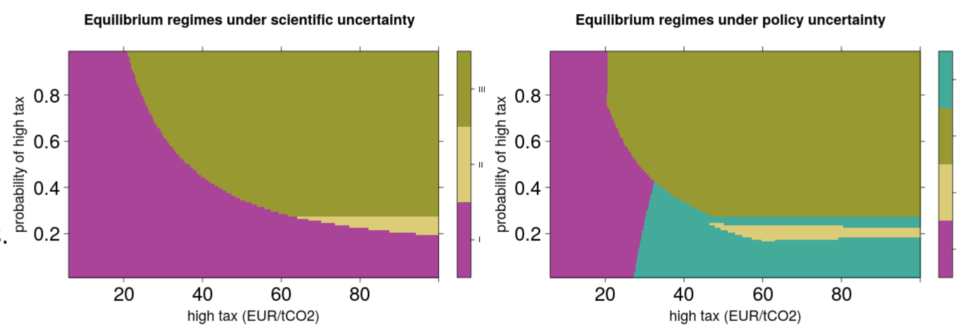

Figure 1 Equilibrium regimes under scientific uncertainty with optimal carbon tax policy and under policy uncertainty with non-optimal carbon tax policy when R&D is determined by the current government

In Figure 1, the panel to the left shows the case when there is scientific uncertainty and the future carbon tax policy is optimal. With optimal policy, regime I (no CCS electricity) exists if the probability of a high tax is high and the level of the high tax is low, or the probability of a high tax is low and the level of the high tax is high. For most other combinations of the probability of a high tax and the level of the high tax, the equilibria are in regime III (no conventional fossil fuel electricity). Finally, if the level of the high tax exceeds 60 euro/tCO2 and the probability of a high tax is in the range of 20 to 30 percent, then the equilibria are in regime II (capacity investments in all electricity technologies).

With policy uncertainty and non-optimal carbon tax policy, the current government has an incentive to correct the R&D investments chosen by the private actors, see discussion above. The right panel in Figure 1 shows the equilibrium regimes when the current government chooses R&D levels that maximize expected social welfare, taking into account the decisions of the private actors in stages 2 and 3. As seen from the Figure, all three regimes exist in equilibrium, but again the set of combinations sustaining regime II is small. Also, with non-optimal carbon tax policy there are combinations of level of the high tax/probability of a high tax for which none of the three regimes exist. For these cases, there will be investment in renewables only (Regime IV in Figure 1). To sum up, our results suggest that there might be coexistence of conventional fossil fuel electricity and CCS electricity, but this exists only for a small set of combinations of level of the high tax and probability of a high tax.

We have compared R&D in CCS electricity and renewables when the government determines R&D under policy uncertainty relative to the case of private innovators deciding on R&D under policy (or scientific) uncertainty (for the same combinations of level of the high tax and probability of a high tax). We find that there exists a large set of combinations for which the current government chooses R&D in renewables above the level chosen by private innovators. However, for a small set of combinations, the current government chooses R&D in renewables below the level chosen by private innovators but R&D in CCS electricity above the level chosen by private innovators. Hence, whether the current government should support R&D investments when the future carbon tax policy might be non-optimal, depends on the true value of the social cost of carbon.

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Plenary Session 3: Climate Policy

Summarized by Arjan Trinks, PhD Student, University of Groningen

This session was chaired by Herman Volleberg, Professor, Tilburg University/PBL Netherlands Environmental Assessment Agency, The Netherlands. He was joined by Ian Parry, Principal Environmental Fiscal Policy Expert, IMF, Washington DC, USA; Carolyn Fischer, Senior Fellow, Resources of the Future, Washington DC, USA; and Michael Grubb, Professor of Energy and Climate Change, University College London, United Kingdom.

Ian Parry presented the carbon pricing approach. As of now, only a small part of GHG emissions are priced in any way, so the global average price of carbon is about $1 per ton. He stressed that policy makers need quantitative information about how policy instruments affect emissions, their economic and fiscal impact and the important trade-offs that they present. A spreadsheet model from the IMF, designed for simplicity and transparency, could be a useful tool for this purpose.

Carolyn Fischer presented that how in a second-best (or nth-best) world there may be a case for renewable energy targets, even though they could force more expensive abatement. Among the other market failures that need addressing are issues like R&D spillovers, network effects, scale effects, learning-by-doing effects, imperfect competition, political constraints on adequately pricing emissions and behavioral gaps on the demand side.

Michael Grubb made the case for distinguishing between satisficing behavior in the short run (behavioral economics), optimizing behavior in the medium run (neo-classical economics) and transforming behavior in the long run (evolutionary and institutional economics) when discussing climate policy. As an example of transformative behavior is the shift to solar as costs fall rapidly, spurred by the support from German and Japanese governments. The carbon price needed to spur this innovation would probably have been hundreds of dollars, and would have been politically unacceptable.

Dual Plenary Session 1: Long-term Energy Scenarios

Summarised by Minwoo Hyun, Green Business and Policy Program, Graduate School of Green Growth, KAIST College of Business

This first dual plenary session was chaired by Christian von Hirschhausen, Technical University Berlin, Germany. He was joined by Ruud Egging, Norwegian University of Science and Technology, Trondheim, Norway; Christian Breyer, Lappeenranta University, Finland: Scenarios for a Lower-Carbon World and Christophe Bonnery, Enedis, France: Economics & Prospectives.

Christian, chair of the session, emphasized the roles of scenarios and modeling on establishing policy process in the introduction of this session.

In the first presentation, pointing out the possibility of mixed interpretations from the scenario studies, Ruud argues that a good scenario generally gives relevant insights into policy decision making. He presented the integration of modeling types including I.A.M., C.G.E., and partial equilibrium with account of their relative strengths. Also, he highlighted the challenges from the process of blending each modeling characteristics such as spatial and temporal granularity, units of measurement, and model linkage methods.

Christian Breyer subsequently provided considerably realistic implications about 100% renewable energy system at a global level. In pursuit of making the lower-carbon future, he pointed out various crucial technologies set consisted of solar PV, wind power, electricity storage, and conversion technologies. He also maintained that high-spatial and temporal resolution-based modelling needs to be applied to suggest unique implications into climate policy.

Christophe presented a recapitulation of the points given in this session and re-emphasized significance of comprehensive thinking on economics in order to build concrete energy scenarios.

IAEE/Affiliate Master Calendar of Events

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

Date	Event, Event Title	Location	Supporting Organization(s)	Contact
2018				
September 23-26	36th USAEE/IAEE North American Conference *Evolving Energy Realities:Adapting to What's Next*	Washington, DC, USA	USAEE	David Williams *usaee@usaee.org*
October 18-20	3rd IAEE Eurasian Conference *Implications of Global Developments within The Energy Industry in the Caspian and Central Asian Region*	Baku, Azerbaija	IAEE	Vilayat Valiyev *waliyev@gmail.com*
November 2-4	6th IAEE Asian Conference *Energy Exploitation and Cooperation in Asia*	Wuhan, China		Xiao Jianzhong *xjianzhong@cug.edu.cn*
December 6-7	1st IAEE Southeast European Conference *Southeast European Energy Challenges and Opportunities*	Sofia, Bulgaria		Atanas Georgiev *atanas.georgiev@gmail.com*
December 10-12	3rd AIEE Energy Symposium *Current and Future Challenges to Energy Security*	Milan, Italy		Andrea Bollino bollino@unipg.it
2019				
February 13-15	AAEE Conference *Heading Toward More Democracy in the Energy System – German/English Speaking*	Vienna, Austria	AAEE	Reinhard Haas *haas@eeg.tuwien.ac.at*
March 11-12	7th ELAEE Conference *Latin America: Decentralization, Decarbonization, Efficiency and Affordability in Energy Systems*	Buenos Aries, Argentina	ALADEE	Gerardo Rabinovhich *grenerg@gmail.com*
May 26-29	42nd IAEE International Conference *Local Energy, Global Markets*	Montreal, Canada	CAEE/IAEE	Pierre-Olivier Pineau *pierre-olivier.pineau@hec.ca*
August 25-28	16th IAEE European Conference *Energy Challenges for the Next Decade:*	Ljubljana, Slovenia	SAEE/IAEE	Nevenka Hrovatin *nevenka.hrovatin@ef.uni-lj.si*
October 17-19	4th IAEE Eurasian Conference *Uncapping Central Asia's Potential: How Central Asia can Contribute to Global Energy Security?*	Astana or Almaty, Kazakhstan	IAEE	Vilayat Valiyev *waliyev@gmail.com*
2020				
June 21-24	43rd IAEE International Conference *Energy Challenges at a Turning Point*	Paris, France	FAEE/IAEE	Christophe Bonnery *Christophe.bonnery@faee.fr*
2021				
July 25-28	44th IAEE International Conference *Mapping the Global Energy Future: Voyage in Unchartered Territory*	Tokyo, Japan	IEEJ/IAEE	Yukari Yamashita *yamashita@edmc.ieej.or.jp*
2022				
March	45th IAEE International Conference *Energy Market Transformation in a: Globalized World*	Saudi Arabia	*SAEE/IAEE*	Yaser Faquih *yasser.faquih@gmail.com*
2023				
June 19-22	46th IAEE International Conference *Overcoming the Energy Challenge*	Istanbul, Turkey	TRAEE/IAEE	Gurkan Kumbaroglu *gurkank@boun.edu.tr*

Credit Constraints, Energy Management Practices, and Investments in Energy Saving Technologies: German Manufacturing in Close-up

BY ANDREAS LÖSCHEL, BENJAMIN J. LUTZ, AND PHILIPP MASSIER

Andreas Löschel is Professor at the University of Münster and Research Associate at the Centre for European Economic Research (ZEW) Mannheim in Germany. **Benjamin J. Lutz** was Researcher and **Philipp Massier** (email: philipp.massier@zew.de) is Postdoctoral Researcher at the Centre for European Economic Research (ZEW) Mannheim in Germany.

See footnotes at the end of text.

Overview

One of the main targets of current energy and climate policies is the increase of energy efficiency. Increasing efficiency of fossil fuel use offers potential economic and societal benefits through the reduction of costs, environmental damage, and import dependencies. Germany aims to nearly double its annual improvements in economy-wide energy productivity[1] to 2.1 percent. However, the German economy is currently not on the trajectory to reach this ambitious energy efficiency target. Official statistics show that energy productivity only increased by about 1.3 percent per year in the period from 2008 to 2015 (BMWi, 2016; Löschel et al., 2016). Consequently, the drivers of and the barriers to energy efficiency improvements have to be identified to increase overall energy efficiency.

This is especially true for the manufacturing sector, a large user of energy and an important cornerstone of the German economy. In 2014 it accounted for 30 percent of total final energy use and 22 percent of gross value added (BMWi, 2015). However, little is known about the underlying firms' investment behavior regarding energy saving technologies and the reasons for trailing the energy efficiency targets. In this context the economic literature shows that energy saving technologies, which promise considerable reductions in financial costs and environmental damage associated with energy use, may not be adopted by firms to the extent that might be justified, even on a purely financial basis (Gerarden et al. 2017). In Germany a portfolio of policy instruments has been implemented in order to incentivize the adoption of energy saving technologies. However, the effectiveness of these measures fell short of expectations. This shortcoming can be explained by the so-called energy efficiency gap. This gap arises as market failures or behavioral obstacles hinder firms from achieving their individual profitable levels of investments in energy efficiency (Gerarden et al., 2017; DeCanio, 1993).

The objective of our study is to shed light on the drivers and the barriers that influence investments in energy saving technologies by German manufacturing firms and to provide insights for the design of energy efficiency policies. More specifically, we analyze the relationship between financial barriers (e. g. credit constraints), information and knowledge (e. g. energy management practices), salience of energy-related topics, and investments in energy saving technologies.

Data & Econometric Model

We conduct a correlation analysis to investigate the decision to invest in energy saving technologies at the firm level by employing different linear and nonlinear regression models. Our empirical analysis utilizes two main data sources. First, we use data from structured telephone interviews that we conducted with managers from 701 randomly selected German manufacturing firms. This unique survey data contains information about the investments in energy saving technologies in production processes or buildings. Furthermore, it includes information on energy management practices and internal investment-related decision-making processes. Second, we merge this data with commercial microdata, which includes general firm characteristics from official sources as well as firm-level credit ratings from Germany's largest credit rating agency.

Utilizing this detailed data set, we are able to analyze two different investment categories of energy-saving technologies separately and jointly, i. e. for production processes and for buildings. The investment frameworks for both the categories differ from each other due to technological factors or the policy framework. Therefore, we conclude that the drivers and the barriers for each investment category are different. However, we can identify this heterogeneity utilizing the aforementioned data set. Furthermore, we contribute to the literature by using external credit rating data instead of self-reported information to determine the role of financial barriers. Thus, by applying objective data provided by Germany's largest credit rating agency, we can identify whether or not the financial barriers are important for the investment decision. Additionally, we provide a more up-to-date analysis of the energy efficiency gap analyzing German firms and also provide insights from the current policy framework for policy makers. Our analysis relies on representative survey data amongst German manufacturing firms. The discrete investment decision is analyzed using a probit model.[2]

Results & Conclusion

We find that credit constraints are barriers to investments in energy saving technologies which increase the energy efficiency of the firms' production processes and that energy management practices increase the probability of investing in energy efficiency of their production processes. The most important management practice is the implementation of energy consumption targets by firms. However, as our analysis shows, the probability of investing in energy efficiency is higher if there are two or more energy management practices implemented. In Figure 1, the relationship between the predicted probabilities of investing in energy saving technologies and the firm's credit rating is shown.

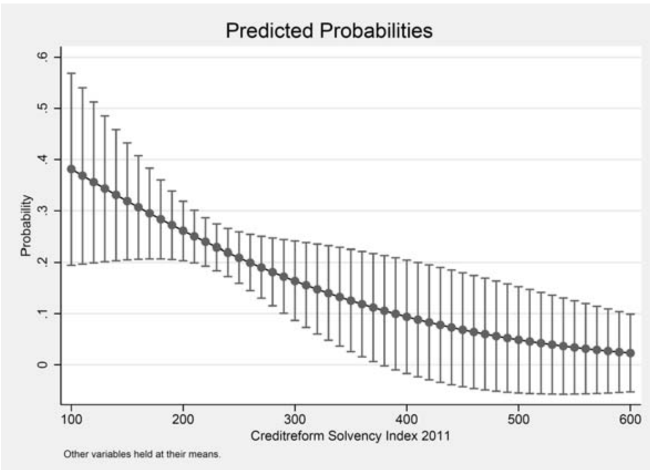

Figure 1: Credit constraints
Notes: A Credit Solvency Index of 100 indicates very good solvency; an index of 600 indicates very high risk.

Furthermore, investments in the energy efficiency of buildings are also positively influenced by the implementation of energy management practices. For buildings, the important management practices are the assessment of the energy efficiency potential and energy management systems. Again, two or more practices significantly increase the probability of investing as compared to just one or no implemented management practices. The higher the energy cost shares of heating or cooling and the energy intensity of firms, the higher is the propensity to invest in energy efficiency. In addition, energy self-generation by firms as well as structured internal decision-making processes positively influence the investments in energy efficiency. The investments in energy saving technologies increasing the energy efficiency of buildings are not correlated with the firms' credit ratings.

An overview over our results can be found in Table 1. The heterogeneity in our results for the different investment categories (production processes and buildings) calls for a targeted analysis of investments in energy saving technologies and the implementation of tailored policy instruments for different investment categories.

Category	**Factor**	**Influence on propensity to invest in energy saving technologies**	
		production process	**buildings**
Financial barriers	Credit rating	-	.
	Investment subsidies	.	.
Information & knowledge	Energy management practices	+	+
	Decision-making processes	.	+
Salience & awareness	Energy intensity	.	.
	Share of heating or cooling in energy costs	-	+
	Buildings' ownership		.
	Energy self-generation	+	+

Table 1: Influencing factors for firms' investment decision on energy saving technologies
Notes: A positive (+) (negative (–)) sign indicates that the factor has a positive (negative) statistically significant correlation with the probability of investing. (.) indicates no statistically significant result.

Footnotes

[1] Energy productivity is defined as price adjusted gross domestic product divided by total final energy consumption.

[2] Additional analyses can be found in the discussion paper version: Löschel, Lutz, and Massier (2017). These include the combined estimation of the investment decision and the investment volume, applying two-part and Heckman selection models.

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Measuring Underlying Energy Efficiency in the GCC Region

BY SHAHAD ALARENAN, ANWAR GASIM, LESTER HUNT, AND ABDEL RAHMAN MUHSEN

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Energy consumption in the six Gulf Cooperation Council (GCC) countries – Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the UAE – has grown rapidly over the last several decades. With low administered energy prices, rapid population growth, and extensive economic development, final energy consumption across the GCC countries increased by an average of 6.8% per annum between 2004 and 2014 – almost four times faster than the global average. Energy efficiency carries the potential to mitigate such growth in energy demand, putting the GCC countries on a more sustainable pathway. However, there is a lack of hard evidence about energy efficiency for the GCC countries. We therefore undertake a benchmarking exercise to shed light on the relative energy efficiency position of the six GCC countries over the period 2004 to 2014 for residential electricity, transportation gasoline, and manufacturing aggregate energy.

Many believe that there have been limited, if any, improvements in energy efficiency in the GCC region, which would not be surprising given the low administered energy prices enjoyed by consumers for decades. In an environment of low energy prices, efficiency policies can play a big role. When consumers lack the incentive to invest in energy efficiency, policies such as minimum energy efficiency standards can drive up energy efficiency levels. Countries in the GCC however have launched a limited number of energy efficiency policies over the last several decades. Nevertheless, policymakers in the GCC have recently shown greater interest in energy efficiency, establishing several comprehensive initiatives across the region such as the Saudi Energy Efficiency Program. Hence the need for more evidence about the energy efficiency performance of the GCC countries.

Energy efficiency itself is very difficult to measure. This makes it difficult to track progress. Because of these difficulties, analysts often use simpler, indirect indicators to track progress in energy efficiency. For households, consumption per capita is often used. A fall in electricity consumption per capita is often believed to be associated with energy efficiency improvements. Davis (2017) for example explores the fall in residential electricity consumption per capita in the US and suggests that the recent uptake of energy efficient lighting is likely responsible for the fall. For firms, energy intensity (or its inverse, energy productivity) is often used. A fall in energy intensity is often associated with improvements in efficiency. The IEA (2017) for example combines decomposition analysis with energy intensity indicators to isolate the effect of energy efficiency, but even with decomposition the result likely captures much more than just energy efficiency. As Filippini and Hunt (2011 and 2015) argue, such indirect indicators can increase or decrease because of many different factors that are unrelated to energy efficiency. Filippini and Hunt (2011) therefore advocate attempting to control for such factors by estimating energy efficiency using frontier analysis.

There are various approaches for conducting frontier analysis, which can be either parametric or non-parametric. Corrected Ordinary Least Squares (COLS) and Stochastic Frontier Analysis are among the most commonly used parametric approaches. For our benchmarking analysis, using a newly constructed dataset, we adopt a parametric approach by estimating econometrically an Energy Demand Function (EDF). According to Filippini and Hunt (2015), the EDF can be used to capture economic inefficiency (both allocative and technical). Furthermore, we apply COLS to the estimated EDFs to measure underlying energy efficiency given our relatively small dataset for the six GCC countries.

Applying COLS to the residential electricity sector in the GCC suggests that between 2004 and 2014 estimated underlying energy efficiency improved in Kuwait, Bahrain, and Saudi Arabia by 18%, 11%, and 10%, respectively, while it deteriorated in Qatar, Oman, and the UAE by 34%, 15%, and 4%, respectively (see Figure 1A). For the gasoline road transport sector, estimated underlying energy efficiency improved in Bahrain, Kuwait, Qatar, and Saudi Arabia by 21%, 17%, 7% and 7%, respectively, while it deteriorated in Oman and the UAE by 47% and 33%, respectively (see Figure 1B). For manufacturing aggregate energy, estimated underlying energy efficiency improved in Saudi Arabia and Bahrain by 31% and 6%, respectively, while it deteriorated in Oman, UAE, Kuwait, and Qatar by 77%, 39%, 18%, and 8%, respectively (see Figure 1C). In summary, the results suggest that there are some relatively large energy inefficiencies in the GCC and that there have been as many deteriorations as improvements. These results validate some of the widely held beliefs around energy efficiency in the GCC and show that there remains great potential for energy efficiency in the region.

Comparing the estimates of underlying energy efficiency to indirect indicators such as energy intensity and energy consumption per capita reveals that: 1) Indirect indicators are generally good at tracking progress in energy efficiency, but are not always perfect at doing so. 2) Indirect indicators are less useful at comparing and ranking countries in terms of energy efficiency – the relative rankings in estimated underlying energy efficiency differ considerably from the relative rankings in energy intensity for example.

The evolution of energy demand in the GCC region over the next several decades is likely to be considerably different to the patterns witnessed in the past. GCC countries have recently started to use both prices and policy to encourage greater energy efficiency. In late 2015, Saudi Arabia for example announced comprehensive increases in energy prices across the residential, transport, and industrial sectors. Saudi Arabia then implemented a second wave of energy price increases roughly two years later. The UAE has also been a leader in energy price reform, as it was the first to implement significant gasoline and diesel price increases. Almost all GCC countries have recently attempted to reform energy prices, although the scale and degree of price reform differ between them. Most GCC countries are also relying on energy efficiency policies, as they have started to develop and update their standards for appliances. Such a two-pronged approach that utilizes both energy prices and policies will likely yield considerable improvements in energy efficiency. Thus, unlike the estimated energy efficiency trends for the period 2004-2014, the trends over the next decade or two are likely to be very different, with the potential for rapidly improving energy efficiency. This in turn will support more sustainable growth pathways for the GCC countries.

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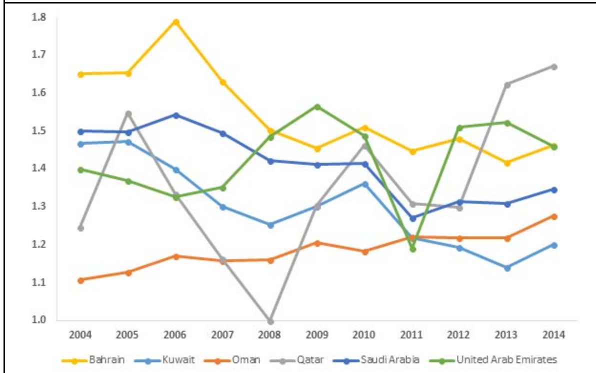
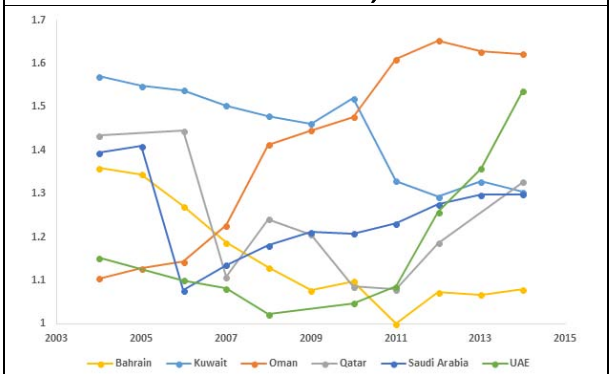
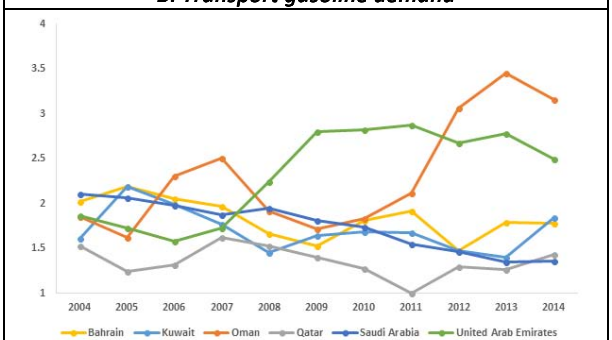
Figure 1. Estimated underlying energy efficiency for the GCC countries.



A. Residential electricity demand



B. Transport gasoline demand



C. Manufacturing aggregate energy demand

Note: For each sector, the data point with an underlying energy efficiency of one is the most efficient (i.e., the benchmark) with values greater than one indicating inefficiency relative to each benchmark.

Figure 1. Estimated underlying energy efficiency for the GCC countries.

Load Shifting Behavior Under Dynamic Electricity Pricing and The Role of Information Feedback

BY YEONSEO KIM, SOYONG YOO, AND JIYONG EOM

Overview

Recent retail market deregulation and ICT-based technological innovation brings new opportunities to dynamic electricity pricing, which is regarded as a promising instrument to manage peak-time electricity demand and to promote allocative efficiency in the retail market. The residential sector in particular has received much attention not only for its relatively economically inefficient use of electricity, but also for its increasing share of national energy system. In the U.S., nearly half of residential consumers are reported to have already installed smart-meters by the end of 2016 (EIA, 2017) and majority of utilities operate any type of residential dynamic pricing program in the form of default or opt-in rate (Faruqui, Hledik, & Lessem, 2014). In attempts to promote the adoption of residential dynamic pricing, utilities have conducted a large number of pricing pilots to test consumer responsiveness and program effectiveness.

Dynamic pricing programs are often assessed based on the extent to which peak load is reduced—*load foregoing*— or shifted to off-peak hours—*load shifting*—in response to price signals. Among the two behavioral responses, although not clearly distinguishable, promoting load shifting instead of simple load foregoing could help consumers continue to enjoy energy services they forego during the peak in different time of the day and thereby bear lower, or even negative costs of adopting the programs. Thus, load shifting, if successfully induced, can not only promote the political acceptance of residential dynamic pricing programs but may also encourage them to alter energy consumption patterns even more aggressively. Previous studies report that households indeed repond to dynamic pricing, but they mostly do so by cutting electricity usage in peak hours with very limited load shifting, often resulting in a net reduction of overall electricity usage (Allcott, 2009; Faruqui, Sergici, & Akaba, 2013; Jessoe & Rapson, 2014).

To the best of our knowledge, little is known about how load shifting behaviour can be instigated and what it would result under residential dynamic pricing. We conducted a controlled field experiment for 320 Korean residential electricity consumers to test whether and how the provision of load-shifting relevant information influences their electricity consumption decisions in a dynamic pricing setting. Specifically, our load-shifting information consists of two parts, alternatives for load-shifting choices and their expected payoffs, which we hypothesize would help complete the consumers' decision basis (Howard, 1988).

There are two interrelated reasons that residential consumers under dynamic pricing may not engage in load shifting behaviour. First, the consumers may not be aware of any alternative, load-shifting way of energy consumption probably due to the absence of relevant information, or they may recognize the load-shifting option but do not know its exact payoffs to motivate such behaviour. These in combination are expected to result decision ambiguity, rendering potentially attractive load shifting options go unexercised. Second, more generally, the complex nature of decision making with relatively small financial stakes makes the consumers behave differently from what the utility-based rational choice theory might predict (Frederiks et al., 2015). It is well known that although electricity consumption involves many small decisions, their precise costs are hard to identify as they are revealed ex-post and intermittently (Gilbert & Zivin, 2014), and not salient either as their sum only account for 2~3% of household spending in general. As a consequence, residential consumers are likely to make only boundedly rational decisions. The decision making may follow so-called 'satisficing heuristics' (Simon, 1997), such as load foregoing or inefficient energy conservation, which would constitute a default set of choices guaranteeing known payoffs, rather than bothering to explore other alternatives that might improve their payoffs further.

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Experimental Design

Our experiment employs a panel of 320 households recruited to receive participation incentives and smart meter installation in return for participating "Smart Energy Campaign" during the winter of 2017. The participants were randomly assigned into three groups varying in the types of electricity prices and SMS-based information feedbacks: Control (n=100), Treat1 (n=110, peak reminder only), and Treat2 (n=110, peak reminder plus load-shifting information). Control group remained under the current flat rate and is not exposed to any intervention. Treat1 and Treat2 groups were all subjected to a de facto TOU tariff characterized by a peak-time rate of KRW700 (=$0.65) on top of the flat rate only during 5-8 pm on weekdays. While Treat1 group received peak-time reminder everyday and weekly reports on individual performance, Treat2 group received additional load-shifting information about choice alternatives and their expected individualized payoffs everyday. The TOU tariff has been operationalized as follows: each participants in Treat1 and Treat2 was given with the initial incentive balance of KRW50,000 (=$46.7) with the start of the experiment; and the initial balance decreased at the rate of KRW700 (=$0.65) per each kWh usage in peak hours until it reaches the minimum balance of KRW10,000 (=$9.3) under which no futher deduction was made. Control group received KRW20,000 (=$18.7) as a participation incentive at the end of the experiment.

Results

We find Treat1 group reduced its peak usage on average by 3.4% and Treat2 by 4.8% (in both cases, p-value<0.001), which inicates households given with load shifting information were more responsive to the increased rate than those without. In terms of daily usage, while Treat1 reduced daily usage by approximately 2.3% compared to its pre-experiment usage, Treat2 exhibited no statistically significant change. The implication is that load-shifting relevant information indeed promoted the consumers to curtail their peak-time consumption even further by inducing meaningful load shifting from peak to off-peak hours.

Several other findings are worth to note. First, the two treatment groups exhibited different usage pattern over the course of the pricing experiment. For Treat1, the peak-time load impact gradually increased over the weeks, which points to the exsistence of possible learning effect for the households in dealing with the dynamic pricing. Treat2 group, however, exhibited relatively large and constant peak-time reduction from the first stage of the experiment. Second, the two groups also differed in daily load pattern, in which Treat2 group responded more to the dynamic pricing than Treat1 in most of hours of the day with the former exhibiting particularly pronounced increase in electricity consumption in early morning period (5~7 AM). That is, Treat2 tended to exercise more distant, aggressive load-shifting options which would have gone unnoticed without the load-shifting information. In summary, our experiment suggests that the provision of information that helps complete the decision basis of households can promote them to undertake more instantaneous and aggressive actions under dynamic pricing than the case without.

Conclusions and Implications

We examined the effect on price response of the provision of information on load-shifting alternatives and their payoffs in a residential TOU setting. Unlike previous studies mainly on the performance of various pecuniary incentives or non-pecuniary interventions (e.g., information feedbacks), our controlled field experiment systematically investigated the role that information on decision alternatives might play in inducing the change in energy behaviour and the process by the change occurs. Our study provides an indirect evidence that residential electricity consumers may remain boundedly rational at least for some period of time in the search for individually efficient price response, unless more concrete, decision-relevant information is provided. The implication is that utility regulators implementing a new dynamic pricing plan are better positioned to ensure that load-shifting information is clearly and effectively communicated, so that the households may adapt to and respond to the plan more efficiently, which may also eventually improve the program's performance.

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The Impacts of Massive Adoption of Distributed Photovoltaic Systems in Mexican Households: A Simulation Approach

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See footnotes at end of test.

Overview

Mexico plans to implement a program to support the adoption of distributed photovoltaic generation (DPVG) in households aiming to reduce the burden of substantial energy subsidies and increase the share of renewable sources used to generate electricity. In this study, we assess the current conditions under which the residential electricity sector operates, and quantify the potential effects that the massive adoption of DPV systems would have on household expenditure and welfare, government revenue, and environment. Based on the optimistic results, our study provides strong support for further design and implementation of a DPVG program.[1]

The context

About 90% of total energy consumption in Mexico comes from fossil fuels, making the country the 13th largest GHG emitter in the world (Mexico represents approximately 1.4% of global emissions).[2] The environmental goals derived from the COP-21 held in Paris (December 2015) require that 35% and 43% of domestic energy should come from renewable sources by 2024 and 2030, respectively. Additionally, the Mexican Energy Reform of December 2013 opened an important window to introduce renewable sources in the electricity generation mix.

To be more concrete, electricity generation explains more than 20% of total GHG emissions and the residential sector accounts for 25% of total electricity consumed. In this context, taking advantage of the fact that more than 75% of the country has an isolation greater than 5 kWh/m2/day, seems to be a very promising opportunity.[3]

On the other hand, the federal government, through the state-owned electricity company (CFE), promotes excessive residential electricity consumption by subsidizing 98% of Mexican households, which on average pay approximately 40% of the total electricity cost -i.e., generation, transmission, distribution and commercialization costs. The resulting fiscal burden has consistently increased during the last decade and currently represents more than 0.5% of the GDP. Moreover, given the universal and uniform application of this subsidy, the tariff scheme magnifies the inclusion error, wasting valuable resources. All this happens in a country where poverty and inequality are significant social problems.

With all the above in mind, an ambitious plan aiming to deploy DPV systems among Mexican households could help solve some of the challenges the country is currently facing.

Empirical methodology

We simulate the implementation of a massive distributed photovoltaic generation (DPVG) program in the Mexican residential sector. In doing so, we first use the System Advisor Model (SAM) provided by the National Renewable Energy Laboratory (NREL) and simulate the performance of residential PV systems for typical users located in each CFE distribution region and tariff category. We consider a representative system that has one single orientation (190° azimuth and 5° inclination), 1:1 DC-AC conversion efficiency, 1.6% inverter efficiency, and 0.5% performance degradation per year. We also use information of a typical meteorological year and assume a standard investment cost of 1.87 USD per WDC. The annual operation and maintenance cost is assumed to be 3.74 USD per KW of PV capacity installed.

Second, we use the 2014 National Household Income and Expenditure Survey (ENIGH-2014) collected by the Mexican National Institute of Statistics and Geography (INEGI), the CFE tariff schedules, and the taxes in effect during the sample period to recover the quantity of electricity consumed by each household.

Third, we establish some requirements to select the group of households that are able to adopt solar panels in their rooftops. Since our goal is to provide an upper bound of the potential program effects, we assume that each household that qualifies as an adopter, does install the corresponding DPVG technology. Concretely, we restrict our attention to dwellings which can support the solar panel structure. We only include independent houses and exclude departments in multi-floor buildings, or commercial premises used as housing. We assume solar panels can only be installed by houses that are occupied fully by the owners. We also assume that only those households with a generation capacity able to cover the total electricity consumption needs are the ones adopting the solar panels. Finally, to simulate the program impact, we assume connection to the grid is done under a net metering scheme with 2014 end-user electricity tariffs.[4]

As a result of all the above, half of the residential users will be potential DPV system adopters. Finally, to simplify our empirical exercise, we do not consider any specific financing alternative and assume that households pay the initial investment in full during the first period. We also assume a uniform discount rate equal to 2%, which is equivalent to the average real interest rate for time deposit during the last five years in Mexico. Finally, we suppose each household electricity spending grows at a 0.5% annual rate (measured in real terms).

Results

The main outcomes of our simulation are as follows. Average annual levelized savings for household electricity spending is 47.6 USD. The implicit payback period is 16 years and the associated internal rate of return (IRR) is approximately 6%. These three figures change to 47.7 USD, 12.4 years, and 9.7%, when efficient opportunity cost pricing is assumed, instead of the current subsidized pricing policy of CFE.

Government savings amount to approximately 1.6 billion of USD annually. This number correspond to the avoided electricity subsidy net of missed revenues from value added tax (VAT), while public lighting spending will remain in place.

The emissions savings are: 69 thousand tons of SO_2, 46 thousand tons of NO_X, and 12 million tons of CO_2. Those numbers correspond to a 1% reduction of total emissions projected under the INDC mitigation unconditional scenario (Mexico Gobierno de la Republica, 2015), and approximately 9% of the 2020-2030 emission reduction target for the electricity generation sector. Addionally, there will be about 13 million m^3 of water savings.

Conclusion

The implementation of a massive DPVG program in the Mexican residential sector would bring more gains than losses. That is true both in economic and environmental terms. Even though residential users are quite heterogeneous, we identify patterns that are common to most of them. Hence, from the perspective of a representative user (e.g., the average user), the initial investment outlay is more than compensated by the reduction in CFE electricity bill.

On the other hand, the current electricity consumption subsidy plays a negative role since for many users it is more attractive to continue paying low energy prices than afford a costly capital investment necessary to install a DPV system.[5] Even for a vast group of households that has an estimated positive net present value from the DPV system adoption, the corresponding payback period is too long to support such an investment. The situation would be quite different if electric prices reflected the true opportunity costs. In that case net present values and IRR would be higher, and the payback period would be considerably shorter. However, returning to opportunity cost pricing seems not to be an option under the current political situation. Moreover, a social tariff scheme that correctly target the poor and excludes high-income households from the subsidy is not even discussed. In that context, a partial transformation of the electricity consumption subsidy to a DPV system adoption subsidy could be a good policy alternative.

From the government perspective, each household adopting the PV technology can represent a reduction in the subsidy account. A low politically costly way to do so would be through a mechanism under which the government replaces the current electricity consumption subsidy with a (temporal) DPV system adoption subsidy. In this setting, residential adopters would not suffer from the negative financial effect implied by the costly capital investment during the transition, and the government would simply transfer the resources from one subsidy account to another. In the medium- to long run, all agents involved would benefit from this policy.

Footnotes

[1] For a full version of this paper, see Hancevic et al. (2017).

[2] See, for example, Damassa et al., 2015, or Mexico Gobierno de la Republica, 2015.

[3] Other countries, such as Germany and Spain, are currently recognized as the world leaders in installed PV systems. However, Mexico's solar potential resources are far superior and could be considered among the largest in the world (see SENER, 2016).

[4] There are at least two alternative ways of selecting the set of potential adopters. One is to estimate the probability of household DPVG technology adoption using some specification that incorporates household and dwelling characteristics. Unfortunately, the number of households that already adopted some DPV system is quite small in Mexico and then it is not possible to estimate such probability. The second alternative is to conduct a meta-analysis looking closer at emerging countries. Regretably, to the best of our knowledge there are not studies that estimate adoption in emerging countries. In addition, the meta-analysis approach could suffer from serious errors due to the matching of variables and the absence of information on characteristics that are relevant for Mexico but probably not for other countries (or vice versa).

[5] For a detailed discussion about the relative advantages/disadvantages of implementing a capital subsidy scheme (that support energy efficienct and clean technology adoption) versus the current electricity consumption subsidy see Hancevic et al. (2017).

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Capacity vs Energy Subsidies for Renewables: Benefits and Costs for the 2030 EU Power Market

BY ÖZGE ÖZDEMIR, BENJAMIN F. HOBBS, MARIT VAN HOUT, PAUL KOUTSTAAL

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See footnote at end of text.

Introduction

It is widely agreed that renewable electricity policies, such as feed-in tariffs, that encourage siting of renewable developments irrespective of the marginal value of their output, promote inefficient investment in terms of maximizing the net economic and environmental value. Instead, the EU and its member states are moving towards feed-in premiums, curtailment requirements, and other policies that result in profits better reflecting the market value of electric energy. Development may therefore be encouraged where resources produce fewer annual MWh, but where the increased market value more than makes up for that decrease due to timing and availability of transmission and dispatchable generation capacity.

However, although such policies might decrease the net economic cost of achieving renewable energy targets, it has been argued that they are still inefficient in achieving the goal of promoting technology improvement. In particular, if learning-by-doing occurs through cumulative MW investment rather than through cumulative MWh production, then policies that are tied to investment rather than output might be more effective in reducing technology costs (Newbery et al., 2017). These policies may take the form of straight-forward per MW investment subsidies. A more sophisticated variant, as described by Newbery et al. (ibid.), would pay a per MWh subsidy, but only up to a maximum number of MWh per MW of capacity.

Here we compare the impact of energy-focused (feed-in premium) and capacity-focussed (investment subsidies) renewable policies upon the EU-wide electric power market in 2030 using a market equilibrium model. Specifically, do capacity-based policies result in significantly more investment (and possibly learning)? We explore how different policies impact the mix of renewable and non-renewable generation investment, electricity costs, renewable output, the amount of subsidies, and consumer prices. In addition, we also evaluate the efficiency of national policy targets for renewable electricity production (as a whole or per technology) and compare these with a cost-effective allocation of renewable enegy production, given resource quality, network constraints and the structure of the electricity system in the various EU countries.

To address these issues, we use COMPETES, an EU-wide transmission-constrained power market model, which we enhanced to simulate both generation investment and operations decisions (Özdemir et al., 2013, 2016). In contrast, other analyses of renewable electric energy policies in Europe have often identified best locations and technologies based on levelized costs or other metrics that disregard the space- and timing-specific value of their electricity output. COMPETES uses linear programming to simulate the equilibrium in a market in which generation decisions simultaneously consider the effect of development costs, subsidies, and energy market revenues on profitability.

Method

A market equilibrium assuming a perfectly competitive market has two characteristics. First, each market party pursues its own objective (its profit) under the assumption that it cannot increase its surplus by deviating from the equilibrium solution. The second characteristic is that the market clears such that supply equals demand for electricity at each node in the network. One approach to modeling market equilibria is to concatenate the first-order conditions for each market party's problem with market clearing equalities, yielding a complementarity problem. Complementarity problems can be solved either by specialized algorithms or, in special cases, by instead formulating and solving an equivalent single optimization model.

The version of COMPETES applied here adopts the latter approach. It uses a single linear program that is equivalent to a market with profit maximizing generators who invest and operate to maximize profits and a transmission operator who minimizes dispatch costs, all subject to policy constraints such as renewable energy or capacity targets and carbon prices. For practicality, this version of COMPETES uses a sample of 1200 hours (sampled from eight years of data from Gorm et al., 2015) to capture load and renewable output variability within a year, and a static (single year) equilibrium is calculated for the year 2030. Also, this version represents the EU 28 country market with 22 nodes, considering net transmission capability constraints between countries or regions.

Results

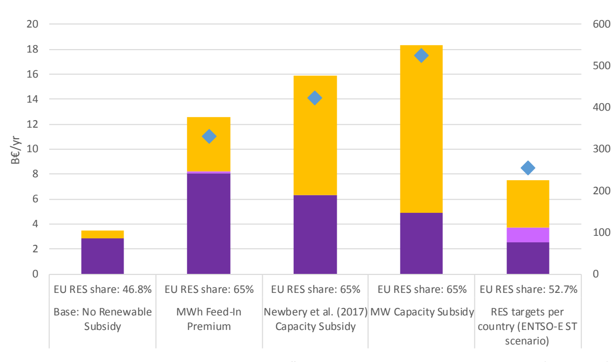
An initial comparison of our baseline scenario of no renewable policies versus three EU-wide policies achieving a 65% renewable electricity target is shown in the first four scenarios in Figure 1. The renewable policies we simulated assume a single EU-wide target without country-specific mandates, and furthermore assume that the same level of subsidy applies to all renewable sources. Of course, the reality of EU policy is that there are distinct programs for wind, solar, biomass, and hydropower, and each country has their own targets, with relatively limited opportunities for countries to satisfy their renewable requirements elsewhere. However, these simplifications allow us to explore the general impact of energy versus capacity policies.

Assuming that policy makers adjust capacity targets to meet a 65% energy target, the basic capacity-based policy would increase the incremental generation cost[1] of achieving that target (by 58%, from 11B€/yr for a feed-in premium policy to 18B€/yr). Using MWh feed-in premiums rather than capacity payments is cheaper because paying for the product that contributes directly to a desired target (MWh rather thn MW) is the first-best way of meeting that target.

On the other hand, the capacity policy does result in higher renewable investments compared to the no-policy case (446 additional GW, which is 63% higher than the 273 GW additional capacity in the energy target case). In contrast, the Newbery et al. proposal's results fall in-between these cases, as it has characteristics of both capacity and energy policies; compared to no policy, it increases the incremental GW capacity investment (by 36%, 372 GW vs. 273 GW) at a somewhat lower cost per incremental GW unit (incremental cost of achieving the target of 14B€/yr).

But if the target is instead capacity (MW) instead of MWh, then the capacity mechanism is cheaper. In other runs (not shown), we have found that the 377.3 GW of new renewables that results from the 65% feed-in premium policy could also be achieved directly by capacity policy at an incremental cost that is 26% lower than the 11B€/yr cost of the feed-in premium policy. On the other hand, the cheaper capacity policy achieves only 59,9% (rather than 65%) renewable penetration.

We also explored the impact of country-specific targets (last scenario in Figure 1). This is a MW-based policy with a minimum amount of renewable solar, wind onshore and offshore capacity by country based on targets reported in theENTSO-E (2018) Sustainable Transition (ST) scenario. The incremental cost of



achieving a 52.7% EU-wide renewable energy goal using the specific country goals was 8,5 B€/yr. This is about seven times higher than than the incremental cost of achieving the same 52.7% level by using the most cost-effective locations and technologies in the EU, and almost as high as the cost of achieving a much more ambitious 65% target by the most cost-efficient means. Moreover, our simulations show that the choice of technologies and locations are equally to blame for the cost increase resulting from country targets, accounting for the 53% and 47%, respectively, of the generation cost increase.

Conclusions

Our findings show that the efficiency of energy vs capacity-focussed renewable policies depends on the EU's renewable energy goals. If the goal is to reach a certain share of renewable energy in total consumption, it is more efficient to use an energy subsidy to achieve a given MWh target than to use capacity-based (MW) mechanisms. But if the objective is to promote technology improvement through capacity installation, then it can be significantly less expensive to use capacity subsidy mechanisms to achieve a given renewable capacity goal than to use renewable energy subsidies.

Moreover, the country-specific targets without renewable energy credit trading greatly increase the cost of renewable policies. Our analysis shows that there is considerable room for coordinating and improving renewable energy policies within Europe which will help reduce the total costs of promoting renewable power.

Footnote

[1] Includes investment and variable generation costs of conventional units, storage and renewables, as well as costs of load shedding. NB: no load shedding was observed in any of the cases. Furthermore, net import costs from non-EU countries are included as well, with import prices adjusted for border congestion, assuming that congestion revenues are equally shared between neighboring countries.

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Strategic Trading and Hedging in Sequential Electricity Markets with Increasing Renewable Energy

BY DERCK KOOLEN, RONALD HUISMAN AND WOLFGANG KETTER

The liberalization of electricity markets and the ongoing integration of renewable energy sources have a dramatic impact on power prices. The integration of wind and solar power introduced more low marginal costs suppliers to the market, as no fuels are needed to produce electricity, and power prices decreased as a result. On the other hand, intermittent supply from wind mills and solar panels in combination with the non-storability of electricity and price inelastic demand cause spot prices to fluctuate heavily. Increased competition, lower prices and more price volatility have drastically changed operations in electricity markets.

The above motivates power agents to use forward contracts to mitigate risk. Pricing forward contracts, however, is tedious, relating back to notions of risk related hedging pressure, strategic behavior and market technology set-up. Moreover, the economics of wind and solar power are very different from conventional power. Applied to markets operating under such heterogeneous operational constraints, empirical literature has presented mixed findings without clear economic interpretations with respect to the behavior and sign of the forward premium. In this work, an experimental design allows us to implement variations with a high degree of control and test decision making in sequential markets with a varying production technology mix under truly ceteris paribus conditions. We validate our findings empirically for the German power market, recently experiencing a sharp increase in intermittent production capacity. Analyzing these systems, relationships between market participants, technology adaption and changes to market behavior provide key ingredients for devising a robust well-functioning electricity market, its design and its governing policies.

Sequential Power Market Simulation

We conduct a series of experiments in order to evaluate the influence of a varying renewable technology mix on hedging and strategic trading in sequential power markets. We set up a market in which participants can trade the commodity electricity in a simulated wholesale environment for a sequence of 20 trading sessions. Each session covers two periods: a forward and a spot market. Participants represent single agents, acting as power producers selling electricity on the wholesale market while hedging against risks from demand uncertainty and variable output. We distinguish between 3 different market set-ups. First, "non-intermittent" (NI), with exclusively producers that bear increasing marginal production costs when their output increases, reflecting the more traditional set of power producers. Second, "low market share intermittent" (LI), with both non-intermittent and intermittent producers. The latter guarantee 33% of the market capacity and do not bear any marginal costs for producing electricity, representing renewables power sources that are dependent on weather conditions like solar radiation or wind speed. The production capacity of zero-cost producers is represented by a random variable, and can be interpreted as a production constraint by nature. Lastly, in "high market share intermittent" (HI) the share of high- and zero-cost producers is inverted, simulating future markets which aim to implement a large share of renewable energy sources. The 3 market structures or treatments were presented in a counterbalanced order over the set of 5 experiments, each consisting out of 25 simulation rounds. Subjects were recruited amongst energy finance experts and energy management students of the Erasmus University Rotterdam, Netherlands with a thorough understanding of energy markets.

Derck Koolen is a PhD researcher at Rotterdam School of Management, Erasmus University and London Business School. **Ronald Huisman** is a Professor at Erasmus School of Economics, Erasmus University. **Wolfgang Ketter** is Professor and Director at Energy Economics Institute, University of Cologne.

Results indicate the well-known negative effect of renewable energy on forward (day-ahead) prices. Mean spot prices vary across markets but we find evidence for significantly increasing volatility in spot markets with a higher renewable capacity share. We observe a clear difference between non-intermittent and intermittent producers' trading behavior, most significantly represented by the fact that non-intermittent producers (are forced to) move from the forward market to the spot market when the share of intermittent producers increases. We find evidence that the merit order effect negatively pushes profits in the forward market of conventional power plants. Non-intermittent producers, however, do seem to gain from trading in the spot market, with higher profits made with more intermittent sources on the market. This indicates that there is a demand for flexible spot production with more intermittent production in the market, i.e. a convenience yield for flexibility in the producer's portfolio. Figure 1 visualizes this effect, showing density distributions of non-intermittent producers' profits in forward and spot markets for all market treatments and experiments. The figure indicates that in all HI forward markets, lower and more similar profit profiles are obtained but there is also less room for strategic behavior. Contrarily spot market profits increase drastically and follow smoother profiles than in NI and LI, indicating lower risks for non-intermittent producers strategically trading in the spot market.

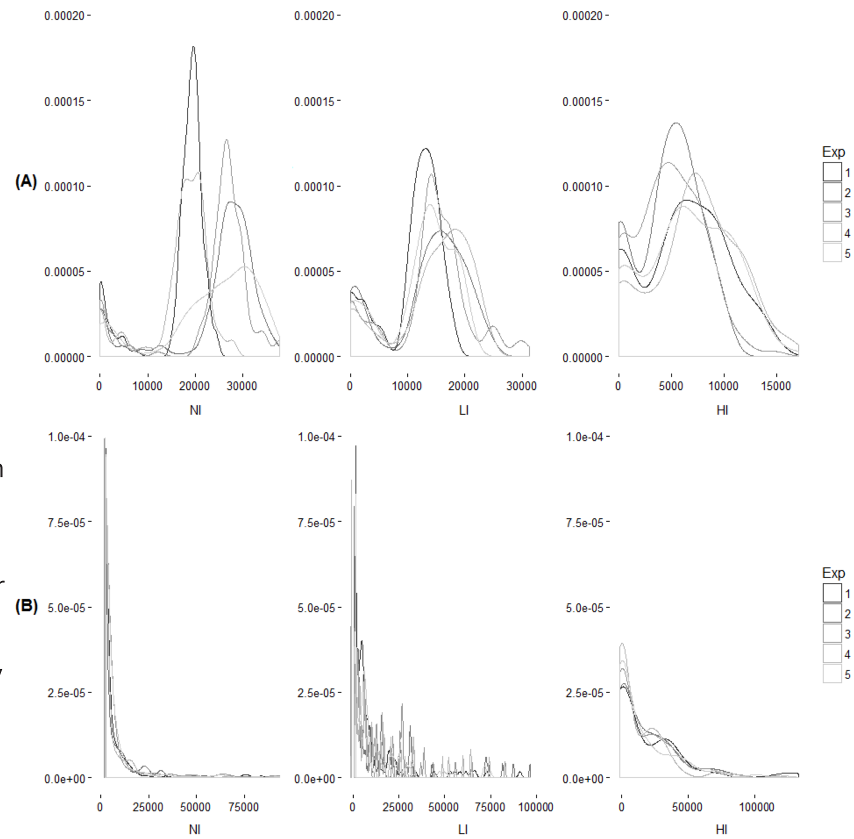

Figure 1: Profit distributions of non-intermittent producers in non-intermittent market (NI), low intermittent market (LI) and high intermittent market (HI) for the forward market (A) and spot market (B).

Empirical Validation in German Short-term Sequential Markets

In electricity markets with increasing intermittent capacity, risk-sharing becomes more important and short-term financial instruments gain liquidity. In the context of the German power market, new short-term market constructs have been put into place to accommodate this transition. As weather dependent intermittent production can only be accurately predicted for a limited time horizon, we compare the effect of high shares of renewable energy on trading in day-ahead, intraday and real-time imbalance power markets.

Results indicate the merit order effect of a negative effect of intermittent power sources on day-ahead power prices. As closer to real-time the time granularity of the traded product increases, intraday and real-time prices experience a pronounced hourly jump with a recurrent hourly fluctuation around the day-ahead forward price. We indicate that where the day-ahead auction may allow traders to anticipate average hourly variations for the next day, the intraday and real-time markets give an opportunity to trade into the within-hourly differences. As such, with prediction accuracy on both production and demand increasing closer to real-time, the hourly jump effect is propagated through markets moving closer to real-time.

Next to this microstructure effect, the real-time imbalance market shows evidence for the strategic effect indicated above. For the German imbalance market, prices are determined and known to market participants ahead of real-time gate closure. Indeed, bidding for the reserve market takes place day-ahead and as such, prices are subject to day-ahead predictions of intermittent production levels. Controlling for imbalance, we find that real-time imbalance prices exhibit larger spikes, i.e. negative prices become more negative and positive prices become more positive, at those moments when day-ahead predictions indicate high shares of intermittent production. This strategic behaviour of price setting in real-time imbalance markets indicates evidence for the above discussed convenience yield for flexibility.

Concluding Remarks

With the growing share of sustainable energy sources, electricity markets experience increasing uncertainty and volatility. Key in the transition process is to ensure that markets provide adequate price signals for assets and investments, ensuring security of supply in an efficient and sustainable way. Future market design must be inherently robust, as markets and financial stakeholders may create instabilities, potentially leading to huge losses and black-outs, while the bill is eventually paid by the customer.

The technology varying risk-premium influences policy practices for current market structures, which aim to integrate renewable energy in an efficient way. Influenced by market conditions as flexibility, producer set up and risk aversion, relative performance of spot and forward markets is bound by the markets' operational constraints. We find that the various operational characteristics of producer technologies affect commodity trading and thereby affect market prices, often not desirable from a sustainable efficient market point of view. This work paves the way for policy makers to examine the implications on existing market structures and their participants' strategic space, considering alternative market designs both from market and individual perspective in order to not only integrate large shares of renewable energy in existing electricity markets but also achieve it in a sustainable manner.

Stranded Generation Assets and the Future Implications for the European Gas Network

BY CONOR HICKEY, PAUL DEANE, CELINE MCINERNEY & BRIAN Ó GALLACHÓIR

Ambitious European targets for renewable energy call for a vast mobilization of capital. At the same time, European electricity market reform, reduced electricity demand, and decarbonisation of electricity generation have had unexpected consequences for risk and return for power sector investors with investments in thermal generation assets (primarily gas-fired generation) becoming stranded and mothballed (Caldecott & McDaniels 2014). Over the last decade, European utilities have been the worst performing sector in the Morgan Stanley index of share prices, halving the market capitalization of some European electric power utilities throughout this period (Caldecott et al. 2017). The drop in market valuation of these assets in recent years reflects investor uncertainty and stranded asset risk for these assets has begun to receive significant attention from investors, rating agencies and regulators. The share of electricity demand from variable renewable power generation is limited by the non-synchronous nature of wind and solar PV (Ibrahim et al. 2011). Sources of flexibility, such as gas-fired generation assets, are required to increase these limits and support a further penetration of variable renewables (Lannoye et al. 2012). Achieving generation adequacy has become a challenge for the EU internal electricity market through the energy-only market model operating in some member states (EPRS 2017). A number of member states have introduced capacity mechanisms which compensate generators for the availability of existing and support an investment case for future generation capacity to supply electricity (Huhta 2018). For example, in 2018, the European Commission approved six additional forms of capacity mechanisms concerned with more than half of the EU population in Germany, Belgium, Italy, Poland, France and Greece (European Commission, 2018).

This paper evaluates the investment risk for both gas fired generation and gas network assets in each of the EU member states using an emissions reduction scenario for 2030. A detailed model-based analysis is developed under the assumptions of the European Commission Reference Scenario 2016. This is coupled with a power system simulation and investment appraisal model to assess if returns to owners of gas generation assets in each EU member state are sufficient to incentivise investment in new gas generation assets in an 'energy only' market. The outputs from this analysis are then linked with a high-level gas network investment and tariff allocation model to assess the implications of significant reductions in gas demand from the power generation sector for owners of gas transmission assets.

Simulating Future Market Conditions

Visions for the future, through energy systems modelling, offer useful insights into how market conditions may evolve. In 2016, the European Commission published the "EU Reference Scenario 2016, Energy, Transport and GHG Emissions, Trends to 2050" hereafter EC Ref. (European Commission 2016). The scenario provides a benchmark for current policy and market trends. It starts from the assumption that the legally binding GHG and RES targets for 2020 will be achieved and that the policies agreed at EU and Member State level until December 2014 will be implemented. The market pricing and operational assumptions for gas generation assets and the gas network are derived from a soft-linking approach between an energy system scenario (the EC ref.) and power system model, as described by (Deane et al. 2012). A Discounted Cash Flow (DCF) model is used to value generation assets and a tariff allocation model for the gas network. The assumption of the DCF model is that generators must achieve a minimum Internal Rate of Return (IRR) of 8% (the hurdle rate of return for capital to be forthcoming from investors) to incentivise investment in these assets, this is generally the purpose of capacity remuneration mechanisms (Pototschnig & Godfried 2014). Payments outside of the energy only market to achieve this are known as out of market payments in this analysis. The required revenue of each member states gas network to remain viable is calculated and tariffs are allocated to all network users based on their respective demand for gas and the operational cost of the member states network. Cost assumptions for power generation assets and the network are sourced from a variety of industrial sources and surveys (JRC 2014; ACER 2015; Lochner 2011). The cost of debt is calculated using a combination of the member state specific 20 year bond yields and a European utility corporate debt premium.

The Future for Gas Generation Assets

Figure 1 shows the percentage of total generator revenues from out of market payments required to achieve and IRR of 8% for owners of gas generation assets. Countries which achieve this return in an 'energy only' market are shown

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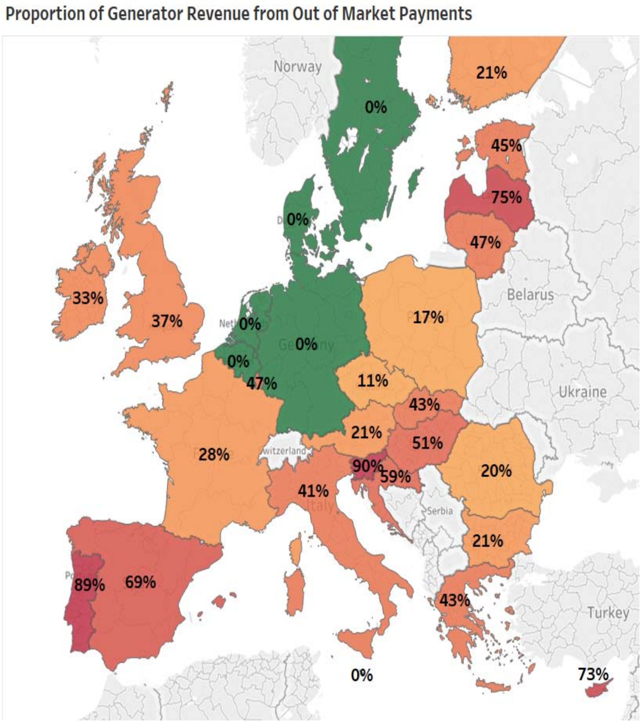

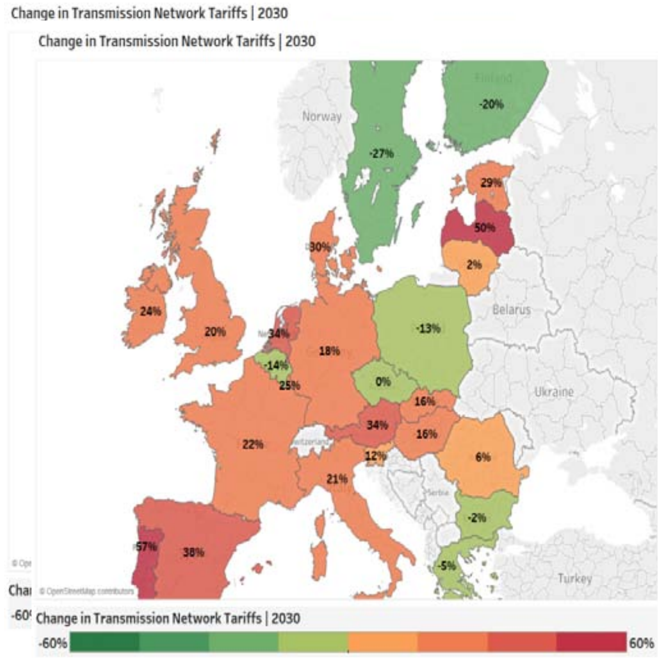

on the graph as 0%. However, the majority of counties will require either capacity payments or other out of market payments to incentivise investment. Member states heavily reliant on out of market payments see gas generation assets out of merit and not recovering long run marginal costs. In an 'energy only' market, investment is unlikely to be forthcoming as investors will not receive adequate return.

The Future for Gas Networks

In the second part of our analysis, we examine the implications of reduced running hours for gas generators on the flow of gas through the gas network and hence payments and return on investment to owners of gas network assets. Figure 2 illustrates a potential change in tariffs charged to gas transmission network customers for transporting gas which factors in gas demand for power generation but also other sectors. These changes in tariffs are required to recover network costs which are largely fixed.

Networks with a greater proportion of gas used in power generation relative to final energy demand are subject to a greater risk of tariff increases in this period. Portugal which could see the highest increase in tariffs is largely being driven from a decline in gas consumption in sectors outside of power generation such as residential, services and industrial demand for gas. The same is also true for Spain and Latvia. This shows that the demand for gas in other sectors can have an impact on the viability of gas in power generation. Interestingly, in some member states, while a fall in gas demand in power generation is increasing tariffs an increase in gas consumption in other sectors is reducing them.

Conclusion

Decarbonisation of European electricity generation has led to significant price volatility and changes in operational regimes for owners of gas generation assets. This has significant implications for risk and return for investors in European electricity generation and related infrastructure assets. This paper provides the first Europe wide assessment of the comparative risk for investors in gas generation and network transmission assets. The findings of this analysis point to an uncertain future for both gas generation and network assets in Europe. Under the assumptions of the European Commission Reference Scenario the investment case depends on the availability of out of market payments. Without significant market reform, investment capital is unlikely to be forthcoming.

Capacity remuneration payments and other out of market payments are being used in member some member states to ensure that gas generation assets recover long run marginal costs (their capital costs) . and to reward generators who provide system services to balance variability from renewables. This analysis represents just one vision for the future, with an assumed price of gas, and there are limitations to the financial modelling approach. However, the paper highlights issues for regulators and policy makers if the EU Target Electricity Model's objectives of reliability, sustainability and affordability are to be maintained.

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Dual Plenary Session 2: Understanding Individual and Collective Consumer Behavior

Summarized by Gloria JinaKim, PhD student, KAIST, Korea

This Dual Plenary Session was chaired by Reinhard Madlener, RWTH Aachen, Germany. He was joined on the panel by Anna Alberini, Dept. of Agricultural and Resource Economics, University of Maryland, USA, Marilyn Brown, School of Public Policy, Georgia Tech, USA, and Kristina Rodig, Head of Global Customer and Market Insights, E.ON, Essen, Germany.

The three speakers discussed the needs and behavior of energy consumers / prosumers, both at the individual level and the aggregate level.

Anna opened the discussion about consumers' understanding on energy price and energy efficiency. She suggested possible behavioral theories, such as habit formation and salience bias that possibly explain consumers' price insensitivity.

Marilyn continued her discussion about the cost of information. Focusing on energy efficiency gap, she proposed plethora of social theories, like beliefs, attitudes, values, social norm and other contextual factors. She enlightened the need for reconciliation of the array of concepts, frameworks and theoretical platforms.

Kristina enriched the panel discussion by adding the real-world practice of consumer behavior. She presented several segments of consumers and appealed the needs for consumer centric lifetime approach for understanding consumer behaviors.

IAEE Best Student Paper Award

By Fabian Moisl, IAEE Student Council Representative

One of IAEE's cornerstone student events in the course of its conferences is the Best Student Paper Award (BSPA) competition. The authors of four excellent papers get the chance to present their work at a special concurrent session and compete for the top prize of US$1000. Furthermore, all four nominees receive a waiver of registration fees.

In a close decision by the BSPA Committee, Derck Koolen, a PhD candidate from the Erasmus University (Netherlands) who presented his paper "Forward Trading and the Value of Flexibility in Sequential Electricity Markets with Increasing Intermittent Supply" was announced as winner during the conference dinner at the Groningen Martini Church.

Three runner up prizes of US$500 each were awarded to Thorsten Burandt from TU Berlin (Germany) for the paper "Emission Pathways Towards a Low-Carbon Energy System for Europe – A Model-Based Analysis of Decarbonization Scenarios", Cyril Martin de Lagarde, Paris Dauphine University (France) for the paper "Diffusion and drivers of residential PV in France" and Jens Weibezahn from TU Berlin (Germany) for the paper "Unit Commitment under Imperfect Foresight – The Impact of Stochastic Photovoltaic Generation".

All presentations can be found online at the Goningen conference website http://iaee2018.com/concurrent-session-b14/

Technical Tour – Groningen Seaports on Thursday 14 June

By Caro Dahl, Professor, Colorado School of Mines

We were greeted at Eemshaven by row upon row of onshore wind turbines turning the winds off the North Sea into power. Eemshaven is a much smaller port than Rotterdam, however it has high value petrochemicals pass through and it is also a staging point for the North Sea offshore wind farms for the Dutch and German sectors of the North Sea. Additionally, it is also a Wetlands World Heritage site and a haven for numerous birds. Port`s representatives are proud of their environmental record and talked of potential plans for decarbonizing the port with a move to a bio-based petrochemical industry fueled by wind and power.

Delegates concluded the overview by donning 3-D glasses for a virtual helicopter trip over the port. Next, we turned in our virtual glasses and donned life vests for a speed boat tour, which gave us a water side view of the port. As boys will be boys, and the speed boat captains were boys, they did their best to get us a little wet with rain and North Sea water and convince us the next swerve would toss us into the drink. But we lost no one and all lived to have another drink on the way back to Groningen.

Since the Dutch are the tallest Europeans, us shorties had a bit more coat than we needed. From the outside we saw turbines, boiler, generators, conveyors, mills, precipitors and more. Although the coal plant is not exactly sustainable, they were proud of the plant being the newest and most efficient coal power plant in Europe and very clean as coal plants go. However, given the Dutch commitments to the Paris Agreement, this plant may not live to a ripe old age. Its demise will require replacing one 1600 Megawatt (MW) plant that runs most of the time with energy dense coal with hundreds of wind turbines and solar panels that run only part of the time but get their fuel for free or with some other yet to be specified option.

Satisfied with our day, we were treated with drinks and snacks along a canal next to an historical Dutch windmill on our way back.

Cost Estimates and Economics of Nuclear Power Plant Newbuild: Literature Survey and Some Modeling Analysis

BY BEN WEALER, CLAUDIA KEMFERT, CLEMENS GERBAULET, AND CHRISTIAN VON HIRSCHHAUSEN

The authors are with the German Institute for Economic Research (DIW Berlin), where they are part of a long-term research program on nuclear energy, run jointly with Workgroup for Infrastructure Policy at the Berlin University of Technology. Corresponding Author: **Ben Wealer**: bw@wip.tu-berlin.de, bwealer@diw.de. For other publications, see: https://www.diw.de/sixcms/detail.php?id=diw_01.c.528152.en. We thank Simon Bauer, and Hannah Seiß for research support; the usual disclaimer applies.

See footnotes at end of text.

Introduction

The perspectives of nuclear power deployment in the long-term depend very much on the development of costs, in relation to other low-carbon options, and the economics of investments into new capacities. While there is a consensus in the literature that nuclear power is not competitive under regular market economy, competitive conditions[1], at least two issues need to be considered going forward. First, the evolution of future technologies, and second, the treatment of "costs" in other, non-market institutional contexts, such as indigenous suppliers or "home suppliers" or the new (heavily subsidized) export models of countries like China or Russia. The objective of this paper is to provide insights into the economics of nuclear power for electricity generation by considering the perspective of a private (or public) investor.

Status Quo: Reactor Vendors in Financial Troubles and Tainted Technologies

Gen I and Gen II reactors were mainly constructed by integrated home suppliers (Thomas 2010). Table 1 shows, that this is still the case for the majority of the current newbuild projects: in China by majority-owned Chinese companies, in Korea by the state-owned KEPCO, or in Russia by state-owned Rosatom. Near-term future deployment in the "West" currently consists of the EPR or the AP1000. But, especially the EPR could never meet its high expectations and today all three construction projects are well behind schedule and well over their initial cost estimate. In the U.S, no Gen III/III+ has finished construction too

A popular financing policy tool for exporting reactor technology is the concept of "nuclear diplomacy", where the reactor technology is practically given away for free. The strategy consists of delivering the needed capital too, i.e. in form of low-interest

Country	Construction capacity in MW (NPP	Technologies	Generation	Supplier
Argentina	25 (1)	Carem25	SMR	Argentina
Belarus	2,218 (2)	VVER V-491	Gen III+ (2)	Atomstroyexport
China	19,500 (19)	ACPR-1000, HPR-1000, HTR-PM, VVER V-428M, AP-1000, EPR	Gen III (13), Gen III+ (6)	China, cooperation with Toshiba, Areva, and Atomstroyexport
Finland	1,600 (1)	EPR	Gen III+	Framatome
France	1,600 (1)	EPR	Gen III+	Framatome
India	3,907 (6)	PHWR-700, VVER-1000,	Gen II (4), Prototype FBR	Indian, Atomstroyexport Gen III (1), Other (1)
Japan	2,650 (2)	ABWR		Hitachi-GE
Pakistan	2,028 (2)	ACP-1000		China
Russia	4,359 (7)	VVER V-320, VVER V-392 M, VVER V-491, KLT-40S	Gen II (1), Gen III+ (4), Other (2)	Russia
Slovakia	880 (2)	VVER V-213	Gen III+	Atomstroyexport
South Korea	5,360 (5)	APR-14000	Gen III	KEPCO (South Korea)
United Arab Emirates	5,380 (4)	APR-14000	Gen III	KEPCO (South Korea)
USA	2,234 (2)	AP1000	Gen III+	Westinghouse
	51,741 (54)			

Table 1: NPP construction projects in 2017 by country, reactor design, and supplier, worldwide
Source: Own depiction based on Wealer et al. (2018, 32) and inspired by Thomas (2010).

loans; this is extensively done by Russia (Hirschhausen 2017) and China (Thomas 2017). As the interest during construction can be as much as 30% of the overall expenditures, financing costs can be a major barrier for investment. To overcome this, grace periods are often introduced, e.g. Russia offered Bangladesh for the Rooppur NPP a 10-years grace period for the around 12 billion low interest loan.[2]

Due to low construction orders since the 1970s the traditional reactor vendors are in serious financial troubles and own production lines were closed. In 2017, Westinghouse filed for Chapter 11 bankruptcy protection in the US and was sold by Toshiba; Areva was bailed out by the French state (5 billion € capital increase), split up, and the reactor division was sold to EDF; while Hitachi never exported a reactor and its ABWR has been proven as unreliable.[3] Applying a conventional economic perspective, such as proposed by Rothwell (2016), to decompose overnight construction costs (OCC) into indirect and direct costs and the latter into different technical components helps identifying cost positions, which have the most impact on total construction cost. The cost breakdown for a Gen III/III$^+$ shows that the reactor equipment has with 40% the highest impact.[4] It is therefore instructive to have closer look on the supply chain, especially for reactor pressure vessels, which is the most constrained.[5] Here, the major player is Japan Steel Works (JSW) with a market share of 80%. Already in 2009, Westinghouse was constrained as some parts for the AP1000 could only be delivered by JSW. The second major player is Areva-owned Le Creusot in France, which is currently being investigated due to irregularities in quality-control documentation and manufacturing defects of forged pieces produced for the EPR as well as the operational reactors, leading to multiple shutdowns in 2016.

The Perspectives for Nuclear Newbuild

Overnight construction cost (OCC) estimates for Gen III/III$^+$

Not only historical OCC show escalation but estimates too: The MIT (2009) study updated its OCC from 2,000 US$/kW to around 4,000 US$/kW, as did the University of Chicago (2011) study. A recent survey by Barkatullah and Ahmad (2017) finds OCC to be (on average) 6,100 US$/kW for an EPR. Sharp and Kuczynski (2016) estimate OCC for the AP1000 to be around 6,000 US$/kW. Figure 1 compiles different construction cost estimates for Gen III/III$^+$ reactors for the US and European market as well as the current cost estimates for the European and US construction projects.[6]

As always all these cost figures omit costs for decommissioning and waste disposal. As of today, only a few reactors have been decommissioned and actual decommissioning costs are scarce. In the U.S., where the most NPPs were completely decommissioned costs show a high variance, from 280-1,500 US$/kW (excluding waste disposal). In Germany, current decommissioning cost estimates are around 1,250 €/kW, if one includes interim storage and final disposal of radioactive wastes this amounts to 2,000 €/kW.[7]

Future reactor technologies: Gen IV and SMR[8]

As large NPPs face increasing construction cost and construction time, SMRs are presented as a possible solution but no SMR has ever been operated and current projects suffer from serious delays, both in construction and reactor design. A necessary condition to export a standardized SMR across borders is to have common licensing and regulations in different countries. Since standardization is key for manufacturing SMRs, regulations have to be harmonized. Regarding the diversity of institutions, Sainati et al. (2015) consider that "it is difficult to make significant progress in this direction in the short-medium term". Multiplying SMRs around the globe can thus only happen if a common regulatory framework is designed. At the moment, the economic viability of SMRs is not clear, and they are no option any private investor would seek (Hirschhausen 2017).

Gen IV reactors are considered to be revolutionary but looking closer at the researched Gen IV reactors, one remarks that they are only partly based on fundamentally different technological concepts, e.g., HTRs have been around for at least half a decade and have been proven unsuccessful, the concepts of FBRs and thorium reactors even since the 1950s. As only a few prototype reactors are under construction (e.g., a lead-cooled fast reactor in Russia), future cost estimates are very uncertain. At the moment, deployment for commercial construction seems far from certain; many experts believe that Gen IV reactor types are unlikely to be readily available and competitive anytime soon due to even higher capital costs than Gen III$^+$ reactors.

Monte-Carlo analysis of investment NPV and nuclear LCOE

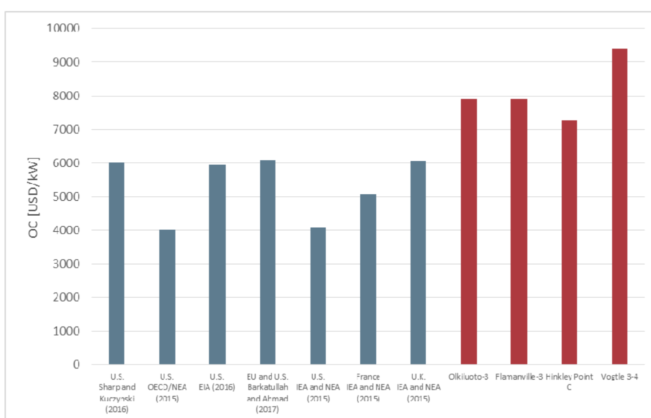

Figure 1: Current overnight construction cost estimates for Gen III/III$^+$ reactors in the US and Europe and cost estimates for current construction projects

Source: Own depiction.

	Nuclear	Coal	Nat. Gas
Baseline (2016) (no CO_2-price)	11.0	5.1	5.0
CO_2-price: 25 €/t	11.0	6.3	5.7
CO_2-price: 100 €/t	11.0	10.0	7.9

Table 2: Levelized costs of conventional electricity (€cents/kWh) Source: own calculations.

Based on the analysis of the levelized cost for electricity generation Davis (2012) concludes, that nuclear power is not competitive compared to natural gas- and coal-fueled electricity generation. This kind of analysis has been conducted in 2016 by DIW Berlin, using a similar methodology, but in a European context. The calculation shows, that nuclear power remains uncompetitive, even when the CO2-price is set to 100€/t CO2 (See Table 2).[9] The investment cost for nuclear power plants have been adjusted to take into account the development since 2013 and are set to 7,500 €/kW[10], and the fuel prices reflect the current situation. An availability of 80% (~7,000 full load hours), and a calculation horizon of 50 years have been anticipated

As neither the LCOE concept nor OCC incorporate any information on the electricity price, we check for profitability for a potential investor by employing a Monte-Carlo analysis of the net present value with the main input parameters wholesale electricity price (30 to 50 €/MWh), investment cost (4,500 to 7,500 €/kWh), debt capital interest rate (5% to 10%), and equity capital interest rate (2% to 10%). The analysis shows that even substantial variations of the main input parameters do not change the overall conclusions: With an average Monte Carlo NPV of around -7.2 bn €, the profitability is very negative. To make investments reach a NPV of 0€ a retail price over more than 90€/MWh would be needed. Considering the falling electricity prices due to a rising share of renewables, this seems to confirm that nuclear power is not competitive under regular competitive conditions.

Conclusion: Nuclear Power is Not Competitive

We find that investment costs for NPPs have significantly increased in the western hemisphere over the last decades and no learning effects could be seen. Current OCC are estimated to be above 6,000 €/kW but they have to be regarded critically; this also applies for decommissioning costs. The breakdown of costs into different systems allowed us to identify some system costs, which are more sensible to future increases. The supply chain for the reactor pressure vessel is the most constrained. In addition, the traditional reactor vendors are in financial troubles with tainted technologies - not one Gen III/III+ has been successfully connected to the grid in the "West". In fact, Post-Fukushima (2011) is characterized by the implosion of nuclear power in Western capitalist market economies, and many of the newbuild projects were abandoned. This leaves the development of nuclear power to "other", non-market systems, where countries hang on to nuclear development, for political, military-strategic, or other reasons, mainly the nuclear superpowers China and Russia. If Russia and China are able to provide the role of a global supplier needs to be seen, but both countries provide a strong government backed package including financing as a policy tool ("nuclear diplomacy"). Although, it is unclear how long Russia is able to sustain this practice, given the macroeconomic weakness of the country (Hirschhausen 2017). When comparing the LCOE of nuclear power plants to other renewable and fossil technologies, competitiveness is far from being in sight, even with a CO2-price of 100€/t, there is no profitable investment to be expected where nuclear becomes competitive.

Footnotes

1 The recent Data Documentation 93 by the DIW Berlin analyzed the worldwide diffusion of NPPs and concluded that none of the 674 reactors analysed in the text, has been developed based on what is generally considered "economic" grounds, i.e. the decision of private investors in the context of a market-based, competitive economic system. See Wealer, et al. (2018).

2 See Schneider, et al. (2017).

3 See Thomas, Steve. 2017. "Corporate Policies of the World's Reactor Vendors." presented at the 21st REFORM Group Meeting, Salzburg.

4 Cost breakdown: structures & improvements (20%), reactor equipment (40%), turbine generator equipment (25%), cooling system and miscellaneous equipment system (15%), and electrical equipment (10%) (Rothwell 2016).

5 As they require heavy forging presses of about 14-15,000 tonnes capacity and need to accept hot steel ingots of 500-600 tonnes. See World Nuclear Association. 2016. The World Nuclear Supply Chain: Outlook 2035.

6 The current cost estimates for the European and US construction projects are drawn from the World Nuclear Status Report 2017 (See Schneider et al. 2017).

7 See Warth & Klein Grant Thornton AG Wirtschaftsprüfungsgesellschaft. 2015. Gutachtliche Stellungnahme Zur Bewertung Der Rückstellungen Im Kernenergiebereich. Berlin.

8 See Wealer et al. (2018) for more details.

9 The basis for the cost estimation can be found in the DIW Data Documentation 68. See Schröder et al. (2013) "Current and Prospective Costs of Electricity Generation until 2050" DIW Berlin, Data Documentation 68.

10 6,000 €/kW + 1,500 €/kW for decommissioning and storage.

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PhD Dinner and Networking Event

By Fabian Moisl, IAEE Student Council Representative

On Sunday evening after the Welcome Reception students and young professionals were invited to meet at the Ni Hao Restaurant in the Groningen city center and enjoy a broad variety of Asian cuisine and drinks.

Student Representative on Council, Fabian Moisl, welcomed the delegates and pointed out all the services IAEE provides for its members: reduced conference fees, access to IAEE's publication (e.g. The Energy Journal and EEEP) and educational programs like summer schools and PhD seminars are just some popular examples.

Furthermore, the fact that motivated students are more than welcome to engage in IAEE by joining a student chapter or creating a new one if none exists at their home university was stressed once more.

Dual Plenary Session 3: Future of Natural Gas Markets

Summarized by Ekaterina Dukhanina, PhD Student, CERNA, Mines ParisTech and Phuong Minh Khuong, PhD candidate, Energy Economics Chair, Karlsruhe Institute of Technology

This dual plenary session was chaired by Machiel Mulder, Professor at the University of Groningen, The Netherlands. Prof. Mulder was joined by Hill Huntington, Executive Director Energy Modelling Forum, Stanford University, USA; Knut Einar Rosendahl, Professor of Environmental and Resource Economics, Norwegian University of Life Sciences, Norway and Ying Fan (Beihang University): Director of Beihang Center for Energy and Environmental Policy Research, Beijing, China.

The session "Future of Natural gas markets" attracted many academic researchers and professionals interested in perspectives on the role of natural gas in the transition of energy markets. After an introduction by Machiel Mulder, Hill Huntington, an Executive director Energy Modelling Forum, Stanford University, provided insights into the US natural gas industry. He pointed out a huge potential of shale natural gas development in the US and highlighted its future trends: with reduced and currently attractive prices, the gas displaces coal for power generation, brings broader fuel competition, and boosts US geopolitical power. However, given its continuing increase, gas will unlikely becomes long-term climate savior since it can endanger groundwater and could cause earthquakes if over-exploitation. In addition, uncertainty of future gas prices might have strong impact for the next decade the shale gas will continue to transform North American markets and exports will become more competitive.

Talking about the future of Russian gas exports to the European market, Knut Einar Rosendahl, Professor of Environmental and Resource Economics, Norwegian University of Life Sciences, Norway, presented the future of Russian gas exports to the European market. Prof. Rosedahl concluded that it is unlikely to have a golden age for the gas in Europe and Russia has other options for its gas (Asian markets and LNG). New pipelines from Russia to the Europe would rather have strategic or geopolitical, than economic interest.

Ying Fan, Director of Beihang Center for Energy and Environmental Policy Research, Beijing, China, provided insights into Chinese gas markets: increasing gas demand in China will be satisfied by new pipelines and LNG. However, the reform of gas pricing system in China and the speed of development of the renewables leave some uncertainties about the future of natural gas in this country.

A Supra-National TSO to Achieve Offshore Meshed Grids Infrastructure in the Baltic Sea: A Legal-Regulatory Point of View

BY CLAIRE BERGAENTZLÉ, KANERVA SUNILA, BÉNÉDICTE MARTIN AND ARI EKROOS

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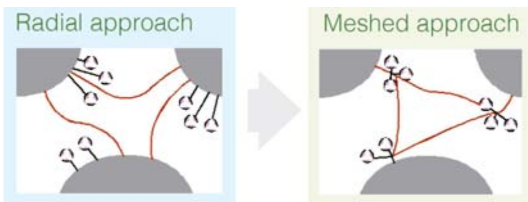
This research is part of the Baltic InteGrid project, which received funding from the Interreg Baltic Sea Region Programme 2014-2020.

The electricity network investment need (EUR 420 billion by 2050 according to [1]), associated with ambitious renewables integration targets, requires to investigate hybrid architectures such as 'offshore meshed grids' (OMGs). OMGs are dual-purpose infrastructure that combine the functions of offshore wind farm (OWF) connection and cross-border interconnection and that span across multiple countries and actors, i.e. independent wind farms operators and national transmission system operators (TSOs) (Figure).



Offshore Meshed Grids to Address European Energy Targets

OMG have gained a growing attention both from European institutions and utilities. The European Union (EU) actively supports several initiatives which contribute to shedding light on a large array of technical, institutional, administrative, legal and economic conditions for OMG development. In 2010, the North Seas Grid Initiative project was launched, followed by the PROMOTioN project and, more recently, the Baltic InteGrid project. Utilities are also engaging in hybrid projects such as the Kriegers Flak Combined Grid Solution project and the future Power Island hybrid project [2]. The Polish TSO, PSE S.A, announced a hybrid offshore grid solution will be considered if offshore wind development is higher than the 4 GW currently planned [3].

The main arguments for OMG are to connect more wind energy while supporting cross-border exchange of electricity, thus tackling the three pillars of the EU energy policy: RES penetration (sustainability), markets integration and system reliability [4]. At the power system level, OMGs optimise the use of the grid infrastructure. The dual-purpose characteristic of OMG increases the network's utilisation factor as compared to a classical radial connection and thereby represents a strong economic argument for development. In addition, OMG would enable the development of large-scale OWF located far away from shore and therefore would not interfere with public acceptability. However, in spite of the expected benefits, the uptake of OMG is slow and remains limited to a small amount of stakeholders.

Past research concludes such situation results from unsuited legal and regulatory frameworks [5]–[10] and studies OMG development using technical-economic optimisation methods based on the assumption that regulatory barriers are removed [11]–[13]. Using the Baltic Sea basin as a case study, our study analytically reviews the main barriers to OMG development by combining legal dogmatics and regulatory economics and addresses how to remove them. Our main contribution is to propose a solution at the crossroad between the two disciplines.

An Unsuited Legal Framework…

Within the legal perspective, difficulties arise from the lack of explicit definition for OMG [14]–[18]. In the EU electricity market law, the high-voltage power cables are basically differentiated according to the purpose and the operator of the cable: the cables considered as part of a transmission system operated by a TSO, and the connection lines and cables linking a connection point (production unit or a consumption place) to the network. The division of regulated assets and private assets vary between the national legal frameworks. Connection cables, if considered as unbundled assets by national legal frameworks, are the responsibility of OWF operators and follow the private investment decisions. Interconnectors are, if not exempted, regulated assets that must comply with the requirements of TSO unbundling. The costs of interconnectors are recovered mainly through national grid tariffs and by congestion incomes.

The cables of OMG serving dual-purpose are currently not delineated. The dual-purpose nature of OMG and the multiplication of applicable rules due to the different co-existing national legal framework at the sea basin level affect inevitably actors' legal and financial responsibilities and risks. Currently, the parties have no incentives, nor necessarily even possibility, to invest in dual-purpose cables [19].

… That Creates Regulatory Barriers and Prevents Investment

Because national legal frameworks and TSOs' regulation are tightly embedded, regulatory economics gives the right conceptual framework to assess the repercussions of the lack of explicit definition. The poor harmonisation across national transmission grid tariffs and the different connection approaches for OWF are the two main factors that hinder coordinated investments in hybrid projects (see table).

Different tariffs applied to a single infrastructure result in different behaviours from the stakeholders in response to: the tariff levels (what proportion of the tariff pay each category of grid user, consumer vs. generator); structures (what distribution between fixed and variable costs); and the presence of locational components. In the Baltic Sea countries, only the generators connected to the Nordic countries' grid must pay a tariff, which substantially differs in its structure and cost components. When assessing the suitability of grid tariffs to promote OMGs, the tariffs' interaction with the intermittency of the electricity generated by the wind farm is the key parameter to consider. Tariffs with a large share of fixed costs and using locational components are, *ceteris paribus*, riskier for OW operators to invest in as compared to simple energy-based tariff (for more details, see [20]).

	Grid tariff			Connection
	Tariff for generator	Tariff structure	Locational component	cost mainly borne by
Denmark	Yes	Energy only	no	TSO
Estonia	No			OWF
Finland	Yes	Energy-based	no	TSO/OWF
Germany	No			TSO
Latvia	No			OWF
Lithuania	No			OWF
Poland	No			TSO/OWF
Sweden	Yes	Capacity-based	yes	OWF

The way OWF's connection costs are distributed between TSO and OWF operator defines who bears the investment risk and also directly affects the viability of the OW project (for a review of the different approaches and their implication see [21]). Launching an OMG initiative in the Baltic Sea without prior alignment in connection cost allocation and access tariff would inevitably result in distorting OWF investments, incentivising connection to the German, Polish or Danish grid, supposedly at the expense of economic and or environmental optimum. For wind energy experts [22], current regulatory frameworks increase investor's perceptions of risk. At the TSO's level, the multiplicity of cost distribution and recovery methods ultimately creates an uneven level playing field among TSOs and conflicts with the completion of a joint coordinated investment project. The entanglement of national interests on top of the investment landscape identified in [17], [19], adds another layer of difficulty before reaching a common agreement on the development of OMG.

Introducing an Independent Offshore TSO

Against this background, the introduction of an independent offshore TSO is investigated to circumvent and enable OMG. First, practically concentrating the grid investment decisions to one entity could solve problems relating to the allocation of costs between several TSOs and OWFs. Accordingly, the investment decisions could become more straightforward. Second, the suboptimal investment incentives for OWFs could at least partly be avoided as there would be a level playing field originating from the clear division of tasks between OWF operators and offshore TSO. In addition, regional approach instead of contradicting national interests could be easier to implement through one entity than by several entities involving in the projects. The introduction of a supra-national offshore TSO would require new legal definitions at the EU level – and harmonisation at some extent – and, for example, the question of offshore grid financing and implementation of right incentives should be solved in this context.

Discussion

The development of offshore meshed grids in Europe has taken its first steps almost a decade ago, but the progress is still hindered by regulatory and legal barriers. This article has focused on the main economic barriers for OMG construction in the Baltic Sea region and stressed out how limited harmonisation of the regulatory framework for transmission system connection cost distribution and cost recovery leads to sending uneven signals to market actors, therefore distorting investment decisions and to creating uneven levels of risk for TSOs at the regional scale. While some energy producers have advocated a shift of grid operation and capital investment activities to the market actors, involving more separated activities and a multiplication of stakeholders, we highlight the need for coordinated actions, pervading to OMG projects, conflicts with such tendency. According to our analysis, the introduction of an independent offshore TSO could address the identified problems in centralising development decisions while responding to a single regulatory framework. However, new questions also arise, mainly relating to the governance of this actor: the introduction of a supra-national TSO necessitates to design a legal framework to implement and monitor its functions, in respect with the EU law and national sovereignty.

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IAEE Student Chapter Leaders Meeting

With the aim of driving forward products and services IAEE offers for student members, the leaders of ten student chapters and IAEE's student representative met in the course of the 41st International Conference in Groningen.

One objective of the meeting was to increase awareness of each other's events and to discuss possible collaboration between student chapters.

Another important item on the agenda was a discussion about how IAEE could retain former students after their transition into professional life, which resulted in a list of ideas of better services for students and young professionals. Among those was the intention of building a mentoring program where seniors provide advice and knowledge to younger members. Furthermore, young professionals could benefit from networking opportunities (e.g. business cocktails) and the student chapter leaders agreed that IAEE's job bank service should be improved including an increase in jobs offered.

Last but not least, the recently established working paper series of USAEE and IAEE aims at increasing the circulation, visibility, and impact of research within the IAEE community and could be of great interest for PhD students and young professionals.

To better point out services and events and to improve communication as a whole, IAEE is setting up a social media team which is currently looking for volunteers who are motivated to contribute.

CONFERENCE OVERVIEW

The 3rd Eurasian Conference will take place in Baku, Azerbaijan, on October 18 -20, 2018.

In addition to its rich program, with its informal social functions, the conference will provide a unique opportunity for networking and enhancing communication amongst energy professionals from business, government, academia and other circles worldwide.

The conference program is being prepared by an International Program Committee to ensure that critical issues of vital concern and importance to governments and industries are presented, considered and discussed from all perspectives. In this context, many existing sessions on key current energy issues, featuring internationally established speakers and lively discussions, can be expected. The local arrangements are being planned by a Local Organizing Committee to guarantee excellent logistics at best quality. The Sponsorship Committee works to make sure the rich program and arrangements of the conference get available to delegates at affordable rates.

CONFERENCE COMMITTEES

General Conference Chair:
Prof. Dr. Vilayat Valiyev, Director of Institute for Scientific Research on Economic Reforms (ISRER), Ministry of Economy of the Republic of Azerbaijan, Vice President of IAEE for Regional Affairs

Program Committee Chair:
Prof. Dr. Gürkan Kumbaroğlu, Boğaziçi University, Past president of IAEE

Local Organizing Committee Chair:
Mr. Fariz Mammadov, Chief Scientific Worker of ISRER

Sponsorship Committee Chair:
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Regional Support Committee Chair:
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TOPICS TO BE ADDRESSED INCLUDE:

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

- **Petroleum Economics**
- **Economics of Gas Trading**
- **Geopolitical Competition in the Caspian Basin and Middle East**
- **Energy Modeling**
- **Energy Markets and Regulation**
- **Challenges in Gas Supply and**
- **Transportation**
- **Energy poverty and Subsidies**
- **Regional Energy Markets**
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Evaluation of the Role of National and Local Authorities in Electric Vehicle Promotion Systems

BY POVILAS MAČIULI, INGA KONSTANTINAVIČIŪTĖ AND VAIDA PILINKIENĖ

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Overview

Although electric vehicles can significantly contribute to energy consumption efficiency, reduction of carbon dioxide emissions and independence from petroleum imports, numerous technical and economic challenges burden electric vehicle mass-market adoption (Kley et al., 2010). Having faced the problems of air quality decrease, a number of countries worldwide are striving to promote electric vehicle usage. One of the reasons why natural market entry for electric vehicles is relatively slow can be linked to their prices, which are higher than the prices of traditional fossil fuel-driven vehicles. Trying to improve the situation, national and local authorities develop promotive policy instruments which enhance competitiveness of electric vehicles and increase their popularity among consumers (Yang et al., 2016). Significant public interest in electromotive technologies and the environmental impact of these technologies determines topicality of such problems as efficiency and effects of electric vehicle promotion measures researched by Hall et al. (2017), Hall and Lutsey (2017), Jin and Slowik (2017), Yang et al. (2016), Mock and Yang (2014), Alhulail and Takeuchi (2014), Windisch (2013), Perdiguero and Jiménez (2012), and many other authors. In terms of promotion of the transition from traditional fossil fuel-driven vehicles to electric vehicles, local authorities do not lag behind national authorities and demonstrate the ability to significantly reduce carbon emissions in the transport sector. Even after incorporating upstream emissions, electric vehicles provide a carbon emission reduction advantage, which in Chinese, European and U.S. markets varies from 30% to over 98% in comparison to the statistics of traditional fossil fuel-driven vehicles. In the area of electric vehicle promotion, contribution of not only car manufacturers but also energy producers is essential, especially in terms of energy decarbonisation (Hall et al. 2017). Nevertheless, electric vehicle promotion systems, measures and even goals may significantly vary at different levels: some of them are implemented at a national level, while others are orientated towards local resources and focus areas (Yang et. al, 2016). Particular effects can also be caused by some other determinants. For instance, Alhulail and Takeuchi (2014) note that the sales of eco-friendly cars can be significantly affected by fuel prices, car model prices and population income. Fuel prices, however, are not stable, and even if high prices can affect the sales of eco-friendly cars, these changes can turn out to be only temporary. The main purpose of this article is to research the most common electric vehicle usage promotion measures at different administrative levels.

Methods

Interdesciplinary research, literature review.

Results

The review of the key differences between the focus areas and promotion measures implemented at the national and local administrative levels has been presented in table (compiled by the authors) on the next page:

Conclusions

The above-analysed examples of electric vehicle promotion indicate that complementation of national policy schemes with local policy measures may help to create electric vehicle-favourable environment and reduce barriers for consumers. Development of charging infrastructures, considered to be the key determinant of electric vehicle promotion, is the responsibility of both national and local authorities: national authorities set the standards and build highway infrastructures, while local authorities take care of arrangement of charging points in each of microdistricts. Arrangement of charging points can be treated not only as a promotive measure (especially, minding subsidies, grants or preferential loans for establishment of charging points at homes, workplaces or public areas), but also as building of the necessary infrastructure.

In the initial stage of electric vehicle promotion, the actions of national authorities that set the political aims of general planning and co-ordination serve as a signal to manufacturers and service provides about the changes in the demand for electric vehicles in the future. Standardisation, which ensures interaction of electric vehicles inside and outside a country, along with economic and regulatory mechanisms can be treated as the other key instruments. The main purpose of financial incentives is to reduce electric vehicle prices or usage costs so that the critical differences between electric and traditional vehicle costs would be eliminated. Regulatory mechanisms, such as pollution taxes, restrictions and limitations, can cause side effects for the substitutes of electric vehicles. The decisions of national authorities may affect fossil fuel prices, while the growth of petrol and diesel prices may directly affect the usage of alternative means of transportation. In this case, sales mandates, which fix the proportion of electric vehicles in the total number of newly-sold vehicles, can be introduced. The

Administrative levels	Focus areas	Policy framework Examples of measures
National	Setting national goals Standardizations Regulations Deployment of chargubg infrastructures Financial initiatives Marketing	• Exemption from VAT • Direct subsidies for vehicle consumers • Tax credits • Financial support for car manufacturers • In•centives in energy taxation • Incentives in vehicle registration taxes • Annual vehicle tax reduction • Initiatives for public charging infrastructure • Regulation of charging infrastructure • Fuel regulation incentives • Cap and trade system • Green public procurement • Obligation for new constructions • R&D stimulation • Sales mandates • Promotion campaigns
Local	Setting local goals Marketing Parking policy Traffic management tools Urban access restrictions Fleets upgrade Private and public partnerships Deployment of charging infrastructures Financial Incentatives	• Initiatives for home charging infrastructure • Incentives for business charging infrastructure • Initiatives for public charging infrastructure • Regulation of charging infrastructures • Obligation for new constructions • Fleet tests and demonstration programs • Incentives in parking policies • Bus lane incentives • Road pricing incentives • Congestion taxes • Low-emission zone incentives • Route/Access restrictions • Promotion campaigns • Consulting

other method, applied in China, is provision of electric vehicle purchase subsidies only for domestically made vehicles. Summarising, it can be stated that the actions of national authorities are concentrated at the macro level.

Despite significance of the role of national authorities, it is also the case that local authorities are closer to consumers, and therefore can more efficiently communicate with all social groups and co-operate with business, which, in turn, helps to create synergy by employing not only financial and non-financial measures, but also marketing campaigns, consulting and provision of the basic information. The latter measures qualitatively change consumer attitudes towards alternative transports. Local authorities can also take the initiative to reform car, public transport and taxi fleets. They have a direct impact on the micro-level focus areas which are linked to traffic and transport regulation: parking policies, traffic management tools and urban access restrictions. Such benefits as convenience and cost saving opportunities are effective electric vehicle purchase and usage motivators. Successful pilot projects implemented on a city scale combine multiple measures.

The findings of this research do not propose that the functions of national and local authorities never duplicate, and the similar or same financial and non-financial measures are never employed at the national and local levels. On the contrary, adjustment of national and local actions along with a comprehensive approach towards electric vehicle promotion can significantly enhance the efficiency of the measures applied. Regions (the role of which has not been comprehensively analysed in this article) are intermediates between national and local authorities. They can also play a significant role in implementation of regional policies. It should be noted that the conclusions of this research on the functions of national and local authorities reflect the regular trends. However, in some cases, irregular administrative distributions can be found. For instance, Chinese municipal authorities provide the subsidies that are commonly provided by national authorities; vast majority of electric vehicle promotion measures in Norway are implemented at the national rather than local level, etc. Hence, as sets of municipal functions and powers may differ, the measures implemented in particular jurisdictions not necessarily suit other jurisdictions.

See References on page 55

Can Transport Policies Contribute to the Mitigation Potential and Cost of Stringent Climate Change Targets?

BY RUNSEN ZHANG, SHINICHIRO FUJIMORI AND TATSUYA HANAOKA

Limiting warming to below 2°C and 1.5°C is ambitious and undoubtedly a very challenging task. Achieving 2°C and 1.5°C goals requires more rapid and profound decarbonization of the energy supply and a high carbon price, which will generate mitigation costs such as GDP and welfare loss. Because the transport sector represents a quarter of global CO_2 emissions and is recognized to be one of the main causes of global warming, the decarbonization in the transport sector is supposed to contribute to the achievement of the stringent climate mitigation targets.

To achieve a better understanding of the role of transport policies in achieving climate change targets, the main purpose of this research is to investigate the interaction between transport policies, global dynamics of transport demand volume, mitigation potential, and the cost of meeting the goal of limiting warming to below 2°C and 1.5°C. To capture the interplay between the transport sector and the macroeconomy, a global transport model, AIM/Transport, coupled with AIM/CGE has been used to overcome the shortcomings of individual CGE and transport models. By doing this, both the traveler's mode choice and technology details, and an interactive analysis on mitigation potential and cost of transport policies, can be incorporated into a projection of global passenger and freight transport activities.

Methodology

A transport model, AIM/Transport, is developed to project the global passenger and freight transport demand for different modes and technologies and transport-related emissions, incorporating transport mode choice and technological details. AIM/Transport is coupled with a global computable general equilibrium model AIM/CGE to capture the interactive mechanism between the transport sector and the macroeconomy. AIM/CGE is also a one-year interval recursive-type, dynamic, general equilibrium model that covers all regions of the world and consists of 42 industrial classifications. An iterative method was used to integrate AIM/CGE and AIM/Transport. This loop continues until the energy consumptions computed in AIM/CGE and AIM/Transport are equal. The iterative procedure helps refine the transport representation in AIM/CGE, based on detailed AIM/Transport information.

We structured the scenario framework in three dimensions. For the GDP and population, shared socioeconomic pathways 2 (SSP2) estimates were employed as default values for GDP and population in AIM/Transport. The second dimension is the climate policy dimension, denoted by "BaU", "2D" and "1.5D". In the "BaU" scenario, no climate mitigation efforts are assumed, while a carbon price is imposed in the "2D" and "1.5D" scenarios to approximately meet emission radiative forcing targets of 2.7 W/m² and 1.9 W/m² in 2100 to limit global warming to 2° and 1.5°, respectively. The third dimension is the transport policy for simulating how different transport factors and policy interventions affect the mitigation potential and cost. We selected representative transport policies from technological and behavioral aspects including energy efficiency improvement (Ei_High), vehicle technological innovation (Tech_Innovation), mass transit-oriented transport development (Mass_Transit), vehicle occupancy (Occu_High), and low-carbon scenario (Low_Carbon) which was applied to combine technological and behavioral issues.

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Results

Scenario simulation results proved that CO_2 emissions can be reduced by implementing transport policies such as energy efficiency improvements, vehicle technological innovations, mass transit-

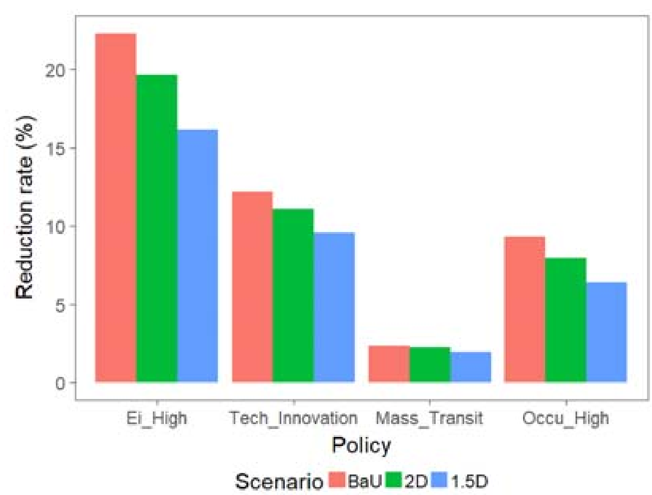

Figure 1. Impacts of transport policies on reduction potential of cumulative emissions

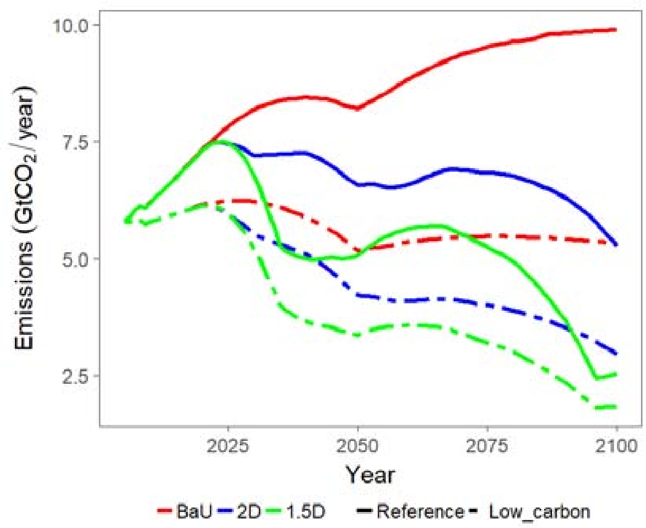

Figure 2. Emissions trajectories during 2005–2100

oriented transport developments, and increasing the occupancy rate of cars in the BaU, 2°C, and 1.5°C scenarios. In summary, Ei_High, Tech_Innovation, and Occu_High have significant impacts on emission reduction, whereas Mass_Trasnsit has relatively weak effects (figure 1). As shown in figure 2, with the implementation of a low-carbon transport policy, the 2°C scenario generated an emission trajectory similar to the 1.5°C scenario, without any transport policy, implying that transport policies can help achieve the 1.5°C goal only by applying the carbon tax rate of the 2°C scenario. Maximum emission reduction can be achieved with low-carbon transport strategies combining both technological and behavioral policies, indicating that the synergistic effect between policies in different sectors needs to be considered for maximum potential emission reduction.

Although road transportation theoretically could become completely electrified over the coming decades, it is still unclear whether there is the prospect of electrified aviation and shipping. Unless all fossil fuels would be replaced by biofuels, the passenger aviation and freight sectors still remain dependent on fossil fuels. The technological and economic optimization leads to there being ongoing use of fossil fuels in the transport sector, mainly for international aircraft, and that negative emissions are thus required to balance this usage in order to meet the temperature goals.

Figure 3 shows that carbon price, GDP loss rate, and welfare loss rate can be reduced in the Low_Carbon scenario. The GDP and welfare loss rate can be lowered because the low-carbon transport policies are conducive to decreasing the CO_2 emissions in the transport sector, which helps alleviate the economic losses generated by stringent carbon tax imposition. Furthermore, the values of the reduction in GDP loss rate in the 1.5°C scenario are higher than those in the 2°C scenario after 2030, implying that the contribution to the reduction in GDP loss is relatively more significant in the 1.5°C target. The degree of contribution of transport policies is more effective for stringent climate change targets.

Discussion and conclusion

The integration of the transport model and CGE model can enrich transport representation in an integrated assessment model and capture mode and technological factors. Simulation results show that transport policy interventions alter global transport-related energy consumption composition and emission trajectories. This study therefore provides a comprehensive and multidimensional policy tool for long-term decision making in transport decarbonization. Implementation of transport policies combining technological innovation and changes in transport behaviors is required to achieve both the 2°C and 1.5°C goals.

The policy with the highest priority is to strongly promote fully battery electric-powered vehicles to achieve the goal of deep decarbonization in the transport sector, though social transformations such as lifestyle change and low-carbon urban reorganization could be effective as supplementary policy tools. Balanced technological and social transformations can mitigate risks that may not be fully addressed via technological innovation alone, for developing an energy-efficient decarbonized transport system.

Because the feedback between the AIM/Transport and AIM/CGE models helps detect the effects of transport sector dynamics on the macroeconomy, these analyses convince us that transport policies provide an effective contribution to modifying the mitigation cost. Because this methodology of transport modeling overcomes the limitations of linking the CGE model and the transport model,

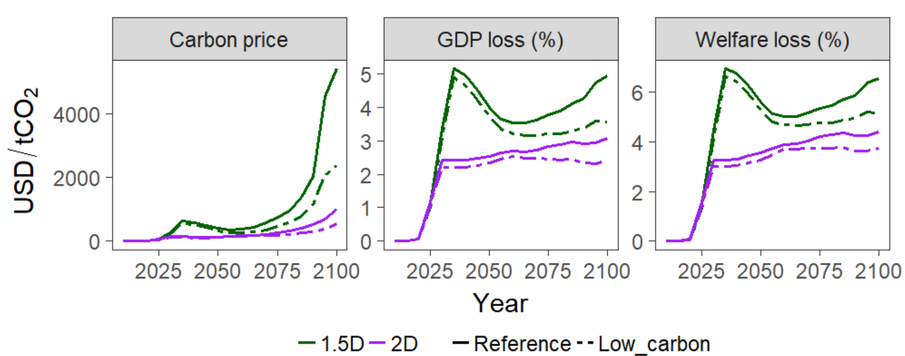

Figure 3. Mitigation cost metrics for the 2°C and 1.5°C targets

it may be used by transport planners to analyze how mitigation options would affect the dynamics of the macroeconomy. Interestingly, the greater effectiveness of transport policies was well demonstrated in the 1.5°C scenario, indicating that the transport sector deserves more attention for achieving stringent climate change mitigation targets.

Policy implications can be drawn from the scenario simulations. First, the liquid fuel savings can be realized directly by the deployment of hybrid vehicles, which is likely to become a significant fraction of new vehicle sales in the interim before becoming fully electric. Then substantial numbers of fully battery electric-powered vehicles can be strongly promoted to achieve the goal of deep decarbonization in the transport sector. Second, it is necessary to establish a public transit system with better accessibility, security, and comfort to influence households' preference on transport modes. Specifically, investing in public transport infrastructure such as dedicated corridors for buses and railways, and high-speed trains such as maglev, can assist in shifting more travelers from carbon-intensive modes to a transit-oriented movement. Third, decarbonization in the transport sector requires innovative policy strategies for lifestyle transformations. The government needs to launch a scheme to promote car sharing and carpooling, to increase the car occupancy rate and cut the number of commuters.

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Dual Plenary Session 4: Energy Challenges in Transport

By Derck Koolen, PhD candidate, Rotterdam School of Management, Erasmus University and Deici Alejandra Giraldo Hurtado, PhD candidate, CREM, University of Rennes, France

The session was chaired by Anna Creti, Professor at Ecole polytechnique and University of Paris, France. Creti was joined by Stef Proost, Professor at Centre for Energy, Transport and Environment, University of Leuven, Belgium; Mats Greaker, Head of Research, Statistics Norway, Oslo, Norway; and Yannick Perez from Université Paris-Sud XI / Ecole Superieur d'Electricite, Paris, France.

The plenary session on Energy Challenges in Transport invited three top-notch academic speakers from across Europe, discussing their outlooks and views on three challenges to transforming the transport sector away from fossil fuels.

Mats Greaker discussed the effect on climate costs of different biofuels and renewable resources for the transport sector. His research showed how global and regional renewable fuel standards increased the use of oil and the total use of transport fuel is reduced. Important for policy makers is the result that a subsidy to biofuels may lead to an increase in climate costs as well. In addition, collateral effects such as congestion should be considered and the efforts to transform transportation should be globally integrated.

Yannick Perez talked about electro mobility and the challenges and implications in the scaling up of this sector for both the environment and the electricity sector. He argued that the problem with the increase is not related to energy but rather to capacity; when everyone will charging at the same time, the current grid infrastructure will likely not be able to deliver. He discussed the different vehicle-to-X solutions, comparing the merits for business cases of EVs delivering to TSO, DSO, home, buildings and load. In all, the deployment of infrastructure, such as plugs and electricity capacity, would require the cooperation between electricity and automotive industry. In the lack of such cooperation, the solution implies higher costs at individual level.

Stef Proost argued that in the field we still need a lot of technological developments. Along the way of making the transition to fully electric vehicles, a good option are biofuels. The development of second-generation biofuels seems promising and it would help to achieve EU biofuel policy target of 50% GHG emissions savings. The question, however, remains is how these new technologies could best be promoted and how right incentives could be given. Proost argued that, in order to make the critical move to a low-carbon transport sector, there is particularly a need for more insights and significant R&D development. The session was concluded with the agreement that there is still a lot of room for further research from a taxation, technological, and economic perspective.

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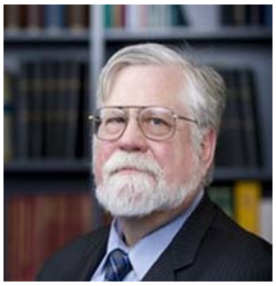
We look forward to your participation in these new initiatives.

Interview with David Knapp, IAEE President



President Knapp is one of the founding members of the IAEE dating back to the late 70s. His career started when after the graduate school he joined an expert panel within a project for the US government working on a world trade model. When in 1973 President Nixon announced the "Independence Project", Mr. Knapp was asked to come to Washington to work on models looking at the US and global energy markets. Mr. Knapp mentioned that over his career the energy security topic was ongoing. Therefore, his research and expertise have become part of the IAEE`s foundation.

According to Mr. Knapp, the Association has changed both in depth and in breadth over the past years. For him, the biggest change within the IAEE as well as in the Energy field is the improvement of the tools. When he first started, there was only a very archaic data system, with a very limited set of analytic tools. The research group Mr. Knapp was part of, became one of the reasons for some advances in the computer science, when senior computer scientists were building operating systems for computers they were using.

As IAEE`s President, he has challenged the organization by emphasizing the importance for the Association to be involved in a constructive way with Developing countries. The first Plenary session of Groningen conference addressed the very different conditions the Developing world is facing when it comes to energy access and energy poverty. Already starting back in 2000 the IAEE`s interpretation of the world`s energy outlook had this topic on the agenda. Right now, the key word is transition. The concept of transition is very different for Europe where we are speaking about the decarbonization and the developing world where it is more general. There is no one-size fit all solution. Hence to go forward there is a need to give good answers but also contribute to the formulation of relevant questions. Therefore, from Mr. Knapp`s perspective, the Association`s main goal is to be a constructive contributor to this challenge, as this strategy goes together with what the Association has been trying to achieve over the past 40 years. One of the achievements Mr. Knapp has mentioned is the development of a solid conference platform within the IAEE, which has strengthened a network of members aiming to contribute to the field by active discussions around these topics.

When asked about the most inspiring aspect of being part of the Association, Mr. Knapp mentioned the importance of being part of the IAEE family. He defined achievements and contributions from the new generation of economists as accomplishments of his intellectual grandchildren. It is inspiring for him to see how the new generations contributes to build and strengthen the IAEE family. Mr. Knapp concludes that IAEE is his professional family - Ohana in Hawaiian.

Interview with Christophe Bonnery, President-elect

Christophe Bonnery has now been a member of the IAEE for more than 30 years and has worked for various energies corporations over his career. IAEE has always attracted him by its international dimension and the academic excellence of its members. In 2010 Mr. Bonnery was elected as President of the French IAEE chapter – FAEE. By the end of his third mandate, the FAEE has increased significantly the number of organized conferences, allowing the French chapter to multiply its membership by six until now. Mr. Bonnery says that it was a great honor, for him and for France, to be first selected by the Nomination Committee and then to be elected by the IAEE's 4000 members as a President-elect.

His role since January 2018, was to take progressively the responsibility over the strategic actions of the Association. Mr. Bonnery says that he is proud to serve the Association by contributing to its geographic development, for example in April 2018, IAEE has opened its South African chapter. With the support of the Vice Presidents and the officers of the Association, he has been able to elaborate and present to the IAEE Council the 2018-2020 Strategic Plan. This Strategic Plan has several goals. The first being to provide both the academic community and policymakers with the best quality of services. The second is to implement the metrics to assess changes within the association's membership, conference attendance and the quality of publications, notably the impact factor of the journals and reviews.

His view for the IAEE in the future is based on the following aspects. There is not any other international organization gathering up to 4000 energy economists from more than 100 countries, all able to produce quality assessments on energy policies. Therefore, the unchallenged value of the IAEE is based on the knowledge of its members. This asset is a real treasury. Hence one of his goals is to continuously increase the IAEE`s value by fostering cross-fertilization. Additionally, his other important goal is to share this treasury with the Society. Otherwise what good would all this science be if it was only exchanged between the members of the Association? Therefore, Mr. Bonnery aims to share this human and scientific capital with the rest of the society. With the help of the Council, he will push the IAEE will be more proactive in intervening more in the society by demonstrating to citizens, consumers, businesses, administrations, politicians, cities and regions, the added value of economic science applied to energy.

Finally, one can observe that many countries are committed into the energy transition. This concept is fore poorly defined; therefore, economists should contribute to its better definition. With the IAEE`s peer-review methods, we can contribute to a better evaluation of the weight of public decisions. Mr. Bonnery announces this will be his goal in 2019, with the commitment of our members and our organization.

Anthony Owen, Past President, Outstanding Contributions to the IAEE Award Winner

The first time Anthony Owen attended an IAEE conference was in Calgary in 1987. In those days the main participants to the IAEE conferences were academics and industry representatives with only a few students. The main topic back then was oil markets. Five to six years later when Fereidun Fesharaki became IAEE`s President, he took the initiative with Mr. Owen to establish the Australian chapter of the IAEE. From there on, the goal was to organize an international IAEE conference in Sidney, which was held in the year 2000. This conference was the most profitable international conference at that time. The next conference Mr. Owen was in charge of was the Asian conference in Perth in 2008. The biggest conference project for Mr. Owen was last year`s conference in Singapore: the 40th IAEE International conference which was held at the Marina Bay Sands Hotel with over 400 participants. This conference was held in one of the world`s most famous hotels, which was possible thanks to David Williams`s outstanding negotiation skill. For each conference one of the most important tasks is to have good sponsorship support in order to organize an unforgettable experience for the delegates. For Mr. Owen being the main conference organizer for the above-mentioned conferences has been a great matter of dedication for the association.

Receiving this award reflects Association`s recognition for Mr. Owen`s hard work and commitment. For him to receive this award means so much more than any monetary recognition. This sign of appreciation is very valuable for the work which is done voluntary based on personal willingness to contribute to the Association. In addition to the academic benefits, the Association has been his second family over all these years. Each conference is a meeting occasion for a group of people whom have been actively involved in the Association over decades. Mr. Owen defines IAEE`s environment as very friendly and family like. As a rule, you can pick up your friends, but you cannot pick up your family, when it comes to the IAEE family, Mr. Owen says that it is a great honor to be part of this family.

One of the memories Mr. Owen shares is from the Prague conference. During one of the social events at the conference, the delegates were told the story about how political dissidents were killed in Prague – they were thrown out of the windows. To designate this awful method a new word was used: "Défenestration". Thought this story described a dreadful time in the country`s history, it was very interesting to learn a new word and its meaning. For Mr. Owen this is one of the examples about how IAEE conferences combine both academic but also cultural experiences for its delegates.

Jean-Michel Glachant, Florence School of Regulation EUI and Adonis Yatchew, University of Toronto - Winners of the Outstanding Contributions to The Profession Award

It is in 1995 that Adonis Yatchew was invited to join the editors of the Energy Journal, since then his work within the Association was mainly done within the editorial team, first as an electricity specialist and later as Editor-in-Chief for the Journal.

Jean Michel Glachant also started his work within the Association in 1995. At that time, he joined the French chapter as a conference organizer at the École Polytechnique. After the conference he continued his involvement within the French chapter until the day when he was asked by Einar Hope to participate in the project to establish a new journal for the Association. At this time, it was an ambitious idea as the Energy Journal was already a reference for everybody and creating a new journal seemed to be very audacious.

Mr. Yatchew says that to receive this award together with Jean Michel Glachant is an honor in itself. When looking back on the list of predecessors who have received this award, one can find a succession of extraordinary prominent energy economists. Therefore, for Mr. Yatchew to receive this award and to be on the same list with the previous winners, is a distinguished recognition of his work and contributions to the Association.

This is not Mr. Glachant's first award. However, this award is full of meaning and has a very precious value for him as it represents the recognition of his peers. It is one of the most distinguished awards as it is awarded by colleagues with whom Mr. Glachant has been working for decades.

Over the past years the Energy Journal has expanded significantly in the number of submissions as well as in its coverage. The most challenging part of Mr. Yatchew`s work within the Journal was when Geoffrey Pearce (who was the managing editor of the Energy Journal since 1992) passed away. Geoff had managed the journal in a most remarkable way. Therefore, the main challenge was then to find a way to keep the Journal functioning. According to Mr. Yatchew, David Williams' and Rebecca Lilley's unflagging support in this process was essential.

The biggest project Jean Michel Glachant has been part of within the Association was to be the Editor-in-Chief of the EEEP (Economics of Energy and Environmental Policy). The main challenge for the first edition was

(Continued next page)

Derck Koolen, Best Student Paper Award Winner

The topic of the award-winning paper is strategic trading and the value of flexibility in sequential short-term power markets with the increasing share of intermittent supply of renewable energy sources. Koolen's paper discusses the impact of a large increase of renewable energy on pricing in power markets and what it means for risk and strategy related behaviour of market participants. His work paves the way for policy makers and major energy players to examine the implications on existing power market structures and their participants' strategic space. It considers alternative market designs both from market and individual perspectives in order to not only integrate large shares of renewable energy in existing electricity markets but also achieve it in a sustainable manner.

"*The energy business is going through a series of swift and radical transformations to meet the growing demands for sustainable energy*," Koolen says, adding that this growing share of sustainable energy sources means that electricity markets experience increasing uncertainty and volatility.

Koolen: "*The various operational characteristics of producer technologies affect commodity trading and thereby affect market prices, often not desirable from a sustainable efficient market point of view.*" He said that key in the transition process is to ensure that markets provide adequate price signals for assets and investments, ensuring security of supply in an efficient and sustainable way. "*Future market design must be inherently robust, as markets and financial stakeholders may create instabilities, potentially leading to huge losses and black-outs, while the bill is eventually paid by the customer.*"

Mr Koolen says that being nominated had been very exciting news for him. According to Mr. Koolen, all nominees had presented very strong work in the field of energy economics. What might have differentiated his paper from others is that it had possible large policy implications in the long run for markets to efficiently integrate large shares of renewable energy. Winning this award and receiving it during the Gala dinner in the Martini Church was a very special and unforgettable moment. Additionally, receiving recognition and having the opportunity to further discuss his work with many distinguished researchers was for Mr. Koolen a highlight of the conference.

Glachant & Yatchew (continued)

to find articles through a pro-active approach, a task in which the editing team have succeeded greatly.

When asked about the best memory Mr. Yatchew has of his work within the Association, he mentions the Venice conference. IAEE`s conferences are always organized in exceptional locations. The Venice conference stayed in Mr. Yatchew`s memory as he could combine both attendance to an interesting conference with a memorable (and romantic) stay with his wife.

The best memory Mr. Glachant shares with us is the closing reception for the 39th IAEE International Conference in Bergen. The reception was held at Einar Hope`s house from where all the guests could be charmed by the amazing view over Norwegian fjords and mountains with a breathtaking light.

IAEE and the National Museum of Energy and Technology (MUNET) in Mexico City, Mexico.

By Arild N. Nystad, Past President 2001

During 2016/2017, IAEE and representatives from Pemex discussed establishing an IAEE Advisory Board to support the new National Museum of Energy and Technology (MUNET) in Mexico City with advice on energy issues. MUNIT is planned to be opened in 2018/2019.

The idea was launched and discussed at the 2016 IAEE Conference in Bergen. IAEE President Ricardo Raineri signed a Memorandum of Understanding (MoU) on behalf of the Council in June 2017 at the Singapore Conference. On the Mexico side, it was signed by a trust responsible for the planning of the museum. Nine members of the Council volunteered and were appointed to the Advisory Board. The coordination is done by executive director David Williams together with past president (2001) Arild N. Nystad, who brought the topic to the Council from his network in Mexico. The key person for coordination in Mexico is Mariana Hoffman Borrego, Advisor to the General Directorate of Pemex.

Topics for the Advisory Board are: Developing educational programs, workshops and material concerning energy and technology; developing specific exhibits, activities, and programs related to energy, technology and innovation; potential to organize future international conferences of the IAEE in Mexico at the MUNET Congress Center; knowledge of how energy and technology impact economics, politics and society; risks and realities of climate change, and related topics of IAEE expertise. The Advisory Board held meetings at the 2017 IAEE Conference in Houston, and at WIESS Energy Hall at the Houston Museum of Natural Science. A further meeting was held at the 2018 IAEE Conference in Groningen with video link to Mexico. The IAEE Advisory Board members are Adonis Yatchew, Peter R. Hartley, John W. Jimison, David Knapp, Ricardo Raineri, Gürkan Kumbaroglu, Anthony D. Owen, Yukari Yamashita, Akinbolaji P. Iwayemi. The network between the IAEE Advisory Board and Mexico will be instrumental in future IAEE Mexico activities and the Mexican IAEE Chapter.

CONFERENCE OVERVIEW

The Trump Administration and changing geopolitical situations are redefining energy directions, layering additional change over ongoing technological and market changes. Removal or revision of regulations, withdrawal from the Paris climate accord, and shifting geopolitical relations add complexity to an energy portfolio still bracing for cyberattacks and weather impacts against vulnerable grids. These geopolitical shifts, and the reactions to them by OPEC, local governments, and other actors, challenge us to chart a path forward through changed and dynamic domestic and international energy and environmental sectors.

The 36th USAEE/IAEE Conference provides a forum for informed and collegial discussion of how the emerging realities will impact all stakeholders—from populations to companies to governments—in North America and around the world.

Nowhere calls out this urgency more clearly than the mid-Atlantic region. The energy mix includes offshore wind, coal mines, nuclear power, solar, and natural gas. Conference attendees will benefit from access to tour some of these facilities as well as tours of federal energy institutions in Washington, D.C.

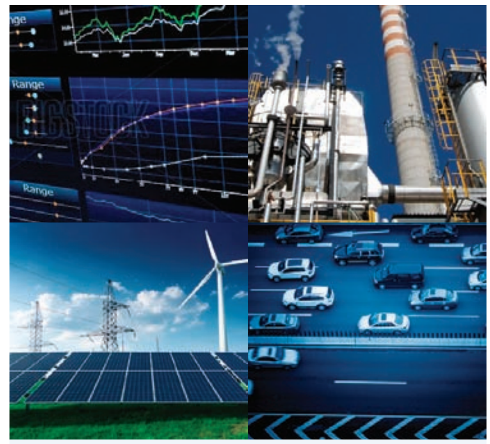
The Washington, D.C. metro area is the epicenter of energy policy and home to legislators, regulators, and diplomats. It boasts the greatest concentration of think tanks and is a bastion of energy thought leaders that bolster the value of networking opportunities provided by the conference.

The conference will highlight contemporary energy themes at the intersection of economics, public policy, and politics, including those affecting energy infrastructure, environmental regulation, markets vs. government intervention, and international energy trade. Participation from industry, government, non-profit, and academic energy economists ensures robust, insightful discussion.

HOSTED BY

USAEE United States Association *for* Energy Economics

IAEE International Association *for* Energy Economics WWW.IAEE.ORG



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: http://www.usaee.org/usaee2018/topics.html

- Energy Protectionism in Practice
- Countervailing Winds: International Geopolitical and Domestic Responses to the New Administration
- The New DOE and FERC Agendas
- How Have Energy Markets Responded to the Shift of U.S. Energy Policy?
- Energy Implications of Environmental Regulations: Future and Impact
- International Energy Policy Responses to the U.S. Departure of the Paris Climate Accord
- A Look at Shifts in Energy Supply: Renewables, Coal, and More
- Deregulation of Marine and Land Use: Offshore Access, Extraction, and Pipelines
- Europe, Russia, and U.S. Natural Gas Exports Recent State Energy Policy Developments
- Energy Innovation and Technology
- Other topics of interest including shifts in market structures and fundamentals, including those induced by policy and technological forces.

IAEE INTERNATIONAL ASSOCIATION for ENERGY ECONOMICS WWW.IAEE.ORG

CALL FOR PAPERS

42nd IAEE INTERNATIONAL CONFERENCE
LOCAL ENERGY, GLOBAL MARKETS
MONTREAL MAY 29 – JUNE 1, 2019

Abstract submission deadline: December 17, 2018

The Chair in Energy Sector Management at HEC Montréal, the Group for Research in Decision Analysis (GERAD), the International Association for Energy Economics and the Canadian Association for Energy Economics have the pleasure to invite you to attend the 42nd IAEE International Conference to be held in **Montreal (Québec, Canada) from May 29 to June 1, 2019**.

Energy is moving up the global political agenda with climate change, social inequity and energy security bringing an awareness of the need for a global energy transition towards a low carbon, sustainable energy future. This year's Conference theme, *Local Energy, Global Markets*, will focus on the development of local energy sources, their abilities and challenges to reach global markets and how local energy sources can be developed to better meet societies' future energy needs.

CONCURRENT & POSTER SESSION ABSTRACT FORMAT

Abstracts must be no more than two pages long and must present an overview of the topic including its background, significance, methodology, results conclusion and references. Abstracts can be submitted for a **concurrent** or a **poster** session.

All abstracts must be submitted online and conform to the prescribed format structure outlined in a template. Visit iaee2019.org/programme/call-for-papers to download the abstract template and to submit an abstract.

CUT-OFF DATES AND NOTIFICATION

Abstract due date:	**December 17, 2018**
Acceptance notification:	**January 31, 2019**
Full paper due date and presenter registration payment:	**April 1, 2019**

Website: iaee2019.org | Contact: info@ iaee2019.org

CONFERENCE TOPICS

Energy transition: national strategies, impact of circular and shared economy on energy

Smart grids and new electricity market regulations: death spiral of utilities, demand charges, load management, storage, renewable integration, ancillary services

Energy corridors: pipelines, cross-border electricity interconnections

Unconventional oil and gas: fracking, market developments, innovation, environmental impacts

Biofuels: current markets, cellulosic and next generation biofuels

Energy as a service: end-user energy demand, new business models, energy consumer behavior

Climate change and carbon markets: carbon pricing, cap and trade developments

Energy in transportation: trends in vehicle sales, zero-emission vehicles, autonomous vehicles

Energy systems: heat networks, sector coupling and optimization, circular economy

Energy and finance: investments, risks, financial and insurance markets, fossil fuel divestment

Energy and macroeconomics: international trade, innovation, growth

Energy policies: key players, theory, regulation, institutional barriers, conflicts with trade laws

Local governments and initiatives: local mobilization, land-use, district heating, microgrids

IAEE INTERNATIONAL ASSOCIATION for ENERGY ECONOMICS WWW.IAEE.ORG | Chair in Energy Sector Management HEC MONTRÉAL | GERAD GROUP FOR RESEARCH IN DECISION ANALYSIS | CAEE Canadian Association for Energy Economics Association canadienne d'économique de l'énergie

We welcome abstracts presenting research using a wide diversity of methods:

- Business cases / case studies / benchmarking
- Economic studies (time series, cross-sections)
- Field and lab experiments
- Surveys, conjoint analysis
- Techno-economic bottom-up models
- General equilibrium, macro models
- Game-theoretical methods
- Simulations (e.g., agent based models)
- Interdisciplinary research (e.g., law and economics, political economy)

Those interested in organizing a concurrent session should propose a topic and four possible speakers to info@iaee2019.org.

The abstracts proposed for a special session should be submitted, following the general submission rules within the deadline of December 17, 2018.

PRESENTER ATTENDANCE AT THE CONFERENCE

The **abstract cut-off date is December 17, 2018**. At least one author of an accepted paper or poster must pay the registration fees and attend the conference to present the paper or poster. The corresponding author submitting the abstract must provide complete contact details — mailing address, phone, email, etc.

Authors will be notified by January 31, 2019 of the status of their presentation or poster.

Authors whose abstracts are accepted will have until April 1, 2019 for registering to the conference and submitting 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.

NOTE all organized concurrent session speakers must pay the registration fee.

OTHER USEFUL INFO

- Registration to the IAEE 2019 Conference will start in October 2018
- Special early bird registration fee will be available for registrations before April 1, 2019
- Accepted presenters in concurrent and poster sessions must finalize registration payment by April 1, 2019
- Best Student Paper application deadline is January 17, 2019
- Gala Dinner will be at the Windsor Station, heritage building in downtown Montreal, on May 30th, 2019
- Special rates are available at the Delta Hotels by Marriott Montreal, between May 24 and June 6, 2019 (475 President-Kennedy Ave., Montreal H3A 1J7 Canada)
- Details for the pre-conference Summer School and technical tours will be announced on iaee2019.org

CONFERENCE LOCATION

HEC MONTRÉAL

Côte-Sainte-Catherine Building
3000 Côte-Sainte-Catherine Road
Montréal (Québec)
H3T 2A7 CANADA

Website: iaee2019.org | Contact: info@iaee2019.org

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