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IAEE Energy Forum

Singapore Issue 2017 | International Association for Energy Economics | ISSN 1944-3188

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INTERNATIONAL ASSOCIATION *for* ENERGY ECONOMICS

CELEBRATING 40 YEARS ANNIVERSARY

CONTENTS

Editor: David L. Williams

President's Message

Dear Members:

A few weeks ago, IAEE hosted its 40th International Conference in Singapore with the theme *Meeting the Energy Demands of Emerging Economies: Implications for Energy and Environmental Markets*. It was a remarkable event, and I thank the host country, the local authorities, our sponsors, all the people who were involved in the organization of the event, the organizing and international committees, and the host institutions, the National University of Singapore, and the Energy Studies Institute.

For four days, the conference congregated a large audience from across the world to discuss key current and future energy challenges. In its 9 keynote and plenary sessions, and 67 concurrent sessions, the dialogue was diverse; for example, from the understanding of the challenges of energy access for those who have been left behind, to understanding how technology and market trends are reshaping the energy scene, and to the needed energy to feed economic growth.

Despite the deep reduction in the number of people who live in poverty worldwide, today we still have 1.06 billion people who are without access to electricity and 3.04 billion who rely on solid fuels and kerosene for cooking and heating. And, in recent years, we have seen that the increase in the number of people without energy is not increasing as needed if we want to eradicate energy poverty as has been committed to in the UN SE4ALL initiative. We have seen that the resources that come from FDA are not enough to close the gap between where we are today, and what is needed to eliminate the problem of energy access by 2030. Our challenges are not restricted to the problems of energy access. By 2040 energy demand is expected to increase by almost 50% according to EIA projections, where more than 80% of this increase will take place in the emerging economies. How the emerging economies will satisfy their energy needs will have important impacts on the demand for resources and by the energy markets. The efficient use of world energy resources will be essential, and that requires well-functioning local and global energy markets which enable the large investments that are required and that properly account for the environmental and social impacts of the different energy sources. The deployment of energy infrastructure, new technologies and business models, will be important drivers to unlock new energy sources and to satisfy the economy's energy needs.

In Singapore, we have had a great debate on all these issues, where it was clear the need for stable business environments and a proper return on investments to mobilize private resource are key, where increasingly this is taking place in a setting of growing environmental and social constraints, and where innovation and disruption of

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President's Message (continued from page 1)

new technologies and business models have become the new normal of energy markets.

We look forward to having you at our coming 41st IAEE International Conference, *Security of Supply, Sustainability and Affordability: Assessing the Trade-offs of Energy Policy*, that will take place on June 10-13, 2018, in Groningen, The Netherlands.

Ricardo Raineri Bernain

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IAEE Mission Statement

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

We facilitate:

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

We accomplish this through:

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

Editor's Notes

We're delighted to bring this special issue of the *Energy Forum* to our members. It is a report on the 40th International Conference held in Singapore this past June. We're especially pleased to have Past President Einar Hope as our guest editor again. As he did with the Bergen Special issue a year ago, he has again presented a fine cross section of the papers given at Singapore. See his note below.

Threaded throughout the issue you will find reports and interviews covering a variety of subjects covered at the conference, including an overview of the conference, an interview with the general manager of the very special venue at which the conference was held, the welcoming address, interviews with a number of our past presidents who were on hand and other interesting snippets from the conference; but first a note from Einar.

DLW

Once again I have had the pleasure and privilege, at the request of IAEE Executive Director and *Energy Forum* Editor, David Williams, of selecting and editing papers presented at the 40th IAEE International Conference in Singapore 18 – 21 June 2017, and co-editing a Special Issue of the E*nergy Forum* of the Conference event.

For this Special Issue of the *Energy Forum* we ended up with 16 selected 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 have also put some emphasis on the geographical dispersion of topics and authors. At the Singapore conference there was a fairly large number of submission of papers from Asian countries, which is to some extent reflected in the selection. However, once again I have to make the same reservation as with earlier selection of papers for EF Special Issues that I edited: It is impossible to make a representative selection from among the around 350 papers that were presented at the conference.

Invited authors were asked to write a summary 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* issue and for pleasant cooperation in the editing process.

I would also like to thank my colleague at the Norwegian School of Economics (NHH), Olga Pushkash, who was actively involved in the administrative team of the Singapore conference and, in addition, had a special task of contributing to the Special Issue with reports from the professional and social "life" of the conference, together with team of selected contributors. And last but not least, I would like to thank the unbeatable Williams team, David Jr. and Sr. for efficient and pleasant cooperation in the editing process of this SI of the Energy Forum.

Einar Hope

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Scenes from the 40th IAEE International Conference June 18-21, 2017


40th International IAEE Conference
Singapore 18-21 June 2017


40th International IAEE Conference
Singapore 18-21 June 2017


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MARINA BAY
40th International IAEE Conference
Singapore 18-21 June 2017


40th International IAEE Conference
Singapore 18-21 June 2017


40th International IAEE Conference
Singapore 18-21 June 2017


40th IAEE International Conference
Conference Banquet
TECHNOFORM GROUP
40th International IAEE Conference
Singapore 18-21 June 2017


TECHNOFORM GROUP
40th International IAEE Conference

Singapore Conference Overview

The 40th IAEE2017 International Conference was organized by the Energy Studies Institute (National University of Singapore) and was held at the Marina Bay Sands Hotel in Singapore on June 18 - 21, 2018. The conference was well attended with 420 attendees and included various activities and social events. Academic presentations were scheduled within the 67 Concurrent sessions and additionally eight plenary and dual plenary sessions were organized. The Conference's opening address was given by Masagos Zulkifli, Minister for the Environment and Water Resources. The following topics were addressed during this session: Global Energy Trends and Climate Change; Singapore's Energy Development and Environmental Sustainability; and the Climate Action Plan.

BREAKFAST MEETINGS

From Monday through Wednesday, the following breakfast meetings were organized. On Monday morning during the Student Breakfast Meeting, Fabian Moisl (IAEE) with Peter Hefele (KAS) met with 90 students in order to facilitate networking and future career opportunities for students. On the same morning IAEE's Affiliate Leaders met to discuss the upcoming IAEE Conferences organized by their local chapters. This meeting was chaired by IAEE`s President Ricardo Raineri Bernain. On Tuesday the Asia/Oceania Affiliate Leaders met to discuss future events, Yukari Yamashita (IEE) chaired this meeting. *The Energy Journal* Board of Editors meeting was held simultaneously, Adonis Yatchew (EJ's Chief editor) chaired this meeting. On the last conference day Christian von Hirschhausen (EEEP's Chief Editor) chaired the *Economics of Energy and Environmental Policy* Board of Editors meeting, while Machiel Mulder (Conference chair) Chaired the 2018 IAEE International Conference Planning Meeting.

IAEE'S 40TH ANNIVERSARY

In 2017, IAEE is celebrating its 40th anniversary. During the Awards Lunch on Monday 19 June, IAEE's President Ricardo Raineri Bernain gave a speech on how the organization as well as the energy sector evolved during these past years. The world we are living in now is very different from the one when IAEE was established. The first IAEE meeting was held in 1977 during the ASSA Conference. Since then, Renewable and Nuclear energy consumption and production trends changed. This generated important changes within the sector. When speaking about energy security Raineri Bernain defined it being: "about politics, sovereignty, political stability, democracy and development". Additionally, a few key non-resources challenges and threats were mentioned: "Civil society; Environment and the threat of climate change; Use of oil as a geopolitical weapon and supply/price manipulation; Dependence on conflict and politically unstable regions; Energy/fossil fuels subsidies, bill collection, non-technical energy losses and sabotage; Investors Risk & Business Environment".

OPENING RECEPTION AND GALA DINNER

Two main social events were organized during the conference. On Sunday 18 June in a beautiful Marina Bay Sands Convention Centre, conference delegates joined for the opening reception to enjoy the networking offered by the conference. The conference gala dinner was held at Capella Hotel located at the Sentosa Island. Capella's modern buildings are blended with both colonial buildings and the vibrant rainforest, having the South China Sea as its backyard. Capella`s historical buildings date back to the 1880s and in 2000 they were given conservation status. The main entertainment of this evening was the traditional Dragon dance. Additionally, conference delegates were offered a five course dinner consisting of a delicious local cuisine. During this evening, Carlo Andrea Bollino was awarded with the 2017 Outstanding Contributions to the IAEE Award.

Geoffrey Arnold Pearce

10/19/1959 – 6/23/2017

Geoffrey Arnold Pearce, the Managing Editor of *The Energy Journal*, passed away unexpectedly on June 23, 2017. Geoff's electronic persona had a global reach, but few in our international community of energy economists had the opportunity to meet him in person.

Geoff was a unique person in many ways. A geologist by training, he loved the outdoors. After graduating, Geoff worked for mining exploration companies during much of the 1980s, often spending months away in the bush, far from the comforts of home. In the early 1990s Geoff worked as a reporter for a mining newspaper.

Geoff began work with *The Energy Journal* in 1992 where he was the Associate Editor and, at the time of his passing, the Managing Editor. He was the cornerstone of the operation, processing hundreds of papers and thousands of referee reports, emails and correspondences year after year. Throughout, Geoff was unfailingly professional, personable and above all, caring. It is especially telling that in a quarter of a century with the Journal, not a single complaint was received about Geoff; not one, only praise. When one considers that Geoff was frequently the deliverer of unhappy tidings, this simple fact speaks volumes.

Geoff was a skilled clarinetist and an accomplished diver. One of his musical favorites was Calypso, a song written by John Denver as a tribute to Jacques Cousteau. The opening verse captures Geoff's essence – his love of nature and the exhilaration of adventure, the challenges of life and service to others, and his unquenchable desire for knowledge and understanding.

> "To sail on a dream on a crystal clear ocean
> To ride on the crest of a wild raging storm
> To work in the service of life and living
> In search of the answers to the questions unknown
> To be part of the movement and part of the growing
> Part of beginning to understand."

Adonis Yatchew
Editor-in-Chief, *The Energy Journal*

Opening Remarks to the 40th IAEE Conference by Minister Masagos Zulkifli

It is my pleasure to be here at the 2017 Conference of the International Association of Energy Economics hosted by the NUS Energy Studies Institute. I am happy to note that this is the 40th year of the Conference, a strong testament to its role as an important platform for top representatives from academic, corporate and public institutions to discuss critical issues affecting global energy markets. I was told that this is the first time that it is hosted in Singapore, and I am pleased to extend a warm welcome to all delegates, and to our foreign delegates, welcome to Singapore.

2017 also marks the 10th anniversary of the founding of the NUS Energy Studies Institute (ESI). It is a key partner of the Government and is also recognised internationally as an important partner in conducting multidisciplinary research on global energy issues, as well as promoting discussion on their national, regional and international implications. The Institute is also a strong supporter in facilitating the global exchange of ideas on energy, which is the reason why we are all here today.

GLOBAL ENERGY TRENDS AND CLIMATE CHANGE

Our world is at an inflexion point – whether it is politics at the international level, or in markets and societies whereby we are seeing the emergence of new consumer trends and patterns; and innovative and disruptive technologies changing the norms that we are all used to. The energy market is no different. In the next two decades, global energy demand is expected to increase significantly. The International Energy Agency's World Energy Outlook 2016 projected in its "main scenario" that global energy demand would rise by 30% from now to 2040.

In particular, we are experiencing major shifts in the global supply and demand of energy. Oil and gas markets continue to be sluggish, keeping energy prices lower for longer than expected. Geographically, emerging economies are progressively taking up a larger share of global energy demand – but it is also heartening to see many of them are trying to do so via renewable energy. Renewable energy is currently the world's fastest-growing source of energy and is projected to nearly double in generation capacity by 2040 , driven by a strong push in emerging economies such as China and India. For example, India has plans to produce 60% of its electricity from non-fossil fuels by 2027. It is thus timely for this year's IAEE conference to facilitate a discussion on energy demand in emerging economies.

Our discussions on the global energy outlook cannot be divorced from developments on the environmental front – the two are tightly intertwined. Last year, 2016, was a historic year in the fight against global climate change. Countries came together in separate forums and negotiated agreements to put forward their best efforts on reducing greenhouse gas emissions and managing climate change impacts. The Paris Agreement on Climate Change came into force last year, less than a year after it was concluded. This was a monumental milestone as the Agreement is the most ambitious global climate agreement ever negotiated. More recently, even though the Trump Administration has decided to pull out of the Agreement, other major players such as China and the European Union have pledged their continued support for it. This shows the very challenging dynamic put forth by climate change – but also underscores the importance of working together as an international community to address it.

Singapore only contributes 0.11 per cent of global emissions, but we believe it is important to play our part as a responsible member of the international community. As part of the Paris Agreement, we formalised our pledge to reduce our emissions intensity by 36% from 2005 levels by 2030, and to stabilise greenhouse gas emissions with the aim of peaking around the same time. This is an ambitious goal, and one that we are committed to uphold. Moving forward, our challenge then is one of how to continue to grow and prosper in an increasingly carbon-constrained world.

SINGAPORE'S ENERGY DEVELOPMENT AND ENVIRONMENTAL SUSTAINABILITY

Let me elaborate further. Singapore is a small, open economy with no indigenous energy resources. We rely heavily on imported fuels – natural gas fuels about 95% of our electricity generation and is an important industrial feedstock – which means that we are heavily exposed to the volatility of energy markets. Our energy demand is projected to increase at a compounded annual growth rate of between 1.2% to 1.8% over the next decade, in line with projected increases in overall population and economic growth. However, we are alternative energy disadvantaged – we lack the land and climate conditions necessary for the large-scale deployment of renewable energy. Solar energy is assessed to be the most feasible for Singapore given our location but large-scale deployment of solar is not without its challenges. We have to face these energy and resource constraints more acutely in a world that will become more carbon-constrained.

On a positive note, we were fortunate to have pursued economic growth in tandem with preserving our environment since the early years of our independence in the 1960s. We strove to create a vibrant and liveable city underpinned by our belief that economic growth and environmental sustainability can and should be pursued together, rather than be seen as trade-offs. This is because there are externalities arising from both these objectives which are mutually reinforcing and would strengthen Singapore's value as a whole.

Given this, we are embracing this new environmental challenge and have embarked on a path to reduce our carbon emissions and energy consumed in tandem with each dollar of growth that we achieve. For example, we are actively building up a clean energy ecosystem to seize new opportunities particularly in the solar energy sector. Since 2007, we have grown our clean energy industry ten-fold . Singapore's green economy generated around 60,000 jobs and contributed around $6.2 billion to our GDP in 2011. We will continue to help the clean energy sector grow, which can translate to more jobs and enterprise, and also promote economic growth.

CLIMATE ACTION PLAN

We released our Climate Action Plan in 2016 which details the measures that we will be taking both on the mitigation and adaptation fronts. We are adopting a multi-pronged approach, involving the key sectors, stakeholders and partners. I will elaborate more.

Our industry sector is the largest consumer of energy, and emitter of greenhouse gases in Singapore – consuming about two-thirds of our total energy consumption, and contributing about 60% of our carbon emissions in 2014. Improving our industrial energy efficiency is thus a key strategy for us to meet our Paris pledge. Earlier this year, we enhanced the Energy Conservation Act – a key piece of energy conservation legislation – to spur efforts to improve energy efficiency in the industry sector. We introduced new requirements for companies to conduct regular energy audits and put in place energy management systems. We will also phase out inefficient motors from our market starting next year.

We also made a decisive move recently to factor the impact of greenhouse gas emissions through a carbon tax to be implemented from 2019. Through enhancements to the Energy Conservation Act and the implementation of a carbon tax, we hope to encourage the industry to reduce their carbon emissions and improve their energy efficiency when and where it makes the most business sense.

As a densely populated city, the building sector is another energy-intensive sector that we are working closely with to manage energy consumption. The Green Mark scheme, administered by the Building and Construction Authority, has been assisting the sector in the shift towards more environmentally sustainable buildings. I am happy to note that nearly one-third of all buildings in Singapore are Green Mark certified as of January 2017, and we are on track to achieve our target of having 80% of all buildings in Singapore green by 2030.

In the transport sector, we are actively encouraging commuters to shift to more sustainable modes of travel such as public transport and improving the energy efficiency of current modes of transport. We also intend to deploy Electric Vehicles in every housing estate by 2020, as part of our "car-lite" vision as a sustainable and liveable city.

I earlier mentioned our vibrant local clean energy sector. We are targeting to increase the contribution of solar energy – the most viable renewable energy available to us – to 1GWp (Gigawatt peak) beyond 2020. At peak periods, this will represent about 15% of our electrical power demand. Some of the initiatives on this front include our piloting of a floating solar PV installation in Tengah Reservoir, an energy storage system test-bed, and the Renewable Energy Integration Demonstrator micro-grid test-bed on Pulau Semakau. We hope that such projects can be the seeds for scaling-up of innovative clean technologies in Singapore, as well as other markets in the region.

A few weeks ago, the Government also published its inaugural Public Sector Sustainability Plan. This is a joint effort by 16 ministries and 64 statutory boards to be more sustainable. Some of the energy-related initiatives in the plan include reducing the public sector's electricity consumption as a whole by 15% from 2013 levels by 2020, and adopting more solar energy on our premises. We hope that this will spur the wider community to adopt more sustainable practices.

However, the best laid policies would not work without the support of businesses, individuals and associations – in fact, everyone needs to play a part in creating a Sustainable Singapore. The heart of each energy-related policy ultimately drills down to encouraging businesses and the individual to go green. For it is only when we have a green mindset that Singapore can become a hub for the cutting-edge business of sustainable development, and Singaporeans can in turn explore new opportunities in this exciting and meaningful sector. I urge you to play a part in the Sustainable Singapore Movement which was launched last year through your actions and decisions in your daily lives.

CONCLUSION

I know that many new studies and findings will be shared at this conference, and I hope that many of them will find their way into policy decisions in your countries and provide lessons for others. I hope that new partnerships will be formed and collaborations strengthened as we work towards a low carbon economy, while keeping to our environmental sustainability and economic competitiveness objectives.

I would like to wish you all a successful conference. Thank you.

Summary of Plenary Sessions

Reporters:

Fabian Moisl, IAEE Student representative, PhD student, TU Vienna

Melissa Low, Research Fellow, Energy Studies Institute, National University of Singapore

Victor Nian, Research Fellow Energy Studies Institute, National University of Singapore

IAEE members can access all the available plenary sessions in video format via this link: www.iaee.org/en/conferences/2017-singapore-videos.aspx

KEYNOTE SESSION: OIL & GAS MARKETS: GLOBAL ACTIONS AND REGIONAL CONSEQUESNCES

This keynote session was chaired by Ron Ripple, Professor, University of Tulsa, USA. He was joined on the panel by Fereidun Fesharaki, Chairman, FGE; Widhyawan Prawiraatmadja, Governing Board of Indonesian Institute of Energy Economics; and Roger Bounds, Global Head of LNG, Shell, Singapore.

The panel spoke to key issues on gas fields in the Persian Gulf, including the ongoing diplomatic and trade issues in Qatar, with the Gulf countries and how that dynamic is affecting trading in natural gas in that region and around the world. The panelists shared that Qatari gas provides huge flexibility into the system, given that a third of it is not committed or contracted in long-term contracts. They noted that if wrangling continues, if this becomes a bigger deal, this would impact supply of gas in the Gulf. They spoke on the likely impact of the Trump Administration pulling the US out of the Paris Agreement, and how countries such as Indonesia, which is an emerging economy will face significant challenges in meeting both development and environmental goals.

DUAL PLENARY SESSION 1: ELECTRICITY ACCESS IN EMERGING AND DEVELOPING COUNTRIES

The session was chaired by Valerie Karplus, Professor, Sloan School of Management, MIT. Prof. Karplus was joined by Gang HE, Professor, Stony Brook University; Abhishek Jain, Council On Energy, Environment, and Water, Delhi, India; Fatima Arthur, Electricidade De Mozambique; and Vijay Modi, Professor, Columbia University, New York, USA.

The four speakers presented the status-quo of electricity access in China, India and Mozambique and addressed the cost/benefit dynamics of different technologies for electrification. China achieved increased access to electricity from 97% of its population in 2002 to 100% by 2015. In India there are still 237 million people without access to electricity. While 96% of all villages in the six least developed states had access to electricity in 2015, only 69% of the households did. The proclaimed goal of Mozambique is to reach universal access of electricity by 2030. This implies 5.4 million households to be connected to the electricity system at a cost of approximately 500 USD per connection.

DUAL PLENARY SESSION 2: CLIMATE CHANGE

The dual plenary session on climate change was chaired by Regina Betz, Zurich University of Applied Sciences, Switzerland. She was joined by Masakazu Toyoda, Chairman and CEO, IEEJ, Japan; Machiel Mulder, Professor, University of Groningen, Netherlands; and Weijen Leow, Senior Financial Specialist of the World Bank Group.

The panelists discussed new approaches to tackling climate change and energy conservation, designing support schemes to trigger investments in renewables and the role of the private sector in unlocking climate finance.

Mr. Masakazu Toyoda shared a total cost minimizing approach to addressing environmental and energy challenges in Japan, including taking ultra-long-term paths and developing new technologies such as nuclear fusion, carbon capture and storage/utilization (CCS/U), and hydrogen plus CCS/U.

Professor Machiel Mulder discussed the prospect of market-based investments and the need for its design to lower costs and risks for society. He added that without any support, investments in RES will remain problematic because of double market value effect and the existing base of conventional power plants.

Mr. Weijen Leow underscored the importance of the work of the World Bank Group in addressing the need to boost development and growth in a fairly balanced way. He added that the regions of Asia-Pacific, South Asia, Latin America and Sub-Saharan Africa are where the bank does most of the lending.

DUAL PLENARY SESSION 3: LESSONS FROM TRANSMISSION GRID EXPANSION AND CROSS-COUNTRY CO-OPERATION

This session was chaired by Christian von Hirschhausen, Professor, Berlin University of Technology; who was joined by Anoop Singh, Professor, Indian Institute of Technology, Kanpur, India; Bruce Mountain, Director, Cme Economics, Melbourne; and Seabron Adamson, Vice President, Charles Rivers Associates, Cambridge, MA, USA.

Anoop Singh opened the plenary session by outlining the potential of a regional power market in South Asia in order to improve energy security, increase access to sustainable energy and thus improve the quality of life. Followed by Bruce Mountain, who spoke about the competition of interconnectors versus batteries to resolve issues on power supply in South Australia and addressed the question whether transmission operators should be prevented from owning batteries. Finally, Seabrom Adams compared recent investments and the expansion of the gas transmission system to the electric transmission system in the United States.

DUAL PLENARY SESSION 4: GLOBAL GAS MARKET DYNAMICS

Jeff Brown, President of FGE, presided this session. Mr. Brown was joined by Jonathan Stern, Distinguished Research Fellow, Oxford Institute for Energy Studies; Anne-Sophie Corbeau, Research Fellow at KAPSARC; and Robert Brooks, President, RBAC.

Sessions presider gave an introduction to the basics of gas, LNG and the market operation. Mr. Stern elaborated his view on future gas market dynamics in Europe. He argued that it's the competitiveness of Russian gas versus LNG rather than Russian gas versus US LNG. Anne-Sophie Corbeau analyzed the present situation and trend in global gas market. Followed by Robert Brooks, who explained their modelling the developing global natural gas market's impact on Asia. They aim to forecast natural gas supply and demand by using existing supply/demand outlooks as benchmark. In a high-growth scenario, they predicted that incremental growth of electric natural gas demand from China and India on average will result in 9.3% higher spot market prices over the entire outlook period (2016-2040)

TRI-PLENARY SESSION 5: THE ECONOMIC FUTURE OF NUCLEAR POWER

This session was presided by Masakazu Toyoda, Chairman and CEO, IEEJ; joined by Michel Berthelemy, Commissariat à l `Energy Atomique; Jan Horst Keppler, Professor, University of Paris-Dauphine; and Yang Kalin, CFO, CGN Power co., Ltd.

The electricity sector has an important role in attaining the climate objectives. Speakers of this plenary session have all reiterated the importance of nuclear energy in decarbonizing the electricity sector. The nuclear industry has gone through a transition from the construction of first-of-a-kind exploratory designs to nth-of-a-kind commercially proven designs. Although recent new build projects, such as the AP1000 in the USA and EPR in France saw cost escalation and completion time overrun, the levelized cost of electricity generation from nuclear energy remain competitive as compared to other energy sources. In addition, design standardization, quality assurance, regulatory improvements, and technological innovations are among the important success factors contributing to the effective control over cost and completion time of nuclear power plant projects in China. The emergence of small modular reactors could further contribute to safer and more economical nuclear energy in the future.

TRI-PLENARY SESSION 6: EAST ASIAN GAS MARKETS IN TRANSITION

This Tri Plenary Session was chaired by Shi Xunpeng, Principal Research Fellow at the Australia-China Relations Institute, University of Technology Sydney and an Adjunct Senior Research Fellow at the Energy Studies Institute (ESI), National University of Singapore. He was joined on the panel by Ken Koyama, Managing Director, Chief Economist of the Strategy Research Unit at The Institute of Energy Economics, Japan (IEEJ); Tatiana Mitrova, Head, Oil and Gas Department, Energy Research Institute of The Russian Academy of Sciences; and Andrew Seck, VP LNG Marketing & Shipping, Anadako, Singapore.

Dr. Shi spoke on LNG pricing reform and the market failure of oil indexation. He noted Asia pays a substantially higher price compared to elsewhere and asked if East Asia has the power to change the price signal.

Dr. Ken Koyama shared the Japanese perspective on this transition. He said it is very likely that demand for this commodity (gas) will rise over time and that a major part of it will come from Asia.

Dr Tatiana Mitrova discussed issues of Russian gas in the East Asian gas market. She said that three years ago, the role of Asian gas exports in the government policy was very high but now there is a disappointing development. She highlighted the huge demand uncertainty due to political changes and financial signals, coming particularly from the US and China, respectively.

Dr. Andrew Seck spoke about emerging changes in gas trade practices from a marketing perspective. While the other panelists noted uncertainties in the gas market, he remained optimistic about taking a Financial Investment Decisions (FIDs) approach for green field LNG projects in order to bring new gas to the market in the future.

TRI PLENARY SESSION 7: ENERGY SECURITY

Philip Andrews-Speed, Senior Principal Fellow at ESI presided this session. Mr. Andrews-Speed was joined by Adam Rose, Professor, University of Southern California, USA; Omowumi Iledare, Professor, University of Port Harcourt, Nigeria; and Ramteen Sioshansi, Professor, Ohio State University, USA

Adam Rose introduced a methodology based on Input-Output Analysis to measure economic resilience of critical energy infrastructure such as seaports. He found that resilience of U.S. seaports is very strong because of the recent boom in oil

shale.

Omowumi Iledare outlined the fundamental energy security issues of Nigeria. He concluded that it is important for Nigeria to adopt a global strategy for primary energy resource supply mix and that transparency in governance, political and policy stability, and energy sector institutional reform are imperative for Nigeria's energy security potential.

Ramteen Sioshansi gave a talk about how electric energy storage systems can improve energy security and resilience. Despite best practice examples, he pointed out that market design and regulatory barriers still remain.

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Interview with Thomas-Olivier Léautier, Energy Journal Best Paper Award Winner

By Fabian Moisl, IAEE Student representative and PhD student, TU Vienna.

The 2016 *Energy Journal Campbell Watkins Best Paper Award* was given to Thomas-Olivier Léautier for his paper titled "The visible hand: ensuring optimal investment in electric power generation". Mr. Léautier is Professor of Management at the University of Toulouse and Research Director at Toulouse School of Economics where he conducts research on risk management and electric power markets restructuring. Moreover, he is the Director of the EDF Group University for Management.

"The paper is a good example of 'applied theory' – Thomas-Olivier builds a model that can be used to analyze three ways of supporting extra generating capacity, shows how they compare with each other and generates results that are insightful.", Anne Neumann, IAEE Vice President for Publications, stated.

"I always admired the work of the previous award winners! Therefore, the award is a great honor for me", said Mr. Léautier. "The most important aspect about the paper, in my opinion, is that it provides a scientific foundation for policy decision-making."

Asked about his advice on how to write a good scientific paper he explained that the reviewing process was very tough and that he had the feeling that one of the reviewers did not fully understand his paper. Thus, it is, in his opinion, of utmost importance that one has to be persistent, believe in their work and themselves and never to give up.

Buffer vs. Speculation: A Review on the Role of Crude Oil Inventory

By Soohyeon Kim, Jungho Baek, and Eunnyeong Heo

1. INTRODUCTION

Crude oil inventories generally respond to oil supply and demand shocks in two conflicting ways. In the event of an oil supply disruption, for example, oil inventories can be released onto the market to cover supply shortages and to help mitigate the upsurge in oil prices, called buffer inventory. Or, they can be hoarded now and sold later at higher prices in order to achieve arbitrage margin, referred to as speculative inventory. In order to fully understand the changing dynamics of the oil market, therefore, it is crucial to identify the role and behavior of crude oil inventories properly. Although studies on the behavior of oil inventories are fairly numerous, the empirical emphasis has typically been on either buffer or speculative motive of oil inventories with few studies considering both effects on the oil market together.

In this article, therefore, we are intended to contribute to the literature by examining the role and behavior of crude oil inventories in an integrated econometric model that encompasses the two different views together. The empirical focus is thus on detecting whether oil inventories react to oil demand and supply shocks as the buffer to the market or as the facilitation of speculative trading. Since the behavior of oil inventories likely depends on where oil prices are headed, for a careful analysis we split our sample into two distinct periods and sign-restricted structural vector autoregressive (SVAR) model is applied to them.

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See footnote at end of text.

2. DISENTANGLING BUFFER AND SPECULATIVE INVENTORIES

In an effort to properly detect the behavior of oil inventories, the first task is to define oil demand and supply shocks used for the analysis. A positive demand shock is defined as the shock that shifts demand curve rightward and hence increases the price level. In this article, this shock coincides with the period of rising and high oil prices between January 2003 to June 2008 (2003:M1-2008:M6), considering significant growth in oil demand oil demand caused by strong economic conditions in oil-importing countries (i.e., China, India and Brazil). On the other hand, a positive supply shock is defined as the shock that shifts supply curve rightward and hence decreases the price level. This shock is associated with the period of low oil prices between July 2009 and February 2016 in the article (2009:M7-2016:M2), given an increase in unconventional shale. Following the definitions, sign restrictions are imposed on the SVAR model, based on the economic theory: an oil price is decreased by a positive supply shock but increased by a positive demand shock.

The second task is then to determine the direction of oil inventories in response to oil demand and supply shocks. Under a positive demand shock, for example, oil inventories could be increased now for the anticipation of higher prices to gain arbitrage margin. Or, oil inventories could be decreased by releasing them onto the market to mitigate the current price increase. In our analysis, therefore, if a positive demand shock leads to a decline (rise) in oil inventories, it implies buffer (speculative) inventories. Similarly, under a positive supply shock, oil inventories are likely to be reduced now by selling them in the market before oil prices fall even further, while they may be increased by absorbing the oversupply of crude oil. Therefore, if a positive supply shock results in an increase (decrease) in oil inventories, it implies buffer (speculative) inventories.

3. VARIABLES AND DATA SOURCES

The first variable is the world crude oil production as a proxy for the oil supply variable and is collected from the U.S. Energy Information Administration (EIA). The second variable is the weighted average of industrial production index for major oil consuming countries, which can be a proxy for world oil consumption. The industrial production indices are obtained from the Organization for Economic Cooperation and Development (OECD). West Texas Intermediate (WTI) crude oil prices (real, 2005=100) are taken from the EIA and used as a proxy for the world crude oil price in this article. We incorporate two types of inventory variables: global and U.S.[1] crude oil inventories. First for global crude oil inventories, a proxy inventory is used to address the lack of open and accurate data, following Kilian and Murphy (2014)'s approach; the U.S. crude oil inventories from EIA are scaled by the ratio of OECD commercial petroleum inventories from EIA over U.S. petroleum inventories from IEA. Second for the U.S.

inventories, EIA's U.S. oil crude oil inventories excluding Strategic Petroleum Reserve (SPR) was used.

4. EMPIRICAL RESULTS

To assess the effects of oil demand and supply shocks on oil inventories, the impulse response functions (IRFs) are calculated for 12 future months after estimating the SVAR model. The values are multiplied by a thousand for the sake of convenience of discussion (Figure 1).

The impulse responses during 2003:M1-2008:M6 show that the response of global crude oil inventories to a demand shock is positive for the first three months, with the highest response (+5.66) in the initial month, indicating a dramatic increase in the inventories, thereby exhibiting speculative behavior. The response caused by demand shock, however, turns negative in the third month with the highest response (-1.41) in the fifth month, providing evidence of buffer behavior. On the other hand, the response of oil inventories to a positive supply shock is negative for the first three months but insignificant. After three months, however, the supply shock responses turn positive, indicating that oil inventories play a buffer role after revealing a short period of speculative behavior. Notably, given the absolute values and significance, speculative trading seems to be more pronounced with demand shock than with supply shock.

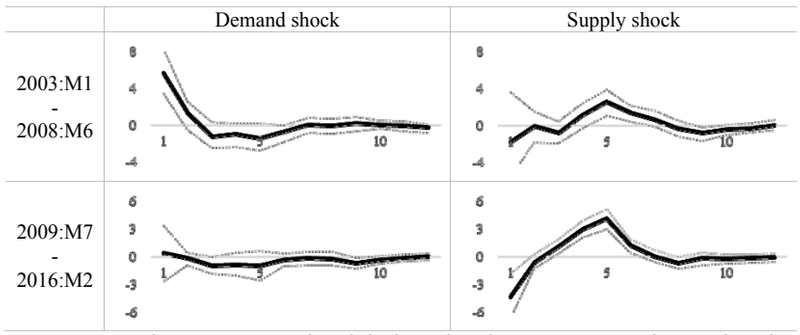

Figure 1. Impulse responses of a global crude oil inventories to demand and supply shocks

The impulse responses during 2009:M7-2016:M2 show that the response of global crude oil inventories to a positive demand shock seems to be rather insignificant. On the other hand, the response of oil inventories to a positive supply shock turns out to be significantly negative for the first two months, with the highest response (-4.37) in the initial month, suggesting an inventory reduction on a speculative motive. Then, responses triggered by supply shock spike to its highest (+4.14) in the fifth month, apparently indicating a buffer function absorbing a glut of oil. Given the absolute values of responses in both shocks, demand shock apparently on the inventory change is outweighed by supply shock impact during the period of low oil prices.

To assess what extent each shock derives changes in global crude oil inventories, forecast error variance decompositions (FEVD) are also calculated for completeness. The results support that in the period of 2003:M1-2008:M6, oil prices demand shock (29.81%) is more important than supply shock (24.04%) in explaining changes in oil inventories. During 2009:M7-2016:M2, on the other hand, the contribution of supply shock (22.69%) to oil inventories is larger than that of demand shock (18.80%).

5. CONCLUDING REMARKS

Oil inventories could react to oil demand and supply shocks either as the buffer to the market or as the facilitator of speculative trading, or both. However, empirical studies that have addressed both behaviors together have been rather sparse. In this article, therefore, we divide the full sample into two distinct periods – 2003:M1-2008:M6 and 2009:M7-2016:M2 and assess the dynamic effects of oil demand and supply shocks on oil inventories in the framework of sign-restricted SVAR. We find that demand shock is the important relative factor in oil price spike during the first period, while supply shock is the main cause for the drop-in oil prices during the second period. We also find that during both periods oil inventories appear to reveal speculative behavior in the early stage of shocks, but later on play a buffer role in mitigating the impact of shocks. In this light, we infer that when examining the effect of oil inventories on the global oil market, researchers need to incorporate both buffer and speculative effects in their models. To our knowledge, these are new findings that have not been documented in the literature yet and hence the main contribution of this article.

Footnote

[1] The results from U.S. crude oil inventories are left out in this article for the limit of pages. The responses of U.S. inventories are found to be consistent with those of global inventories.

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Enhanced Oil Recovery (EOR) as a Stepping Stone to Caebon Capture and Sequestration (CCS)

By Dana M Abdulbaqi, Carol Dahl and Mohammed AlShaikh

OVERVIEW

Fossil fuels promise continuous domination of the global energy mix with mounting carbon emissions and climate threat for decades to come. While the growth of enhanced oil recovery that utilizes CO_2 (CO_2-EOR), especially in the US, has been curbed primarily because of limits on accessibility to affordable supplies of CO_2. Environmental concerns about carbon emissions coupled with the oil industry's need to secure additional CO_2 for EOR has sparked interest in the potential CO_2-EOR may have in jumpstarting carbon capture and sequestration (CCS).

Published work highlighting the viability of CCS when coupled with EOR have generally placed more focus strengthening one aspect: engineering or economic policy. Furthermore, associated modeling efforts presented stop at the end of the productive life of the field. Most engineering studies focus on the technical aspects of the design of the CO_2-EOR project to produce the maximum amount of oil while simultaneously storing the most CO_2 with the economics as an afterthought. While most economic studies found have focused on a singular aspect of the issue such as impacts of exogenously varying injection rates. We found only one study (Leach et al. (2011)) that simultaneously modeled engineering and economic policy aspects of the co-optimization of CO_2-EOR and CCS in a dynamic optimization framework. We build on the limited previous work by combining robust engineering and economic policy aspects to investigate the practicality of wide scale implementation of CCS when partnered with CO_2-EOR.

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METHODS

Published work highlighting the viability of CCS when coupled with EOR have generally placed more focus strengthening one aspect: engineering or economic policy. Furthermore, associated modeling efforts presented stop at the end of the productive life of the field. Most engineering studies focus on the technical aspects of the design of the CO_2-EOR project to produce the maximum amount of oil while simultaneously storing the most CO_2 with the economics as an afterthought. While most economic studies found have focused on a singular aspect of the issue such as impacts of exogenously varying injection rates. We found only one study (Leach et al. (2011)) that simultaneously modeled engineering and economic policy aspects of the co-optimization of CO_2-EOR and CCS in a dynamic optimization framework. We build on the limited previous work by combining robust engineering and economic policy aspects to investigate the practicality of wide scale implementation of CCS when partnered with CO_2-EOR.

The oil producer in our first stage maximizes profits by optimizing the choice of using CO_2 from natural or captured sources to achieve their optimal CO_2 injection rate which impacts both oil production and CO_2 sequestration. The carbon tax penalizes the producer for every unit of CO2 emitted when their oil is consumed as well as every unit of CO_2 they extract from natural sources during operations. The producer is also credited for every unit of CO_2 they sequester in the EOR process. This stage allows us to simulate oil production, CO_2 usage and sequestration by source to the end of the economically productive life of the field subject to a known oil stock constraint, natural CO_2 stock constraint and reservoir capacity constraint. Tracking the consumption of CO_2 from both natural and captured sources under increasing levels of carbon tax shows a transition from usage of natural CO_2, currently the most common and cheapest source of CO_2, to captured CO_2. The second stage involves extending the model beyond oil production activities. The oil producer maximizes profits from selling pore space for sequestration of captured CO_2 via their optimal CO_2 injection rate subject to a reservoir capacity constraint. Our reservoir capacity constraint in this stage is a function of cumulative oil production resulting from our first stage. This stage allows us to simulate CO_2 sequestration beyond oil production activities during which all production wells are capped and CO_2 is injected into the reservoir with no physical outlet.

RESULTS AND CONCLUSIONS

The producer switches from one stage to the next when the total benefits that can be obtained from sequestering CO_2 is more than the total benefits that can be obtained during CO_2-EOR. This decision

is affected by the interaction of geological, technical and market conditions. The major findings relate to the optimal time of switch from one stage to the other, total volumes of captured CO_2 sequestered and how each is influenced by the tax and oil price levels set in the first stage. The intent is to be able to inform policy makers how to design policy in the presence of a market for CO_2.

Adjusting the Leach et al policy to penalize the producer for every unit of natural CO_2 used is effective in encouraging the producer to transition from sole use of natural CO_2 to sole use of captured CO_2 in the first stage. Under the assumption that CO_2 from both sources are perfect substitutes, the tax threshold above which the producer switches from sole use of natural CO_2 to sole use of captured CO_2 is equal to the difference in price between captured and natural CO_2. Natural CO_2 usage declines with increases in tax levels up to the tax threshold because the credit they receive for sequestering CO_2 gets negated by the tax they have to pay for every unit of natural CO_2 they use. Above the threshold captured CO_2 usage increases with higher tax levels. The revenues accrued to the producer from CO_2 sequestration provide the needed incentive to increase CO_2 usage which will positively impact both sequestration and production

We consequently see a significant jump in net sequestration above the tax threshold. The jump in sequestration of captured CO_2 at tax levels above the threshold is attributed to the transition to sole use of captured CO_2 at those tax levels. Model results suggest that the amount of captured CO_2 sequestered in the EOR process (stage one) is on the order of hundreds of thousands of barrels which equates to tens of thousands of tonnes. Mirroring the Leach et al. results, we observe that at higher oil prices resulting in higher revenues make it optimal to increase CO_2 injection levels over the life of the project leading to increases in cumulative sequestration. With higher tax rates, initial CO_2 injection rates are increased but we also observe a more rapid decline in the injection rates over time which results in an accelerated switch to water flood. Nonetheless, the impact on cumulative sequestration is positive because the amount of CO_2 sequestered early on when injection rates were higher more than compensates for the lower sequestration later due to reduced injection and earlier switch to water flood.

The amount of CO_2 we can sequester in our second stage is a function of cumulative oil production resulting from the first stage. We assume in the second stage that the producer sells available pore space to facilities in need of storage space for their captured CO_2. As expected, total volumes of sequestered CO_2 across both stages eventually increases with higher tax rates. But, at lower oil prices we see the trend in volumes of captured CO_2 sequestered over both stages decrease until the tax threshold and then increase post the tax threshold. The burden of the tax at lower oil prices induces limited or no use of CO_2 in the production process leading to less cumulative oil production. This leads to less sequestration across both stages because of the limited use of CO_2 and less cumulative oil production in stage one; releasing less space for sequestration in stage two.

Oil price and tax levels will also influence the timing of the switch from our first stage to the second. We find that at fixed price levels, but increasing tax rates the time of switch from one stage to the next is accelerated. Increased tax accelerates oil production in the first stage which results in a quicker decline in oil production thus inducing the accelerated switch to the second stage where the operator can accrue greater profits from just sequestration. On the other hand at fixed tax levels, but increasing prices the time of the switch from stage one to two is delayed. Higher oil prices encourage longer production periods coupled with the volumes of oil produced and CO_2 sequestered outweigh potential benefits from our second stage for longer periods of time.

The model developed appropriately values CO_2 emissions and reservoir pore space. The results of the model in conjunction with estimates of CO_2 demand for EOR purposes provide an appropriate foundation for future work. We aim to continue bridging the gap between engineering and economic policy aspects whilst providing an easy to use tool that allows for evaluation the practicality of wide scale implementation of CCS when partnered with CO_2-EOR.

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The Technical and Economic Viability of Producing Marginal Oil Fields in the Niger-Delta Using Water Injection

By Rita U. Onolemhemhen, Sunday O. Isehunwa, Akin P. Iwayemi, Adeola F. Adenikinju

INTRODUCTION AND OVERVIEW

Marginal fields are economically sensitive to develop which is why marginal fields are faced with challenges ranging from technical to economic challenges. Producing marginal fields conventionally is one of the ways operators of marginal fields cut cost of development and production. Marginal Fields are currently estimated to contribute about 30% to 40% of global oil produced and are gaining ever growing importance due to the natural production decline of large, mature fields. Large International Oil Companies (IOCs) and smaller independent companies are developing skills and capabilities to unlock the potential from marginal fields and small developments. However, since the beginning of Petroleum exploration in Nigeria in the 1930's, many oil fields have been left undeveloped and termed marginal by the International oil companies (IOCs) (Offia 2011). This is as a result of the volume of the oil and gas in such fields (small reserves) and the economic sensitivity attached to developing them.

According to the US Legal.com, marginal field refers to an oil field that may not produce enough net income to make it worth developing at a given time. However, should technical or economic conditions change; such fields may become commercial fields.

Given that the era of easy to find oil is coming to an end and the persistent plunge in crude oil prices, the future of marginal field operators seem less assured due to the economic sensitivity of such fields. This study, therefore investigated one of the ways of increasing production from marginal oil fields within an economic framework through the improvement of recovery factor.

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OVERVIEW OF MARGINAL FIELD POLICY IN NIGERIA

Marginal Fields development is an offshoot of Federal Government policy to kick-off indigenous participation in the upstream sector of the petroleum industry. The government sought to achieve this objective by ensuring the farm out of marginal fields within the concessions of the major multinational oil operators to the indigenous operators.

The principal legislation of the Nigerian Petroleum Industry is the Petroleum Act 1969 Laws of The Federation of Nigeria (The Act) which vests ownership and control of all petroleum to the Federal Government. The Act provides for the grant of three types of interest in oil blocks by the Minister of Petroleum Resources as well as a provision for assignment/ farm out of rights held under such licenses. The licenses are exploration licenses, oil prospecting license (OPL) and oil mining lease (OML).

Marginal oilfield became a policy of Government under the Petroleum (Amendment) Decree No 23 of 1996, which introduced paragraph 16A to the 1st schedule to the Petroleum Act. The legislation provides that the holder of an Oil Mining Lease may with the consent of the Head of State farm-out any oil Field within its leased area or the Head of State may cause the farm-out of a marginal field that has been left unattended to for a period of not less than 10 years from the date of first discovery. This can hardly be regarded as a definition. Furthermore there were serious implications attached to this form of definition - that of the arbitrary classification of fields as marginal. In order to restrict the arbitrary classification of fields as marginal, the Department of Petroleum Resources issued guidelines enumerating the features, which must exist before a field can be classified as marginal. They are as follows:

1. Low stock tank oil initially in place (STOIIP) and therefore low reserves.
2. Long distance from existing production facilities, thereby making them uneconomically viable to put on stream.
3. Fields with crude characteristics that is different from current streams (such as crude with very high viscosity and low API gravity) which cannot be produced through conventional methods.
4. Fields not yet considered for development because of marginal economics under current market and fiscal conditions.
5. Field with one or more wells which have not been developed by the operating companies as

a consequence of the company's ranking including unappraised discoveries and undiscovered fields, but excluding fields with high gas and low oil reserves.
6. Producing fields, which have become uneconomical when close to or passed abandonment limits (DPR, 1996).

METHODOLOGICAL REVIEW

Water injection is an old method of oil recovery and pressure maintenance technique. Water injection can be classified in two ways depending on the objective for injecting the water. Water injection for the purpose of sweep efficiency is called water flooding while water injection for the purpose of pressure maintenance is simply water injection. However, over the years, water flooding has gained more popularity than water injection. Studies have also shown that water injection is more economical than water flooding which is why it can be considered in marginal oil fields which are already characterised with economic sensitivity.

The development of marginal oil fields is of key interest to the government and the Nigerian oil and gas sector. Therefore, one way of economically increasing oil recovery from marginal oil fields is through water injection to maintain pressure and enhance productivity. However, there is a dearth in literature on the technical and economic evaluation of this production technique in the Nigerian marginal oil fields. This study, therefore, investigated the technical and economic viability of increasing oil recovery through water injection from Nigeria's marginal oil fields in the Niger-Delta.

This study was anchored on the Least Square Method. Thirteen reservoir parameters: original oil-in-place, permeability, initial water saturation, reservoir pressure, oil viscosity, initial water saturation, reservoir thickness, porosity, API gravity, solution gas oil ratio, water viscosity and residual oil saturation were collected from 136 oil reservoirs producing under water drive and 129 reservoirs producing under solution gas drive. Preliminary screening was done to ascertain the impact of these parameters on oil Recovery Factor (RF). New models were developed for Primary oil Recovery Factor under water drive, solution gas drive and Secondary oil Recovery Factor under water injection. All the models were validated with data from producing marginal oil fields. The economic viability of water injection in the marginal oil field was estimated using two approaches; the deterministic and the probabilistic approach. The deterministic approach evaluated the project through a single point analysis with assumptions made for the base case scenario, according to the existing fiscal and regulatory framework in Nigeria. However, the deterministic analysis, decision making only would not have provided insights on certainty value and sensitive parameters which are key to determining the input parameters that impact most on the water injection project.

Therefore, the probabilistic approach was used to determine the effects of each input variable on the output.

KEY FINDINGS

Based on this study, the following observations were made.

- Water injection improve recovery factor by about 60%
- That the project will have a negative cash flow when the recovery factor is below 20%.
- It was also observed that discount rate and oil prices do have impact on the NPV.
- Results obtained from the profitability analysis showed a positive NPV of $198.35 million and an IRR of 38.12% for offshore and a positive NPV of $228.25million and an IRR of 45.71% which is above the hurdle rate meaning the investment is viable.
- The project also has a good payback period of 2 years which will be the total number of years it will take to recover the capital.
- The project also has a discounted profitability index above zero (0) which indicates that the project is economically viable.

With respect to risks and uncertainties, the probabilistic approach gave a 45.5% certainty of having a positive Net Present Value (NPV) of $228.25million for onshore and $198.36million for offshore. However, there is a 95% chance of having an NPV of about $290.42million for onshore and $263.99million for offshore, a 50% chance of having an NPV of $236.17MM for onshore, $206.39million for offshore and a 5% chance of having an NPV of $185.72MM and $154.02million for onshore and offshore. These values clearly show how economical and profitable a water injection project can be in a marginal oil field. The sensitivity analysis outlined discount rate, development cost and nominal price (oil price) as key sensitive parameters in maximising profit while production rate and operating expenses were the least sensitive thereby having little impact on the profitability of the water injection project. This was

also confirmed by the tornado charts which displayed ranges of profit/loss derived through the effect of these parameters and the spider chart which displayed their impact based on the steepness of the slope.

CONCLUSION

In conclusion, water injection project for marginal field is technically and economically viable and will give good returns on investment under the technical and economic conditions established in this study. With the help of the range of the economic indices shown in the results obtained, it is a project that marginal operators will be willing to undertake. However, the discount rate, development cost and oil price are the key to making final investment decision in the project.

KEY RECOMMENDATIONS

Based on the findings from this study, the following recommendations were made:

Firstly, water injection project should be considered as a development plan in developing a marginal field as this study has shown that it will not only increase production and reserve but it will extend the economic life of the field. However, the recovery factor must be above 20%.

Secondly, the water injection model developed in this study should be used as a screening tool in identifying reservoirs that are good candidates of water injection so as to initiate a water injection program early in the life of the reservoir.

Interview with Carlos Andrea Bollino, Professor of Economics, Università degli Studi di Perugia, Perugia

By Melissa Low, Research Fellow, Energy Studies Institute, National University of Singapore

Professor Carlos Andrea Bollino, Professor of Economics, Università degli Studi di Perugia, Perugia expressed thanks to the organizers of the 40th IAEE International Conference held in Singapore from the 18-21 June 2017. He said it was important for the energy research community to have a platform to exchange ideas. He added that the IAEE International Conference is an excellent platform to hear from academics and industry practitioners on the major energy trends at the plenary sessions. By bringing together the academic community with business leaders, it makes for more realistic application of economics research. When asked about the paper he presented at this year's conference, he said that it was on the effect of preferential trade agreements on energy imports from Chinese and exporters' perspective. He added that the paper presents a novel analysis of Chinese trade flows from Chinese partners and overseas parties and looks at the determinants of trade flows by industries.

As a side note, IAEE is pleased to announce that Carlos Andrea Bollino has won the 2017 Outstanding Contributions to the IAEE Award – see picture collage page in this issue of the *Energy Forum*.

Interview with Ong Wee Min, Executive Director, Sales, Marina Bay Sands

Photo credit: Marina Bay Sands

1. *When was the MBS Sands built and what was the total budget for this project?*

Marina Bay Sands opened in April 2010. It was built at an investment of US$5.6 billion, inclusive of land cost.

2. *How large is the hotel's total room capacity and how many guests could you host?*

Marina Bay Sands is an integrated resort which offers a luxury hotel, state-of-the art convention and exhibition facilities, theatres, world-class entertainment and the best shopping and dining in the region.

We have the biggest hotel in Singapore, offering 2,561 luxury rooms and suites across three 55-storey towers. The hotel is capped by the Sands SkyPark, which offers 360-degree view of Singapore's skyline. It is home to restaurants, lush gardens, an infinity edged swimming pool and the world's largest public cantilever housing an observation deck.

Sands Expo and Convention Centre has 1.3 million square feet of flexible convention and exhibition space. It can host over 45,000 delegates, 2,000 exhibition booths and 250 meeting rooms. It features Southeast Asia's biggest ballroom, which can accommodate 6,600 people for a banquet and up to 11,000 for an auditorium-style lecture.

3. *How many employees do you have?*

Marina Bay Sands has over 9,500 direct Team Members or staff. Thousands more work in the retail shops and restaurants in the mall.

4. *Could you name the biggest event which was organized in your Convention Centre?*

Our largest association meeting was SIBOS 2015 with more than 8,200 delegates while our largest business event is CommunicAsia with more than 33,000 delegates.

5. *From your perspective, which factors make your hotel one of the biggest attractions of Singapore?*

As a MICE-led integrated resort, Marina Bay Sands has been a huge contributor to the growing appeal of Singapore as one of the most sought-after Asian destinations for both leisure and business travelers. Marina Bay Sands offers the MICE delegate a truly integrated solution that no other venues in the world can offer - delegates can stay in our distinctive Hotel, transact business networks and exchange knowledge and contacts in the Sands Expo & Convention Centre, and entertain in our celebrity chef restaurants and other iconic attractions such as ArtScience Museum.

Content renewal is also a key focus. Whether it is through the shows and events we bring in, celebrities and renowned chefs we attract, or the expansion of luxury retail footprint, we are constantly creating new experiences for our guests and repeat visitors. It's our mandate never to settle for what we have currently, but to continuously push boundaries and create the best.

As the main business event venue in Singapore with more than 3,000 events hosted annually on property, Marina Bay Sands takes pride in our track record and deep expertise. It's our goal to ensure the seamless execution of all events with the support from our in-house professionals. These best-in-class teams span technical and logistic specialists, catering professionals, to event and sustainability experts.

6. *Could you please describe a few most inspiring aspects of your job?*

Being part of something that is bigger than oneself is one of the reasons why I love working in Marina Bay Sands. Every

(continued on page 23)

Experience Curve for Natural Gas Production by Hydraulic Facturing

By Roku Fukui

OVERVIEW

Hydraulic fracturing technology, or "fracking", spurred the massive increase of shale gas production in the U.S. over the past 10 years. Beginning around 2005, the shale gas revolution has helped the U.S. reach unprecedented levels of natural gas production. Unsurprisingly, the increase of unconventional gas production impacted the U.S. natural gas market, causing a sharp decline in the wellhead price (Mazur, 2012). As hydraulic fracturing techniques and drilling technology continue to develop, resulting in additional production increases, further price declines are possible. Both the private and public sectors value analysis regarding the potential effects on market prices of continued growth in unconventional gas production. In this article, based on an inspection of progress achieved in the field of hydraulic fracturing technology so far, we provide an indicator for potential future gas price reductions.

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See footnote at end of text.

While plenty of literature exists on price and manufacturing cost reductions, as well as on learning-by-doing phenomena, for a large range of energy technologies, comprehensive research on price reductions for the use of hydraulic fracturing technology has not yet been undertaken. As production of unconventional natural gas continues to grow, it is insightful to investigate past and prospective gas price developments. This article presents an experience curve for the US natural gas industry from the start of the shale gas revolution. We examine the impact of increased shale gas production on the wellhead price of natural gas, and show that a learning-by-doing trend exists that reflects past achievements deriving from the accumulation of experience. This trend may be indicative for future price developments, or even for the prospects of the gas industry as a whole. We present an experience curve that may provide insight into one of the factors determining future gas price levels and that, complemented with other price development indicators as well as ancillary knowledge on limitations to its extrapolation, could possibly be used as empirical information for strategic considerations in industry, as background material for public policy planning, or as input for climate change mitigation research. For instance, in principle this experience curve could be implemented in integrated assessment models as used for low-carbon energy technology diffusion studies such as by the Intergovernmental Panel on Climate Change (IPCC, 2014), although such models normally require cost-data rather than price-based information as input.

METHOD

$$P(x) = P(x_0)\,(x/x_0)^{-L}$$

x:	*Cumulative output*
$P(x)$:	*Price at cumulative output*
L:	*Learning parameter*
$LR = 1 - 2^{-L}$:	*Learning rate*

Experience curve analysis is a method for expressing the relationship between price reductions and cumulative production of a good or technology. The experience curve is related to the learning curve, which is a way of illustrating the relationship between cost reductions and cumulative production (see Wene, 2000), for details on the distinction between these two concepts). Based on the correlation between price and production observed for the past, experience curves yield information for potential price reductions in the future. The steepness of the experience curve, expressed by the value of the learning rate, identifies the rapidity of structural market, manufacturing, or industry change for in principle any technology. The experience curve methodology stipulates that every doubling of cumulative production of a certain commodity or technology generates a constant relative reduction (in %) of its price, which is the learning rate.

RESULTS AND IMPLICATION

The experience curve depicted in Fig 2 captures the shale gas revolution from a perspective of in-

dustrial production and price data in the period 2005–2015. The learning rate of this curve is 13%, that is, a doubling of shale gas output results on average in a 13% fall in constant US(2009)$ terms of the price of natural gas. The R^2 of this regression is 0.66, hence the fit is reasonable but implies by no means a conclusive statistical reliability. In order to derive a statistically more significant experience curve, future analysis should incorporate a larger data set, ideally covering at least two orders of magnitude of expansion of cumulative production of shale gas, as pointed out in Ferioli et al. (2009). The 13% steepness of our learning curve is an indicator for the speed of experience gained by the industry from new hydraulic fracturing technologies and drilling techniques.

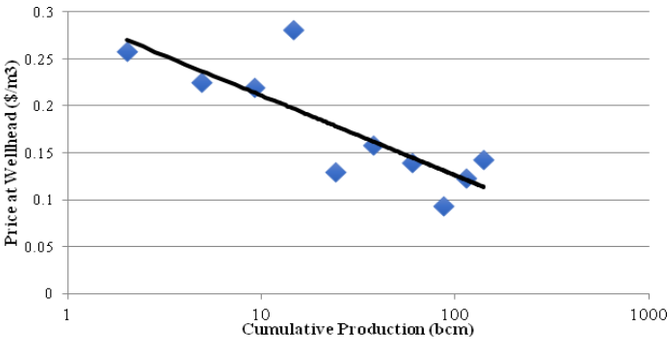

Fig 2: Experience Curve for Natural Gas Production by Hydraulic Fracturing. (Data from 2005 to 2015).

There are a number of factors that can limit the further production of unconventional gas. Correspondingly, there are factors affecting the stability of the experience curve, both internal (or endogenous) and external (or exogenous) to the learning system. The distinction between these two types of factors is policy relevant, because internal disturbances may threaten the survival of the learning system, while the learning system may have mechanisms to handle external disturbances (see, e.g., Wene, 2015).

CONCLUSION

From 2007 to 2012 shale gas production in the U.S. expanded at an astounding average growth rate of over 50%/yr, and thereby increased nearly tenfold over this short time period alone. Hydraulic fracturing technology, as well as new directional drilling techniques, played key roles in this shale gas revolution, by allowing for extraction of natural gas from previously unviable shale resources. Although hydraulic fracturing technology had been around for decades, it only recently became commercially attractive for large-scale implementation. As the production of shale gas rapidly increased in the U.S. over the past decade, the wellhead price of natural gas dropped substantially. In this paper we express the relationship between wellhead price and cumulative natural gas output in terms of an experience curve, and obtain a learning rate of 13% for the industry using hydraulic fracturing technology. This learning rate represents a measure for the know-how and skills accumulated thus far by the U.S. shale gas industry. The use of experience curves for renewable energy options such as solar and wind power has allowed analysts, practitioners, and policy makers to assess potential price reductions, and underlying cost decreases, for these technologies in the future. The reasons for price reductions of hydraulic fracturing are fundamentally different from those behind renewable energy technologies – hence they cannot be directly compared – and hydraulic fracturing may soon reach, or maybe has already attained, a lower bound for further price reductions, for instance as a result of its water requirements or environmental footprint. Yet, understanding learning-by-doing phenomena as expressed by an industry-wide experience curve for shale gas production can be useful for strategic planning in the gas sector, as well as assist environmental policy design, and serve more broadly as input for projections of energy system developments.

While this experience curve may help illustrating the "learning-by-doing" effect for hydraulic fracturing in the U.S., it must be handled appropriately in order to offer robust and reliable considerations for energy policy making and strategic purposes. In particular due attention needs to be given to the fact that experience curves eventually level off. The important question that still needs to be answered is when and at what total cumulative capacity this leveling off will occur for hydraulic fracturing (see Ferioli et al., 2009). Also, experience curves themselves offer little explanation with regards to the underlying technological change, reasons for learning, and causality between cumulative output and price reductions of production (Yeh and Rubin, 2012). In our case, much still needs to be understood with regard to why precisely learning occurred in the U.S. shale gas industry: was it due to an increased number of wells drilled, or maybe the number of wells completed per square kilometer, or perhaps the number of fracture stages, or possibly higher production volumes per well drilled? These are the sorts of questions that further research could potentially answer. In order to better place our experience curve and corresponding price-production relationship into perspective, we have discussed some of the main factors that may affect the experience curve for hydraulic fracturing into the future.

As the U.S. transitions to the world's top natural gas producer, there are a number of factors to con-

sider that may advance or hinder further unconventional gas production. Tighter regulations for the use of chemicals and water may on the one hand obstruct further gas price declines, while on the other hand encouraging further technological development of hydraulic fracturing as producers are forced to become more efficient in the production process. At the same time, stricter policy measures to regulate where and how a well may be hydraulically fractured can potentially result in reduced production. Such exogenous factors can affect the shape and slope of the hydraulic fracturing experience curve. Continued increases in output will eventually lead to a point at which the wellhead price of natural gas no longer falls. Such a price floor, hotly debated by specialists in the industry, implies a flattening of the experience curve. Further research is needed to assess the potential effects of low gas prices. Too low a spot price may limit unconventional production, while too low a wholesale price may create an oversupply problem. More analysis is also required on R&D investment trends and on the application of hydraulic fracturing technology outside the U.S. and in other (energy) sectors.

Footnote

To see the full paper, see the publication in Energy Policy: http://www.sciencedirect.com/science/article/pii/S0301421517301027

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SANDS HOTEL INTERVIEW (continued from page 20)

day, we work closely with business events professionals from around the world to co-create memorable experiences for their communities. We could be planning an event two years down the road, having endless discussions over Skype to tweak plans and make them perfect. The magical moment comes when our clients thank us for a job well done – to me, making a difference in the process of creating a successful event, is one of the most inspiring aspects of my job.

7. Last but not least do you have any interesting facts about the hotel and the past events which were organized at MBS which will be interesting for our readers?

Few would have thought that a hotel and an exhibition venue would be able to host para-Olympians and the demanding nature of their sports competitions. But we did it in December 2015. The ASEAN Para Games was special as the various divisions in Marina Bay Sands worked closely with the APG Organizing Committee to conceptualize and create a "Games Village" within Marina Bay Sands where the special athletes lived, ate and interacted with their fellow counterparts from different countries.

We also leveraged on Marina Bay Sands' CSR platform "Sands for Singapore" as a platform, working with the organizer to amplify key objectives of the Para Games and truly celebrate the extraordinary. This included a special appearance by David Beckham at the Games Village to inspire the athletes. It was a magical moment that capped a successful event.

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

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The abstract must be no more than two pages in length and must include an overview of the topic including its background and potential significance, methodology, results, conclusions and references (if any).

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The abstract cut-off date is January 8, 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, fax, e-mail, etc. Authors will be notified by February 23, 2018, of the status of their presentation or poster.

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

BAEE IAEE International Association for Energy Economics www.iaee.org university of groningen faculty of economics and business Energy Academy Europe

CONFERENCE TOPICS

- **Oil and Gas markets:** Carbon capture, Pipelines, Strategic trade
- **Electricity Markets:** Capacity markets, Flexibility, Storage, Intra-day markets, Cross-border effects
- **Energy Demand:** Demand elasticity, Energy efficiency, Behavioral economics, Fuel poverty
- **Climate Change:** Emission Trading, Promoting Renewable energy, Cross-border adjustments
- **Energy and Macroeconomics:** International trade, Innovation, Growth
- **System Integration:** Interaction of different energy sources, Heating, Sector coupling
- **Energy and Finance:** Climate risks, Financial markets, Investments, Hedging, Funding of RES, Insurance markets
- **Country Studies:** Energy transition, General lessons
- **Energy Policy:** Law and economics, Network regulation, International institutions
- **Disruptive Innovation:** Business models, Technological change
- **Local Governments:** Consumers collectives, District heading, Land-use
- **Energy and Transportation:** Electrification, Hydrogen, Biofuels

CONCURRENT SESSIONS Methods

- Econometric studies (time series, cross-sections)
- Field experiments, lab experiments
- Surveys, conjoint analysis
- Techno-economic bottom-up models
- General equilibrium, macro models
- Game-theoretical methods
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Those interested in organizing a concurrent session should propose a topic and 4 possible speakers to info@iaee2018.com. The abstracts proposed for the special session should be submitted, following the general submission rules within the deadline 8 January 2018.

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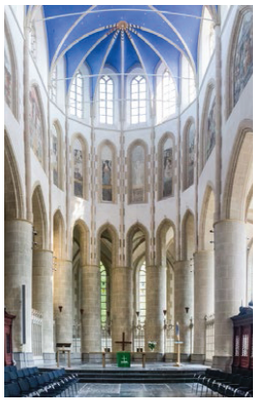
- Gala dinner at the 16th century Martini Church



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Too Big to Fail in the Electricity Sector

By Sebastian Osorio, Erik R. Larsen and Ann van Ackere

INTRODUCTION

Sebastian Osorio has recently received his PhD in Information Systems from the University or Lausanne, Switzerland. (Corresponding author: **sebastian.osorio@unil.ch**). Ann van Ackere is Professor at the Department of Operations, University of Lausanne. Erik R. Larsen is Professor at the School of Business and Social Sciences, Aarhus University, Denmark.

There have always been certain sectors that are critical for the functioning of society. Examples include hospitals, gas, railways, electricity, etc. Such sectors used to be state-owned, or subject to strict regulation. But over the last decades many of these have been deregulated and privatized, with the creation of markets and competition (Newbery, 2002).

However, what happens when one or more key companies of these industries face bankruptcy, threatening the availability of the service? While this issue has received attention since the start of the privatization process, the discussion has remained very much theoretical, with occasional problems being solved on a case by case basis. The situation changed drastically in 2007/2008 when the USA mortgage crisis created a snowballing effect, causing a global collapse of the financial sector to become a realistic prospect.

During the decade following this crisis the financial sector was subject to a close scrutiny, with particular attention to the influence of individual financial institutions on the overall system. In addition to a general tightening of regulation and oversight, there was a focus on identifying system critical institution; these became the subject of careful monitoring, and were required to increase their capitalization to increase their solvency, so as to reduce the risk of a rerun of the financial crisis.

In this paper we address the following question: given the essential role of electricity in today's society, is there a need for a similar critical evaluation of the electricity sector to ensure security of supply? While the electricity sector does not have the same global inter-connectedness as the financial sector, it has become increasingly connected. The failure of a major generator or distributor, leading to reduced access to electricity or even large-scale blackouts would have devastating effects, spreading well beyond national boundaries. As was the case in the financial sector, public intervention would be required to prevent such a disastrous event.

COMPANY FAILURES IN THE ELECTRICITY SECTOR

Over the past twenty years the electricity sector has faced a number of potential large or critical failures. We discuss three examples to illustrate the cost and consequences of such events.

Maybe the best-known case is the shortages in California at the beginning of the century. For a number of reasons, which have been studied extensively, California faced a situation where limited supply drove up wholesale prices, while the regulated retail prices did not reflect these price increases in the short term. Consequently, distribution companies were forced to operate at a loss, and found themselves on the edge of bankruptcy. The State of Californian state intervened by issuing bonds to raise capital to rescue these companies (Sweeney, 2002). Fifteen years later the Californian taxpayers are still paying off these loans.

A similar case occurred in the UK, where the company owning the nuclear plants in England and Wales almost went bankrupt in 2002. The company, which was privatized in 1996, started facing problems around 2000: the combination of a low electricity price, problems with long-term contract with British Nuclear Fuels and technical problems with several reactors led to the need for a state injection of almost three billion Euros; the bondholders took over the company and the shareholders lost most of their investment (Taylor, 2007).

A more recent example concerns the troubles faced by Electricaribe, a subsidiary of Gas Natural Fenosa. Electricaribe is a distributor in the north of Colombia, which in 2016 was running out of cash, due among others to the fact that it was unable to collect payment for over 25% of its electricity production. The company became unable to satisfy the minimum quality requirements specified in its contract with the regulator and its suppliers demanded to be paid in advance to supply electricity. The parent company did not manage to turn around the problems and refused to refinance the company as it could not get guarantees from the local government concerning payment of future electricity supplies. Eventually the state was forced to take over the company to ensure that the two and half million customers would continue to receive electricity (El Pais, 2016).

As illustrated by these examples, in the electricity sector system critical companies are not allowed

to go bankrupt; the state intervenes to prevent potentially disastrous consequences, such as millions of people being suddenly deprived of electricity, an event which, at least in the developed world, would ensure the fall of governments. However, such interventions are costly and in the end it is the taxpayer who foots the bill. This raises the question of if and how such situations can be prevented.

RECOGNIZING WHEN AN ORGANIZATION IS TOO BIG TO FAIL

When should a generator in the electricity market be considered as "too big to fail"? Below we discuss three elements that could guide such a decision.

The capacity margin is a key indicator of capacity adequacy, which is critical for security of electricity supply (SoES). A first approach for evaluating the criticality of a generator thus consists of a direct comparison between its share of installed capacity and the capacity margin. A company whose share of installed capacity or generation is close to the capacity margin should be considered critical, as its failure would endanger SoES. However, before deciding whether or not to declare a generator critical, its size should be put into a wider perspective by considering the availability of substitutes. For instance, a country might be able to import significant volumes of electricity at short notice, at reasonable prices. This would require sufficient cross-border transmission capacity and neighbours with excess generation capacity; one example is the size of the cross-border capacity between Finland and Russia (Ochoa and Gore, 2015).

Another sign is low profitability, which provides an early warning signal well before a company's financial viability is threatened. A natural reaction to decreasing profitability is an attempt to control costs, with preventive maintenance and general upgrades often being the victims of such cost-cutting exercises. This increases the likelihood of unscheduled down-time due to technical failure, a frequent cause of cascading blackouts. There are recent examples in Colombia where generators paid for to provide reserve capacity (firm energy) were unable to produce at full capacity when required to do so during a period of shortages (El Tiempo, 2015).

Internationalization of electricity companies is another potential risk factor. A company might suffer financial strain following the failure of investments in another jurisdiction, distant from the home country. Or a subsidiary may be let down by its (financially sound) foreign parent company, as was the case in the Colombian example discussed above.

This short discussion of these three elements is meant as an illustration of the type of indicators one should look for when attempting to identify companies that are "too big to fail"; there clearly are other equally important elements which cannot be discussed in this short note due to space limitations.

CONCLUSION

What should the regulators and policymakers do to prevent companies from becoming too big to fail, thus avoiding the costly intervention these may entail? There is unfortunately no simple answer to this question.

Let us start by identifying situations which should be prevented from occurring. Firstly, a moral hazard situation (which many claim occurred in the financial sector), where large companies (and their share- and bondholders) are convinced that the government will bail them out whatever happens, should be avoided. Such a belief induces companies to take excessive risks, as it limits the downside if things don't work out. In the British Energy case discussed above the government saved the company, but the shareholders lost most of their investment; this illustrates that it is possible to intervene without creating a moral hazard situation.

Secondly, regulators should prevent companies from become a too dominant player. This can be achieved by a strict regulation of mergers and acquisitions in the industry: a merger or acquisition resulting in company's capacity getting close to the reserve margin should be stopped.

Thirdly, in a situation where a large company already exists (e.g. the incumbent company) and there is no desire to break it up, several measures can be implemented: capital requirements (for international companies), plant maintenance schedules, a request to dispose of certain units, etc.

Finally, while two of the three examples we mentioned occurred a decade or more ago, we should not conclude that such events belong to the past. If anything, the combination of decarbonisation of electricity markets, low commodity prices and efforts to decrease demand put the profitability of major market players at risk. The first warning signs are starting to appear: in Europe several gas plants have been closed down. As a consequence, regulators are forced to intervene, e.g., through capacity mechanisms. While saving small companies or providing limited capacity incentives is feasible, emer-

gency intervention to bail out a major player could have dramatic consequences for the economy of a country or a region. It is thus of paramount importance to identify and monitor closely "to big to fail" companies in the electricity sector.

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Interviews with IAEE Leaders Past and Present

To mark the Association's 40th Anniversary we asked IAEE's present leadership and Past Presidents, who have been actively involved within IAEE for many years, about what IAEE meant to their careers and how they perceived the Association's evolution over the past years.

By Olga Pushkash, Administration Manager, Norwegian School of Economics NHH

RICARDO RAINERI, IAEE PRESIDENT

IAEE family provides a friendly and stimulating environment for academic and professional development. It is a great association where converge professionals, policy makers, executives, academics and students who have an interest in energy economics. IAEE conferences and publications provide a forum for the exchange and the fostering of new ideas,;it allows its members to be knowledgeable on current energy economics research and markets trends, and global as well as local energy challenges. Together with giving me the great opportunity to meet with leading energy experts, IAEE has given me the opportunity develop a wonderful friendship with people from around the world. In my more than 20 years of membership, I have witnessed an important advancement in our association, on the outreach of its conferences, publications, membership and it's footprint around the globe. World energy demand has more than doubled since IAEE foundation, with deep changes in the energy sector as well as on environmental and social concerns, where innovation, new technologies and best practices in business and energy policy, have been a key player to unleash the resources which are needed to satisfy the world growing energy needs. Over all this time, IAEE has always been at the forefront of the energy discussion.

(Interviews continued on page 37)

Smart Demand Side Management: Storing Energy or Storing Consumption: It´s Not the Same

By Joachim Geske, Richard Green, Quixin Chen, and Yi Wang

Joachim Geske and Richard Green are at the Imperial College Business School in the UK, while Quixin Chen and Yi Wang are with the Department of Electrical Engineering, Tsinghua University, China. **This research was funded by the UK Engineering and Physical Sciences Research Council and the National Science Foundation of China.** **Corresponding author: Joachim Geske (j.geske@imperial.ac.uk).**

It is expected that energy systems with a high share of intermittent renewable electricity generation (fed in at a range of network levels) will require a high proportion of low-load conventional peak load generation and have high residual load gradients. A strategy to deal with these characteristics is the transition to an energy system with more flexible components. On the supply side, the relevant technical options include the use of more flexible generators, more long-distance transmission, energy storage and demand response (DR).

Demand response includes pure changes in the volume of demand such as load shedding (or the increase in load to absorb surplus power) and the quantity-neutral load shifting. However, that kind of load shifting can be interpreted as storing consumption. The technical vision of consumption storage includes the preference-based control of individual devices, which, in addition to the extent of the temporal shift, also takes account of the resulting monetary returns (price advantages). Sufficiently low equipment costs, ease of usage, a high time resolution of the market system and modern information technology for the transmission of price signals are prerequisites for the implementation of this technological vision.

This kind of load shifting is not entirely visionary, as radio-based peak load shaving was developed in the US in the 1970s. Today there are numerous products with negative power supply which are traded as ancillary services, making it possible for large industrial customers to generate revenues with load shifting. Contemporary potential analyses of load shifting are focused on these technical processes and their potential to shift significant loads over hours. In addition to these large-volume - long-time shifting options, there may be significant cope for the coordinated shifting of many small loads by short periods. In many applications, like refrigerators, a shift of load by 10 minutes is costless. In addition, consumption storage also offers the advantage of low degradation and lower capital requirements in comparison to conventional hydro or chemical energy storage.

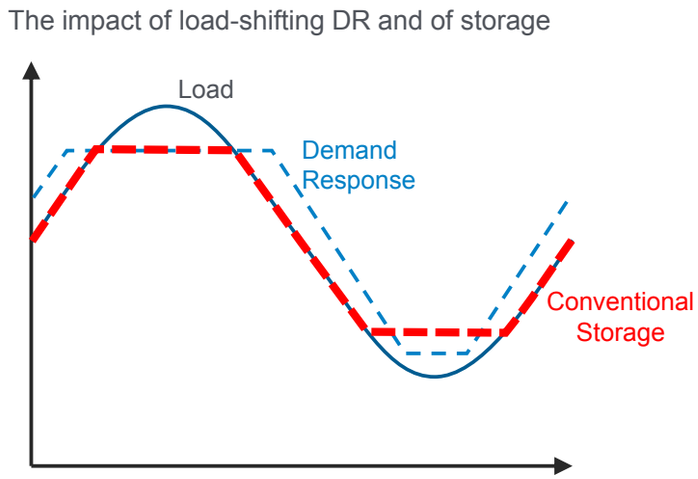
What is the potential of load shifting? Which methods are applicable to analyse it? How does a rational consumer select the devices for load shifting and how does he program them? What are the effects of a series of rational load shifts in a system with conventional generation? Can a huge number of consumption storages be coordinated by markets to act as a single virtual storage? None of these questions is trivial to answer, but the answers are essential to evaluate load shifting technology.

In our article, we design a micro-founded model of load shifting by a rational consumer. The consumer selects devices and programs that balance the shifting quantity and time depending on the price development. To model the cost of load shifting, it is assumed that there is a specific indifference time zone for the use of an electrical device. In a variety of applications this will not be the case - e.g. watching live television, but in other cases, consumers would not care exactly when a washing machine finishes, as long as the clothes are dry enough at ironing time. Similarly, the insulation of refrigerators allows for a slightly longer gap before starting the cooling compressor without increasing the spoiling risk. Outside this indifference zone – beyond the indifference threshold time – there is an increasing cost of delay (or anticipation – some activities can be brought forward).

We show in our analysis how the optimal device mix can be determined from assumptions about the distribution of indifference threshold times and power consumption of electrical devices. With the optimal selection of devices, the cost of load shifting can be derived. Under simplifying assumptions, an analytical expression for the cost of load shifting can be deduced as a function of the shifted load and the shifting time. In this context, the value of lost load can be regarded as a limiting case for the cost of unlimited shifting time and it can be used for calibration.

With this approach, the optimal DR consisting of shifting quantity and time can then be determined for a given pattern of prices over time. Characteristic of load shifting is the indifference between storing a large quantity for a short time and storing a small quantity for a longer time. In this sense, consumption storage is limited in its capacity by two dynamic components: 1. the storage time and 2. the load that is available for shifting. This basically distinguishes load shifting from energy storage, which has a fixed capacity over time.

To analyse the effect of load shifting in a fully coordinated market system, a simplified model of load



shifting was then embedded in a simple electricity system model. One typical result is shown in the Figure. The underlying load is shown by a continuous line, and the effect of energy storage (the thick dotted line) is to remove load peaks (by discharging) and displace them into load valleys (when charging takes place). In contrast, shifting consumption leads to a different pattern, shown by the thin dashed line. As the load level falls, so does the shifting potential available. Therefore, a "part of the load" that has been displaced from the peak must reappear "on the way from peak to valley". This is reflected in the load pattern as a "landslip" on the slopes of the peak. Whether this also leads to an increase in the load gradients may well depend on parameter values. As expected, this "landslip" effect intensifies as the load valley deepens.

These analyses show that, even under conditions of optimal coordination through a system of markets, this kind of load-shifting has some properties that differ from those of simple energy storage. Furthermore, it can be expected that energy and consumption storage are not necessarily substitutes for each one another, but that DR might be efficiently complemented by conventional energy storage to fill the valleys in loads more smoothly.

Overview of Special Student Events

During the 40th IAEE International Conference a special program for student delegates was offered to allow for networking within the student community; starting on Sunday evening with a "Happy Hour" reception and followed by a Student Breakfast Meeting on Monday morning with roughly 45 attendees. IAEE Student Representative, Fabian Moisl, presented the benefits of an IAEE student membership such as a free subscription to the IAEE's publications, reduced conference fees and scholarships to attend IAEE conferences, access to IAEE's job market database and much more. Dr. Peter Hefele presented on the Konrad Adenauer Foundation (KAS), which sponsored the Breakfast Meeting and the Happy Hour.

Four excellent papers were presented during the IAEE Best Student Paper Award Session on Monday afternoon. The award was given to Nathalie Hinchey, PhD Student at Rice University, for her paper titled 'The Impact of Securing Alternative Energy Sources on Russian-European Natural Gas Pricing'.

The final student event was a casual get-together at Makansutra Gluttons Bay hawker center where students had a chance to experience local food, network and socialize with fellow students of their academic fields.

Exploring Interaction Effects of Climate Polices: A Model Analysis of the Power Market

By Machiel Mulder and Yuyu Zeng

INTRODUCTION

In order to reduce carbon emissions in the power sector, governments are implementing a set of policy measures. These measures vary from subsidies for renewable-energy techniques to taxes on fossil-fuel electricity production and mechanisms for trading in emission rights. While some measures are taken on the national level, others have an international character. Within the EU, each Member State has to realize the renewable-energy target, but these countries are free to choose their own policies to stimulate deployment of renewable-energy sources. EU countries utilize different measures for this purpose, such as feed-in-tariffs, subsidies and quota systems (Haas et al., 2010). In addition to this, several countries are considering to impose constraints on conventional power plants, in particular coal-fired power plants (EIA, 2014). These measures vary from implementing additional environmental standards (e.g. on fuel efficiency or emissions per unit) which makes it complicated if not impossible for (old) coal-fired power plants to operate or to imposing a carbon tax which, in particular, raises the generation costs of coal-fired power plants.

Besides this set of different national policy measures to reduce carbon emissions by the power sector, an emissions-trading system has been implemented on the EU level. This EU Emission Trading System (ETS) is the largest cap and trade mechanism in the world in CO_2 emissions. It sets a cap on the total amount of CO_2 emitted by installations of firms subject to this scheme. This cap is reduced annually in order to realize an overall reduction in carbon emissions. The initial allocation of the cap to participants was initially allocated by grandfathering, but more and more auctioning is used as allocation method (EC, 2012). In the secondary market, participants can trade in permits which result in a carbon price.

Together with these climate policies, the European Commission is promoting the integration of national electricity markets to facilitate border-free trading across Europe, see Keay (2013). As a result, national power markets have become more closely integrated with each other, which may increase the international spillovers of national climate policies.

It is well established in economic literature that the coexistence of different types of climate policies may have counteracting effects (Bohringer et al., 2016). This holds in particular when a cap-and-trade emissions scheme is implemented. In that case, theoretically, the level of emissions is only determined by the cap in the emissions trading scheme. If the cap remains the same, other instruments only affect the costs of reaching that target, but not the amount of emissions. If an emissions trading scheme is combined with subsidies for solar panels, for instance, it can be expected that the emissions within the power sector are reduced which lowers the overall demand for and, hence, the price of emissions permits, which in turn can stimulate other firms participating within the emissions trading scheme to raise their emissions since emitting has become cheaper. This effect is called the waterbed effect of climate policy. In this paper, we explore the conditions for the interaction effects to occur.

METHOD

We analyze the interaction of three types of policy measures to realize a transition of the electricity industry based on fossil fuels towards an industry with a lower level of carbon emissions. These policy measures are subsidies for renewable electricity, a fuel tax for fossil-fuel power plants and an international emissions trading scheme. In order to analyze the interaction of different policy measures, we build a concise interconnected two region model with a large and small country in size.

In this model, some producers are perceived as strategic players; hence they can exercise market power and influence the wholesale prices. In our model, international trade is based on price-arbitrage opportunities. The energy trade is realized through the cross-border transmission lines. The size of the cross-border transmission capacity determines the magnitude of international trade and, hence, the potential cross-border spillover effects. Moreover, a carbon market is added to the electricity market, and consequently, the carbon price is part of the variable generation costs of fossil-fuel producers. In

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The research for this paper was part of the research project "Redesigning the electricity market in order to facilitate the transition towards a sustainable energy system", funded by the Dutch Organisation for Scientific Research (NOW) and a number of stakeholders in the Dutch energy industry.

addition, we also take the stochastic nature of both supply and demand into account. Firms base their decisions regarding investments and the dispatch of plants on expected values for weather conditions, load levels and scarcity levels. Including probability distributions for wind and demand allows us to control for the volatility of market conditions in the power market.

RESULTS

Using a numerical application of our partial two-country equilibrium model of the power market which also includes a cap-and-trade carbon system, we find spillover effects due to the integration of the two markets. Imposing a fossil-fuel tax in one country leads to a higher cost for fossil-fuel producers. Hence, this country imports more from the neighboring country. As a result of this, we observe a higher utilization of fossil-fuel capacity in the neighboring country. The lower the cap in the emissions-trading system, the stronger this effect appears to be. This result indeed shows that national policies to reduce carbon emissions may be offset by international spillover effects. Coordination of such policies may improve the effectiveness of such policies.

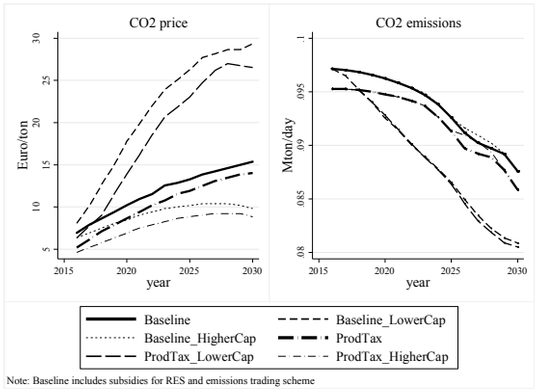

Figure 1: Model results: CO_2 price and CO_2 emissions in 6 policy variants

In our Baseline scenario, where subsidies for renewable energy are implemented besides an emissions-trading scheme, the CO_2 price gradually increases over time while the CO_2 emissions reduce in line with the implemented cap on emissions. If on top of these measures a producer tax on carbon is implemented, the carbon price reduces, but we also see a decline in the overall level of emissions (see Figure 1). This result comes from the fact that the carbon price in the trading scheme has a floor, i.e. it can never be lower than zero. If subsidies for renewable energy result in a large amount of renewable-energy capacity this may in some periods, when there are many sunny and windy days, result in an overall demand for carbon permits being below the supply of permits which brings the carbon price to zero. In such circumstances, imposing a tax on the use of fossil fuel reduces the emissions by fossil-fuel plants without being neutralized by a waterbed effect. This effect is stronger the higher the cap.

CONCLUSION

Our findings show that implementing national policies on top of an international emissions trading scheme can still be effective in reducing carbon emissions in spite of the waterbed effect. It appears that the waterbed effect only holds if the cap-and-trade system is constantly binding, which means that there is always a positive price for the carbon permits. The probability of an always binding emissions-trading system reduces if countries keep increasing the size of installed RES capacity, as is currently the case in several European countries.

The policy consequence of this finding is that national climate policies such as subsidy schemes for renewables may have a positive effect on the reduction of carbon emissions, although the general economic literature says that such cannot be the case when an emissions-trading scheme exists. Although adding a carbon tax on top of an emissions trading scheme may result in more emissions reductions as the waterbed effect does not always work, this does of course not mean that such a policy is efficient.

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Policy Effectiveness Assessment of China's Optimal Adaptation and Mitigation

By Hongbo Duan and Shouyang Wang

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To limit the global warming-rise below 2 degrees Celsius by the end of this century (relative to the pre-industrial level) arrives at a consensus worldwide; and during the COP 21 of the United Unions Framework Convention on Climate Change (UNFCCC) in 2015, this target has been formally and legally included in the Paris Agreement. To date, the global average temperature has increased by over 0.8°, which implies that the achievement of this goal may be full of challenges (Parry, 2009; Peters et al., 2013); and the implementation of Intended Nationally Determined Contributions (INDCs) mitigation plan of Paris Agreement is hardly enough to keep temperature from exceeding the critical threshold (Reis et al., 2016). In this circumstance, it is of great necessity to start adaptation actions and cope with the climate residual damages that are not avoided by mitigation.

With respect to the world, the specific countries or regions may suffer more acutely from the global warming impacts, owing to the significant differences in location, climate adaptation capability as well as vulnerability (Baker et al., 2012), implying that adaptation may be even more promising at the regional level (Lesnikowski, et al., 2015; Araos et al., 2016). In this circumstance, we attempt to develop a framework of regional integrated assessment model, coupling with both adaptation and mitigation mechanism, to systematically examine the effectiveness of China's optimal adaptation, and portrait the relative adaptation cost curve; in particular, we explore the influence of induced optimal mitigation, given the 2-degree warming-rise target, on the benefit-cost effectiveness of adaptation.

This research is conducted by employing the regional 3E-integrated assessment model, CE3METL, in which we implement both adaptation and mitigation as well as all the empirical simulations (Duan et al., 2013), and the global 3E-integrated assessment model, E3METL, which mainly provides the emission trajectories for the rest of the world and the references of the global average radiative forcing change and warming rise (Duan et al., 2015). To fulfill the proposed ends, we design several policy simulation scenarios in addition to the reference scenario, i.e., the optimal adaptation scenario, the mitigation scenario under the Paris agreement and the policy mix of both adaptation and mitigation.

On average, optimal adaptation in China could avoid 28% of climate-related damages, with the highest damage-reducing rate reaching 66%. It is worth noting that adaptation alone is far from enough to hedge against all the possible climate change risks, and our result supports that even though no adaptation restrictions are considered, the protection level resulting from adaptation is far from 100%. Similarly, mitigation alone cannot avoid all the climate damages as well; in addition, the effectiveness of mitigation is significantly lower than that of adaptation, implying that in the short term, it remains true that adaptation is more effective than mitigation in response to climate damage reduction at the regional level, particularly for China. What needs to be emphasized is that the given Paris Agreement climate target, i.e., keeping the global temperature-rise from exceeding 2 degrees, is actually much stricter than the INDC plans, which should be largely responsible for the high mitigation cost and low short-term effectiveness. It can therefore be inferred that the policy effectiveness of mitigation would be greatly strengthened if the INDC plans were set to be the target.

Given the higher mitigation costs under the strict 2-degree warming control target, climate change costs in the presence of mitigation is significantly higher than that in the optimal adaptation case, in which adaptation gains the highest effectiveness in avoiding climate damages, and the ratio of benefits to costs increases prominently after 2050, and by 2100, this ratio approaches 2 (Figure 1). In the short run, mitigation may be an expensive way of avoiding adverse climate effects; however, its policy effectiveness would be significantly enhanced as time

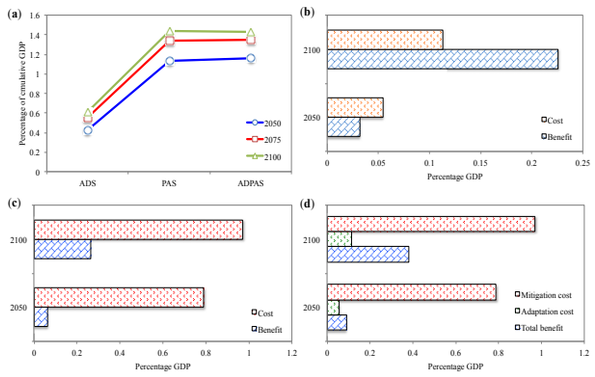

Figure 1. Cumulative costs of climate change across various scenarios (a) and ratios of cumulative benefits to costs (b-d), corresponding to the adaptation scenario, the mitigation scenario and the portfolio scenario, respectively (we choose two time periods, i.e., 2010-2050 and 2010-2100, to accumulate the variables, with the discount rate assumed to be 5%)

progresses, owing to the inertia of the carbon cycle and climate system, the time-consuming process of economic restructuring and energy technology development and switching. As noted by de Bruin et al. (2009), the damage-avoiding benefit of adaptation remains much higher than that of mitigation, even in 2130, and after that, mitigation starts to reduce the bulk of damages. This implies that to successfully and earlier attain the point of effectiveness (i.e., the point at which the policy benefit begins to exceed the relative cost), earlier mitigation-related investment is urgently required.

An important finding is that the effectiveness of a policy mix of adaptation and mitigation in response to avoid climate damages appears not to be '1+1= or >2'. Actually, the policy benefits under the portfolio scenario are far lower than the sum under both the mitigation and adaptation scenarios but are still higher than any single policy scenario (Figure). Thus, there exists a negative interaction effect between mitigation and adaptation, owing to the crowding-out effect of investment. In contrast, the negative effect associated with mitigation intervention will be offset to a large extent by the increasing damage-reducing benefit. As a consequence, the portfolio policy is still the best option to cope with the climate damage risks.

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Social Awareness, Consumer Lifestyles, and Household Carbon Emissions in China

By Dayong Zhang, Jun Li, and Bin Su

OVERVIEW

Global average temperatures were 1.3 degrees Centigrade higher in 2016 than that in 1880, and they are expected to rise further. The urgency of controlling global warming (i.e., achieving an increase of global temperature with no more than two degrees) and limiting greenhouse gas (GHG) emissions led to the conclusion of the Paris Agreement adopted by 195 countries in 2015; since then, the US government, though an original signatory, has unfortunately announced its plan to withdraw from the agreement. As the world's biggest carbon emitter, China pledged to reach its carbon emission peak by 2030, which is a very ambitious goal and requires a combination of mitigation policies. An emissions trading system, renewable energy standards, and other instruments have been developed to reduce emissions on the production side. Although economic incentives are effective mechanisms for producers and are relatively easy to implement, mechanisms to affect consumption-side emissions are potentially more complicated.

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GHG emissions can result from the direct use of fossil fuels and indirect emissions from consumption of final goods/services by households. They contribute significantly to total emissions in both developed and developing economies. For example, Bin and Dowlatabadi (2005) find that households account for more than 80% of total emissions in the United States; Baiocchi et al. (2010) show that around 74% of carbon emissions in the United Kingdom comes from households; In China, Liu et al. (2011) find that household emissions make up over 40% of total emissions, which has increased recently with rises in Chinese household income and in demand for goods/services.

Many efforts have been made to promote a green consumer lifestyle, and evidence shows that people have been paying more attention to environmental issues (Gadenne et al., 2011). The question is, however, whether awareness can actually cause changes in consumer behavior. Using a unique nationwide survey in China, our study explicitly tests the link between social awareness and carbon emissions by Chinese households. More importantly, we take consumer lifestyles into consideration and see how they interact with the awareness-emissions relationship. The results on the effects of awareness are mixed, depending on which measures we use to capture awareness, but we find that having a green consumer lifestyle does play a strong role.

CHINA HOUSEHOLD FINANCE SURVEY (CHFS) DATA

One of the major obstacles to understand household-level consumption behavior is the lack of micro-level data. The CHFS data, collected by the Survey and Research Center for China Household Finance at the Southwestern University of Finance and Economics in China, comprises a high-quality and detailed nationwide survey about household income, expenses, assets, debt, insurance, employment, subjective attitudes, and other demographic information, which enable us to address the aforementioned issues. Our analysis is based on the first round of the survey results conducted in 2011 with a sample of over 8,000 households in 80 counties and 25 provinces in China (excluding Tibet, Xinjiang, Inner Mongolia, Hong Kong, Macao, and Taiwan). It employs a stratified three-stage probability proportion to size random sampling design that covers both rural and urban households.

SOCIAL AWARENESS AND LIFESTYLES

Two major data issues need to be solved in the empirical study. First, household carbon emissions are not directly available in the survey. We follow Wei et al. (2007) to divide household consumption emissions into direct and indirect emissions. Direct emissions come from the residential consumption of gas, electricity, and other utilities, and indirect emissions result from the consumption of food, clothing, household services, medicine and medical services, transport and communication services, education, cultural activities, and recreation. With the conversion coefficients such as Wei et al. (2007), the monetary expenditure in each category is converted into equivalent carbon emissions. For example, spending on clothing that totals RMB 10,000 (in 2000 prices, equivalent to around 150 US dollar) gener-

ates 0.302 tons of carbon.

Second, subjective social awareness and consumer lifestyles are likewise not observable directly from the questionnaire. So we have to extract this information from the survey results. Gadenne et al. (2011) review the literature on psychology and sociology and investigate the role of beliefs, social responsibility, and attitudes about energy-saving behavior. Based on their arguments, we choose relevant questions in the CHFS survey to design four measures of social awareness.

In the survey, people are asked for their opinions about local social welfare (*welfare*), whether they obey traffic regulations (i.e., wait for the light to turn green before proceeding or stop when it is red) (*obey*), what kind of information normally interests them (*focus*), and whether they donated to funds intended to help the millions of victims of the 2008 Wenchuan earthquake in Sichuan Province (*donate*). The general arguments/hypotheses about these factors are:

- people who have a positive opinion of social welfare tend to act in ways that benefit society and to be willing to protect the local environment and thus more likely to adopt a green lifestyle;
- a person who obeys social norms/rules tends to follow suggestions on how to reduce emissions; people who pay more attention to social problems tend to be more informed and thus more likely to adopt a green lifestyle;
- people who made donations to assist the victims of the Wenchuan earthquake tend to have greater sympathy for those in distress in their community, which could reflect their positive attitude towards the society.

Economic theory generally assumes that the consumer decision-making process is risk averse, which relates to a preference of consumption smoothing. Psychologically, people value their habitual level of consumption and will be very reluctant to deviate from it. Following this logic, we believe that consumer lifestyles matter in the awareness-behavior relationship. Three measures of consumer lifestyle are used in our empirical study: (a) eating out as a share of total food expenditure, (b) whether people buy luxury goods, and (c) education and training expenditure as a share of total spending on education-culture-recreation. The first two measures are straightforward and show whether a person maintains a frugal lifestyle; however, the third measure is more complex. Investing more in education rather than recreation shows a person's time preference, so this type of household is expected to demonstrate a stronger awareness-behavior link.

RESULTS

We use a natural logarithm of carbon emissions (per head in a household) as the dependent variable, and subjective measures as the key independent variables in the regression analysis. The main results are summarized as follows:

- Residential (direct) emissions are the majority of these emissions, accounting for about 51% of total household emissions in China, followed by the indirect emissions from consuming food, education-culture-recreation, clothing, and other sources.
- Regression results show mixed evidence of an awareness-behavior link. Only welfare has a significant and negative impact on emissions, whereas obey and donate are all positively linked with carbon emissions.
- There are clear rural/urban and regional differences, with positive links found in baseline regressions driven mainly by households in urban areas in Eastern China.
- Maintaining a consumer lifestyle has significant importance in the awareness-behavior relationship. People with a higher share of expenditures on eating out and purchasing luxury goods tend to generate a higher level of emissions. The coefficients of the interaction term of the share of higher education in education-culture-recreation expenditures with obey and donate are all significantly negative, indicating that people who value their future more and who also have a positive attitude tend to reduce their emissions, though the coefficients are generally small.

CONCLUSIONS AND IMPLICATIONS

Using data from a recent national household-level survey in China, this paper presents an overview of the consumption side of carbon emissions. The empirical results demonstrate the significance of household consumption in China's total emissions (over 40% come from households). We also show evidence of the existence of an awareness-behavior link in China. Although many efforts have been made to promote a green lifestyle/low carbon consumption in China, consumer awareness does not necessarily result in a lower level of emissions. This pessimistic result may be due to the preference for consumption smoothing and maintaining a particular lifestyle. In the absence of clear economic

incentives, changing people's habits and encouraging people to adopt green consumption behavior voluntarily is difficult.

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Interviews continued

DAVID WILLIAMS, IAEE EXECUTIVE DIRECTOR

As administrators, we work at the pleasure of the Council; it is our job to implement their vision of the organization. One of our roles is to build a sustainable financial model for the Association and I am happy to say that over the years we have accumulated a good financial base. As a result, the Association can use this reserve to develop new products and services to service the needs of its members. The technological revolution has helped to bring new opportunities for IAEE. Back in the early days we only had one journal, a newsletter (which was very thin) and we didn't have a website. Most of our products are now website-based, which makes the information easily accessible. We have now electronic versions of the *Economics of Energy and Environmental Policy* (EEEP), of *The Energy Journal* as well as of the *Energy Forum* (newsletter). In the future, we continue to focus more on technologically based membership services to benefit our members. One of our coming projects is to develop an application within the website, which will be "Amazon like" – giving a more dynamic web experience for users.

I am very passionate about the organization and have been since day one. IAEE is like a family. We all grow and learn together by sharing our experiences within the field of energy economics. The organization stands on three pillars: business, academia and government. It means a lot to me to work with such a wide group of people. Our leadership is very much involved within the organization; Council members are very enthusiastic about the projects they take on. You might have heard about the Mexico Energy Museum project. During the Singapore conference, we had a meeting between the IAEE's advisory group and energy professionals from Mexico, who are running the development of this project. Our advisory board of energy professionals aims to provide the project with rich knowledge about the history of energy development. In addition to developing the historical background of the energy sector, we also work on the understanding of what does energy mean for our future.

(Interviews continued on page 40)

The Evolution of the Energy Security Concept and APEX Energy Cooperation

By Kazutomo Irie

OVERVIEW

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Energy security was originally perceived as a stable supply of energy (mainly oil as the most important energy resource) against geopolitical risks such as conflicts between or within nation state(s).

Since the beginning of the 21st Century, three major incidents have changed and expanded this classical concept of energy security including new threats and energy sources to be protected: firstly, the September 11 attacks in 2001; secondly, the Russia-Ukraine gas dispute during 2005-06; and thirdly Hurricane Katrina in 2005.

In energy cooperation under the framework of Asia-Pacific Economy Cooperation (APEC), energy security as a new broader concept is being pursued, especially through APEC Oil and Gas Security Exercises (OGSE). In each exercise, new facets of a broader concept are focused on. These practices are expected to enlighten energy policymakers in the APEC Region on the new broader concept of energy security.

METHODS

Historical analysis of the concept of energy security since the beginning of the 21st Century, mainly referring to policy documents.

RESULTS

The concept of energy security originated from oil supply instability in Europe during the Suez Crisis in 1956. After two oil crises in 1973 and 1979 triggered by the Yom Kippur War and the Iranian Revolution respectively, energy security was originally perceived as a stable supply of energy (mainly oil as it was the most important energy resource) against geopolitical risks such as conflicts between or within nation state(s), especially in the Middle East region, as Martin, Imai and Steeg once suggested.

This classical concept of energy security was one of the most important criterion, if not the most important, for energy policy for most countries by the end of the 20th Century. Developed countries formed the International Energy Agency (IEA) in 1974 and pledged to build oil stockpiles in order to countervail oil supply restrictions by petroleum producing countries.

Since the beginning of the 21st Century, three major incidents have changed and expanded the definition of energy security, even though the stability of energy supply, which once was the core meaning of energy security, remains unchanged.

Firstly, the September 11 attacks in 2001 have shown not only nation states, but also violent non-state actors (VNSA) can be a threat to national security. As an integral part of national security, energy security has also had to cope with VNSA or terrorists. In addition to oil trade, other energy supply systems such as the electricity supply system have come to be considered as potential target for terrorist attacks. Because of the enormous radiological hazard, nuclear power stations and related facilities have become important targets in need of protection. The International Atomic Energy Agency (IAEA) has integrated various protective measures under the new concept of 'nuclear security.' Moreover, in addition to physical attacks, cyber attacks have become a threatening tool used by terrorists because information and communication technology (ICT) has been well developed and widely employed in energy supply systems. As a result, a new concept of 'cyber security' was formed and used by energy policymakers. These three new elements, a new type of actor, additional high-risk energy supply systems and a new means of threatening action, were added to the definition of energy security.

Secondly, during 2005-06 the Russia-Ukraine gas dispute caused a supply shortage of natural gas in Europe. Though oil remains the world's dominant fuel, natural gas has become another major fuel source for heating and power generation. In addition, unlike oil, natural gas is very difficult to stockpile and has therefore become a major concern for energy security. Energy Ministers of APEC instructed senior energy officials and Asia Pacific Energy Research Centre (APERC) to launch OGSE in 2012 and APERC later expanded it to APEC Oil and Gas Security Initiative (OGSI) in 2014.

Thirdly, Hurricane Katrina severely damaged crude oil production and petroleum refining facilities in the Gulf of Mexico in the United States in 2005. The U.S. Department of Energy released its strategic petroleum reserves and the IEA called for release of members' oil stockpiling based upon the Initial Contingency Response Plan (ICRP). This meant natural disasters such as Hurricane Katrina were recognised as a threat to energy security. Unlike the aforementioned terrorism, natural disasters cannot be classified as a geopolitical risk. In other words, a completely new category of threat was added to the energy security concept. Thereafter, natural disasters have continued to threaten energy security in various countries. The Great East Japan Earthquake in 2011 seriously damaged energy infrastructure in Eastern Japan, including the Fukushima Daiichi nuclear disaster. Hurricane Sandy in 2012 damaged infrastructure in the northeastern United States, and the Super Typhoon Haiyan in 2013 hit energy infrastructure in the Philippines. Thus, as the hosting economy of the APEC Energy Minister Meeting in 2015, the Philippines proposed 'energy resiliency' as one of policy targets for APEC energy cooperation. Focusing on the physical sturdiness of energy infrastructure against natural and man-made disasters, energy resiliency will be further developed as a subordinate concept of energy security.

In the energy policy cooperation framework of APEC, energy security as a new broader concept is being pursued, especially through OGSE. In each exercise, new facets of a broader concept are focused on.

As the first OGSE, the Joint Southeast Asian Exercise was held in September 2013 involving seven economies: Brunei Darussalam, Indonesia, Malaysia, the Philippines, Singapore, Thailand and Viet Nam. The two stages of the oil and gas emergency scenarios were prepared by APERC and they reflected the evolution of the energy security concept. In the first stage of the hypothetical emergency situation, a terrorist group sabotaged the shipment of oil and natural gas export from Middle East, using both a physical and a cyber-attack. While the second stage presented the assumption that a natural disaster, such as a typhoon, or another type of accident damaged gas facilities in each economy.

In the second OGSE held in October 2013 in Jakarta, Indonesia, a three-stage oil emergency scenario was presented. In the first stage of the scenario, an earthquake damaged Indonesia's Cilacap Refinery leading to decreased petroleum production. The second stage of the scenario envisaged a worsening of the situation at the refinery because of a major aftershock . The third stage scenario considered a cut of crude oil supplies to the Dumai Refinery because of local residents' action to decrease its refining capacity.

In the third OGSE, and the first after being incorporated under the OGSI project, the Philippines hosted an exercise in December 2015. In this exercise, diversified threats to energy security were assumed in three stages of an emergency scenario. In the first stage, the collision of a cargo ship and an oil tanker caused the cargo ship to sink and to damage the Malampaya underwater gas pipeline. In the second stage, a strong typhoon caused damage to the Petron Refinery. In the last stage, the typhoon that hit the Philippines also made a landfall in Chinese Taipei and caused damage to two oil refinery facilities, which resulted in a reduction of their oil products exports to the Philippines.

The fourth OGSE, the second as a part of OGSI, was held in March 2017 in Melbourne, Australia, extended invitations to several APEC economies in order to encourage regional capacity building for emergency preparedness. In this exercise, gas supply security was addressed as well as oil supply security. Emergency scenarios for the exercise also introduced diversified threats.

CONCLUSIONS

Since the beginning of the 21st Century, the concept of energy security has expanded with the addition of non-state actors and the inclusion of natural disasters, man-made disasters and cyber attacks as threats. The concept also now includes natural gas and other energy infrastructure more generally as objects requiring enhanced protection. In order to attain the current broader concept of energy security, energy experts (policymakers, business leaders and policy researchers) should familiarize themselves with these newly emerging factors for energy security: non-state actors, natural and man-made disasters and cyber attacks. This familiarity is necessary in order to secure the stable supply of natural gas, electricity and oil. The related notions of 'nuclear security', 'cyber security' and 'energy resiliency' should also be kept in mind. As a part of such efforts, APEC has carried out emergency exercises that assumed scenarios of terrorist attacks, including cyber attacks, natural disasters such as earthquakes or typhoons and man-made disasters such as the collision of ships. In each exercise, new facets of the broader concept are focused on. These practices are expected to enlighten energy policymakers in the APEC Region on the new broader concept of energy security.

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Interviews continued

EINAR HOPE, PAST PRESIDENT AND VICE PRESIDENT FOR CONFERENCES.

My first encounter with IAEE goes back to 1984 to the International Conference in New Delhi; a most memorable conference event, under the leadership of R. Pachauri. Since then I have followed the development of the Association with keen interest and active involvement.

The IAEE conference concept has appealed to me right from the start, with its focus or research based knowledge of quality and relevance in an interface with business and policy to discuss contemporary energy economics issues in an international setting. In my opinion the IAEE organization has evolved in quite a constructive way, expanding in terms of geographical as well as topical coverage. Geographically, IAEE is becoming a truly international association with affiliates and chapters more or less globally and with regional conferences becoming an important aspect of the conference portfolio. However, there is still scope for further development, with regard to both membership growth and regional conference initiatives. The current Present President, Ricardo Raineri Bernain, has taken an interesting initiative for such developments.

For me personally, it has been even more interesting to observe the topical expansion of energy economics into new fields, like engineering, psychology, and political science, incorporating theories and elements from such fields to broaden the scope and relevance of energy economics as traditionally understood. However, it is the integration of energy and environmental economics that I consider as one of the most important aspects. Seeing these changes, I took the initiative, when I was the IAEE President in 2010, to establish a new journal: Economics of Energy and Environmental Policy (EEEP). Today with the The Energy Journal, the EEEP as well as the Energy Forum, the Association has a well- balanced portfolio of high-quality ranking journals. Given also its conference portfolio, I am happy to say that IAEE is well "in tune with the times". However, the Association should always strive to be updated and actively picking up developments within energy and environmental economics, and related fields, in its conferences and journals.

(Interviews continued on page 45)

Strategic Interaction Via Derivatives: on the use of swaps in electricity markets

By Chloé Le Coq and Sebastian Schwenen

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Electricity spot prices are highly volatile and may expose market participants to substantial price risk. To mitigate this risk, market actors typically insure against price volatility by signing forward contracts. As a consequence, electricity generating companies can take financial positions on derivatives markets while at the same time being active on the "physical" power market. This paper discusses how derivatives markets can be used as a commitment device for generating companies to lock into collusion-like strategies in the physical market.

A case in point has been observed in the New York power market, more specifically, on the ISO capacity market in New York City, where two major electricity producers, KeySpan and one of its largest competitors, Astoria, both engaged in a financial arrangement. Each month, both firms bid their available generation capacity into the New York City capacity market auction and, if procured, must offer energy during the next month's electricity spot market.

In 2006, KeySpan and Astoria signed opposite swaps with Morgan Stanley – based on a strike price in the capacity market they were active in. KeySpan signed a swap contract specifying that, for a quantity of 1800 MW, Morgan Stanley will pay KeySpan the difference between the realized market price and the strike price of $7.57. Payments would reverse for market prices below $7.57. Astoria signed the opposite swap contract, paying to (be paid by) Morgan Stanley the difference of any price above (below) $7.07. Putting aside Morgan Stanley's $0.5 margin, these opposite swap contracts constitute transfers between Keyspan and Astoria.

Drawing from this particular case, below we provide an analytical framework to understand how such financial schemes may affect competition in electricity spot markets (and capacity markets, as in the example above). We focus on uniform price auction markets, which constitute the dominating auction format in electricity wholesale markets. Following Fabra and von der Fehr (2006) and Schwenen (2015), we consider a multi-unit auction framework in which two capacity constrained bidders with constant marginal costs compete in electricity auctions. As most power markets feature price or bid caps, we assume that a ceiling price exists in the physical electricity market. Prior to the electricity wholesale market stage, the two firms may sign opposite swap contracts with a financial intermediary. We argue that swap contracts may be used as a commitment device to either increase market prices or, alternatively, to lock-in one of several possible pricing equilibria on the physical market.

Note that in the physical market, each firm is pivotal when both firms' capacities must be deployed to satisfy demand. In these cases, all pricing equilibria are characterized by one firm being inframarginal and its rival firm submitting a high, market clearing price (that both firms receive). Due to its market power vis-à-vis residual demand, the price-setting firm can charge a high, supra-competitive price. It might however compromise on selling parts of its capacity. If its inframarginal competitor is bidding low enough, undercutting is, however, no profitable option for the price-setting firm, so that it in equilibrium prefers to serve the remaining demand left by its competitor.

How can derivative contracts change these market outcomes on the physical market? Suppose the contract is specified as in the example above from the New York power market, a market that can indeed be characterized as a very concentrated market. Further suppose that the price cap is not binding for the price-setting firm's optimal bid on the spot market. Lastly, assume that the two firms have clearly assigned who will be the price-setting bidder. Then, signing an opposite swap increases both firms' profits. The intuition is as follows. The price-setting bidder specifies a contract that creates transfer payments for higher prices than the strike price and is consequently willing to offer a higher bid. The firm thereby increases the market price. Crucially, this firm gets the higher price not only for its dispatched units, but also for the swapped quantity specified in the financial contract. Moreover, the increased spot profit (due to the higher market price) for the inframarginal firm may be large enough to more than offset the swap payment it has to make to the price-setter via the financial intermediary.

However note that this result holds only if the price cap is not binding ex ante of the swap, and therefore higher market prices can indeed be realized. Otherwise, when the price cap is already binding prior to the swap, such financial agreements, of course, cannot trigger a market price increase and cannot generate and allocate additional profits among the contract parties. Interestingly, before KeySpan and Astoria signed their swaps, the market price had constantly been equal or close to the price cap.

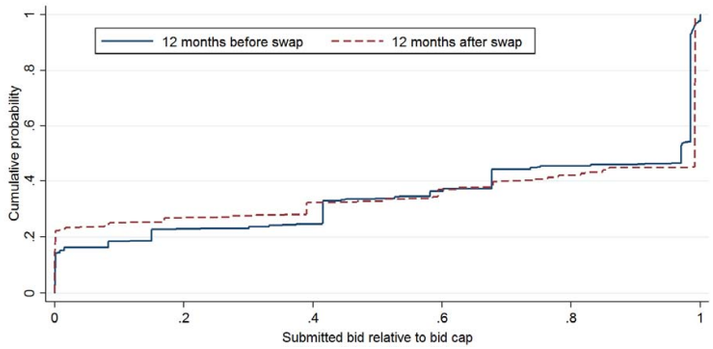

Figure 1: Cumulative distribution of submitted bids. Data downloaded from the NYISO's website.

Figure 1 shows the cumulative distribution of all bids submitted to the monthly New York City capacity market for the 12 month prior and for the 12 month ex post of the start of the swap. Submitted bids are plotted relative to the bid cap, so that a value of 1 represents a bid equal to the price cap. As can be seen, before and after the swap a mass of bids was submitted at bids equal or close to zero (about 20%). These were low bids by inframarginal firms. Importantly, before and after the swap a similar mass of bids was also submitted at the price cap (more than 50% of all bids). These are the price-setting bids. In fact, each of the 12 auctions prior to the swap cleared at or close to the price cap already. Hence, all else equal, the swap could not have been motivated by increasing the market price for capacity. Given the similarity in the bidding strategies prior and after the swap, it may at first be difficult to rationalize the reasoning behind KeySpan's and Astoria's financial positions.

So far, by assumption, the identity of the pivotal bidder had been clearly assigned. However, from previous theoretical literature it is well-known that with sufficiently symmetric firms, each firm would prefer to be the inframarginal one, sell all its capacity and be rewarded at the high market price determined by its competitor. As Le Coq et al. (2017) already point out, players in such games consequently face a severe coordination problem.

In the presence of a price cap, it is this coordination problem that may be resolved by firms signing opposite swap contracts. Here, swaps can act as a commitment device. The transfers implicitly determine what firm will be the inframarginal one and what firm will be price-setting. This is in line with the industrial organization literature that shows that side-payments may be used by firms to enforce collusion (Harrington and Skrzypacz, 2007). There is therefore a rationale for signing opposite swap contracts between two generators, even when the price cap is binding and no price effect is expected. Firms simply agree on who has to be inframarginal and who has to be pivotal. In the above example, if Astoria was price-setting, its incentives to set a high market clearing price would clearly be downward biased by the swap agreement. Therefore both KeySpan and Astoria would prefer KeySpan to set the market clearing price. It still holds that the pivotal firm, here KeySpan, then wants to price high and the inframarginal firm sufficiently low in equilibrium, but the roles in this game are clearly assigned and the coordination problem on what firm will be price-setting is solved.

It is interesting to note that in the example market above, KeySpan was always the high, market clearing bidder and Astoria the low and inframarginal bidder. Before the swap came into force, Astoria invested in new capacity and then closely matched the generation capacity of KeySpan. According to theory, becoming more symmetric makes the coordination problem more severe. Signing this opposite swap contract may have been the solution to countervail the increased symmetry between the two firms. An empirical analysis would however be warranted to fully assess the mechanism that we are suggesting.

The described swap eventually turned into an antitrust case. The corresponding complaint argued that "the clear tendency of the Morgan/KeySpan swap was to alter KeySpan's bidding" (US District Court, 2011). This paper shows that the discussed financial scheme may indeed increase KeySpan's market power but only with a non-binding price cap. Our theoretical considerations above provide another rationale for signing swaps – that is beneficial to market actors even with equilibrium prices unchanged. To conclude, if firms are (or are becoming more) symmetric, swaps may work as a commitment device towards solving coordination and free-riding problems by transferring rents via the financial market.

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Mapping Residential Thermal Comfort Gap at Very High Resolution Spatial Scale: Implications for Energy Policy Design

By João Pedro Gouveia, Pedro Palma, Júlia Seixas and Sofia Simoes

OVERVIEW

With the purpose of meeting the set targets for 2020, the European Union (EU) has steered its policy towards the reduction of building's energy consumption, which currently represents 40% of the EU total energy consumption. Nevertheless, the residential sector cannot disregard the thermal comfort, which is interconnected with people's health, welfare and ability to function. The effect of changes to buildings' structure, materials used or appliances, should always take into account the maintenance of the indoor thermal comfort (Peeters et al., 2008). In EU, due to poor building construction, low household income and the rise in energy costs, between 50 and 125 million people are not able to ensure thermal comfort in their households (WHO, 2012). Chronic exposure to low ambient temperatures results in an adverse impact to the physiological condition of humans (Healy and Clinch, 2002).

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In this work we use Portugal as case study due to its location in Southern Europe, targeted as one of the most likely climate impacted regions (Santos and Miranda, 2006). The achievement of thermal comfort is a relevant issue to be addressed, as about 24% of the population are unable to keep their house warm during the winter, the highest 5th highest percentage among the EU28 (Eurostat, 2017). During the summer, an estimated 36% of the general population cannot keep their house cool (Eurostat, 2017), ranking second in all EU28 countries, as most residential buildings rely on natural ventilation for cooling (Barbosa et al, 2015). Simoes et al. (2016) analysed 29 Portuguese municipalities and estimated that 22% and 29% of the inhabitants are potentially fuel poor, regarding the heating and cooling needs of their homes.

The aim of this study is to determine heating and cooling energy needs and assess the energy performance gap on thermal comfort of households, as in Wilde (2014) and Callì (2016), both in heating and cooling seasons. The approach was applied throughout the five climatic zones of Portugal, ranging from the coldest, with more than 1800 heating degrees-day per year and a summer outside temperature between 20º and 22ºC, and the warmest zone with less than 1300 heating degrees-day/year and an outside summer temperature above 22ºC. All the 3092 civil parishes and near 3.8 million dwellings, occupied and of usual residence, were considered, while capturing specific details of construction, climate, average households areas for each region to support the definition of local dedicated energy efficiency policies and instruments. Current average country consumption for heating is 1.51GJ/capita and for cooling is 0.35 GJ/capita in the residential sector (INE and DGEG, 2011 and DGEG, 2017).

METHODS

A buildings typology approach supported on a set of key building's characteristics (e.g. area, walls, bearing structure) was used. A total of 11 different building typologies were established for each region of the country. The specific building characteristics of each region were taken into account in the typologies. The number of dwellings was estimated from building stock data (INE, 2011) and subsequently assigned to the different housing typologies. Energy needs for space heating and cooling were calculated according to the most recent legislation - Residential Buildings Energy Performance Regulation (REH) using a steady state method (Palma, 2017), and building upon previous work by Simoes et al. (2016) and Lopes (2010). Heating/cooling energy demand derived from this method, indicates the value of energy needs for a household, considering the hypothesis of a permanent heated/cooled area during the heating/cooling season. These needs are theoretical, since in residential buildings, the actual cooled and heated area represents only a small fraction of a household, and the devices that supply this demand are switched-on only part of the time. As mentioned by Asimakopoulos et al. (2012), the partial coverage of the energy needs due to social and economic reasons is difficult to predict (i.e. evolution

of poverty). The results were benchmarked to the real energy consumption estimated for heating and cooling equipment ownership data and energy use statistics (DGEG, 2016). Two sensitivity analysis scenarios (Conservative and Strict) based on regional adjustments concerning the typologies average cooled/heated areas and the operating hours related to different occupancy schedules were tested in order to analyse a more realistic approach than the theoretical energy needs. Results were mapped using the QGIS software for visualization and detailed spatial analysis.

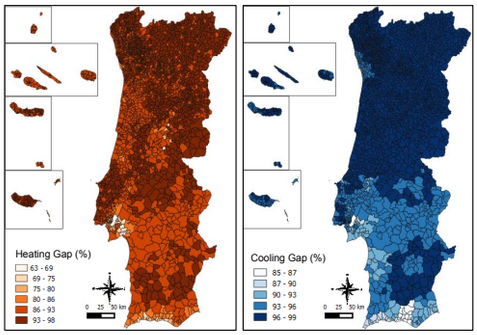

Figure 1 - Heating and Cooling gaps for the Reference scenario

RESULTS

Our study for the all civil parishes shows that the average gap between the real energy consumption and heating and cooling energy needs, is respectively 92.5% and 97.1%, considering the indoor temperature set by the legislation. This means that the average energy consumption of a Portuguese civil parish is only 7.6 and 2.9%, for heating and cooling respectively, of what it is theoretically demand in a reference scenario, assuming that the whole dwellings' area is heated and cooled for 24 hours a day.

About 87% of all civil parishes have a heating gap higher than 90%, whilst 99% have a cooling gap bigger than 90% (Fig. 1). The parameters set in the reference scenario for the estimation of the energy needs are the main reason for such considerable gaps. The low percentage of central heating and cooling equipment ownership and the considerable number of aged buildings (about 20% of dwellings were built before 1960) without insulation and with materials with high thermal conductivity, are also important factors that explain these gaps. For cooling, the gaps are even higher due to the low rates of ownership of any kind of cooling device. In order to bridge this thermal comfort gap, the national consumption for heating and cooling, would be approximately 12 and 26 times (respectively) higher than the 2013 consumption. This analysis red flags the problem for public policies, both for addressing the current fuel poverty levels across the country and also to understand how this issue could be tackled in a sustainable environmental way. Under the sensitivity analysis scenarios, where the shares of households' area heated/cooled and the operating hours of equipment were changed within the different climatic zones, the results show, that for different reductions in household heated areas and different hours of equipment use, the average civil parish' heating gap is reduced to 52%, and the cooling gap to 76% in the Conservative scenario. In the Strict scenario, the average civil parish' heating and cooling gaps are 11 and 23%. About 24% of all civil parishes still have a heating gap, while approximately 75% have a cooling gap.

CONCLUSIONS

The results obtained from the scenarios indicate that the civil parishes' gaps that are annulled, might be explained by climatization patterns set purposely by the consumers. Heating and cooling only a fraction of the dwelling's area, and for a selected period of the day, does not necessarily jeopardize the state of thermal comfort (Magalhães and Leal, 2014), which can be assumed for this case. As for civil parishes that still have a gap in the Strict scenario, this difference between energy needs and consumption is of such magnitude, that it might highlight energy poverty levels of the population and a systemic problem of thermal discomfort. As demonstrated in this work, lack of thermal comfort is still a real concern to a considerable part of the Portuguese population and it is an issue that should be quickly and seriously addressed, as it constitutes a risk for population's health and proper living. Policies and strategies related to building rehabilitation and building construction are paramount, instead of the current trends on creating social energy tariff support as done by the government. The outcomes of this analysis are key to support EE policies at central and local level, allowing effectiveness on energy consumption reduction, while guarantying acceptable thermal comfort levels.

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Interviews continued

ARILD NYSTAD, PAST PRESIDENT AND PAST VICE PRESIDENT FOR CONFERENCES

I have been connected to this organization as a member since 1984 when we established the Norwegian chapter. I have served as VP Conferences for 7 years, president elect and President in 2001. During my years as a VP Conferences I enjoyed working closely together with David Williams to re-shape the conference planning for the international conferences. We worked out a new conference manual and went from a three months planning horizon to a three years with the result of safeguarding the IAEE economy.

For me the value of IAEE has three features:

Firstly the networking part: I always enjoy meeting people from academy, industry and oil producing countries. This aspect of IAEE becomes quite addictive as we are all part of the same family and we enjoy spending time together. This networking part has value for my work and gives stimuli to new ideas.

Secondly the global energy aspects that gives the opportunity to learn more about energy policies, environmental aspects and new research. I work within oil and gas sector, and listening to discussions and paper presentations during IAEE conferences contribute to my understanding of the O&G markets and the environmental aspects, which gain more and more focus.

Thirdly the international aspect of IAEE has great value. I have been to conferences in many countries and I enjoy learning other cultures. As an example of international projects, we have recently established an advisory group within IAEE, collaborating with Mexicans in an advisory capacity for the new Energy Museum in Mexico (MUNET) related to energy and educational expertise from the IAEE's council members.

Finally we should make priority to bring the young generation actively into our organization. The young professionals have a great potential to contribute for the understanding of the new challenges and bringing new ideas to IAEE.

(Interviews concluded on page 55)

Is "Being Green" Rewarded in the Market? An Empirical Investigation of Decarbonization Risk and Stock Returns

By Soh Young In, Ki Young Park, and Ashby Monk

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See footnote at end of text.

OVERVIEW

While investors are increasingly prioritizing climate finance and looking for investment opportunities of "yield with impact," they seem still reluctant. It is mainly because they need more clear understanding on the return-risk relationship related to investing for a clean energy economy. To shed more light on the market evaluation of decarbonization, this study empirically investigates the relationship among firm-level decarbonization, financial characteristics, and stock returns by analyzing 75,638 observations of 739 U.S. firms during the period of January 2005 to December 2015. The main research questions include: (1) what types of firms are more likely to take decarbonization actions; (2) whether carbon-efficient firms' stocks are likely to outperform carbon-intensive firms' stocks; (3) and if so, whether these excess returns on decarbonization are from a pure alpha or market compensation from bearing additional risk.

We define firm-level carbon intensity as the actual amount of greenhouse gas (GHG) divided by company revenue, construct EMI ("efficient-minus-inefficient") portfolio based on carbon intensity, and find that EMI portfolio exhibits a large positive cumulative return from 2009. By applying multi-factor asset pricing models using factor-mimicking portfolios of market, size, value, operating profitability, investment, and momentum, we find that those well-known risk factors cannot fully explain EMI portfolio return and the estimated positive alphas of EMI portfolio amount to 7.7~8.9 percent of abnormal returns per year. In addition, estimating factor loadings on industry portfolios, we also find that EMI portfolio has explanatory power that is independent from well-known risk factors. We discuss how carbon intensity is related to other firm-level characteristics concerning corporate governance and financial performance, along with implications for climate finance in the viewpoints of investors, firms and policymakers.

DATA AND METHODOLOGY

We mainly use four databases: Trucost for carbon emission data; KLD (Kinder, Lydenberg, Domini and Company) for measures on ESG (environmental, social, governance) data; Compustat for financial variables; and CRSP for stock prices/returns. As proxy measures of firms' carbon emission, we use the actual amounts of GHG emissions reported by companies in tCO2e that include direct emissions from operations (Scope 1), indirect emission from purchased electricity (Scope 2) and other supply chain emissions (Scope 3). Then we define carbon intensity as the amount of GHG emissions divided by million USD of revenue.

Based on firm-level carbon intensity, we name a firm with relatively low intensity "efficient" and a firm with relatively high intensity "inefficient," and construct an EMI ("[carbon] efficient-minus-inefficient") portfolio in a similar way to the Fama-French procedure used for the construction of SMB ("small-minus-big") and HML ("high-minus-low") factors:

EMI = 0.5 x (small efficient + big efficient) - 0.5 (small inefficient + big inefficient)

where small firms and big firms consist of the bottom 10% and top 10% in terms of market capitalization and efficient and inefficient firms represent the bottom 33% and top 33% in terms of carbon-emissions intensity. We double-sort EMI portfolio on size and carbon efficiency to reduce the size and industry-specific effect of carbon emissions. Then we apply multi-factor asset-pricing models to test whether the observed returns on EMI portfolio can be explained by well-known risk factors such as market, size, value, profitability, investment, and momentum. Next, we use EMI portfolio as additional risk factors and test if EMI portfolio can price industry portfolios.

RESULTS AND DISCUSSION

EMI Portfolio and its Market Performance

Figure 1 demonstrates that EMI portfolio exhibits a large positive cumulative return and this pattern is more pronounced during the period of January 2009—December 2015. We show four time-series of cumulative returns on: (1) EMI portfolio when we use the sum of Scopes 1 and 2, divided by a firm's revenue as carbon intensity, (2) EMI portfolio when we use returns without dividends, (3) EMI portfolio when we use the sum of Scopes 1, 2, and 3, divided by a firm's revenue as carbon intensity, and (4) EMI

portfolio when small firms and big firms consist of the bottom 20% and top 20% in terms of market capitalization and efficient and inefficient firms represent the bottom 20% and top 20% in terms of carbon-emissions intensity.

Pricing EMI Portfolio with Risk Factors

We perform GRS tests to see if well-known risk factors can price EMI portfolio. We consider four models: (1) CAPM model, (2) Fama-French 3-factor model, (3) Fama-French 3-factor model with momentum factor, and (4) Fama-French 5-factor model. Our results in table 1 show that, while it shares some characteristics of HML, WML, and RMW, EMI portfolio still has its own characteristics that cannot be fully explained by these factors during the period after 2009. We also note that alphas are all positive and statistically significant during the period of January 2010–December 2015.[1] It suggests that the return on EMI portfolio cannot be priced with standard risk factors, implying a positive alpha. The magnitudes of alpha's suggest that an investment strategy that purchases shares of carbon-efficient firms and sells shares of carbon-inefficient firms earns abnormal returns of 7.7~8.9 percent per year.

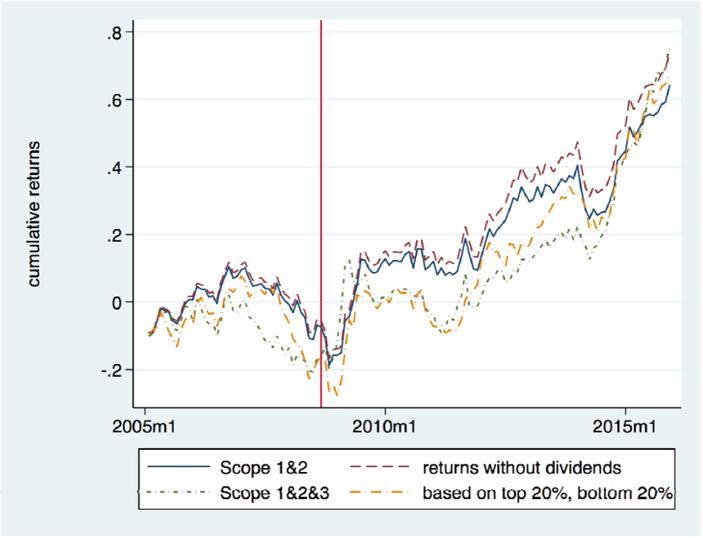

Figure 1. Cumulative Returns of EMI Portfolios
This figure shows the cumulative returns of EMI portfolios, defined in various ways. A red vertical line denotes September 2008, when Lehman Brothers filed for bankruptcy.

Industry Portfolios and Bivariate-Sorted Portfolios

To see whether EMI portfolio has an independent explanatory power, we estimate the factor loadings of 12 industry portfolios, including sectors of consumer nondurables, consumer durables, manufacturing, energy, chemicals, telephone and TV transmission, utilities, wholesale and retail, health care, finance, and others. In terms of the number of statistically significant factor loadings, we find that EMI portfolio is the second to market excess return portfolio, and has an independent explanatory power that other risk factors do not have.

Carbon-Emissions Intensity and Firm Characteristics

To examine what types of firms show lower or higher carbon intensity, we analyze the average values of firm-level characteristics by quartiles defined by four proxy measures of firms' decarbonization. Our results suggest that carbon-efficient firms are more likely to be firms with lower book-to-market ratio, higher ROA (return on assets), higher Tobin's q, higher free cash flows and cash holdings, higher coverage ratios, lower leverage ratios, and higher dividend payout ratios. Note that ROA and Tobin'q are the frequently-used measure of financial performance.

CONCLUSION

To sum, we measure firm-level carbon intensity using the actual amounts of GHG emissions available from Trucost database, and construct EMI portfolio based on firm-level carbon intensity. We find that carbon-efficient firms tend to be those with lower book-to-market ratios, higher ROA, higher Tobin's q, higher free cash flows and cash holdings, higher coverage ratios, lower leverage ratios, and higher dividend payout ratios. Most surprisingly, we find that EMI portfolio exhibits a large positive cumulative return after 2009, suggesting that carbon-efficient firms outperform carbon-inefficient firms in the stock market. In addition, we find that this extra return is not priced by well-known risk factors of size, value, momentum, operating profitability, and investment. When estimating factor loadings on industry portfolios, we also find that EMI portfolio has explanatory power that is independent from well-known risk factors.

Our findings will provide additional information on how the market evaluates firms' decarbonization activities, and raising the understanding of investors and policy makers on mobilizing capital toward corporate environmental investments.

Footnote

[1] Figure 1 shows that EMI portfolio start to earn positive returns from 2009:1. We estimate the same regressions during the period of 2009:1-2015:12 and find that alphas become larger with higher statistical significance.

	(1)	(2)	(3)	(4)
	CAPM	FF 3-factor	With momentum	FF 5-factor
	Sample period: 2005m1-2015m12			
Market excess return	0.176**	0.194**	0.140**	0.111
	-2.46	-2.63	-2.11	-1.64
SMB (size)		0.027	0.044	-0.053
		-0.25	-0.39	(-0.48)
HML (B/M)		-0.135	-0.265**	-0.145
		(-1.36)	(-2.51)	(-1.02)
WML (momentum)			-0.196**	
			(-2.13)	
RMW (profitability)				-0.573**
				(-3.07)
CMA (investment)				-0.034
				(-0.12)
Alpha	0.172	0.151	0.208	0.347
	-0.69	-0.6	-0.86	-1.45
R^2	0.064	0.075	0.151	0.138
N	132	132	132	132
	Sample period: 2010m1-2015m12			
Market excess return	-0.018	0.043	0.032	0.016
	(-0.21)	-0.510	-0.380	-0.190
SMB (size)		-0.096	-0.057	-0.156
		(-0.71)	(-0.43)	(-1.03)
HML (B/M)		-0.380**	-0.450**	-0.469**
		(-2.66)	(-3.04)	(-2.16)
WML (momentum)			-0.165**	
			(-2.25)	
RMW (profitability)				-0.268*
				(-1.77)
CMA (investment)				0.163
				-0.480
Alpha	0.588**	0.451*	0.543**	0.459*
	-2.050	-1.670	-2.000	-1.710
R^2	0.001	0.098	0.135	0.117
N	72	72	72	72

Table 1. GRS Test
*This table shows the results of GRS test, based on two sample periods, January 2005-December 2015 and January 2010-December 2015. *, **, *** denote p-value<0.10, p-value<0.05, and p-value<0.01, respectively.*

Potential for Renewable Energy's Application for Heating in the Industrial Sector – A Case Study of Selected APEC Economies

By Sichao Kan, Yoshiaki Shibata, Alexey Kabalinskiy, and Cecilia Tam

INTRODUCTION

Industrial sector is a major source of carbon emissions. According to the International Energy Agency (IEA), the industrial cumulative CO_2 emissions from 2015 to 2050 is the highest (compared to power, transport, buildings, agriculture, and other transformation) in its 2°C scenario (global temperature rise below 2°C above pre-industrial levels) (IEA, 2016a). Direct fossil fuel combustion to meet the heating demand from various industrial processes is the largest cause of industrial carbon emissions. Unlike the decarbonisation of power sector, which is well under way in recent years, the mitigation of industrial carbon emissions is a much more difficult task. While, a higher target was set in the Paris Agreement dealing with global climate change, by keeping temperature rise "well below 2°C" compared with the previous "below 2°C". To achieve that goal further actions, including more efforts on carbon reductions from the industry sector, are required.

Sichao Kan and Yoshaike Shibata are researchers at The Institute of Energy Economics, Tokyo, Japan, while Alexey Kabalinskiy and Cecilia Tam are with the Asia Pacific Energy Research Center, Japan. Corresponding author: Sichao Kan (kan.sichao@tky.ieej.or.jp).

In the APEC region, more than 71% of industrial final energy consumption is for non-electricity purpose (IEA, 2016b). Therefore, besides Carbon Capture and Sequestration (CCS), to mitigate the industrial carbon emissions, fossil fuel combustion has to be reduced. This can be achieved by energy efficiency improvements, switching to electricity (and decarbonizing the power system) for meeting heating demand, as well as replacing fossil fuels by renewables.

This paper is looking into the potential of renewable energies' application for heating purposes in the industrial sector in selected APEC economies (Chile, People's Republic of China, Japan, New Zealand, Republic of the Philippines, Russia, Thailand, and the United States). The study in this paper serves as support for the Asia Pacific Energy Research Center (APERC)'s APEC Energy Demand and Supply Outlook 7th Edition.

METHOD

In the industry sector most of the heating demand is for process heating. Applications of process heating are diverse and require different working temperatures. According to IEA's categorization, heating demand below 100°C is referred to as the low temperature (LT) range, heating demand from 100°C to 400°C is in the medium temperature (MT) range, and heating application at the temperature higher than 400°C is categorized as high temperature (HT) heat demand. Solar, geothermal (In this study only Ground Source Heat Pump (GSHP) technology was selected as the representing technology for geothermal. However, it should be noted that not all APEC economies include GSHP in their RE policy), and biomass are the options that can provide industrial process heat. However, renewable technologies that are capable to meet high temperature heat demand are limited. To simplify calculation this study focuses on renewable options that are relevant to most of the APEC economies and industry subsectors that are promising for renewable energy heat. A screening process was taken out to determine the technologies and subsectors. The result is shown in Table 1.

	Geothermal (HP or thermal water)			Solar thermal			Biomass		
	LT	MT	HT	LT	MT	HT	LT	MT	HT
Iron and steel	•			•			•	•	
Chemical and petrochemical	•			•			•	•	•
Non-metallic minerals	•			•			•	•	•
Machinery	•			•			•	•	•
Food and tobacco	•			•			•	•	
Paper, pulp and printing	•			•			•	•	•
Non-specified (industry)	•			•			•	•	•

Table 1 Renewable heat technology and industrial sub-sector matching
Source: Authors

The calculation process is comprised of 3 modules: the heat demand profile module, the renewable resource supply potential module, and the renewable heat potential determination module. In the heat demand profile module, useful heat demand from each temperature range in each industrial sub-sector was estimated for all the selected APEC economies. In the supply potential module, the potential of solar thermal, GSHP, and biomass was assessed by considering the constraints like available area in the factory compound, feedstock potential, and so on. In the renewable heat potential determination module, the potential of renewable en-

ergies' application for heating is determined by the smaller of two: the useful heat demand and the renewable energies' supply potential. However, since GSHP, solar thermal, and biomass are all suitable for providing heat for LT applications priorities were assigned to the options based on their levelised heat supply cost. Actually one of the key components in the renewable heat potential determination module is the calculation of the levelized heat supply cost.

RESULTS AND CONCLUSIONS

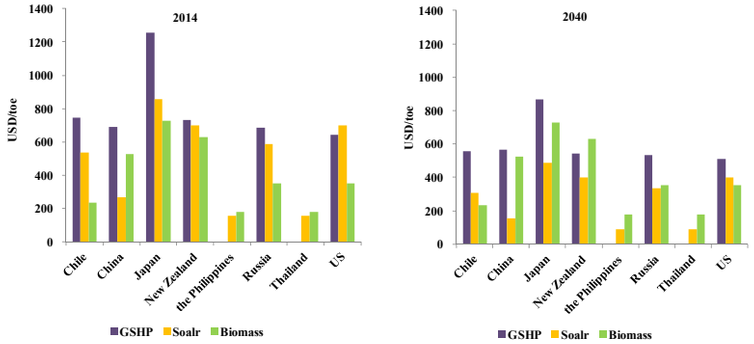

Fig.1 Levelised heat supply cost of the three renewable heat supply options
Source: Authors' estimations

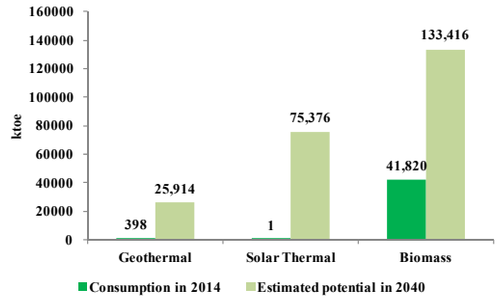

Fig.2 Total renewable energy consumption for heat in all the selected industry subsectors in all the economies in 2014 and potential in 2040 by energy source
Source: IEA, 2016b and author's estimation

In the 8 selected APEC economies, renewable energies are already being utilized for heating in the industry sector. The Food and tobacco subsector, and the Paper, pulp and printing subsector are especially noticeable for renewable heat deployment. And these two subsectors are promising for renewable heat in the future, with potentials estimated to be 42,012ktoe for the Food and tobacco subsector and 49,110ktoe for the Paper, pulp and printing subsector in year 2040. Besides, Chemical and petrochemical subsector is expected be the subsector with the highest potential for renewable energy heat in 2040 given the facts that the subsector is expected to see substantial energy demand growth over the projection period and that low temperature heat demand, which could be supplied by all the renewable options, constitutes more than a third of the subsector's total heat demand.

Among the 8 economies, United States and Thailand have the largest renewable consumption for heat in their industrial sectors. When looking at the renewable heat's share in total final energy demand in the selected subsectors, Chile, Thailand, and the Philippines come as the front runner at the moment. Although the renewable energy consumption for heat in the People's Republic of China is negligible given its huge industrial energy demand, the potential for renewable energies' application for heating, 95,229ktoe in 2040 is estimated to be the largest among the economies. United States has the second largest renewable heat potential for industry use; the potential in 2040 is estimated to be 83,876ktoe, about 3 times of its current industrial renewable consumption for heat.

At present, biomass is the most important renewable option for meeting industrial heat demand and it is expected to remain such over the projection period. In 2040, biomass is supposed to be the renewable energy option with the largest potential for providing heat in the industrial sector. Biomass is suitable for meeting heat demand in different temperature ranges and the utilization of biomass require less change to the industrial facilities. Besides, in economies with abundant biomass supply, like the United States, levelised cost of heat supply of biomass is the lowest among the 3 options. The next promising renewable option for industrial heat is solar thermal despite the fact that its consumption in 2014 in the industry sectors is only 1 ktoe. Although solar thermal is suitable only for low temperature, its cost is expected to decline in the future, making it the most cost competitive renewable option for low temperature industrial heat supply in 2040 in many economies.

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Decarbonizing the Indian Energy System until 2050
An Application of the Open Source Energy Modeling System OSeMOSYS

By Konstantin Löffler, Karlo Hainsch, Thorsten Burandt, Pao-Yu Oei, and Christian von Hirschhausen

INDIA ON THE WAY TOWARDS DECARBONIZATION

India has emerged as a major energy producing and consuming country, and it is also one of the largest emitters of greenhouse gas emissions worldwide. With a doubling of its energy use since the turn of the century, and still a relatively modest per capita energy consumption, India faces significant challenges when addressing the low-carbon energy transformation. On the one hand, its nationally determined contributions (NDCs) are at least partially ambitious, i.e. with respect to renewable energies (Ministry of Environment, Forest and Climate Change, 2015), foreseeing not less than 100 GW of solar capacities by 2022, and 175 GW of renewables overall (2016: ~ 35 GW). On the other hand, the future use of coal is uncertain; the draft plan by the Central Authority of India stating that beyond 2022 no more additional coal plants would be needed in the country (Central Electricity Authority of India (CEA), 2017).

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There is an increasing state of literature on different decarbonization pathways for India. These range from the IEA's "new policies" (NPS) and "450ppm" scenarios (International Energy Agency, 2015) to low-carbon scenarios by Indian scholars such as IRADE (2014) and Singh (2017), to scenarios targeting a 100% renewable energy system for India by 2050, such as Jacobsen (2016) and Gulagi et al. (2017). In this article, we analyze alternative pathways to decarbonizing the Indian energy system until 2050, using an energy system model adapted to the specifics of the Indian electricity, heating, and transportation sectors.

METHODOLOGY, DATA, AND ASSUMPTIONS

We have adapted the Open Source Energy Modeling System OSeMOSYS (http://www.osemosys.org/) to India, adding several features including the transportation sector and equations for storage; a stylized representation of our model setup is displayed in Figure 1. We rely on much of the input data for 2015 provided by Gulagi et al. (2017), including the split of India into 10 regions; from there, we calculate pathways to 2050 in five-year steps. Every year is split into several time-slices which are differentiated by seasons, different days of a week, and different hours of a day. We develop three different scenarios, two of them leaning on the IEA scenarios "New Policy Scenario" and "450 ppm", including the CO_2-budgets determined by the International Energy Agency (2015), and a third one that targets 100% renewables energy supply by 2050. In addition, we use cost assumptions from Schroeder, et al. (2013).

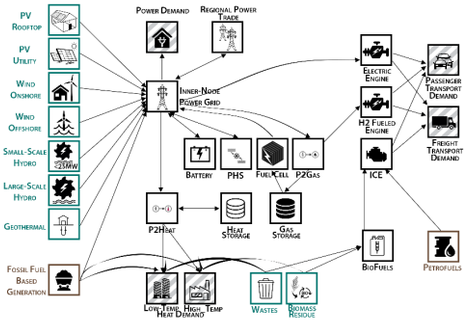

Figure 1: Model representation
Source: Own illustration

SOLAR POWER LIKELY TO DOMINATE THE FUTURE INDIAN ENERGY SYSTEM

The results indicate that the least-cost solution of different low-carbon scenarios include a dominance of solar energy, whereas coal is more expensive and loses significantly in market share. Other renewable energy sources such as wind and biomass also play a significant role, whereas natural gas and nuclear power are not part of any 2050 scenario, due to their high costs. Figure 2 shows the energy mix in 2050 under the NPS, 450ppm, and 100% RES scenarios, respectively; whereas solar plays a dominant role, the share of coal is determined by the available CO2-budget, which is highest in the New Policy Scenario (159000 mn. t).

Figure 3 shows the dynamics of electricity generation from 2015 to 2050, for the middle-scenario "450ppm". Contrary to the status quo prevailing in India, with the largest share of electricity coming from coal and some from wind, solar is expected to outpace wind which is growing at a much lower rate. After 2025, the share of coal in electricity generation is decreasing, and it reaches 5 % in 2050. Once again, natural gas plays no role; contrary to other transformation processes, e.g. in the United States, India seems to leapfrog the age of natural gas; instead, coal is the "transformation fuel".

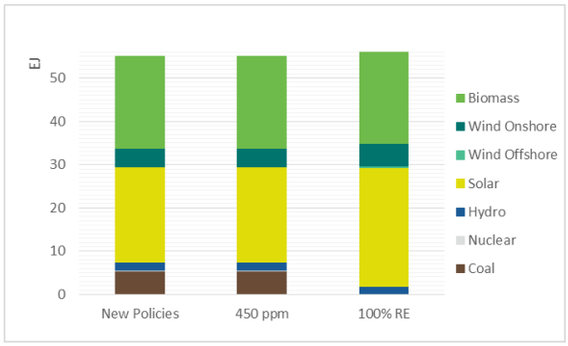

Figure 2: Energy mix in three scenarios (NPS, 450ppm, 100%RES) in 2050
Source: Own illustration

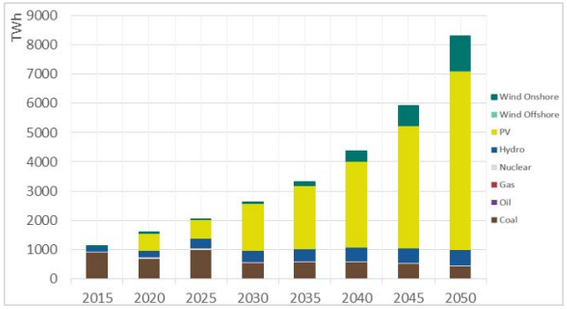

Figure 3: Development of electricity generation in the "450ppm" scenario, 2015 – 2050
Source: Own illustration

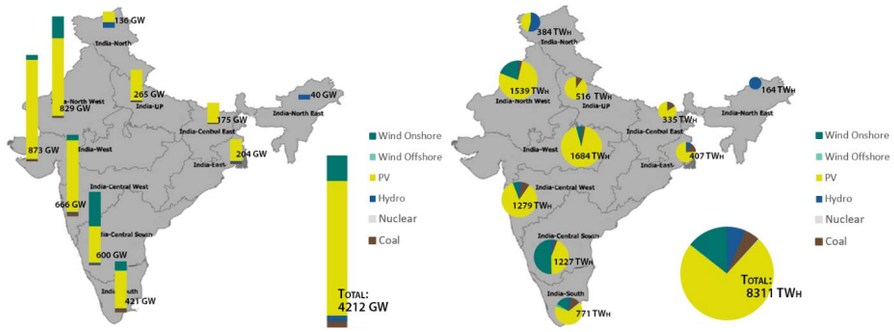

Figure 4: Installed capacities [GW; left] and electricity production [TWh, right] in the "450ppm" scenario" for 2050
Source: Own illustration

For the electricity sector, hydro and wind in combination with storages (Pumped hydro storage, gas storage and batteries) are used to satisfy the demand during nighttime. This mix of technologies is able to handle the greatly increased power demand of India, in addition to the sector coupling with the heat and transport sectors. The heat sector is divided up between space and water heating and process heat. Coal still plays a major role, especially in the industrial heating sector; in the 100% RES scenario, it is replaced in the 2040's by biomass and electric heating.

REGIONALIZATION OF PRODUCTION PATTERNS

India is a very large and federally structured country with a lot of regional diversity. The regionalization of our model based on Gulagi, et al. (2017) allows us to derive first insights into the regional distribution of electricity generation, once again taking the 450ppm as the middle scenario (Figure 4). Clearly the share of coal electrification remains significant in the Center and in the East, hydropower is important in the North and the North-East, and wind plays a significant role in the South. The regional patterns also provide some insights into the upcoming structural reform process, in particular in the coal-intensive regions of the country.

CONCLUSIONS

India plays an increasing role in the global energy and climate policy discussions, and the Indian government has stepped up its commitments significantly. Model-based analysis of different low-carbon pathways to 2050 indicate that solar energy is likely to play a dominant role in the future, because it has clear cost advantages over coal, the environmental benefits not even being considered. A regional differentiation proves to be useful to identify specific challenges of structural change of the energy mix. Future research needs to provide a more detailed disaggregation of the analysis, both with respect to time slices, trade between regions, and the role of storage in the energy transformation.

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Consumer's Attitude Towards Investments in Residential Energy-Efficient Appliances: How End-User Choices Contribute to Change Future Energy Systems

By Mattia Baldini, Alessio Trivella and Jordan Wente

INTRODUCTION

The proliferation of increasingly energy-efficient (EE) appliances is a key strategy to address the impacts of rising residential electricity demand (Danish Energy Agency 2017). To this end, governments and institutions are interested in understanding the drivers of consumer choice between conventional and environmentally friendly alternatives when purchasing new household electric appliances. This study employs empirical data from a survey conducted by the Danish Energy Agency to model the decision criteria behind Danish consumer investment in energy-efficient labeled appliances. The analysis uses logistic regression over a set of socio-economic, demographic, and behavioral variables to predict purchase propensities. The findings are relevant for policy makers interested in targeting consumers in the appliance market, particularly for a relatively wealthy national context. The study concludes by integrating the predicted propensities with an energy-systems model to assess the nation-wide impact of efficient appliances' uptake in terms of electricity, emissions and economic savings.

The authors are with the Technical University of Denmark, Department of Management Engineering. Mattia Baldini and Alessio Trivella are PhD candidates at the System Analysis and Management Science divisions, respectively. Jordan Wente is a graduate from the Sustainable Energy Master program. E-Mail: mbal@dtu.dk.

METHOD

The dataset analysed is the Danish Energy Agency's bi-annual survey, "El-model Bolig" for the year 2012, sample totaling 1716. The dataset's demographic distributions are compared against national registries from Statistics Denmark, without sampling error, and are deemed representative. Socio-economic variables are chosen with the intention of predicting investment in a highest EE labeling appliance: age, quantity of inhabitants, housing type, house size, year built, income and other additional questions regarding profession and end-use behaviour for appliances. All pertinent questions related to energy savings behavior are combined into a singular composite variable: EE index. The consumer's propensity to invest in a household energy-efficient appliance is evaluated with a discrete choice model, using logistic regression. If the investment is considered as a binary outcome Y (1 = investment, 0 = no investment), the model assumes that:

$$logit\,(P(Y=1 \mid X_1 = x_1,\ldots,X_n = x_n)) = \log \frac{P(y=1 \mid X_1 = x_1,\ldots,X_n = x_n)}{P(y=1 \mid X_1 = x_1,\ldots,X_n = x_n)} = \beta_0 + \beta_1 x_1 + \cdots\cdots + \beta_n x_n$$

where X represents the vector of explanatory variables (age, job, income, type of house etc.) and β the weight vector fitted through logistic regression on the survey's data. The probability of investment (i.e., Y=1), is computed as a standard logit function:

$$\hat{\pi} = P(Y=1 \mid X_1 = x_1,\ldots,X_n = x_n) = \frac{exp(\hat{\beta}_0 + \hat{\beta}_1 x_1 + \cdots\cdots + \hat{\beta}_n x_n)}{1 + exp(\hat{\beta}_0 + \hat{\beta}_1 x_1 + \cdots\cdots + \hat{\beta}_n x_n)}$$

To complete the analysis, the predicted consumer investments are embedded into the partial-equilibrium energy-systems model Balmorel (Balmorel 2015) to assess the system-wide socioeconomic impacts. The standard model, normally used for power generation dispatch, has been extended to handle investments in EE appliances (Baldini & Trivella 2017). Investment in EE appliances in a given region reduce the electricity consumption of that region, modifying consequently the optimal configuration of generation technologies and lowering the system costs.

RESULTS AND INTERPRETATION

The results of the logistic regression and the socioeconomic variables, significant in predicting EE appliance investment, are reported in the Table.

Assuming all the other variables fixed, a marginal increase in income by 100,000 DKK, for instance, results in a 1.079 (i.e. exp(0.076)) times greater odds of investment. The estimates show that the EE index is among the most important predictors, along with house type and age of the respondents. Surprisingly, the income variable is not as a strong predictor as expected.

The contribution of different behaviors to the EE index is presented in Figure 1. The heat map is presented per house type and shows that specific EE-related actions contribute more than others. For example, having EE lights (X800s), lowering indoor temperature (X580) and loading dishwasher/washing machine to at least 50% fullness (X359, X401) more often increase the value of the EE index and, consequently, the probability of investing in EE appliances.

Variable	Estimate	p-value	Significance
Intercept	-1.746	<0.001	***
Income	0.076	0.0110	*
Farmhouse	0.692	0.0024	**
Single-family house	0.555	<0.001	***
Town-SD-row	0.290	0.0924	.
Age: 30-39 years	0.746	0.0046	**
Age: 40-49 years	0.758	0.0015	**
Age: 50-59 years	0.789	0.0008	***
Age: > 60 years	0.919	0.0001	***
Qty-inhabitants	0.215	0.0009	***
EE-index	1.021	0.0011	**
Significance codes: 0.001 '***', 0.01 '**', 0.05 '*', 0.1 '.'			

To study how the predicted probabilities in EE investments change when varying the explanatory variables, we compute probability curves. Figure 2 shows the development of the expected probabilities for different levels of income (it is similar for other variables). The increasing trend suggests that the higher the respondent's income, the higher the probability that the same respondent will invest in more efficient household appliances. The curves are split by housing type to show the relevance of this factor.

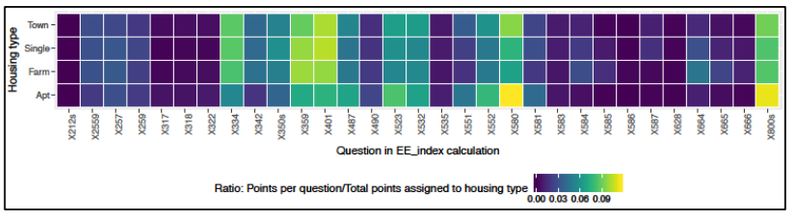

Figure 1

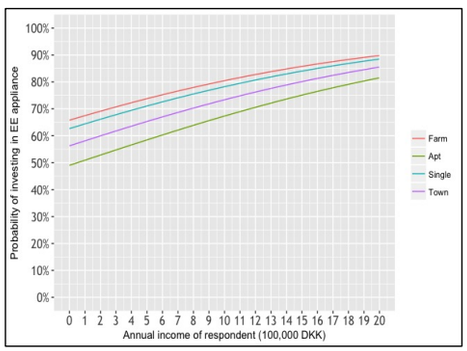

Figure 2

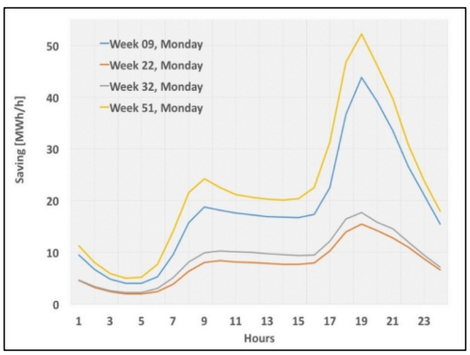

Figure 3

Integrating the estimated investment propensities with the energy-systems model Balmorel results in a larger share of EE appliances and a reduction of consumption profiles. Figure 3 illustrates the electricity demand reduction resulting from the EE investments in four representative days (one for every season) used in the simulations (year 2012). The reduction is higher for load peak hours (morning 7:00-10:00 and evening17:00-20:00) as well for winter weeks. On a yearly scale, the electricity and emissions savings amount to 125 GWh/year and 75 Kton CO_2. For the end-user, the annual net economic savings amount to 25-35 €.

CONCLUSION

The reported study focused on the drivers for investments in energy efficient appliances and the estimated systems-wide consequences of this uptake. Results indicate that the housing type, quantity of inhabitants, income, age, and end-use behaviour are strong predictors for investment in energy efficient appliances. Using a logistic regression model, socioeconomic and housing characteristics were found to be highly significant when explaining investment in efficient appliances (p-value <0.05), with housing type the stronger of these predictors. Income was a positive predictor for EE investment although with much less influence on the total probability than other variables. The further implementation of the investment probabilities in Balmorel characterized quantitatively the impact of the consumer's choices within the energy system. The results lead to the conclusion that the consumers' attitude towards energy savings has an impact on the whole energy system. In total, annual energy and environmental savings correspond to approximately 125 GWh/year and 75 Kton CO_2.

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Interviews concluded

ANTHONY OWEN, PAST PRESIDENT

The IAEE for me has both academic and social dimensions. I look forward to associating with stimulating company at the annual and regional conferences, whilst renewing long-term friendships with colleagues and their partners. I have encouraged early career members of my staff to contribute to the proceedings so that they can gain the benefits of high quality academic feedback in a non-threatening environment. Such exposure has often resulted in a much longer term commitment to the association and the discipline of energy economics. In addition, over my almost 30 years with the IAEE, energy economics has moved from a position of relative obscurity to the forefront of global policy making in the drive to reduce our dependence on polluting activities. The greatest challenge as the association moves forward is to maintain its relevance in a rapidly changing technology-driven environment, whilst still maintaining its role as a meeting place of conviviality.

IAEE CONFERENCE EXPERIENCE BY DELEGATES

Yaser Faquih, Senior Economist at Saudi Aramco

"IAEE conferences in general provide a very open and relaxed venue for new research to be presented, discussed, and critiqued. The fact that the audience is diverse and represent both the academic and industry viewpoints is among the chief benefits of these conferences. The plenary sessions which feature key industry figures often help align the research agenda of young researches. On the other hand, the rigorous academic work often challenges untested theories and market views harbored within industry circles. This cross pollination of ideas is what I find most intriguing in IAEE conferences."

Peter Volkmar, PhD Student at Rice University.

"Meeting people and making connections that will help my research going forward is the most beneficial aspect of IAEE conferences. In Singapore I saw a lot of intriguing presentations given by people excited to discuss their subject matter. I found a group of people working on problems similar to those of my own research and was able to mull over ideas with them and see the issues from slightly different angles."

Come to Groningen!!!

Dear IAEE member,

Now that the successful Singapore conference has ended, we are looking forward to welcoming you in Groningen, the Netherlands, for the 41st international IAEE conference. In Singapore we have discussed our plans with a delegation of members from various regions. The theme of this conference will be "Transforming Energy Markets". Many events will be organized, varying from a preconference Doctoral seminar to Round Tables with academia, business and politicians and an excursion to the Groningen gas fields. We cordially invite to you follow our website www.iaee2018.com for the latest news on our programme.

Best regards,
Bert Willems, program committee chair
Machiel Mulder, general conference chair

University building, University of Groningen: venue for welcome reception and master classes on Sunday 10 June 2018

CONFERENCE OVERVIEW

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

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

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

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

TOPICS TO BE ADDRESSED INCLUDE:

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

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

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USAEE United States Association for Energy Economics

IAEE International Association for Energy Economics www.iaee.org

USAEE Houston

35TH USAEE/IAEE NORTH AMERICAN CONFERENCE

CONFERENCE SESSIONS & SPEAKERS

Visit our conference website at: **www.usaee.org/usaee2017/**

PLENARY SESSIONS

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

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

SPEAKERS INCLUDE

Guillermo Garcia Alcocer
President Commissioner, Energy Regulatory Commission

Kemal Anbarci
Managing Executive, Chevron Energy Ventures

Caldwell Bailey
Senior Consultant, IHS Energy

Brad Burke
Managing Director, Rice Alliance for Technology and Entrepreneurship

Jason Blumberg
CEO and Managing Director, Energy Foundry

Melanie Craxton
PhD Candidate, Stanford University

Carol A Dahl
Senior Fellow, Colorado School of Mines

John Daniel
Senior Research Analyst, Oilfield Services, Simmons

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

Alejandra Elizondo
Research Fellow, CIDE

Martha Goodell
Managing Partner, Enigami Partners LLC

Ron Gusek
President, Liberty Oilfield Services

Benjamin F. Hobbs
Professor of Environmental Management, Johns Hopkins University

William W Hogan
Professor of Global Energy Policy, Harvard University

David H Knapp
Chief Energy Economist, Energy Intelligence Group

Alberto J Lamadrid
Assistant Professor, Lehigh University

Chiara Lo Prete
Assistant Professor Energy Economics, The Pennsylvania State University

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

Robert McNally
Founder and President, The Rapidan Group

Garfield L Miller III
President and Chief Executive Officer, Aegis Energy Advisors Corp

Edward L Morse
Global Head of Commodities Research, Citigroup

Zoltan Nagy
Professor, UT Austin

Surya Rajan
Managing Partner and Vice President, Profitability3

Joshua D Rhodes
Postdoctoral Research Fellow, University of Texas Austin

Michael Robinson
Principal Advisor of Market Design, MISO

Anna Scaglione
Professor, Arizona State University

Jim Sledzik
Senior Partner and President of Houston Office, Energy Ventures

Shree Vikas
Director Market Intellience & Business Analysis, ConocoPhillips

Tina Vital
Director, Aegis Energy Advisors Corp

Michael Wara
Associate Professor of Law, Justin M Roach, Jr. Faculty Scholar, Stanford Law School

Elizabeth Wilson
Professor, University of Minnesota

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INTERNATIONAL ASSOCIATION *for* ENERGY ECONOMICS

IAEE/Affiliate Master Calendar of Events

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

Date	Event, Event Title and Language	Location	Supporting Organization(s)	Contact
2017				
September 3-6	15th IAEE European Conference *Heading Towards Sustainability Energy Systems: by Evolution or Revolution?*	Vienna, Austria	AAEE/IAEE	Reinhard Haas haas@eeg.tuwien.ac.at
October 12-14	2nd IAEE Eurasian Conference *Energy in Eurasia: Economic Perspectives On Challenges, Risks and Opportunities*	Zagreb, Croatia	IAEE	Gurkan Kumbaroglu gurkank@boun.edu.tr
November 12-16	35th USAEE/IAEE North American Conference *Riding the Energy Cycles*	Houston, TX, USA	USAEE	David Williams usaee@usaee.org
2018				
April 22-24	11th NAEE/IAEE Conference *Theme to be Announced*	Abuja, Nigeria	NAEE/IAEE	Wumi Iledare wumi.iledare@yahoo.com
June 10-13	41st IAEE International Conference *Transforming Energy Markets*	Groningen, The Netherlands	BAEE/IAEE	Machiel Mulder machiel.mulder@rug.nl
September 23-26	36th USAEE/IAEE North American Conference *Theme to be Announced*	Washington, DC, USA	USAEE	David Williams usaee@usaee.org
2019				
May 26-29	42nd IAEE International Conference *Local Energy, Global Markets*	Montreal, Canada	CAEE/IAEE	Pierre-Olivier Pineau pierre-olivier.pineau@hec.ca
August 25-28	16th IAEE European Conference *Energy Challenges for the Next Decade: The Way Ahead Towards a Competitive, Secure and Sustainable Energy System*	Ljubljana, Slovenia	SAEE/IAEE	Nevenka Hrovatin nevenka.hrovatin@ef.uni-lj.si
2020				
June 21-24	43rd IAEE International Conference *Energy Challenges at a Turning Point*	Paris, France	FAEE/IAEE	Christophe Bonnery Christophe.bonnery@faee.fr
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

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Join the

International Association for Energy Economics

In today's economy you need to keep up-to-date on energy policy and developments. To be ahead of the others, you need timely, relevant material on current energy thought and comment, on data, trends and key policy issues. You need a network of professional individuals that specialize in the field of energy economics so that you may have access to their valuable ideas, opinions and services. Membership in the IAEE does just this, keeps you abreast of current energy related issues and broadens your professional outlook.

The IAEE currently meets the professional needs of over 3400 energy economists in many areas: private industry, non-profit and trade organizations, consulting, government and academe. Below is a listing of the publications and services the Association offers its membership.

- **Professional Journals:** *The Energy Journal* is the Association's distinguished quarterly publication published by the Energy Economics Education Foundation, the IAEE's educational affiliate. *Economics of Energy & Environmental Policy* is a new journal published twice a year. Both journals contains articles on a wide range of energy economic and environmental issues, as well as book reviews, notes and special notices to members. Topics addressed include the following:

Alternative Transportation Fuels	Energy Management	Natural Gas Topics
Conservation of Energy	Energy Policy Issues	Natural Resource Issues
Electricity and Coal	Energy Security	Nuclear Power Issues
Emission Trading	Environmental Issues & Concerns	Renewable Energy Issues
Energy & Economic Development	Hydrocarbons Issues	Sustainability of Energy Systems
Energy & Environmental Development	Markets for Crude Oil	Taxation & Fiscal Policy

- **Newsletter:** The IAEE *Energy Forum*, published four times a year, contains articles dealing with applied energy economics throughout the world. The Newsletter also contains announcements of coming events, such as conferences and workshops; gives detail of IAEE international affiliate activities; and provides special reports and information of international interest.

- **Directory:** The Online Membership Directory lists members around the world, their affiliation, areas of specialization, address and telephone/fax numbers. A most valuable networking resource.

- **Conferences:** IAEE Conferences attract delegates who represent some of the most influential government, corporate and academic energy decision-making institutions. Conference programs address critical issues of vital concern and importance to governments and industry and provide a forum where policy issues can be presented, considered and discussed at both formal sessions and informal social functions. Major conferences held each year include the North American, European and Asian Conferences and the International Conference. IAEE members attend a reduced rates.

- **Proceedings**: IAEE Conferences generate valuable proceedings which are available to members at reduced rates.

To join the IAEE and avail yourself of our outstanding publications and services please clip and complete the application below and send it with your check, payable to the IAEE, in U.S. dollars, drawn on a U.S. bank to: International Association for Energy Economics, 28790 Chagrin Blvd., Suite 350, Cleveland, OH 44122. Phone: 216-464-5365.

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_____**Yes**, I wish to become a member of the International Association for Energy Economics. My check for $100.00 (U.S. members $120 - includes USAEE membership) is enclosed to cover regular individual membership for twelve months from the end of the month in which my payment is received. I understand that I will receive all of the above publications and announcements to all IAEE sponsored meetings.

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IAEE ENERGY FORUM *Vol. 26, Singapore Special Issue 2017*

The *IAEE Energy Forum* is published quarterly in February, May, August and November, by the Energy Economics Education Foundation for the IAEE membership. Items for publication and editorial inquiries should be addressed to the Editor at 28790 Chagrin Boulevard, Suite 350, Cleveland, OH 44122 USA. Phone: 216-464-5365; Fax: 216-464-2737. Deadline for copy is the 1st of March, June, September and December. The Association assumes no responsibility for the content of articles contained herein. Articles represent the views of authors and not necessarily those of the Association.

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